Antonio M. Battro · Pierre Léna
Marcelo Sánchez Sorondo
Joachim von Braun   *Editors*

Children and Sustainable Development

Ecological Education in
a Globalized World

PONTIFICIA ACADEMIA SCIENTIARVM

Springer

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Editors
Antonio M. Battro
Academia Nacional de Educación
Buenos Aires
Argentina

Pierre Léna
Observatoire de Paris
Université Paris Diderot
Paris
France

Marcelo Sánchez Sorondo
The Pontifical Academy of Sciences
Vatican City
Holy See (Vatican City State)

Joachim von Braun
Center for Development Research
University of Bonn
Bonn
Germany

Canticle of the Creatures

Most high, all powerful, all good Lord! all praise is yours, all glory, all honor, and all blessing. To you, alone, Most High, do they belong. no mortal lips are worthy to pronounce your name.

Be praised, my Lord, through all your creatures, especially through my lord Brother sun, who brings the day; and you give light through him. and he is beautiful and radiant in all his splendor! of you, Most High, he bears the likeness.

Be praised, my Lord, through sister Moon and the stars; in the heavens you have made them, precious and beautiful.

Be praised, my Lord, through Brothers Wind and air, and clouds and storms, and all the weather, through which you give your creatures sustenance.

Be praised, My Lord, through sister Water; she is very useful, and humble, and precious, and pure.

*Be praised, my Lord, through Brother Fire,
through whom you brighten the night.
He is beautiful and cheerful, and powerful
and strong.*

*Be praised, my Lord, through our sister
Mother Earth, who feeds us and rules us, and
produces various fruits with colored flowers
and herbs.*

*Be praised, my Lord, through those who
forgive for love of you; through those who
endure sickness and trial. Happy those who
endure in peace, for by you, Most
High, they will be crowned.*

*Be praised, my Lord, through our sister
Bodily Death, from whose embrace no
living person can escape. Woe to those who
die in mortal sin! Happy those she
finds doing your most holy will. The second
death can do no harm to them.*

*Praise and bless my Lord, and give thanks,
and serve him with great humility.*

Francis of Assisi

Preface

The present book, "Children and Sustainable Development. Ecological Education in a Globalized World," represents the fruit of a series of presentations and discussions drawn from the Pontifical Academy of Sciences' workshop "Children and Sustainable Development: A Challenge for Education," held at the Vatican in November 2015. This conference was directly inspired by the previous workshop, "Sustainable Humanity, Sustainable Nature: Our Responsibility," at which leading scientists gathered at the Pontifical Academy in April 2014 to reflect on the projected impact on society posed by climate change and social justice.

This latest volume testifies to the long-standing interest of the Pontifical Academy in areas pertaining to education, especially in topics involving science, as expressed in the previous notable workshops "The Challenges for Science: Education in the 21st Century" (2001); "Globalisation and Education" (2005); and "Bread and Brain: Education and Poverty" (2013).

"Children and Sustainable Development" was attended by participants from many different nations, covering a great variety of disciplines—drawn from across the natural as well as the social sciences—boasting rich expertise in educational research.

The workshop included a number of testimonies, dealing with bottom-up practical activities in both developing and developed countries, many of which were directly related to science education, climate change, and the environment.

The theme and the timing of this workshop were motivated by the conjunction, in 2015, of three exceptional events, namely:

- the United Nation's proclamation of the Sustainable Development Goals (SDGs), especially SDG#4 on universal education and SDG#10 on reduced inequalities (September 2015);
- the Conference of Parties on Climate Change (COP21 December 2015), concluded by the signing of the Paris Agreement;
- most significantly, Pope Francis's Encyclical Letter "Laudato Si' On care for our common home," which makes a plea for an "ecological education and spirituality" (May 2015).

The workshop underlined that having an adequate education for the next generation would be a decisive factor in the success of these three sources of inspiration given to humanity. To explore these themes in more detail, a broad spectrum of perspectives was presented, covering topics extending from scientific analysis of global warming and its environmental impact, to experimental research on cognitive learning and child development, teaching practices, pilot projects, and large-scale innovative implementation in education.

Participants considered the most diverse cultural, social, and economical environments, paying special attention to the poor and to child empowerment—a relatively new idea indeed! In this respect, a key relevant contribution was the testimony of young students themselves, drawn from several countries, who gave vivid accounts of their own life experiences in different educational environments (Part IV).

This present tome is organized over five parts and thirty-two chapters, containing contributions written by the speakers on the basis of their presentations at the workshop:

Part I—Environment, Climate and Education
Part II—How Could Education Evolve in a Diversity of Contexts?
Part III—Children, Students and Teachers
Part IV—The Voice of Children and Teenagers on Sustainability and Climate Change
Part V—Values and Perspectives.

The recommendations adopted by the participants and presented in Chap. 31 result from the extensive roundtable discussions held at the end of the workshop. We sincerely hope that the ideas presented—and the network of actors who met during the workshop—will contribute, at the global as well as local levels, to motivate educators, scientists, and policy makers to innovate and to act.

We are most grateful to His Holiness Pope Francis for his encouragements to hold this workshop hosted by the Pontifical Academy of Sciences, and to His Eminence Cardinal Peter Appiah Turkson, President of the Pontifical Council for Justice and Peace, who closed the workshop with an inspiring plea for action and solidarity for the sake of the common good of our endangered planet.

We acknowledge the generous support of Mrs. Courtney Sale Ross, Honorary President of the workshop. We would like to close in thanking all of the authors for their contributions, and to everyone at Springer for their dedication and support in publishing this book.

Buenos Aires, Argentina   Antonio M. Battro
Paris, France   Pierre Léna
Vatican City, Holy See (Vatican City State)   Marcelo Sánchez Sorondo
Bonn, Germany   Joachim von Braun

Word of Opening

As President of the Pontifical Academy of Sciences, I am pleased to present this book, which contains the contributions of the participants to our Workshop on *Children and Sustainable Development*.

I simply summarize here the major mission and activities of our academy. We follow the current developments of available scientific knowledge and of the applications by technologies principally aimed at the benefit of mankind and its environment. This allows us to address the recommendations to the Church and generally to the political leadership. We defend the view that established scientific knowledge has cultural values. Updated knowledge on the laws of nature enriches our orientational knowledge that exerts its impacts on decisions to be taken in the course of our lives. A part of such decisions concerns the use of practical, technological applications of scientific knowledge for innovations contributing to the shaping of the future. Cultural values can in fact also be seen in technological developments that contribute to facilitate our living conditions without harmful impacts on the long-term sustainable development. In this context, it is essential that all members of humankind obtain a qualified education. Our deliberations, presented in the present book, will hopefully contribute positively to an important goal: providing an appropriate education to all human beings as a basis for the shaping of our sustainable development.

Werner Arber
President
Pontifical Academy of Sciences
Biozentrum Department of Microbiology
University of Basel, Switzerland
E-mail: W.Arber@unibas.ch

Presentation of the Workshop[1]

In May 2014, the Pontifical Academies jointly held an excellent Workshop on Sustainable Humanity, Sustainable Nature: Our Responsibility. A remarkable series of contributions produced a clear picture of the issues and stressed the urgency to act. It also raised the need for spiritual and moral leadership. But the workshop stopped short of elucidating the role of education in the changes to come and making proposals for action in this direction. These essential questions form the basis of the present book.

The goal is to build, through education, an inclusive society in which all people can have the resources to develop a life project in harmony with their culture and beliefs, transcultural universal values, and respect for the environment. Children must develop an approach open to the other as oneself so that the world, without losing the richness of diversity, can become ever-more integrated. To prepare their active participation in the common good, promoting a cooperation between students in their relationships with civic awareness, and valuing cooperation and solidarity above all forms of competitive selfishness are essential. Cognitive and health sciences provide today a better understanding of the way children grow, from birth onward, and develop their cognitive abilities not only to read and write but also to reason, as well as their emotional senses and empathy.

In many countries, one may already observe that "education for sustainable development" is becoming part of the agenda of education leaders and authorities. As science plays an essential part in the acceptance and understanding of the issues, it appears that science education of children and youngsters (and their parents) is at the heart of the action; hence, this new workshop is convened by the Pontifical Academy of Sciences. Progress in general education is slow and the United Nations Millennium Goals for the period 2000–2015 have not been achieved, although some progress has been noticeable in various parts of the world, including Africa

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[1]This Argument was prepared in a collective manner to focus the Workshop, then finalized by the present author. Translations of this introductory text in French, Italian, and Spanish may be found at casinapioiv.va/content/dam/accademia/booklet/booklet_children.pdf.

and Asia. Progress in science education is much slower, despite the efforts of science academies, Unesco, and some private institutions. The number of poorly educated children is increasing, affected by population migrations, urban uprooting and poverty, wars, forced labor, refugees conditions, and other changes of migrant work force. In many countries, especially developed ones, anti-science movements arise questioning the ability of scientists to arrive at some truth about natural phenomena, showing a poor understanding of the nature of scientific reasoning and a lack of confidence in the scientific institutions which disseminate the results of research. In other countries, parents and sometimes official agencies, basing themselves on religious principles, oppose scientific evidence to the detriment of children. In both cases, the lack of understanding, by the general public, of the nature of science is evident: It has not been transmitted by a proper education pattern.

Today's children will be the adults of tomorrow, confronted with the consequences of today's actions or inactions. More important even, they will be the ones to act, and to act properly if properly prepared. Education has to convey to them hope, not despair or grim perspectives, giving them self-confidence in their intelligence. Hope and trust in human capabilities need to be first embedded in a solid knowledge and then deeply rooted in a message of spiritual nature, since so many factors could lead these children, students in today's schools, to despair. Children are of special concern in the Gospel (Mat 19, 13–15), and education, not only religious, has always been treated as an essential gift to humanity by the Church. The Church itself having millions of students in catholic schools, and these can therefore play a significant role. Indeed, in Chap. 6, the Encyclical Letter Laudato Si' makes a plea for "education and ecological spirituality."

Schools in today's world are confronted with massive urban migrations, the digital revolution, the lack of qualified teachers and their low income, the explosion of scientific knowledge, and the deep changes in jobs requiring new skills. It is in this context that schools will have to absorb the Sustainable Development Goals, proclaimed by United Nations in the fall of 2015, and to reconsider their science education in order to deal with interdisciplinary complex issues which demand a new vision. There lies a formidable task in connecting education with the urgency of the issues of climate, development and sustainability, caring for poverty, inequalities, and social conditions.

At the end of the workshop, a global discussion will lead to the establishment of guidelines for action.

Pierre Léna
Pontifical Academy of Sciences & University Paris-Diderot
and Observatoire de Paris
E-mail: pierre.lena@obspm.fr

Contents

Part I
Environment, Climate and Education

Chapter 1
Educating Children to Bend the Curve: For a Stable Climate, Sustainable Nature and Sustainable Humanity

Veerabhadran Ramanathan, Hahrie Han and Teenie Matlock

Abstract While climate change is one of several major challenges for sustainable development, it has become a poster-child for unsustainable consumption and for the gross failure of current models of economic growth, which do not value the depletion of natural capital. It is a poster child because climate change links all aspects of human well being, including ecological, cultural, social, economic and political aspects. The stock of climate pollutants already in the atmosphere is sufficient to warm the climate to unprecedented levels within 35 years, with serious if not devastating consequences to the poorest three billion people, who had very little to do with the pollution. But there is still time to avoid catastrophic climate disruption—which could result in systemic risks and even existential threats for all. While the present generation is taking positive steps (with the 195-nation Paris agreement a decisive major step), these steps and actions are not commensurate with the urgency or scope of the dangers of climate disruption.

Addressing the climate crisis will depend on the next generation. They have to become the agents of change. This is only possible with a fundamental shift in attitudes towards our own selves, each other, and Nature. It is of paramount importance that we educate even the youngest in the next generation to cope with and adapt to the problems they inherited, so that they can become better stewards of

V. Ramanathan
Pontifical Academy of Sciences, Scripps Institution of Oceanography,
University of California, San Diego, CA, USA
e-mail: vramanathan@ucsd.edu

H. Han (✉)
Department of Political Science, University of California,
Santa Barbara, CA, USA
e-mail: hahrie@polsci.ucsb.edu

T. Matlock
Cognitive and Information Sciences Program,
University of California, Merced, CA, USA
e-mail: tmatlock@ucmerced.edu

the planet, and protect nature and natural resources for generations to come. We must prepare children to have a critical eye and a hopeful heart so they can become agents of change.

These children need to develop a critical understanding of the complex inter-actions between natural and social systems and how such interactions connect local actions with global consequences. Considerable thinking and brainstorming must occur among educators with respect to effective methods of education, such as the use of metaphors, living laboratories, and examples of the art of the possible. We have to impart interdisciplinary thinking so they can figure out how natural and social systems interact, the so-called discipline of Integral Ecology as expounded in Pope Francis' encyclical. The education system, however, cannot burden them with the knowledge of problems alone. It must also cultivate the sense of agency they need to act on innovative solutions. After all, climate change and other problems of sustainable development are solvable problems. More importantly, the solutions are bound to open new doors for human advancement and well-being.

1.1   How Did We Get Here?

Since the 1880s, human exploitation of the natural environment has increased dramatically. Population has increased six fold; the economy has grown 14-fold; energy use has increased 16-fold; water use has increased nine fold; and we have witnessed forbidding increases in emissions of numerous pollutants. Emissions of the greenhouse gas carbon dioxide has increased 17-fold, and sulfur dioxide, which causes acid rain, has increased 13-fold. There is now compelling evidence that ecological boundaries are being surpassed. About 7 million people die every year from air pollution; blue whale populations have decreased by 99 %; species extinction are about ten to hundred times the background rates of extinction. Perhaps the change that is the most existential threat (when combined with other ecological threats) is unmanageable climate change by 2100 and beyond. If we continue with current rate of increase in per capita energy consumption and with population on target to approach 9.5 billion by 2050, the planetary warming and resulting climate disruption can reach unmanageable levels. The acidity of the oceans due to the carbon pollution will also become a major threat for the food chain. With such changes in the physical, chemical and biological climate, the people and all living things inhabiting the planet by 2100 will be witnessing an environment unlike any the planet has witnessed in the last tens of millions of years. As proposed by Crutzen, human beings have become a geological force and ush-ered in the Anthropocene epoch, at the heels of the Holocene epoch, which we inherited about 11,000 years ago.

1.2   What Do We Need to Do?

Clearly we have to Bend the Curve on air pollution, energy consumption, unsustainable exploitation of natural resources, species extinction, and many other human influences.

Particularly with the signing of the Paris Agreement on Climate mitigation, we are optimistic that this generation will take meaningful steps to reduce climate change. However, since we have delayed actions to limit our pollution for decades, there is a huge gap between the steps being contemplated and the steps we need to limit climate change to manageable levels. Many of the challenging tasks ahead will be left to the next generation. It is in this context that we consider the need to educate children to be agents of change. Children must become better stewards of the planet. To bend the curve, this should become one of the highest priority solutions, if not the highest priority solution.

Undoubtedly, such education has to be targeted based on nationality, cultural diversity, and economic strata. It has to include a wide range of topics, from environmental science, to morality and ethical issues of climate change, to ecological boundaries. It must educate children on what it means to pursue the common good, including preserving nature for generations of unborn, and protecting the vulnerable three billion people who had very little to do with climate pollution. The challenge is to accomplish such education without overburdening children or discouraging them about the mammoth tasks ahead. We also foresee that such education must reach beyond the classroom to engage parents, faith leaders, civic institutions, and local and national governments as educators.

1.3   Educating Children: Cultivating a Critical Eye and a Hopeful Heart

Veteran community organizer and Harvard professor Marshall Ganz argues that young people have always been at the forefront of every major social movement our world has seen. "Young people come of age with a critical eye and a hopeful heart," he writes. "It's that combination…that brings change" (Ganz 2009). As educators, the challenge before us is to cultivate, with intentionality, the "critical eye" and the "hopeful heart" that enables our youth to become change makers. Yet, how do we do it?

The challenges are formidable. First, the young must be educated about natural and social systems—and the relationships therein—so that they develop the "critical eye" they need to look reflectively at the world. We need to teach them about the science of climate change, but also the history of how we got here, and the implications of their current actions for future generations. They have to understand the choices they have, and the possible consequences of each of them, to be able to think carefully about creating the world they want for themselves, for others who share the world with them, and for future generations. They must learn to see the world as the

complex system that it is. Given its complexity, this learning cannot happen overnight, but should start at the kindergarten level and continue through college. Students, however, should have the motivation to learn since they would be witnessing marked changes in extreme weather and climate affecting their daily lives.

In addition, this content must be communicated in a way that is understandable to and resonates with children across a wide range of cultures, socio-economic strata, and backgrounds. The information that children must learn is complex, and is made more complex by the need to reach children around the globe. The enormity of the challenge of climate change necessitates reaching all people, from both a scientific and moral standpoint. Thus, we must consider educational methods that will help us do this. In this chapter, we discuss the use of metaphor as a way of achieving these goals.

Finally, we must recognize that having a "critical eye" alone is not enough; children also need a "hopeful heart." Young people not only have to understand the danger; they have to feel like they can do something about it. Yet, all around the world, we see a growing sense of despair among many people. As Pope Francis said at the World Meeting of Popular Movements in Bolivia in July 2015, "I have sensed an expectation, a longing, a yearning for change, in people throughout the world…Many people are hoping for a change capable of releasing them from the bondage of individualism and the despondency it spawns…[Yet,] looking at the daily news we think that there is nothing to be done, except to take care of ourselves and the little circle of our family and friends…What can I do…?" Polling data supports the sentiments Pope Francis espoused: Even people who support change often feel like they lack agency to make it happen. Overcoming this despair, and replacing surrender with agency (discussed in more detail later) is a core task of environmental education. Not only do we need to teach children the science of being stewards of the environment, we have to inspire them to realize that they have the capacity to be agents of change themselves. Only then can we cultivate the "hopeful heart" young people need to become effective stewards of our world.

These are three challenges that any educational program must encounter, but we are hopeful that we can address each of them. First, what do educators need to know to develop a "critical eye" in children? Second, how can they do it in a way that is clear and reaches across multiple boundaries? Third, how can they also cultivate the "hopeful heart" children need to act purposefully? Below, we address each of these challenges in turn.

1.4 What Do the Educators Need to Know?

We begin with a discussion of what educators need to know to develop children's "critical eye."

- Each decade will be different from the previous one; Changes in climate and extreme weather will be that fast—much like the speed of technological change

hitting society now. Disruptive changes such as mega droughts, floods, and heat waves can affect large regions and create tens of millions of climate refugees. We should prepare children to live in a world with rapidly changing weather, climate, and ecology. We should teach them to take responsibility for the actions of their parents' and grandparents' generations.

- Consumption of fossil fuels and other natural resources without concern for others, future generations, or nature, has come at a huge cost to everyone and the eco-system. About 7 million people die prematurely each year due to air pollution resulting from the burning of fossil fuels and biomass. These are the same sources of carbon dioxide, the major climate-warming agent. Tens to hundreds of millions suffer from air pollution-related health problems. Species destruction during the last century is about 10 to 100 times the background rate of extinction.
- Climate change is the greatest threat to global health. Projections by the Lancet commission (Watts et al. 2015) include the following: Three billion additional exposure to heat wave events every year for the elderly. Women, children, and the poor will be the worst affected. It also threatens to undermine the last half-century of development gains; in short, climate change is a medical emergency.
- Local actions have global consequences. Climate pollution from cars and power consumption in a medium-sized city like San Diego, California can lead to droughts over sub-Saharan Africa and displace thousands of villagers on subsistence farming.
- About 60 % of the climate pollution is due to the top (wealthiest) one billion people and only 6 % of the climate pollution is due to the bottom (poorest) three billion people, who still cannot afford or have access to fossil fuels to meet even basic needs like cooking.
- If unchecked, sea level can rise about 2 meters this century and as much as 30 meters in the centuries beyond, affecting lives of generations yet to be born. These future generations cannot be at the table today to inform and pressure our leaders to take actions.
- These ethical and moral issues of climate change are layered onto other intra- and inter-generational challenges. If the worst possible outcomes of climate change emerge, the confluence of all these things would make climate change a major source of geo-political, multi-cultural, multi-ethical conflicts within nations and across national boundaries.
- Destruction of species as well as human habitat from heat, droughts, floods, and regime shifts in climatic zones, and destruction of marine species due to acidification of the oceans could pose existential threats in several decades.
- Fossil fuels have become an outdated source of energy. We have abundant sources of renewable energy to fuel all of our and those of future generations' energy needs. We need to invest our resources, human and financial, in a transformational change that taps into renewable energy sources. This step by itself would resolve about 70 % of the pollution that warms the climate.

- Our current economic models of growth couple growth with consumption of fossil fuels and other natural resources. These also are outdated ideas. Switching to renewables can and will decouple growth from development. The issue is the cost to the present generation. In weighing the cost-effectiveness of clean energy sources, our models and policies should given equal weight to the intra- and inter-generational equity issues—the so-called Social Cost of Carbon.
- Popularly held views, such as the idea that air pollution is an unavoidable side effect of economic growth, have been proved wrong time and again. California is the most well-known example. During the last 50+ years, it has reduced by 90 % the pollution emissions that lead to ozone smog, soot, and carbon monoxide. Each dollar spent on cleaning the air netted about $30 in terms of health benefits and creation of about 155,000 jobs (CARB 2013). There are several other such living laboratories in developed countries.
- Both air pollution and climate pollution are solvable problems. We just need to empower millions of young new minds to solve the problem. They need living laboratories to learn the art of the possible. Universities and cities can and should provide such laboratories for innovation. For example, the University of California, a public system of ten campuses, has decided to go carbon neutral by 2025. About 50 academics from the University of California system have come together to identify 10 ways to scale up these local solutions to the national and global levels (Ramanathan et al. 2015).
- Solutions to the climate change problem require revolutionary steps and not incremental steps. There is not much time left for incremental steps to take hold.
- Solutions also require a fundamental change in attitude towards nature and towards each other.
- Nature has boundaries. When you see brown-ish skies, it means we have exceeded nature's capacity to process air pollutants; likewise, dead-sea zones caused by excess nitrogen carried by river runoff is indicative of exceeding nature's boundaries; disappearance of more than 30 % of Arctic sea ice is another indicator.
- Our individual actions of consumption have negative consequences for thousands of innocent bystanders thousands of miles away and for thousands of unborn generations.
- We can enjoy our standard of living without inflicting pain on others or on future generations by becoming of agents of change and innovating ways to effect that change.

1.5 Cross Cultural Ways to Educate the Children: The Use of Metaphors?

Considering the second challenge, then, how do we educate children in a way that communicates complex information, and also reaches across boundaries?

In grade school, we learned that metaphor is a rhetorical tool that is used in the written and spoken word. We learned this while reading and analyzing popular poems such as Emily Dickinson's 'Hope is the Thing with Feathers', which portrays the concept of hope in terms of a bird that "perches in the soul" and "sings a tune without the words," as well as in Ralph Waldo Emerson's 'Snow Storm', which portrays a winter storm as an invisible agent who wildly alters the landscape by laying "tile" that comes from an "unseen quarry" and who "leaves" the scene when the sun appears.

What we did not learn is that metaphor goes far beyond poetry and literature. It is pervasive in all languages, and plays an important role in everyday communication. It is found in all forms of communication, from colloquial talk in gossip to text in scientific journals to formal speech in government proclamations. Sometimes metaphor is colorful and easy to identify as metaphor. We see this in statements such as "the heart of the theory" and "the heart of the soul," where "heart" refers to what is most central, meaningful, and important, and in "heart-warming acts of kindness" and "follow your heart", where "heart" refers to the center of emotions, often implying good will and good intentions. More often than not, though, metaphor is mundane and barely detectable at all, as seen in statements like "artichoke heart" and "heart of palm", where "heart" merely refers to the center of an object.

Metaphor is far more than linguistic expression. It is the heart of everyday thought. It shapes how we learn, how we form attitudes and opinions, and how we make decisions. As noted by linguist George Lakoff and philosopher Mark Johnson, "The way we think, what we experience, and what we do every day is very much a matter of metaphor" (Lakoff and Johnson 1980). It allows us to understand things that are relatively abstract by drawing on our experience of things that are relatively concrete, often physical space and physical processes. Time is a good example of this.

Time is inherently abstract. We cannot feel it, see it or touch it. To reason about time, we rely on our tacit knowledge of physical space. We rely on spatial representations of time, such as calendars, which spatially display days of the week along a horizontal axis from left to right. We use spatial language about time, including language that refers to motion that transpires along a path, apparent in statements such as "We're approaching the weekend", where we portray ourselves as moving through time to a "place" in time, and "The weekend is quickly approaching", in which time is construed as moving toward us. Both types of statements imply motion along a path, but they differ as to whom or what is construed as "moving" (time or ourselves). We also refer to outcomes and events that will happen soon as close to us, as in "near future", and outcomes and events that will happen after much time as far from us, as in "distant future". In climate change, for example, scientists use "near-term" to indicate changes in the coming decades and "longer term" for changes beyond 2100.

1.6   Metaphor is Needed for Inclusion and Unity

We face two forbidding challenges in our attempts to slow climate change. Let us take the American example to illustrate the two challenges. First, roughly 140 million Americans (45 %) still are not convinced of human impacts on climate change. Second, even among those who understand the reality of anthropogenic climate change, very few really understand the urgency of the issue. They fail to understand how unprecedented warming and disruptions can occur in the near-future (by 2050), and that to prevent this, we have to take drastic actions right now. If we wait another 15–20 years, the changes will become large enough to be perceived by everyone—but it may very well be too late to initiate actions then.

Careful consideration needs to be given to how we discuss our changing climate. We know that metaphor can make complex or abstract things easier to comprehend. It can help frame large-scale messages for the general public as well as tailored messages for particular groups. This is important because the content and presentation of messages about climate change influences what opinions people form, what they remember, and what becomes part of their belief systems. In the end, metaphor can have a powerful impact on what they decide to do or not do.

It is important to be objective and factual when reporting research findings about climate change, but it is equally important to present the information in a way that is mindful of a diverse audience—the information needs to engage and make sense to all readers and listeners. Scientists are good at presenting their work to their peers, but they are not always good at presenting it to journalists, policy makers, and the general public. Many are unsure how to talk to non-experts, including K-12 educators and children. This gap in knowledge makes sense given that presenting research findings to the general public is not an integral part of most scientists' academic training. Learning to use visual and verbal metaphors to explain scientific research findings would open doors and make dialogue about climate change more inclusive.

In a similar vein, it is important to tailor messages to people from diverse cultural backgrounds, especially when different languages are involved. People speaking different languages not only have different sound systems, words and sentence structures, they have different metaphors and conceptual systems. An example of this is seen in Aymara, an indigenous language spoken in the Andes. English speakers construe of themselves as moving forward through time toward future events. Many cultures have this way of metaphorically thinking about time, and it resonates with how they actually move their bodies forward toward destinations they can visually perceive. In contrast, Aymara speakers implicitly view the future as if it were behind them and the past as if it were in front. One explanation for this is that Aymara speakers view the future as unknown and obscure, and hence, not in view, not visible (see Núñez and Sweetser 2006). Different metaphorical systems will lead to different inferences when it comes to making sense of abstract information, such as information about climate change. A one-size-fits-all message intended to be inclusive may wind up excluding groups of people who have different belief systems.

Metaphor can also help connect people and give them a unified vision. It can serve as the machine that helps build and sustain common belief systems. In the 2012 U.S. Presidential election, incumbent candidate President Barack Obama used the slogan "Forward" as a centerpiece in his platform. This simple message was powerful because it simultaneously created unity and hope. It gave millions of American voters the desire to move forward into the future as a team.

1.7 Metaphors for Education

Because metaphor helps us understand abstract concepts, it is a useful tool for teaching children about climate disruption and increasing their awareness of the problem. Metaphor helps mathematics teachers convey abstract information about numbers, relations, and functions. Real numbers are metaphorically understood as points along lines that extend indefinitely along a horizontal. We talk about positions of numbers as if they could move relative to ourselves, and as if we were located "at" the default position of zero. This allows us to talk about numbers coming before or coming after, as in "The number 67 comes before 68" and "The number 68 goes after 67." Objectively the information in these two sentences is the same, even though the viewpoint relative to the self differs.

Relying on metaphor to describe the core concepts of climate disruption can also be useful. Jean-Baptiste Fourier in 1824 proposed the idea of greenhouse effects. He described the atmosphere as a glass cover on a plant box. While this metaphor is still used, some scientists point out that this is not an accurate portrayal of how some gases in the atmosphere trap the heat radiation (infra red energy) and prevent it from escaping to space and thus warm the planet. So some of us have switched to the metaphor of a blanket (see Ramanathan and Feng 2008 for a written description) when discussing the greenhouse effect of gases. A blanket keeps us warm by trapping the body heat. Similarly, certain gases like atmospheric carbon dioxide trap the infra-red heat from the surface of the planet and keeps it warmer. These and other examples of metaphors are discussed in Brown (2003) in his book *Making Truth: Metaphor in Science*. Greenhouse gases can be described as a blanket for the planet.

1.8 Developing a Hopeful Heart: What is Agency?

Finally, if we are able to do the work outlined above to develop a "critical eye" in children, how do we also cultivate their "hopeful heart"? Developing this "hopeful heart" depends on developing their sense of agency.

Martin Luther King famously defined agency, or power, as "the ability to achieve purpose." Do people have the capacity to achieve the purposes they desire? Those purposes can be wide and varied, from attaining food and housing, to finding

community with others. Just as people have many purposes, there are also many reasons why people lack the capacities they need to achieve their purposes. Perhaps they do not have the skills they need to reach out and build relationships with others. Perhaps there are structural inequities that hinder their ability to attain housing. Perhaps, around issues like working for climate justice, they are not educated or motivated to take these actions. In thinking about whether people have the ability to achieve their purpose, agency must contend with these multiple capacities.

Yet, in many instances, we see scholars and practitioners alike thinking about agency in relatively uni-dimensional terms. First, many people think of it as having only a cognitive, or emotional component. Political scientists, for instance, are concerned with questions about participation—Why do people participate in civic and political action? What motivates them to engage in those behaviors? Among political scientists, there is widespread recognition that efficacy is a core motivator for political action; to participate, I have to feel like my participation matters. Yet, political scientists often do not tie that sense of efficacy to the opportunities people have to act. Similarly, if we observe different issue campaigns and social movements around the world, many try to develop people's sense of agency through messaging. Consider, for instance, numerous campaigns that develop advertisements telling people, "You can make a difference!" These advertisements are trying to develop people's cognitive sense that they matter, hence developing one aspect of their agency.

Focusing only on the cognitive or emotional aspect of someone's agency misses the fact that agency also has a structural component. Social psychologists argue that agency is critically related to both competence and autonomy (Fiske et al. 2010). Not only do I have to feel like I make a difference (competence), I also need the independence, or space, to be able to act on my goals (autonomy). Agency is not just about what someone thinks or feels. Instead, it is also about whether they are granted the opportunity to act on their goals. The structures and spaces in people's lives that enable—or hinder—their ability to act on their goals critically shape the development—or decline—of their agency.

In addition, people often think only about individual agency, as opposed to understanding the importance of cultivating people's sense of collective agency. To realize the change that we need around environmental issues, we not only have to teach young people to act alone, we need them to realize the importance of acting with others to protect their communities and their world. Collective agency, then, is not just about the realization of one's own individual power, but also the power of working with others. What can we do when we join with others?

Recognizing the multiple dimensions of agency has profound implications for educators and organizers seeking to develop agency in others. If agency is about more than what people think or feel, simply sending me a message seeking to convince me that I can be an agent of change is not enough. Teaching children the science of climate change, and then telling them they should act on it is not enough. Instead, I must also be given an opportunity to act on my goals—only through that experience of acting will I begin to develop my agency. In addition, if agency is not just about individuals but also about collectivities, we have to consider where people develop the skills, motivations, and capacities to work effectively with

others. Children have to realize, through their experiences, the power of what they can do together as stewards of their world. Whether these opportunities for children exist depend on whether democratic organizations—like schools—create those opportunities for people to develop their agency.

1.9 How Do We Prepare the Young to Be Agents of Change?

If children need to develop a sense of agency to become effective stewards of their environment, how do we cultivate that agency in children? How do we educate them in ways that develop not only their understanding of the science of their environments, but also their sense that they have the responsibility and power to protect it?

Much research on the cultivation of agency focuses on the extent to which people have transformative spaces through which their agency develops. When Alexis de Tocqueville came to the United States 200 years ago to observe American democracy, he argued that civic associations were key to making democracy work because they acted as "great free schools of democracy" (de Tocqueville 1969). By coming together with others in shared civic spaces, Americans became transformed. They developed crucial capacities of citizenship, such as developing a sense of a shared public interest, and learning how to work with others to achieve a common goal.

Even in the modern era, much research reaffirms Tocqueville's sense that these shared civic spaces are crucial for transforming people's sense of what role they place in our democracy. In his study of activists at the very front lines of the pro-life movement, for instance, sociologist Ziad Munson finds that 47 % of these activists were either pro-choice or indifferent to issues of abortion when they first joined the movement (Munson 2009). They first became involved in the movement not because they believed in the issue, but instead because of social or biographical reasons that drew them into the movement. Perhaps a friend asked them to attend a meeting and they could not say no. Perhaps they had just moved to a new town and were looking for new people to get to know. Regardless of why they joined, once they got involved, their experiences in the movement shaped not only what they believed on the issue, but also what they felt their responsibility was to act. Because of what I believe, what must I do? Their experiences within the movement itself transformed both their beliefs and their sense of agency. Likewise, psychologists Brian Christens and Paul Speer find that people's early experiences with community organizations critically shape their willingness to stay involved the organization. They detect a difference as large as 28 % points in whether people will engage in ongoing activism depending on whether their early experiences shaped their sense of agency or not (Speer and Christens 2011). This research demonstrates the transformative power democratic organizations can have on people's civic capacities. In doing so, it affirms the multi-dimensional view of agency we discussed above. To develop agency, democratic organizations must structure opportunities that give people the autonomous space they need.

If we think about how these findings apply in the context of education for children, we must begin to ask whether our schools are acting as those Tocquevillian "schools of democracy" that shape their agency. At the individual level, whether students develop the sense of agency—the "hopeful heart"—that we need them to have depends in many ways on how we think about motivation in the educational context. Educational researchers make the distinction between extrinsic and intrinsic motivation (Ford and Smith 2007; Ryan and Deci 2000). If students are motivated extrinsically, they are motivated by outside rewards, or forces external to themselves. Getting good grades, or working to receive praise from a teacher are both examples of extrinsic rewards. The student is not doing the work because she wants to do it; instead she is doing it because she is worried about the consequences imposed by others if she does not do it. Intrinsic motivation, in contrast, focuses on the extent to which students are motivated not by external rewards, but by internal ones. An intrinsically motivated student is a student who seeks learning not because she is worried about the grade she will receive, but because she wants to understand the world around her, or figure out solutions to a problem she sees. To cultivate a sense of agency among students, we need to focus on intrinsic motivation.

Many teachers, schools, and educators in the world are already doing important work to cultivate students' sense of intrinsic motivation. The movement for student-focused learning, for example, focuses on identifying core areas of interest among students, and creating curricula tailored to those interests. Many teachers around the world work with students to instill in them a joy of learning, a curiosity about the world around them, and a commitment to ongoing exploration.

How do we begin to channel those efforts towards helping students develop a sense of themselves as agents of environmental change? How do we take these students who are developing their own sense of individual agency and help them realize their collective agency? Looking at history can be instructive here. Throughout history, many social movements have cultivated agency by creating experiences of collective action for young people. In the United States, for instance, a recent example of widespread activism among young people concerned the DREAM movement, an effort to provide legal status to undocumented youth brought to the United States by the parents. As part of this movement, undocumented youth around the country organized to pressure state and federal governments to reform our immigration procedures (see Jimenez and Dreier 2015 for a discussion of this movement). Although they did not win the national legislation they sought, they eventually won relief through an executive action from President Barack Obama (commonly known as DACA, "Deferred Action for Childhood Arrivals"). Where did these youth find the courage to protest a system that systematically excluded them and, in many cases, presented genuine risks to them and their families for speaking out? In many cases, these youth first became involved in the movement by getting involved in local actions in their community to stop the deportation of specific families they knew. Their early actions, in other words, were not political acts designed to change a system of exclusion—instead, they were social acts designed to protect personal friends and family. Once engaged in collective action, regardless of whether they were successful or not, these youth

learned the power of working with others. They realized that what they could do when they worked with others was different from what they could do alone. They realized, in other words, the agency they had.

The experience of the DREAMers in the immigration reform movement is consistent with the experience of other social movements throughout history. At the turn of the twentieth century, for instance, women's rights advocate Frances Scott Willard was trying to work on the issue of domestic violence. She realized that alcoholism was an important source of violence against women, since men, when drunk, would abuse their wives. To address this issue, she began to develop a campaign for a constitutional amendment banning alcohol. Building momentum for a constitutional amendment in the United States is no easy task. To build the movement, Willard traveled around the United States trying to engage grassroots activists. To engage them, she asked them to do two things before they joined the movement: first, she wanted them to take a personal pledge to swear off alcohol. Second, she wanted them to join with others in their community to shut down a local bar. This second ask was designed to cultivate people's sense of collective agency. Whether or not Joe's Bar in Anytown, USA was open did not make a big difference to the movement. Instead, just as the DREAMers realized their power by working together to stop deportations, so did Willard's activists. She wanted was for people to realize what they could do when they worked with others.

The challenge for educators, then, is to think about how we create equivalent experiences of collective action for children. What, in other words, is the equivalent experience for children? What is the Joe's Bar for young environmental activists?

1.10   Moving Forward

Teaching youth around the world to become agents of environmental change is not just about what we teach them, but also about how we teach them. It's not just about developing their "critical eye," but also their "hopeful heart." Developing human agency is no easy task, however. It has cognitive, emotional, and strategic dimensions to it. In the context of social change, it has an individual and collective dimension. As we think about the educational experiences we create for young people, we should constantly be asking ourselves how we address all of those multiple dimensions.

In speaking to activists around the world in Bolivia, in response to growing lack of agency he detected, Pope Francis said, "I would even say that the future of humanity is in great measure in your own hands, through your ability to organize and carry out creative alternatives, through your daily efforts to ensure the three 'L' (labor, lodging, land) and through your proactive participation in the great processes of change on the national, regional and global levels. Don't lose heart!" So too must we think about the possibilities for our youth.

We need to educate them in ways that develop not only their understanding of the science of their environments, but also their sense that they have the responsibility and power to protect it.

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Chapter 2
Children as Agents of Change for Sustainable Development

Joachim von Braun

Abstract Children under the age of 15 represented 26 % of the world population (893 million girls, 956 million boys) in 2014. They mainly live in low and middle income countries. Children are exposed to current and future social, economic and environmental sustainability problems, but are also potential agents of change for sustainability, even in childhood. This paper explores how the role of children can be enhanced by transformative education in support of their experiences in discovery, participation, and agency of change. Action-related projects and new information technologies offer opportunities. The tremendous diversity of the living conditions of the world's children (e.g. related to their age, gender, rural/urban, poor/non-poor, cultural contexts, discrimination and marginality), and the types of children's respective sustainability problems need to be considered. Experiences with children's roles as agents of change for sustainability (incl. influence on adults' behavior) are reviewed, based on educational initiatives related to innovation, environmental protection, consumption, health, water and sanitation, and caring for others. Such actions are to be considered as promising public investments in sustainability. Recognition of children's potential role as agents of change implies that concepts of investment in education should not just be guided by human capital formation for life-time earnings in markets and by cultural dimensions, but should be expanded by inclusion of externalities of children's contributions to a sustainable development of societies.

2.1 Introduction

Never before has the world had so many children. Children need protection, must have access to quality education to reach their potential, but children can also play critical roles as agents of change in their families and communities. The latter is the

J. von Braun (✉)
Pontifical Academy of Sciences, Center for Developmental Research ZEF, University of Bonn, Bonn, Germany
e-mail: jvonbraun@uni-bonn.de

focus of this paper.[1] Children's agency is elaborated, and experiences with initiatives of children's active engagement for sustainable development are reviewed. The building of human capital and social capital intersect in education for sustainability and related children's agency. Schools can play key roles not only for children's understanding of sustainability in its local and global dimensions, but also for fostering their active roles in making a difference themselves, throughout childhood and the transition into adulthood.

The number of children in the world has now reached a peak of about 1.9 billion. They represent 26 % of the world population. The absolute number will be about the same in 2050, but then children will make up 21 % of the world population (UN Department for Economic and Social Affairs 2015).

A large share of the world's children live in poverty and will be severely affected by sustainability problems. Can children play a direct role even throughout childhood to address sustainability in its four dimensions, that is, socially, environmentally, economically and culturally? Even if children's contributions were only small on a per child basis, the mere number of the world's children suggests that their role for global advancement of sustainability may become large, provided that children's rights and related programs are facilitated for and with them.

In the past, the potential children might have had to influence their social environment and to generate public goods was neglected and in most parts of the world this still is the case. This paper will focus on the role of the agency of children for development. 'Agency' is understood here as a person's active initiative toward the achievement of a goal, that is, actions undertaken in order to have an impact on someone or something.

Relevant case studies that are globally situated are considered to evaluate the actual scope and identify possible results. Children's potential of making use of their right to participation can be constrained by several factors such as exclusion and inequality. Wealth-based inequality is a global phenomenon. Children need cognitive stimulus to fully unfold their capacities, and this stimulus is often not given in poor households (The World Bank 2015).

To this day, the probability of having less than 4 years of formal education increases if a child is born poor; the term 'education poverty' is used in this context (UNESCO 2010). However, higher household income does not necessarily translate into higher school attendance per se. In low income countries, in which a large share of poor people still rely on agriculture, children often actively participate in the work force. This 'wealth paradox' (Kielland and Tovo 2006) partly explains that school attendance does not linearly increase with household income. This phenomenon can take the shape of a U-curve meaning that, for example, a rural household with a low income will most likely send their children to school because there might be no work for them in the household or on the farm. Increasing income can be associated with a

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higher workload, such that children are required to work, and as a consequence their school attendance will suffer. However, if the household income increases further, the household may rely on more efficient adult workers and labor-saving technology, and send their children to school in view of long-run expected returns on education investments. The wealth paradox can be seen as the tradeoff of opportunity costs. In this context, providing improved school infrastructure and more equipment alone does not have much impact (Banerjee et al. 2007).

Inequalities can also be found between children living in rural areas compared to those living in urban areas. In many low income countries, child labor is a rural phenomenon (Admassie 2003). Children who have to work and go to school often have lower academic scores due to exhaustion. Furthermore, gender inequality is still present especially regarding school attendance in low income countries. The probability of participating in child labor is higher for girls than for boys. In addition, more boys are enrolled in school and thus have the possibility to benefit from more years of education (Ersado 2005). When children do attend school, quality of schooling matters a lot. The conditions of education, which especially poor children are subject to result in sixth grade students in many African countries only reaching a level of literacy and numeracy of 20–30 % of the competence levels expected under more favorable circumstances (SACMEQ 2016).

Given these considerations, the following two questions are addressed:

1. How may the potential of children as catalysts or agents of change for sustainable development be nurtured in responsible ways?
2. How can children's agency for sustainable development be scaled up through education in different settings, especially among the poor?

Following this introduction is a section, which provides a brief historical background on the concept of childhood and education. The third section introduces the case studies and the fourth section discusses the potential of information and communications technology (ICT)-based approaches to foster children's agency for sustainability. The fifth section will conclude with implications for policy initiatives to enhance children's agency with education for sustainability.

2.2 Concept of Childhood and of Children's Agency

2.2.1 Defining the Concept's Elements

The debate about children's nature and their potential and right to agency has deep historical and cultural roots. The term 'agency' in this context means that a person actively initiates an action directed towards achieving a specific goal (Fig. 2.1). In other words, a person's action has an impact on someone or something (Reunamo 2009). Agency of children means that they actively take part not only in the process of decision-making but that they are also engaged in the following action-taking

Fig. 2.1 Elements of agency
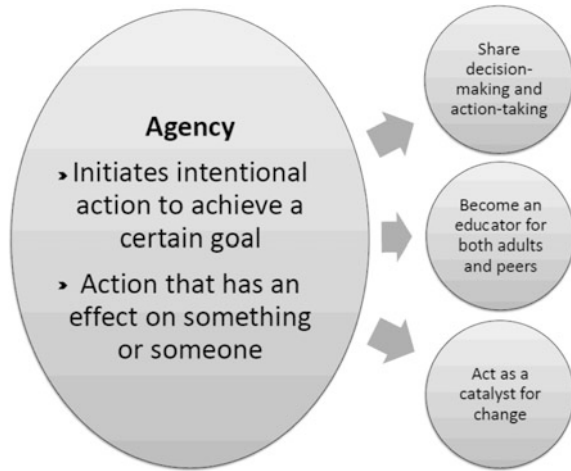
(Stuhmcke 2012). This could mean that children become educators not only for their peers but also for adults. In this context, children's role in development is also described as catalytic (Davis 2009).

The concept of *education* is understood as a means of socializing and thus integrating children into society. More specifically, the term 'education' refers to the (intrinsic) value of being educated as well as to various learning contents such as knowledge in visual and performing arts or (foreign) language skills. Education can also be viewed as the imparting of a certain value system in order to shape the character of the student. Among such values may be the ideal of maintaining an open heart and mind which, again, would be favorable for continued learning and education. A somewhat similar orientation towards future activities is also given through an education that stresses the importance of responsibilities held by the individual or society as a whole.

Related to the ideal of responsible behavior of society and economy is also the concept of '*sustainability*', a term which was first coined by von Carlowitz (1713/2013) in the context of making forestry environmentally sustainable for the benefit of society. Following the World Commission on Environment and Development (WCED) and its publication of the so-called Brundtland Report (United Nations 1987) as well as the Agenda 21 for Culture (United Cities and Local Governments 2015), sustainable development shall be achieved by taking into consideration the environmental, the social, the economic, and the cultural dimension. Understanding education and rights in this context implies that children and youth should not be exploited for any purposes, but that education means practicing responsible guidance and taking children and their needs and knowledge seriously (UNESCO 2005).

For the first time in the history of UN development goals, the so-called Sustainable Development Goals (SDGs) make explicit reference to children's agency:

> "What we are announcing today – an Agenda for global action for the next fifteen years—is a charter for people and planet in the twenty-first century. Children and young women and men are critical *agents of change* (emphasis added) and will find in the new Goals a platform to channel their infinite capacities for activism into the creation of a better world" (United Nations 2015, § 51).

This statement is expressed merely as a philosophical underpinning in the introductory section "Call for action to change our world". The actual SDGs and their respective targets appropriately emphasize child health, education, gender inequality, and children's rights—they do not comprise a concrete goal or target related to children's agency.

2.2.1.1 Ethical, Religious, and Historical Perspectives

Different world religions and schools of ethics differ in their perspective on the role of children. Christianity emphasizes protecting, respecting, and recognizing children's spiritual role (Matthew 19:13–14, 18:2–5). A quite remarkable statement can be found in Mark 9:35–37, where Jesus equates a child with his twelve followers, that is, with his agents of change.

In the Jewish tradition, it is the responsibility of the parents or, if they are unable to fulfill this role, that of the community to educate children so that they can live up to their maximum capability and lead a life that is in accordance with Jewish morality and spirituality. In this way, children are recognized as essential and existential to the wellbeing of the community and to the continuance of the Jewish ethnicity, culture, and religion (Rosen 2004).

In Islam, the legal and ethical code defines responsibilities of parents prior to the birth of a child and throughout childhood (Gilandi, 2009). Major emphasis is laid on the importance of education since acquiring knowledge is perceived as a religious duty. Through the educationally-fostered development of children's intellectual capabilities, children are integrated into their community (Al-Azhar University and UNICEF 2005).

Confucius' (551?-479? BC) thought on education clearly emphasizes the need for education and study, which he regarded of utmost importance for the (moral) development of men (Riegel 2013).

In modernity, the discourse on education and children's agency was strongly influenced by philosopher Jean-Jacques Rousseau (1712–1778) who emphasized that children were innately good (Reese 2001) and willing to learn for which reason children should interact with their environment (Palmer et al. 2001). Educational reformer Johann Heinrich Pestalozzi (1746–1827) went one step further and postulated that children should be enabled to help themselves (Pestalozzi 1994). This also implies that older children should help younger children and thus become agents and enablers of change themselves. The philosophy of education developed by Maria Montessori (1870–1952), again, expresses the belief that children should become their own agents of change (Montessori 2013).

Despite this evolving thought on education and children's agency in Europe, research in the field of environmental education has given only minimal attention to children's ability to have an impact on their parents' and other adults' knowledge and actions (Ballantyne et al. 1998). At the same time, existing studies on environmental education programs indicate that students do share their obtained knowledge with their parents and thereby influence household behavior (Ballantyne et al. 2001). Moreover, research-based recommendations suggest that education for sustainable development should begin early on in children's educational careers (Davis 2009) as the starting point for lifelong learning on sustainability (Davis et al. 2009).

In this way, the goal of education should be to enhance the commitment and skills of children and youth for the global transition to sustainability (Stuhmcke 2012).

2.2.1.2 Conceptual Framework

Figure 2.2 depicts a framework of children's agency for sustainability which is based on the above-mentioned concepts and observations. It shows how children, if educated in a stimulating and participatory way, can act as agents of change and thus may have an impact on their family and peers as well as on their entire local community. This impact will ideally foster people's livelihood and actions towards a sustainable future. If sustainability in all its dimensions is enhanced, this will further influence how children are perceived and treated in the educational sector and society as a whole. In this way, there is an interdependency of teaching sustainability and stimulating children, on the one hand, and children as agents of
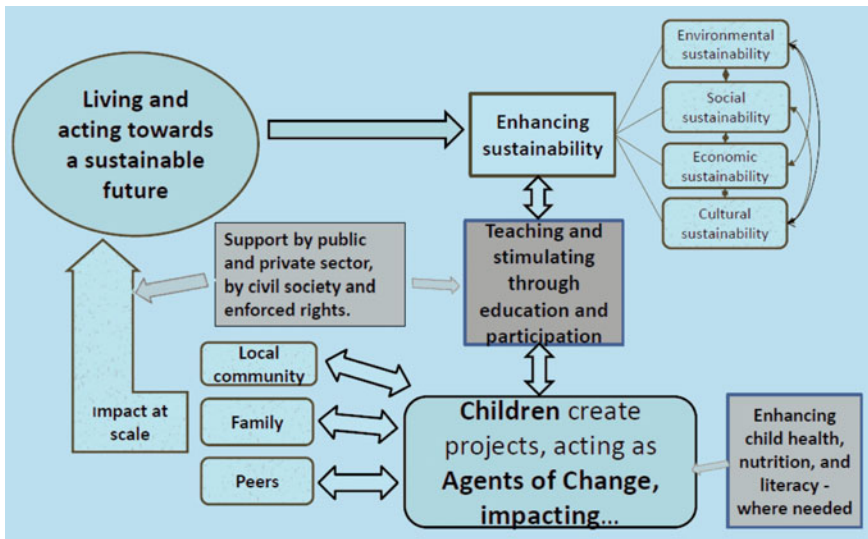
Fig. 2.2 Framework: children's agency for sustainability

change, on the other hand. However, with regard to the two questions posed above, it is important to notice that children's potential as catalysts for a sustainable development can be nurtured through support on the part of the public and the private sector as well as through a civil society that respects and appreciates children's agency and is ready to enforce children's rights.

There are, however, some basic preconditions that have to be met so that children's agency can unfold (see bottom right of Fig. 2.2). Given that globally one in three children under the age of five are malnourished, improving children's consumption of micronutrients, preventing and treating infections, and fighting stunting in general are basic preconditions for children's agency that must be addressed. Enhancing children's health, nutrition, and literacy is essential. Otherwise, their cognitive capacity is impaired (Hoddinott et al. 2008). Naturally, these measures apply especially in the case of children who would otherwise remain marginalized due to their own or their family's poverty (von Braun and Gatzweiler 2014). Millions of poor children, and homeless street children in particular, exercise agency by being economically active in the informal labor market and in services inside and outside of households. Overcoming this burden is also a precondition for children's agency for sustainability. Fundamentally, childhood needs to be redefined to tap and foster children's potential role as catalysts for sustainability.

2.3 Promising Examples for Children as Agents of Change for Sustainability

Such a redefinition of childhood in favor of children's agency is far from being ubiquitously accepted. Yet there are some positive examples of children-led education and science initiatives, which address one or more of the outlined dimensions of sustainability (see Fig. 2.3). Six of the examples briefly characterized in Fig. 2.3 were chosen as case studies to provide further insight into means of fostering children's agency.

One of the most internationally-present examples of child education regarding environmental change are so-called *Eco-Schools* (Eco-Schools, n.d.). 46,000 schools operate in 58 countries. However, most schools are located in Europe and, compared to the global north, the global south is less represented. The purpose of these institutes of education is to improve the environment of the school itself as well as that of the broader community by empowering students of all age groups. To achieve this goal, children are viewed as decision-makers and they are encouraged to collaborate to attain an environmental improvement of their context. Whereas students from Eco-Schools demonstrate a higher awareness of environmental issues, students' environmental behavior and their preservation values do not seem to be positively influenced by this type of schooling (Boeve-de Pauw and Van Petegem 2013).

Children's actions	Addressing Sustainability Dimensions			
	Environmental	Social	Economic	Cultural
Child education for environmental change — Eco-schools, multi-country	X			X
Child education for environmental change — Kindergarten projects, Australia	X			
Child education for environmental change — Disaster prevention, Philippines	X	X		
Broad-based science education, stimulating children's own actions for science creativity — Kleine Forscher, Germany	X			X
Broad-based science education, stimulating children's own actions for science creativity — Jugend forscht, Germany	X			
Broad-based science education, stimulating children's own actions for science creativity — United World College	X	X	X	X
Direct and indirect child agency for education, health and nutrition — Health info: Toy effect, Peru		X		
Direct and indirect child agency for education, health and nutrition — Barefoot College, India	X	X	X	X
Direct and indirect child agency for education, health and nutrition — Iron deficiency, Peru		X	X	
Direct and indirect child agency for education, health and nutrition — Agricultural extension by children, Peru		X	X	
Direct and indirect child agency for education, health and nutrition — Food for Education, Bangladesh		X	X	
Direct and indirect child agency for education, health and nutrition — Drinking Water testing, Ghana	X	X		
Direct and indirect child agency for education, health and nutrition — Sanitation Brigade, Bangladesh	X	X		

Fig. 2.3 Review of children-led education and science initiatives related to sustainability

An examination of *child-centered approaches to disaster risk reduction* in El Salvador and the Philippines comes to the conclusion that children actually do take action in favor of risk reduction (Mitchell et al. 2009). In the analyzed contexts, children of all age groups were encouraged to increase their awareness of disaster risk in their community. Children's agency was expressed in that children were able to influence their parents to act upon, for example, the risk of a landslide threatening to destroy their school.

Stimulating children and youth to take action is also the focus of two broader *science and education initiatives*: Within the context of Germany's "Jugend forscht" program (Fasse et al. 2015) children and youth from fourth grade (approximately age nine or ten) through young adulthood (age 21) are encouraged to research natural sciences. On a yearly basis, competitions are organized during which awards are given to the best submitted proposals. This approach clearly engages children in decision-making and problem-solving activities and thus views them as valuable agents. Moreover, participants often focus on science as a means to promote sustainability (Fasse et al. 2015).

Barefoot Colleges in India (Barefoot College, 2015) offer education for children from poor families in rural regions of six Indian states. At these colleges, children get to choose their own curriculum (younger children can attend crèches). Covered topics range from solar electrification to livelihood development and thus cover all four dimensions of sustainability. In so doing, Barefoot Colleges serve as community action programs with schools which empower children through attending collaborative classes and working on creative projects (Roy and Hartigan 2008).

Children's agency in the context of health, nutrition, and agriculture was also confirmed through two research and action initiatives conducted in Peru and Ghana,

respectively. The research project located in Peru examined to which extent health information regarding livestock transmitted diseases and disease prevention provided to children (age 6–17) had an influence on their parents' actions (Maruyama et al. 2012). Indeed children were found to act as vectors that stimulated health conscious behavior in their fathers. In this way, children's agency can foster the quality and extension of treatment opportunities.

Strengthening children's agency through access to technology that enhances their roles in their communities is a growing opportunity, as certain technologies become more affordable. An example of the positive influence of available technology on children's agency was realized within the scope of the research project: Ghanaian youth from age 12–16 were trained in their school context on sophisticated water testing equipment to assess the water quality of their households (Okyere et al. 2015). Results showed that children equipped this way educated other household members on hygiene problems and on how to keep drinking water clean at home and in the field. Thus, in the context of this research project, acknowledging children's agency improved the quality of drinking water.

2.4 Fostering Children's Agency Through ICT

Information and communications technologies (ICT) change the context of social and economic development (Torero and von Braun 2006). This also applies to the role children take in relation to their community.

In this way, an approach to strengthen the agency especially of marginalized children may be to improve their access to ICT. Various projects and research initiatives draw a rather heterogeneous picture of the feasibility and impact of such approaches. This heterogeneity is likely due to differences in the quality of the provided software and the exact setting in which ICT was integrated into school education (Murnane and Ganimian 2014; Light 2016).

The perhaps most broadly known of these projects is the One Laptop Per Child (OLPC) concept established by Nicholas Negroponte and presented at the World Economic Forum in Davos, Switzerland, in January 2005. The OLPC project attempted to distribute to poor schoolchildren up to 15 million low-cost laptops annually as of the end of 2007 in order to give marginalized children access to software and information that would increase their self-dependent learning. Negroponte's vision may still be ahead of its times, and he has so far been unable to fully meet this ambitious goal regarding the mere distribution of the laptops as well as their actual impact on children's learning (Kraemer et al. 2009). An evaluation of the OLPC program conducted in Peru, for example, came to the conclusion that children's basic computer skills increased but that the access to ICT in school did not have an effect on literacy- and numeracy-related test scores. Yet general cognitive skills were positively affected (Cristia et al. 2012). Another evaluation

assessed the impact of the OLPC program on migrant children in China. Here, the program not only improved children's basic computer skills but also increased their math test scores. However, in this specific context children were entitled to take the laptops home and the devices provided for software that directly supported the math contents covered in class. Furthermore, this evaluation observed that participating in the OLPC program improved children's self-esteem (Mo et al. 2013).

Other studies evaluated the impact of computer-assisted learning (CAL) in India. Linden (2008) found that CAL was only supportive to children's learning if offered as an additional out-of-school activity, whereas if used to substitute for regular classes student's performance in math tests decreased. Then again, Banerjee et al. (2007) assessed the impact of a 2-year CAL program which was offered as a mixed in-class-out-of-class approach on students' mathematical skills and came to the conclusion that children's test scores increased. However, the CAL program was more expensive than the tutoring program "Balsakhi", a remedial education intervention in the context of which a young adult from the local community serves as a tutor for children in second, third, and fourth grade who have fallen behind their peers with respect to basic numeracy and literacy skills. Yet another research initiative (Mitra and Dangwal 2010) found that marginalized school children in India benefited from self-dependent group learning with a computer with internet access and that this effect on their test scores was further enhanced by contact to local or online mediators.

Other ICT programs like "mJangle" (SenMobile 2015) rely on the broad distribution of smart phones in Africa and in so doing aim to improve pre-school and primary education of marginalized children via Apps. Yet other programs use interactive radio instruction to compensate for a lack of qualified pre-school teachers in rural and urban environments (Hinostroza et al. 2014).

This brief overview shows that there is a variety of small- and large-scale ICT projects and research initiatives. Nevertheless, there remains a lack of systematic impact evaluations and an aggregation of the findings on a meta-level (Hinostroza et al. 2014). Furthermore, on a practical level, the issue of availability of basic hardware from access to electricity to a reliable Internet connection (Light 2016.) has to be tackled and the privacy protection of children has to be secured (Kelly 2013). These constraints are probably going to be overcome in coming years. The potential of ICT projects goes far beyond in-school test scores: Literacy and numeracy are of great importance in lifting poor children out of their marginalized situation and pave the way to higher science education and related empowerment. Research also indicates that ICT used in a non-formal setting may improve the agency of children on a much broader scale and help to overcome the gender gap prevalent in access to information and learning materials (Kozma 2005). Giving children access to ICT may allow them to increase their agency for sustainability virtually on their own. Moreover, it may permit children to inter-connect with each other globally, and thereby, for instance, bring locally isolates sustainability initiatives to scale.

2.5 Implications for Education Policy and Sustainability Actions

Seeking sustainability within the 2030 Agenda for Sustainable Development (2015), that is, "[making] development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987), could already be interpreted as a mandate to give those a voice who are directly affected by the future, namely the children. It is within this context that responsible enhancement of children's agency has to be considered.

Various education and science initiatives around the world have already integrated children's roles as agents of change. They provide evidence that children, indeed, have the potential to be catalysts for enhanced sustainability in their local environment and beyond. Throughout history the perception and role of children have been subject to change. It may, again, be time to redefine childhood and the role of children both in today's society and for future generations. This does not necessarily mean breaking with long-standing religious and philosophical traditions of the meaning of "childhood". However, with new and emerging technology and inter-connectedness among children, they themselves may be about to redefine their childhoods.

From the above review of small and large initiatives, the following implications for action and policy support shall be highlighted:

1. *Invest in poor children's preconditions for agency*: in order to have the capacity to function as agents of change, children's living conditions need to be improved to meet certain standards regarding their health and nutritional status. Marginalizing factors such as poverty, gender inequality, illiteracy, and child labor have to be overcome.
2. *Strengthen the role of research on children's agency*: through experimental designs and impact analysis of existing initiatives, scientific research can identify best fits of enhanced children's agency in diverse (school) contexts. Obviously, experiments with children need to follow strict ethical standards of informed consent etc.
3. *Sharing experiences with child agency worldwide*: the accessibility of knowledge obtained through research and practical experience should be increased through social media in order to enable people to learn from example. Children as agents of change have to be part of this process.
4. *Facilitating a web-based global platform on which children can meet* and share their experience about sustainability related projects would be of great importance. The examples of the children-led education and science initiatives clearly show the potential of children and youth as agents of change. Yet the selective initiatives need scaling up. School systems could facilitate such platform opportunities, as many school children do not yet have web access.

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Chapter 3
Notes on Child Labor and Education: A Personal Statement

Kaushik Basu

Abstract It is a matter of concern that in today's prosperous world, there are 168 million children who work as laborers, deprived of not just the joys of childhood but also of the education that is essential for decent life as an adult. As the world advances in terms of information technology and in other ways, literacy becomes more important than ever before. Child labor and the deprivation of education persisted for so long partly because of the naïve belief that markets, left free, would correct these ills. In reality, we need well-crafted interventions. But, this essay argues, the argument is more complex than appears at first sight. A blunt, legalistic intervention, as often proposed, can curtail child labor but only by exacerbating child poverty. The problem has to be tackled through a cocktail of interventions that involve government, civil society and the private sector. Unless this urgent problem of our times is attended to, we are likely to see rising inequality, deprivation and conflict.

It is an honor to speak at the Pontifical Academy of Sciences. The last time I was invited to be here for a conference, the date conflicted with preparations for the Indian Union Budget. I was then the Chief Economic Advisor to the Indian Government. Though I was tempted to come to the Pontifical Academy, I felt it would have been too blatant a dereliction of duty on my part and so I, reluctantly, declined.

Growing up in Kolkata (formerly Calcutta), where one of my four sisters worked closely with Mother Teresa, I witnessed what pure, instinctive compassion could achieve, and heard many stories from her of Mother Teresa's kindness, tolerance and innate propensity to reach out to anybody who needed help, regardless of race,

K. Basu (✉)
Cornell University, Ithaca, New York, USA
e-mail: kb40@cornell.edu

K. Basu
The World Bank, Washington, DC, USA

gender and religion. Today, being at the Vatican, connects me to those memories. Thank you very much for the invitation and for giving me an opportunity to return to a field of research which was once a near full-time occupation of mine.

Child labor and lack of education are an embarrassment for our modern world of so much prosperity and growth. The art of writing and reading was invented in 3200 B.C. in Mesopotamia. That 5200 years after inventing this art, we still have 15 % of the adult population of the world unable to read or write must be some kind of record in slow achievement. This is however no surprise given that 168 million children (between the ages of 5 and 17 years) work as laborers (that is 10.6 % of all children of that age group) and so get little education, as well as no time to absorb the education they do get.

It is true that we have come a long way since immediately after World War II, when effort was made to compile statistics in developing economies and it was found that 48 % of children in China and 35 % in India (of the age group 5–15) were laborers; and also a long way from 1860 when 37 % of children in the United Kingdom worked as laborers.

Nevertheless, 168 million children working and being denied proper education is unconscionable in today's world. I am glad that the Pontifical Academy of Sciences is taking an interest in this important field because this is one area of economic policy which requires scientific inquiry and analysis as well as passion and moral commitment, and the Vatican has the convening power for this.

Child labor persisted partly because those who were better off did not care and partly because a lot of early economics was under the sway of free market fundamentalism, a philosophy that suggested (conveniently, for those who have done well by the status quo) that whatever the market delivered, with no state intervention and civil society meddling, was good and was to be welcomed. Luckily this is changing and it is time to act.

It was in 1994 that I got drawn into this subject, without quite intending to. I had moved that year from India to the United States, as professor at Cornell University. At that time, the US Congress was considering what was known as the Harkin's Bill, to stop any product that had used child labor as a factor of production from entering the United States. The intentions were clearly good. The argument was premised on two assumptions, to wit, that child labor was a product of (1) the greed of firms and employers trying to earn extra profits and (2) the sloth and cruelty of parents not hesitating to send their children to work.

Having lived in India and witnessed child labor, and knowing some of the parents who sent their children to work, I felt strongly that, of these presumptions, (1) was right but (2) was wrong. While there may be a few parents who, out of their own laziness, send their children to work, when child labor is a mass phenomenon such as it is in large parts of Sub Saharan Africa, South Asia, and even sections of South East Asia and Latin America, it has nothing to do with parental sloth. Parents typically love their children and send them out to work only when poverty and hunger leave them with no other option. If this is correct, then a sudden ban on child labor, if effectively enforced, would indeed put an end to child labor but, likely do so by exacerbating child poverty and starvation. So while child labor is a

dreadful practice and ought to be brought to an end as quickly as possible, we have to think of a combination of policies that support poor households as they are weaned away from child labor. A sudden legislative ban, on its own, is not the axiomatic right step some take it to be.

I felt this was an important enough argument to bring to the attention of campaigners so single-minded about child labor that they were unmindful of the risk of child starvation and hunger and I published an article in the *New York Times* on 5th of December, 1994, stating my reasons for not supporting the Harkin's bill. I had no doubt that it was a well-meaning bill; but its argument did not strand up to scrutiny. Minimally, it had to be combined with many other complementary policy interventions.

My article caused a furor, including a letter to the editor by Senator Harkin. I received a huge amount of letters, some very thoughtful ones, like a memorable one from the eminent economist Albert Hirschman, but also several angry letters. I had no choice. I decided that now that I had written on child labor, it was time to begin to read about it and educate myself. This is what drew me into the subject of child labor and education.

The subsequent research that I did with my student Pham Hoang Van (Basu and Van 1998) showed that there are some situations where a pure legislative ban on child labor is the right way to go to curtail child labor, increase education and enhance child welfare. But the argument was not as straightforward as some may have thought. The conclusion was reached by using some very natural assumptions and then building on them using economic theory. The research showed that some societies are characterized by multiple equilibria, in particular, one stable equilibrium with low wages, and lots of children laboring; and another stable equilibrium where wages are high, and children do not work.

The intuition (spelled out in Basu 2003) is easy. Consider a society and focus on its unskilled labor market. Suppose, to start with, adult wages are very low, and to stave off extreme poverty, parents are forced to send out their children to work. And the employers are happy to use this abundant supply of cheap labor. In this society, if a law is enacted that stops children from working, it seems reasonable to conclude that this withdrawal of children from the labor market will cause a shortage of labor and drive up adult wages. If these are pushed up sufficiently high (which can happen depending on the elasticities of labor demand), it is possible that at this new high wage parents anyway prefer not to send their children out to work. In other words, the law banning child labor can deflect society from a bad equilibrium with children working to a good equilibrium where adult wages are higher and children are anyway not sent out to work. In brief, the labor market in developing countries may be characterized by multiple equilibria.

This work gave rise to a lot of empirical analysis, and the assumptions of the model, in particular, the so-called 'luxury axiom', namely that parents do not send their children to work once they have higher income from non-child labor sources, found wide corroboration. The literature on this is large; to cite one particularly convincing study, I may point to Edmonds and Schady (2012). For a general survey with focus on policy action, see Basu and Tzannatos (2003).

However, there were also situations, especially in very poor countries, where a ban may not deflect the economy to another and a better equilibrium. In such situations the problem called for a concerted use of several complementary policies, ranging from enhancing adult wages, to providing better schooling facilities for poor children. There is a very large literature now on this subject.

There is also a substantial literature, more specifically, on child labor and education. Some of this is part of the "Understanding Children's Work" Program, such as Biggeri et al. (2003). There are studies that look at the links between child work and education—to cite a few from a large literature, see (Ray 2000), (Cigno and Rosati 2005) and (Edmunds et al. 2009). This research provides prima facie evidence that child labor negatively impacts education and so can hurt the children not just in the short run but through life.

The relation between child labor and education is, however, complex. It has been found, for instance, that there is a non-negligible number of children neither in school nor working as child laborers (Biggeri et al. 2003). A part of the explanation lies in the fact that there are other kinds of work beyond paid child labor. Many children for instance do unpaid household chores which take a toll on schooling but do not have them classified as laborers.

There are important questions about the causal connections between child labor and education that had for long remained unanswered. Is it the weaker student who stays away from school and joins the labor force, thereby explaining why those who are less educated are laborers, or does child labor damage learning? A recent paper by Emerson et al. (2014) tries to nail down the causal relation by doing an experiment pertaining to Prova Sao Paulo, in Brazil. They designed a test and a survey and then, using the method of difference-in-difference and instrumental variables estimators, discover that to work and to go to school amounts to a loss of 11 points in mathematics and 12 points in Portuguese, which is equivalent to missing a quarter year of school. Further, they found that this had lingering effect with diminished cognitive ability and negative impact on education in future years.

To take on the challenge of children's education and child labor, we have to act on many different fronts, including our own mindsets. We don't have to go very far back in history to see how dramatically our mindsets have changed. In 1741, when John Wyatt invented a new spinning machine and wanted to persuade the Attorney General in England to give him a patent on the machine, the argument he used would appear strange today. He advertised how if a clothier had hundred adults working as spinners, he could, now, with this new machine, dismiss 30 of them and replace them with "ten infirm people or children." The Attorney General was so impressed by the machine that in granting the patent he pointed out that children as young as 5 or 6 years old could operate this machine.

In the writings of that time, there were repeated mention by wealthy English mill owners that long hours of work by children (needless to add, other people's) built character and strength. The change that occurred subsequently required new labor regulation laws, such as the various Factories Acts, starting with Robert Peel's Act in 1802, but these were in turn predicated by sustained activism by progressive groups and parliamentarians.

What was revealed by the Parliamentary Committee investigating child labor in the first half of the nineteenth century was heart-rending. Here is an excerpt of the Committee interviewing a child laborer in June 1832.

Q. "… How long did you work?"

A. "We began at 4 o'clock in the morning and worked till 10 or 11 at night; as long as we could stand upon our feet."

Q. "You hardly could keep up for that length of time?"

A. "No, we often fell asleep."

The big problem in the early 19th century was a shift of mindset, an understanding we must not be victims of free market fundamentalism, the orthodoxy that emerged, erroneously, from Adam Smith's theory of the invisible hand. Fortunately, there are few (but be warned, not zero) adherents now of this extreme view. It is now accepted that when the market gives rise to great inequalities or injustices, such as children been deprived of education and been forced to work, the state has a responsibility to intervene. It is what creates a special role for the state and civil society to introduce appropriate regulation and to influence our thinking.

The problem is vastly diminished compared to the early years of the Industrial Revolution. But we live in a much more prosperous world today. Further, with the arrival of the Internet and the digital revolution, to be illiterate is a greater handicap than ever before. To that extent, the prevalence of child labor and the deprivation of education is unconscionable. The Pontifical Academy of Sciences' interest in this topic, which is so critical to child welfare, is most welcome. We should continue to collect data and do research but it is also imperative to turn to policy and action.

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Chapter 4
Scholas Citizenship

María Paz Jurado

Abstract Scholas Citizenship is an educational program of Scholas Occurrentes that aims to promote the social commitment and participation of youth, starting from their own experiences and concerns, to produce positive changes in themselves and their communities. This essay firstly describes the main characteristics of the program: its target audience, its implementation stages, and its methodology; describing how it includes, alongside the learning of the social sciences' research method, the constant involvement of arts, sports, technology, and play. The second part of the essay explores the reasons that support the program's methodology according to research-based knowledge. It explains why students select the issues they are going to work with, stating that giving students the opportunity to choose the subject they would like to learn about increases their motivation and commitment and therefore improves their learning outcomes. Then, it also describes why in Scholas Citizenship students work in concrete projects, explaining the relevance of involving them in teaching strategies that require their commitment in the accomplishment of certain objectives. Finally, it analyzes why the program encourages sports, arts, technology, and play, mentioning that these tools help students develop social and emotional.

> We won't change the world if we don't change education
>
> Pope Francis (2015)

Scholas Citizenship is an educational program of *Scholas Occurrentes* that aims to promote the social commitment and participation of youth, starting from their own experiences and concerns, to produce positive changes in themselves and their communities.

MaríaP. Jurado (✉)
Scholas Occurrentes, Vatican City, Holy See
e-mail: maria.jurado@scholasoccurrentes.org

37

The origins of this educational proposal is the School of Neighbors (*Escuela de Vecinos*) program created by Jorge Bergoglio as Buenos Aires Archbishop, in the pursuit of building bridges amongst different schools within the city. Said program, leaded by José María del Corral, current President of Scholas, started after the 2001 economic and social crisis in Argentina with the participation of eleven schools of diverse religious communities: Muslim, Jewish, Evangelist, and Catholic. Students from these schools were invited to get together to identify their common concerns and join their efforts to solve them collectively.

Today at the City of Buenos Aires more than 60 state-run and private schools are part of the program, some religious and some non-religious, from different creeds, and from the 15 boroughs that comprise the city. Moreover, as a request of Pope Francis to take this program globally, the experience is being implemented in every one of the Argentine provinces as well as in Spain, Paraguay, Haiti, Colombia, the United Arab Emirates, and Mozambique, reaching thousands of students from around the world.

Along this essay I will firstly describe the main characteristics of the program or, in other words, *what* is it that we do when we implement it in the field. Then, on the second part of this essay, I will reflect on *why* we do what we do, identifying the key elements for success of the program according to research-based knowledge.

4.1   What We Do

Scholas Citizenship engages secondary school students from 15 to 17 years old, who at the moment of living the experience are in the penultimate year of secondary education. It is paramount that program participants represent the multiplicity of schools within their communities. That is to say, there should be participants from state-run, private, religious, secular schools, and various modalities: artistic, technical, human baccalaureates, and others.

A number of 15–20 students from each participating school are part of the program having, on the one side, the opportunity of living the Scholas Citizenship experience during six journeys together with other 300 students from different education institutions; and, on the other side, the responsibility of being ambassadors of their classmates representing all of them while the program lasts, and communicating their experience once it has finished.

The methodology of Scholas Citizenship is intrinsically participative and democratic, including alongside a social sciences' research methodology, the constant involvement of arts, sports, technology, and play as key elements for learning. The program entails two stages:

4.1.1   Issues Selection

During this stage, that lasts 1 day, students choose two issues from their communities that affect them, that they are interested in and wish to analyze in depth in order to devise a solution. During this stage students are encouraged to deepen their reflection on the problems that concerns them, analyzing, as well, what are the problems that mostly affect their companions and being generous so as to agree in concerns that represent the whole of them.

4.1.2   Immersion Week

During second stage, that entails five working days, participants do in depth research on the previously selected issues. They develop working hypothesis; create tools to gather data so as to test their hypothesis; conduct field work through the development of interviews, surveys, and observations; develop a diagnosis of the state of affairs of those issues in their communities; and finally propose projects to solve them. These projects include both actions that participants can implement by themselves as well as public policy proposals for their governments. The youth present their findings, commitments, and proposals to their local authorities during the last day of this second stage.

Each working day in both stages starts with a moment called *re-creo* (re-create) in which participants are invited to play, express themselves through art, and offer their talents to their new companions. This space is conceived as a moment of self-exploration as well as a space for participants to know each other and develop a sense of community. During the *re-creo*, students break barriers between themselves and build the needed trust to open their selves to others and to commit to work together towards a common end.

Arts, sports, play, and technology are elements constantly present during the program. At the *re-creo* participants play games and sports, as well as use art as a tool to express their personality and share their identity with others. Those who are interested in continuing exploring their artistic self are invited to deepen their reflection on the two issues chosen and express them through music, painting, writing, or the artistic language they choose. Work methodologies taken from artists are also used with participants who are taking forward their research on the two issues selected, so as to motivate creativity and strengthen motivation. Finally dynamic learning practices that require active student's engagement are encouraged, for example: role playing, small groups discussions, debates or interviews.

The program also counts on a virtual platform through which students can contact each other as well as other students who have already participated from the program in different places of the world. They can also upload information and working material, engage in conversations regarding the issues and collaborate in the development of final documents.

4.2   Why We Do What We Do?

After doing a brief description of the program, the following step is to explore the reasons that explain our methodology according to research-based knowledge. At this point I wanted to thank doctor Facundo Manes from Fundación Ineco, and his assistant Daniel Sánchez, for their commitment to Scholas through their collaboration in the writing of this part of the essay.

4.2.1   Why Do Students Select the Issues They Are Going to Work with?

> Scholas Ciudadanía generates an encounter through which other people's problems, as distant as they could be from mine, become mine as well.
>
> (Fabrizio Sánchez, participant from Scholas Citizenship in Asunción, Paraguay)

The literature agrees that giving students the opportunity to choose the subject they would like to learn about increases their motivation and commitment towards learning. Moreover, it promotes student's autonomy that is related to positive learning outcomes in diverse populations of youth.

A literature review developed by Evans and Boucher (2015) on the relationship between the giving of options to students and their autonomy and motivation towards learning, mentions that giving students the opportunity to choose what they want to learn increases their perception of autonomy and, therefore, increases their motivation. In fact, this research mentions that the main goal of the educator should be to understand the true interests of the students, and help them connect those interests with their academic objectives. Moreover, a literature review performed by Deci et al. (1996) also concluded that internal and external motivations are positively related with deep learning.

Nonetheless, it is important to mention that Evans and Boucher suggest the connection between autonomy, increased motivation and better learning happens only when the options given to students are relevant for them and are connected to their life and interests; and when the tasks given to students are challenging enough.

Following these ideas, then, Scholas Citizenship gives students the opportunity to select the issues they would like to learn about. These options can be considered relevant for them because they emerge from their own interests and concerns. And finally, the tasks given to students during the immersion week are challenging enough to keep them busy and motivated, but at the same time achievable so as to avoid frustration.

4.2.2   Why Do Students Work on Concrete Projects?

With these encounters we become aware of what we can do if we join in one cause. It was interesting to see how many of us had similar ideas about how things should be, but we had never spoken about them. We used to believe that if something was done one way, it had to remain that way, and we couldn't question it. But, why should we not question if we know what we want and have the energy and willingness to do it? To "make trouble" is not to sit and wait for things to happen, it is to go out and seek what we want, make our voices heard, and produce change

(Maia Bronstein, participant from Scholas Citizenship in Neuquén, Argentina)

The UNESCO "Education For All Global Report" (2012) mentions that, "far too often, learning is still limited to memorizing and recalling facts, and geared towards passing paper-and-pencil tests in order to progress to the next level of schooling. Students often lack the capacity to make sense of their knowledge and use it for effective problem solving in real-life situations."

On the other side, de Podestá, de Fox and Peire at "The adolescent brain" (2013) mention the relevance of involving young students in dynamic teaching strategies, that are contextualized in students interests and concerns, and that require them to commit in the accomplishment of certain objectives. These teaching strategies could include the use of interactive guides, role-playing, tutoring of younger students by older students, newspaper writing, radio programs, or real interviews, among others. *Learning by doing*, they say, encourages critical thinking, teamwork, and communication skills.

Through the promotion of project-based learning, then, Scholas Citizenship aims at encouraging students to collectively create knowledge, and to apply it to real life problems so as to solve concrete concerns. By doing so they get to understand the practical use of their learning, acquire relevant knowledge and skills, and gain awareness of the impact that their behavior and decisions could cause to themselves and their communities.

4.2.3   Why Do We Encourage Sports, Arts, and Play?

We could take off the blindfold we had, see the reality of where we live, and explore within ourselves

(Angie Cruz, Rosario de Lerma, Argentina)

Pope Francis mentioned in a communication between children from Cuba and the United States organized by Scholas, that "Every child has the right to play, and part of educating is teaching children how to play. Because one learns to be social through play, one learns the joy of life through play."

In fact, Fisher et al. (2010) in a literature review on the effects that play has on learning mention that while playing children develop social relations and discover

the existence of conflictive interactions that they need to solve by themselves. In that process, they acquire a wide variety of social skills including the ability to take perspective from one situation and analyze how to approach it, the capacity of controlling themselves, and the skills of negotiation, communication, cooperation, problem solving, and respect towards others.

Moreover, the researchers found that playing not only encourages the development of social and emotional skills, but it is also important for children and youth to acquire information, expand their competences, and practice the ones they already have. When play is used as an educational tool, they say, student's performance improves in subjects such as math, reading, and writing, and their motivation also increases. Besides that, the training of educators in playful learning has been demonstrated to improve students learning outcomes, creativity, pro-social behavior, and persistence (Bellin and Singer 2006).

Finally, regarding the use of art not only as an independent discipline but also as a teaching tool, a recent publication made by UNESCO (2012) states that it stimulates creativity, emotional learning, sensitivity, and critical thinking; while it also strengthens youth's interests in both academic and social issues. The author of that essay, Sonia Bahri, former chief of the section for secondary education at UNESCO, affirmed that the teaching of art and its use as a teaching tool across the curriculum can be a strong mean to start changing the way we learn at school.

Following these ideas, at Scholas Citizenship sports, arts, and play are constantly present not as tools to entertain the youth during breaks, but as instruments to create and transmit knowledge, as well as to express deep feelings and emotions.

In conclusion, at Scholas and particularly through the here described program, we try to showcase that a new of way of teaching and learning is possible: putting the students at the center; trying to harmonize the languages of the hands, the head, and the heart, as Pope Francis asks; and encouraging participants not to merely acquire and repeat information, *but to learn how to learn, to do, to live together, and to be* (Delors 1996).

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Chapter 5
Learning, Literacy and Sustainable Development: Inclusion, Vulnerability and the SDGs

Daniel A. Wagner

Abstract Pope Francis has called on the world community to address sustainable development, stating that "no renewal of our relationship with nature [can be achieved] without a renewal of humanity itself." This chapter reviews the ways in which literacy and education address the challenges of the new 2030 United Nations Sustainable Development Goals (SDGs). A number of key issues are discussed. *First*, international and national development commitments to literacy and basic education are reviewed and progress is noted. *Second*, we consider the impact of globalization that is already putting demographic, migration, technological and other pressures on our planet. *Third*, we look at how climate and environmental changes intersect with and carry their own impending consequences for sustainable development. *Fourth*, we review how literacy and schooling can foster both awareness and complex thinking skills concerning the complexities of sustainability challenges, and how to prepare the next generation of children and youth. *Fifth*, the vulnerability of poor and marginalized populations is delineated, along with new ways for multi-sectoral partnerships in agriculture and health. *Sixth*, implications are drawn with respect to the breadth of the SDGs, and their interaction with literacy education. *Overall*, we argue that greater investments in content awareness and critical thinking skills are needed to help people learn about and manage sustainability, and that special consideration must be given to the impact of sustainability on poor and marginalized groups.

> We are not faced with two separate crises, one environmental and the other social, but rather one complex crisis which is both social and environmental. … There can be no renewal of our relationship with nature without a renewal of humanity itself. … What kind of world do we want to leave to those who come after us, to children who are now growing up? The question not only concerns the environment in isolation; the issue cannot be approached piecemeal.
>
> (Pope Francis 2015)

D.A. Wagner (✉)
Graduate School of Education, University of Pennsylvania, Philadelphia, PA, USA
e-mail: wagner@literacy.upenn.edu

Education either functions as an instrument which is used to facilitate integration of the younger generation into the logic of the present system and bring about conformity or it becomes the practice of freedom, the means by which men and women deal critically and creatively with reality and discover how to participate in the transformation of their world.

(Paulo Freire 1972)

Few have said it as succinctly as Pope Francis: our planet is at risk. Much of what we do in our everyday lives, and in our seeking out of economic prosperity, must be rethought in an era where sustainability and planetary health must take precedence.[1] Development can no longer be understood as a single immutable concept, such as income growth per capita. Development should be defined according to the problems addressed, context, population and so forth. However defined, it must be seen in relation to the costs associated with more pressure on the available resources in a single sphere called Earth. This has not been and will not be easy. Nation building—indeed much of human well-being—has been dependent to no small degree on resources taken from the planet for the benefit of people—land, water, air, animals, agriculture, and much more. Should these resources continue to be depleted at current rates, development itself will need to be rethought. This is, of course, a primary reason for the word 'sustainable' in the new 2030 United Nations Sustainable Development Goals (SDGs). As we shall see, this perspective is also very much in line with the life work of Paulo Freire.

In this paper, we consider the ways in which education can be linked to sustainable development. These linkages may take a number of forms, as discussed each in turn. First, there is already a long history of international and national development commitments to education (including learning and literacy[2]). Second, we must consider the impact of globalization that is already putting demographic and other pressures on our planet. Third, climate and environmental changes need to be understood as they intersect with, and carry their own impending consequences for, sustainability. Fourth, schooling is a fundamental locus of where learning about sustainability, climate change and environmental conservation must take place in order to prepare the next sustainable generation of children and youth. Fifth, vulnerability and sustainability are inextricably linked, and this is nowhere more evident than in how education and other sectors—such agriculture and health —might work more closely together. Sixth, a number of implications are drawn with respect to the new era of the SDGs. Finally, we conclude with a set of recommendations as to how educators may play an even more effective role in promoting sustainable development.

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[1]On the notion of planetary health, see: http://assets.rockefellerfoundation.org/app/uploads/20150625163005/Planetary-Health-Special-Report_06.25.14.pdf. Accessed June 1, 2016.

[2]Education is used here as a gloss for human learning as well as its most common basic cognitive goal—literacy. At various points these terms are used in specific ways, mainly due to the research that supports varied scientific approaches.

5.1 Commitments to Education and Development

Background The World Conference on Education for All in Jomtien (Thailand) was a watershed moment in international education and development. Held in 1990, the conference embraced two key challenges: first, to significantly increase access to education for children in poor countries; and second, to promote the quality of learning in education.[3] A decade later, at the World Education Forum (WEF) in Dakar in 2000, these same two challenges were enlarged in a more detailed list of six Education for All (EFA) targets, including a 50 % improvement in levels of adult literacy, especially women.[4] Later in 2000, the international community adopted the United Nations Millennium Development Goals (MDGs) for 2015, which had a narrower focus in education, mainly through the second of eight major goals on universal primary education and the third one on gender equality and empowerment of women (UN 2000).[5] Later this month, the UN will ratify a new set of Sustainable Development Goals (SDGs) that will include: "By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy." These global efforts have been linked not only to substantive increases in international development assistance to education, but also to greater attention in the broader public arena regarding the importance of literacy on a global scale.

Consequently, over the past two and half decades since the Jomtien Conference, major progress in educational development has been made in low-income countries (LICs). In sub-Saharan Africa, for example, primary school enrolment climbed from under 60 % to nearly 80 %, putting millions of additional children in school; and adult literacy rates have climbed to about 61 %, with modest gains in gender parity.[6] Still, when compared with the stricter standards of the wealthier OECD countries, the lower income countries lag far behind in adult literacy (OECD 2013).

Even before the Dakar WEF conference in 2000, it was clear that the quality of education was a serious concern in low-income countries. For example, a World Bank national household survey in rural Bangladesh found that 3 years of schooling had approximately zero value in terms of learning achievement (Greaney et al. 1999). In other words, the effort of getting children into school had little or no

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[3]The subtitle of the Jomtien conference was "Framework for action to meet basic learning needs."

[4]The six goals of the Dakar Framework for Action, to be met by 2015, were the following: (1) expansion and improvement of early childhood care; (2) compulsory and free good quality primary education; (3) equitable access for all to appropriate learning programs; (4) a 50 % improvement in levels of adult literacy, especially women; (5) elimination of gender disparities and achievement of gender equality; and (6) improved quality of measurement of learning outcomes (UNESCO 2000, pp. 15–17).

[5]While a focus on universal primary education (UPE) is no doubt the major contributor to achieving adult literacy in the long run, the MDG emphasis on UPE also tended to draw attention away from direct work on adult literacy programming.

[6]These numbers for adult literacy are, nonetheless, well below the target levels of the EFA goals.

payoff with respect to educational gains. That was in 1999. Today, after more than 15 years of substantial investments in education development, new studies are appearing with the same basic result: in many countries, children cannot read a single word even after attending school for several years (in other words, schooling does not guarantee literacy).

5.1.1 Learning and Literacy

Over time, various rationales have been put forward to justify investments in learning and literacy: economics (higher skills lead to economic growth); social development (women's empowerment); political science (growth of democracy, national identity), education (literate parents foster literate children), and now, with the new SDGs, a sustainable planet. Even so, literacy is not only a United Nations goal—it is also a key outcome of schooling in every nation in the world. Further, the science of literacy acquisition demonstrates the important and reinforcing linkages in literacy from childhood to adulthood—as part of lifespan human development.[7]

To have a realistic policy goal of increasing learning and literacy, we need to have a clearer understanding of socio-cultural contexts. Much of the research on literacy in Western-type school settings has been only partially relevant to those interested in the promotion of literacy around the world (Wagner 2015). The picture began to change at the turn of the 21st century, as research on global reading began to grow. European and American research studies have made the case for teaching early reading using the phonics (decoding) approach to acquisition, along with an important input of reading support by parents and teachers inside and outside of school. This Western approach to reading achievement has already contributed to research in low-income countries, but nevertheless languages and scripts vary in important ways around the world. We can be less sure of experimental interventions or statistical analyses when contexts vary so dramatically. For example, in non-alphabetic scripts, such as Chinese, a strict decoding approach will be of little value (Taylor 1999). When letters have multiple forms (such as in Telugu and Kannada in South India), the emphasis on early letter discrimination may be of relatively greater importance (Daswani 2001). Finally, although the use of new technologies in education is expanding rapidly, we are only now beginning to have more evidence on its effectiveness in the low-income countries, and some promising new developments (see below).[8]

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[7]This also builds on the notion of "lifespan" literacy development (Wagner 2010).

[8]See Wagner et al. (2010) for a study in India; Wagner (2014) for a review of mobiles for improving reading; also, Wagner (2009) on pro-poor ICT solutions, see: http://bit.ly/1NFQMDh, Accessed June 1, 2016.

In the research policy arena, it is crucial to understand the pros and cons of language of instruction (LOI) in schools as a key determinant of literacy achievement. Often the decision on national or official language(s) is based on such factors as major or dominant linguistic groups, colonial or postcolonial history, and the importance of a given language to the interests of economic development. Official languages are typically those most commonly used in primary and secondary school, although there may be differences between languages used in beginning schooling and those used later on. One result of the continuing policy debate on LOI is that reading proficiency in any language remains quite low in many low-income countries (Gove and Cvelich 2010). Figure 5.1 shows reading levels at end of second grade or later in selected languages and countries. The use of mother-tongue instruction in primary education remains a topic of continuing debate (Alidou et al. 2006; Wagner et al. 1989). Of course, one of the key barriers is the extent to which youth drop out of school, as shown by the youth educational survival rates in Fig. 5.2.

Societies today are changing rapidly, along with a global economy that requires ever more skills and more learning in a competitive marketplace. To understand, predict and cope with these transformations, and to be better prepared for a sustainable future, we need to understand the ways for societies to cope with changing demands on human skill and human development.
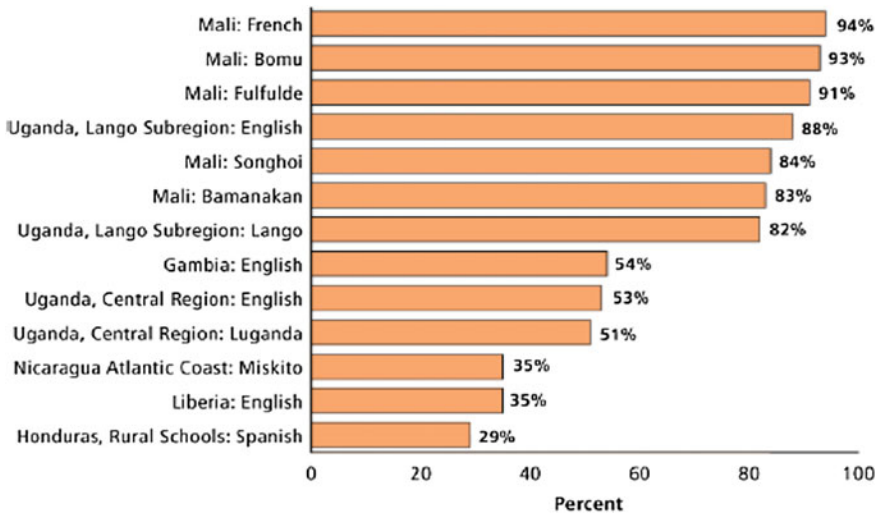
Fig. 5.1 Percentage of children who cannot read a single word after 2 years of school, 2008–2009. *Source* adapted from Gove and Cvelich (2010, p. 10)
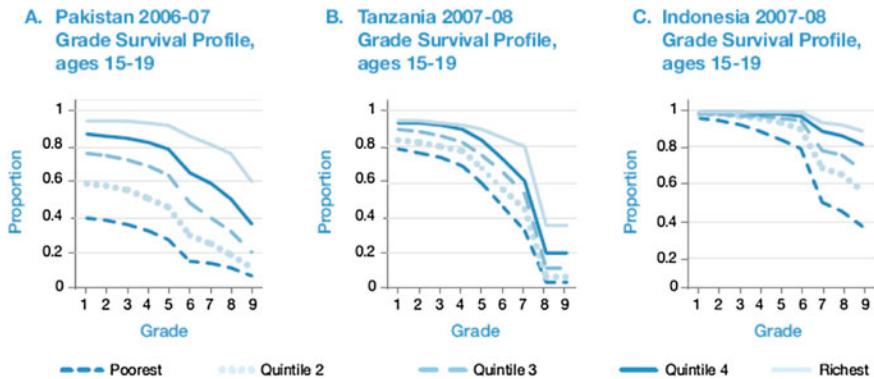
Fig. 5.2 Comparison of youth aged 15–19 years who have completed a given Grade, by Income Quintile, various Years. *Source* adapted from World Bank (2011, p. 18)

5.2 Globalization

5.2.1 Historical Background

In 2005, Thomas Friedman published a highly influential book entitled The World is Flat (Friedman 2005). In it, he described the kinds of changes that the Internet and other communications technologies, global trade and cultural transfer were going to happen in the coming decades. Part of his argument was that this process —termed by some the advent of public awareness of globalization—would flatten (or reduce) many differences in the world, differences that had been maintained by the distances of time and space between cultures around the world. Cultural differences (and insularity) would begin to fade away, leading to a world where competition would necessarily grow between nations, cultures, and corporations. Friedman further posited that the market would help drive competition between the skills (and education) of workers, thereby increasing global productivity and connectivity—thought (by some, but not all) to be a positive outcome.

Of course, globalization (and flatness) did not begin in 2005. If we think historically, globalization began with the first international travelers, such as Marco Polo and Ibn Khaldun, who brought back facts, objects and wondrous tales from their explorations of previously unknown cultures. Some centuries later, imperial colonizers and missionaries traveled the world to spread their power, their languages and their gospel in ways that would forever change the peoples with whom they had contact. Indeed, it has been noted that "[t]he processes that are usually meant when we speak of globalization …have existed for some 500 years." (Wallerstein 2000, p. 250, cited in Breidlid 2013). In today's terms, however, globalization has been defined as "a set of processes by which the world is rapidly being integrated into one economic space via increased international trade, … production and financial markets, … a commodity culture promoted by an increasingly networked global telecommunications system" (Gibson-Graham 2006, cited in Stromquist and Monkman 2014, p. 1).

Globalization has also had a major impact on the field of education. The ways that we think about education, literacy and even childhood itself have been directly affected by the globalization of knowledge, attitudes and values. What is a "good" education or a "happy" child? Many points of view are possible. Even so, it is clear that a near worldwide consensus has been achieved that views education as a gateway to social mobility, positive economic outcomes and global citizenship. This consensus has been driven by many factors, not the least of which is the perception by families and communities the world over, and among the poor as much as in wealthier classes, who see the demonstrable consequences of education on the lives of their children and those of their neighbors.

5.2.2 Demographic Change

Over the last quarter century, the world's population has increased by about 50 % —from 5 to nearly 7.5 billion people today, with most of this growth happening in developing countries.[9] In many countries, and especially in developing countries, the rate of change across age groups has been dramatic particularly for youth and young adults. Low-income countries have a clear 'youth bubble' that is creating a serious problem for both educational and economic planners (UNESCO 2015). The pressure or 'stress' of this bubble, when linked to the school leaving issues, makes it exceedingly difficult to assume that educational achievement or higher numbers of high school or university diplomas will necessarily lead to employment or to increased GNP, as there are just too many young people entering the workforce for the number of jobs available. In other words, particular regions and sub-regions of the world have still not taken sufficient control over population growth, even as some parts of the world done so (e.g., Europe, China, Central Asia).

5.2.3 Migration

An important consequence of demographic growth, high unemployment and climate change is human migration. In the period from 1990 to 2010, the number of international immigrants increased by nearly 60 million people worldwide, with over 200 million people living outside their country of origin by 2010.[10] Internal migration within countries is about the same as the documented international migration rates with both showing important increases in the global South over recent decades. This seems to occur most notably as part of worldwide urbanization, as rural families search for labor opportunities in cities (UNDP 2009)

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[9]http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf.

[10]http://esa.un.org/migration/p2k0data.asp. Accessed 1 June 2016.

(International Organization for Migration 2010) (Skeldon 2012). The broad trends of migration are massive and growing, with major consequences for education and social services. They are also highly sensitive to regional political instability, national conflict, and natural disasters, giving rise to a new subfield of education in fragile and conflict zones (UNESCO-GMR 2011) (Pigozzi et al. 2014).

Although migration research often focuses on changes in the labor market, the implications for literacy, and for educational systems more broadly, are sometimes overlooked. In each instance of translocation, children and youth confront the challenges of adapting to a new environment that may expose them to different languages, dialects and cultures—with major consequences for the learning contexts of their everyday lives. In schools, student migrants must cope with contrasts in culture, lifestyle and language of instruction, and then will have to demonstrate skills and achievement that may vary dramatically from their culture of origin (Yoshikawa and Kalil 2011) (Suárez-Orozco et al. 2009). Curricula that assume cultural and linguistic common denominators among students and teachers are often insufficiently aligned with these new trends in the diversification of student populations. Often, there is too little support for teachers as they try to meet the needs of students whose cultural and linguistic backgrounds are significantly different from their own.

Closely tied to both globalization and migration are the massive changes in urbanization. An average of only about 30 % of the world's population lived in urban areas worldwide, while this number has jumped to about 54 % in 2014 (United Nations 2014). Today, nearly 90 % of the remaining rural populations in the world live in Africa or Asia (especially influenced by the large populations in India and China). Perhaps less well-known is the fact that half of the world's urban residents live in relatively small cities of less than 500,000 inhabitants, while only around one in eight live in the largest 28 mega-cities with more than 10 million inhabitants (United Nations 2014). These large population transfers have many causes, but most seem related to the perception, among rural communities, that life and livelihoods are better in the city. Aspects of this presumption may be both accurate and inaccurate—and is certainly quite variable across individuals and groups—depending on the values that are placed on urban settings (e.g., proximity to better employment, health services, sanitation, schools, and so forth).

5.3 Climate and Environmental Change

5.3.1 Background

As the well-known cognitive scientist Steven Pinker famously put it,

> The goal of education is to make up for the shortcomings in our instinctive ways of thinking about the physical and social world.[11]

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[11]Cited in Williams (2011), from Pinker (2007, p. 439).

Few would doubt that climate and environmental changes run counter to what our human instinctive ways of existence, even if most of the world is now fully aware of catastrophic fluctuations that are currently taking place. Only in recent years have we become able to call climate change a global crisis.

Yet, over two decades ago, Robert Kaplan, in a highly publicized and very prescient article in the Atlantic Monthly, predicted—what he called a "premonition"—that the next few decades in West Africa were likely to bring "[d]isease, overpopulation, unprovoked crime, scarcity of resources, refugee migrations, the increasing erosion of nation-states and international borders, and the empowerment of private armies, security firms, and international drug cartels" (Kaplan 1994, p. 3). One may reflect on recent years—of Ebola, massive out-migration, civil conflict, rising income inequality—to see how close he was to seeing the future. And, this is not only in one region of Africa, but increasingly in the Mideast, parts of South Asia, the Balkans, and other unstable parts of the world. More recently, the well-known climatologist, James Hansen, and colleagues have stated that our whole civilization is now at serious risk (Hansen et al. 2015).

5.3.2 Climate Prognosis

Climatologists and others have been forewarning problems of changing environment for more than a century, with ever more greenhouse gases (especially CO_2) being emitted by industry into the atmosphere, the rising temperatures in the oceans, and the measurable changes in weather patterns.[12] During this same time, concern has grown about the depletion of forests that absorb CO_2 (such as in the Amazon basin), and the melting of glacial ice at the North and South poles. In addition, there is increasing concern about the declines in biodiversity (both flora and fauna) through which hope of better adaptation to such global environmental changes must reside. Fewer species of fish, insects, and diversity of land resources will necessarily limit the ability of the earth's complex ecosystems to survive as climate warming, and related consequences, challenge our planet's ability to adapt.[13] In sum, it is clear that the earth's changing ecological 'footprint' is no longer sustainable.

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[12]Arrhenius (1896), a Nobel Prize winning chemist, first wrote about carbon dioxide concentrations as having a deleterious affect on the atmosphere.

[13]Quotation from Louv (2012) is at: Interview: http://news.nationalgeographic.com/news/2013/06/130628-richard-louv-nature-deficit-disorder-health-environment/. Accessed June 1, 2016. Also, see useful discussion on nature and sustainability in the context of social change in McMichael (2011, pp. 9–11).

5.3.3 Types and Timing of Sustainability

Embedded within the public discourse concerning sustainability is a major debate about what more precisely needs to be sustained. Amidst the growing research on this topic, three major types of sustainability have been described (Goodland 1995; Morelli 2013). First, there is social sustainability, maintaining the local and regional communities that could be torn asunder by the effects of environmental change. Second, economic sustainability refers to the need to maintain a balance between the natural resources and human consumption that can generate goods and services without degradation of the balance between the two, and without increasing global economic inequities. Third, environmental sustainability focuses on the limitations within the biophysical environment—protecting the planet. Each type of sustainability has its proponents, possibilities and challenges. It has been said that the "world will in the end become sustainable, one way or another" (Goodland 1995, p. 14). Policymakers can choose the timing, types and levels of the transition, or natural depletion and pollution will dictate the terms in a less planned and abrupt manner.

5.4   Literacy, Schooling and Sustainability

5.4.1 Literacy and Environmental Literacy

How should the field of education react to climate and environmental threats to sustainability? First, there needs to be a much broader recognition of the environmental problems we face. Clearly, the way people (and especially the next generation of children and youth) think and act about environmental change will be central. For this reason, the UN and its specialized agencies have tried during the recent UN Decade of Education for Sustainable Development[14] (2005–2014) to raise awareness, in part through inputs into the curricula of schools. While environmental literacy[15] (or awareness) has increased, there remains large variation across the globe (see Fig. 5.3).[16] Awareness of climate change is typically higher in better-educated populations.[17]

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[14]http://www.desd.org.

[15]The term environmental literacy largely refers to work done in raising awareness about sustainability, such as through "through the skills and knowledge that its graduates learn and put into practice, its research and exchange of knowledge through business, community and public policy engagement." Cited in Kopina (2015, p. 988). See also: http://www.sustainabilityexchange.ac.uk/news/the_sustainability_literacy_test_the_first_worl. Accessed 1 June 2016.

[16]See recent poll by Pew Research Center, http://www.pewglobal.org/2015/11/05/global-concern-about-climate-change-broad-support-for-limiting-emissions/. Accessed 1 June 2016.

[17]The one exception in education related awareness of the impact of climate change is in the U.S., where the median is lower than any other OECD country.
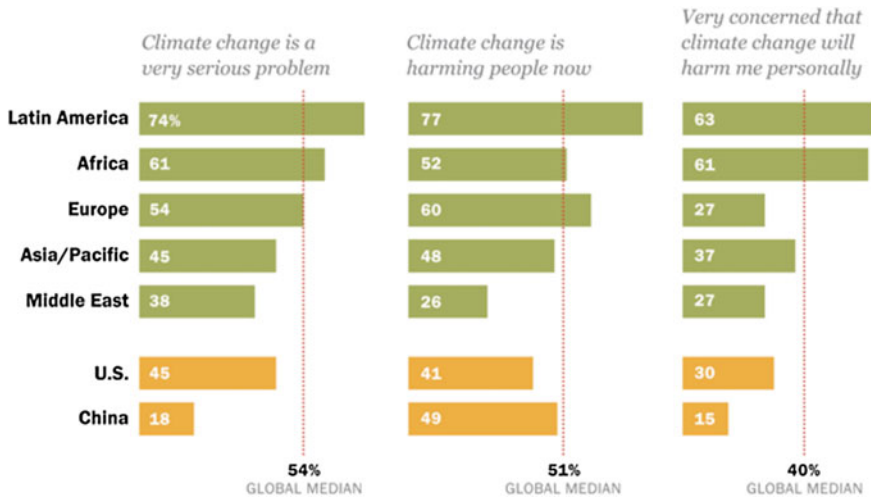
Fig. 5.3 Global public awareness of climate change (as of 2015). *Note*: Regional medians; Russia and Ukraine not included in Europe median; Asia-Pacific median includes China. *Source* Pew Research Center (2015)

Nonetheless, it does not necessarily follow that those most aware are those who act most in concert with environmental goals. This conclusion comes from studies that have shown that there are entrenched beliefs about climate change that are difficult to counter.[18] On the other hand, without basic education, our ability to foster sustainability awareness in present and future generations will be severely limited. Clearly, much must be done to improve learning and literacy (Easton 2014).

5.4.2 Complex Thinking

Environmental awareness as taught in schools—if only as facts—is not enough. Critical thinking is required to understand the complexities of climate variation, and the oft-occurring counterintuitive changes that occur (such as colder winters in Europe at the same time as glacial melting in the Alps). Research suggests that an issue like climate change can be very difficult to fully understand. Indeed, it constitutes what has been called a 'perfect storm' in moral and critical judgment, since there are conflicting dimensions between individual and collective needs as well as

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[18]See for example, the problematic finding that those who are more 'scientifically literacy' in the U.S. tend to be more opposed to policies that are more environmentally friendly (Kahan et al. 2012). Naturally, this finding, based on models of cognitive risk and awareness, may or may not be replicable in other countries.

between generations—since climate affects future generations more than current ones (Gardiner 2006; Anderson 2010; Mochizuki and Bryan 2015). These complexities reside further within a sense that the individual has little power over the collective nature of the problem, especially in a context where many of the specific scientific issues remain uncertain.[19] Even so, some striking examples of the costs associated with failure to take into account the total cost of industrial production and pollution may be seen in the now-famous example of the "$200 hamburger" (see Box 1) Clearly, there is a central role for improving educational quality, both in terms of basic skills to absorb needed information, as well as in critical thinking, 21st century skills, and what will likely be a new subfield of sustainability thinking.[20]

Box 1 The $200 hamburger.

…[T]he true cost of a McDonald's hamburger should be $200 if one includes the full spectrum of implied costs associated with its carbon footprint, water use, soil degradation, and the hidden health costs for treating diet related diabetes and heart disease from its consumption.

Source: Ricciardi (2011)

5.4.3   Risk Reduction

Another approach is to consider the consequences of environment for the education of those most at risk. On the one hand, these may be populations who reside in high-risk geographical zones—such as those at low sea levels, or tropical climates that are becoming even warmer, those that are undergoing major environmental destruction (such as the Amazon rain forests), and subject to instability that may be caused by environmental changes. In these zones, which are at serious risk, there are opportunities for direct action, such as the Sandwatch Initiative that brings communities into direct contact with the changes that will affect their lives.[21]

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[19]In a review of psychological and social norms concerning climate change, the World Bank (2015, p. 171) found that there exist serious cognitive barriers, such that "Human beings are far more concerned with the present than with the future, whereas many of the worst impacts of climate change could take place many years from now."

[20]OECD (2005) on twenty-first century skills. As part of a new effort to consider global citizenship skills, see Anderson (2012); Hoskins et al. (2011). These efforts have focus on the attitudes and participation of citizens in addressing issues of environmental sustainability. Kopnina (2015) provides a useful critique of what she terms "neoliberal education" where all views are considered equally valid, but where the environment continues to suffer. She argues for new ways to overcome this impasse.

[21]On the Sandwatch Initiative, see Anderson (2010, p. 10). Also see Kagawa and Selby (2012, p. 209), on disaster risk reduction; they state that: "Disaster risk increases when an exposed, vulnerable and ill-prepared population or community encounters a hazard event."

5.5 Vulnerability and Sustainability

5.5.1 Vulnerability and the Poor

Vulnerability has many causes. Human beings across the world acquire different sets of skills and capabilities—such as language, literacy, problem-solving, content knowledge and much more. Learning and literacy are at the essential core of the human ability to respond to the economic, social and environmental changes.

Of course, not all populations are equally vulnerable. The world's poorest groups have been impacted by decisions to advance industrial agriculture or global business that force people off of their ancestral lands. They end up in urban slums where life is challenging in many ways, but where climate change (bringing tempests of ever-greater severity) will increase the health risks, and make quality schooling even more difficult to maintain. The risks for indigenous peoples are also well documented. According to the UN, they make up 5 % of the world's population, but own 22 % of the world's land on which 80 % of the planet's biodiversity is located. Their ecosystems are especially vulnerable to shifts in climate, as they may reside in small island states, on coasts or at high altitudes or in artic regions—areas that may threaten livelihoods of hunting, fishing and farming (UNDP 2011). In other words, there is little doubt that creating a sustainable future for all will require an increased focus on the lives of the poor.

5.5.2 Literacy, Agriculture and Sustainability

According to the United Nations sustainable development vision:

> We will strengthen the productive capacities of least-developed countries in all sectors.

> (United Nations 2015, p. 7)

This strongly suggests that the education sector—including education policy makers, ministries of education, and educators—should see other ministries as collegial allies in addressing problems of sustainability. Let us take agriculture as a first example.

While less than 20 % of the world's population is directly engaged in farming, the range is huge between countries. For example, only about 2 % of the working population in the United States is involved in farming, while in India, the figure is more than 50 %, and varies between 30 and 50 % in many of the world's low-income countries. Can literacy help agriculture be more productive and efficient—in ways that make the earth more sustainable? This simple question seems only rarely discussed and studied in the education community.

Yet, research has accumulated in a variety of countries showing that rural farmers are better farmers if they have been to school (Asadullah and Rahman

2009) (Jamison and Lau 1982) (Asfaw and Admassie 2004). A number of reasons have been put forward for this conclusion:

1. Schooled farmers have better decision-making and management skills;
2. Schooling and literacy allow the farmer greater access to information (particularly about prices for both purchasing and selling);
3. Educated farmers are more likely to adopt new technologies (such as the Internet) or enhanced water conservation methods;
4. All of the above contribute to a generalized ability to evaluate opportunities and risks on investments (such as optimizing a mix of crops to reduce risk) leading to a per-annum increase in agricultural productivity of about 3.2 % (Reimers and Klasen 2013).

Based on this work, national governments should be making much greater investments in the schooling and literacy of farmers, especially with populations in countries with vulnerable populations.

5.5.3 Literacy, Health and Sustainability

A second example is literacy and health. The relationship between health and other development factors such as wealth and education have long been known. Whether in OECD or low-income countries, it is widely understood that GNP per capita is a strong predictor of lower rates of poor health, lower infant and maternal mortality, and access to better health services (Pritchett and Summers 1996). Within this general context, we might also ask the question about the degree to which learning also might impact health. There is ample research on this topic as well. One of the most comprehensive systematic reviews—looking at more than 3000 studies in the United States—found that low reading skills were directly related to adverse medical outcomes.[22] In India, it was found literacy can have significant effects on improved health outcomes independent of household income. More broadly, in developing regions considerable data has shown that there are significant consequences of years of maternal education on specific health consequences, such under-5 infant mortality rates (see Fig. 5.4).

Nonetheless, one of the quandaries of the 'education leads to better health' claims is understanding the mechanisms by which this happens. What is it about the mother's education, or literacy, that leads to better health outcomes? Explanatory rationales have included: increased monetary expenditures, women's empowerment, improved knowledge, and adoption, of modern medicine. Literacy is sometimes evoked (as the above case in India), but actual measurement of literacy and its impacts have rarely been the focus of attention. Fortunately, a long term

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[22]DeWalt et al. (2004). One recent study in Mozambique found that HIV/AIDS knowledge was strongly related to both basic reading and basic mathematics (Ciampa et al. 2012).

Fig. 5.4 Under-5 mortality
rate, regional weighted
average, by mother's
education, 2004–2009
Adapted from UNESCO
(2011, p. 35)
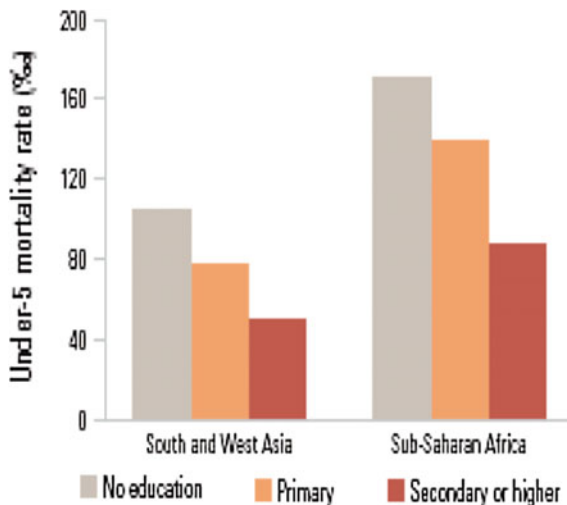
four-country comparative study—in Mexico, Nepal, Venezuela and Zambia—addressed this question (LeVine et al. 2012). Employing both qualitative and quantitative methodological designs, the researchers were able to find clear evidence that maternal education led to particular oral language and literacy skills that were statistically related to their understanding of key health messages. Further, it was found that mothers acted as teachers in their interactions with children, a finding that was further substantiated by field-based behavioral observations.

Another way to think about the role of learning and health is to consider how small behavioral changes can influence how the individual utilizes the knowledge that he or she already possesses. One of the most promising new ways to achieve adherence to drug use—a major issue especially among the poor in many countries —is to provide reminders. Most people know the importance of taking a specific prescribed medication, for example, but it is not always/easy to remember to do so. Hence, the use of text message reminders, such as those used in rural Uganda for adherence to HIV/AIDS anti-retroviral therapy, has become popular. As expected, the level of literacy (defined here simply as the self-assessed ability to read a sentence) was a strong predictor of whether the patients could read a direct (or coded or pin-protected message) about the results of their medical testing. Similar results were found with those most literate returning to their health clinic as requested within a seven-day time period (Siedner et al. 2015). Over recent years, there has been increasing collaboration between health and education ministries, often based on the use of school infrastructure in support of health innovations.[23]

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[23]See, for example, Rwanda's school based HPV vaccination program that had the health, education and gender ministries collaborate in schools for a major and rapid increase in HPV vaccinations (Farmer et al. 2013).

5.6   Implications for the SDG Era

In September 2015, the United Nations ratified a set of 17 Sustainable Development Goals (SDGs). As shown in Fig. 5.5, these goals cover a wide variety of global efforts to assure a more sustainable and less consumption-oriented future for the planet. Included at the *left side* of the list, as with the earlier set of MDGs, are goals focused on poverty reduction, food security and agriculture, health, education, and gender equality—the most vulnerable populations. On the *right side* is another set of goals that are focused mainly on sustainability. As discussed, literacy is a core component to achieving all the SDGs. Without improved learning and literacy, each of the SDGs will limit the ability of citizens to be sufficiently informed on key issues, and less empowered to take action.

At the same time, in order to achieve a more literate world, the education sector —largely responsible through its support of formal and non-formal programs— could benefit greatly from linkages that build on improvements in each of the SDGs. As described in the previous section, the sectors of education, agriculture and health, have natural affinities. By improving agriculture, we know that food security can be better achieved, and thus children will have time to go to school and be properly nourished. And, ministries of agriculture need to increase their demand for more literate farmers, knowing that these farmers will be more able to produce more efficient crops.

Similarly, improvements in health services contribute to increased student enrollments learning in school, thereby improving literacy. Above we also noted research showing that literate mothers are especially able support healthy behaviors
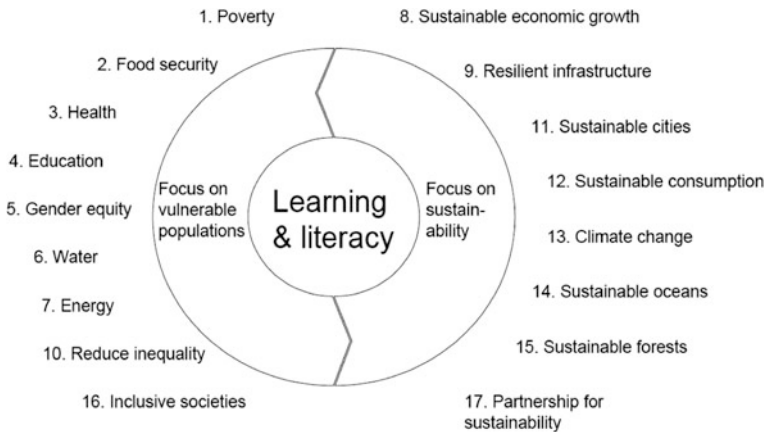
Fig. 5.5 The 17 UN sustainable development goals. These are divided into those that focus on vulnerable populations and those focused on sustainability. Learning and literacy are at the center of these sets of goals. *Source* Author

in children. The list of multi-sectoral collaborations will no doubt grow, but surely could be enhanced under the new framework of the SDGs, and the call for more partnerships.[24]

5.7 Conclusions and Recommendations

Nearly a half-century ago, Paulo Freire took a strong ideological stance (as shown in the opening quotation), arguing that: Education (learning and literacy) are key components in helping communities in the "transformation of their world." It is probably no accident that Pope Francis and Paolo Freire both originate from South America (from Argentina and Brazil, respectively), and both were influenced by the liberation theology of that time. The common thread between these two intellectual and moral giants is that the world is ultimately in our hands, and if we cannot find ways to transform our own increasingly unsustainable needs and consumerism, the consequences will be ours to bear.

In this review, we have noted the escalating changes due to globalization. Some are threatening, such as climate and environmental changes that put at risk not only peoples in some parts of the world, but nearly everyone in all parts of the world. The complex spillover effects of these changes on education, social and political conflict, national and international migration, and employment may be catastrophic in the coming years and decades—if not attenuated soon. And yet, some changes are hopeful as well, such as an increasingly aware global citizenry, increased access to new technologies, and greater respect for the world's essential resource limitations.

Education—of which the core is both learning and literacy—is central to any set of sustainability solutions, and across all development sectors. We now need to make renewed and innovative advances to use education as a means for the formidable transformations in sustainability that are required over the next 15 years of the SDGs and beyond. It is not enough to inform the public about the challenges of globalization, climate change and sustainability. Our education goals must include new ways to address these challenges and overcome them.

With these perspectives in mind, several recommendations should be considered:

1. Education specialists will need to invest more in content awareness as well as critical thinking skills that can help people (especially children and youth) learn about, and address the challenges of, sustainability and its consequences—what we have termed here sustainability thinking. A broad focus on improving learning is the key to managing a very challenging future for this planet.
2. Educators (at all levels) will need to further develop and expand effective connections and partnerships with other sectors and broader stakeholders to

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[24]See also: http://www.project-syndicate.org/commentary/pope-francis-universal-literacy-by-daniel-a–wagner-2015-10. Accessed June 1, 2016.

address sustainability challenges as part of the new SDGs. New uses of pro-poor technologies can play a crucial role in sustainable solutions.

3. Finally, educators should be especially alert to the impact of sustainability on the most marginalized and vulnerable groups (especially children, women, indigenous and disabled populations) across the world, in an era when those groups are most likely to be disproportionally impacted by environmental change.

There is no doubt that we know more in 2015 about development than we did in the year 2000 when the first UN development goals were ratified, and considerable progress has been achieved. However, it is also true that the ground has literally changed under our global feet in the last decade and a half. We may be able to improve classroom learning, reach more children in conflict zones, and develop better methods of teaching training. All of these dimensions and more will no longer suffice to address the new era of the 2030 Sustainable Development Goals. These new global efforts, as the Pope aptly put it, will require a "renewal of humanity," as well as new ways of learning, thinking and prioritizing our educational mission for all.

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Chapter 6
Educating Students to Sustainability: The Experience of "La main à la pâte"

David Wilgenbus

6.1 Introduction: Sustainability: A Recent Concern

A simple Google search on the phrase "sustainable development" returns more than 40,000,000 results: encyclopedias, national or international institutions, NGOs, major banking institutions, educational sites, research papers … the expression is on everyone's lips. Yet it is a very recent concern: 30 years ago, "sustainable development" was an emerging concept. Why now and not before?

Although there is a great historical and cultural diversity in our relation to nature, we can consider that the environmental movement really emerged in developed countries around the 70s (Dunlap and Mertig 2014). The rise of a post-materialism movement after the World War II, the emergence of an activist culture encouraging young people to solve society issues, and the development of outdoors activities making people face directly environmental degradations have participated to make environmental issues to become a social problem. In addition to these factors, science and technology played a key role in the emergence of environmentalism.

Figure 6.1 illustrates a fundamental change in how we perceive the world. From 50 years, space exploration has enabled us for the first time in the history of mankind to observe the Earth from outside, from space. What we have seen is not a puzzle of states and countries but a whole planet uninterrupted by boundaries: a small planet, like a lost oasis in the middle of a huge, cold and dark universe. This kind of representation has had a significant impact in the way of seeing and thinking

D. Wilgenbus (✉)
Foundation La Main à La Pâte, Paris, France
e-mail: david.wilgenbus@fondation-lamap.org

our planet (Lazier 2011). Famous photographer Galen Rowell called it "the most influential environmental photograph ever taken" (Life 2003).

Anthropology (the quest for the origins of humanity), geology (the discovery of plate tectonics), mathematics (atmosphere viewed as a dynamic system)… a lot of scientific discoveries made during this period deeply transformed our vision of the Earth as a dynamical, complex, fragile and "not so big" planet. More recently, concern has focused on the atmosphere (ozone layer, climate change…), or the oceans, which we are only beginning to perceive the complexity, importance, and fragility.

Meanwhile, global population has experienced in the twentieth century, an unprecedented growth. While mankind took tens of thousands of years to reach 1 billion people, its population reached 7 billion individuals in less than two centuries… and is believed to reach 9.5 billion by 40 years (see Fig. 6.2).

Environmental, health, economic and social issues have nothing to do if the entire world's population is less than that of New York. We will come back to this later, but we have to keep in mind, when educating students for sustainable development, not to blame them or put the finger on the younger generation: students, or their parents, are no less virtuous than the previous generations… but

Fig. 6.1 "Earthrise" viewed from the Moon, Apollo 8 mission, NASA/Bill Anders. 1968
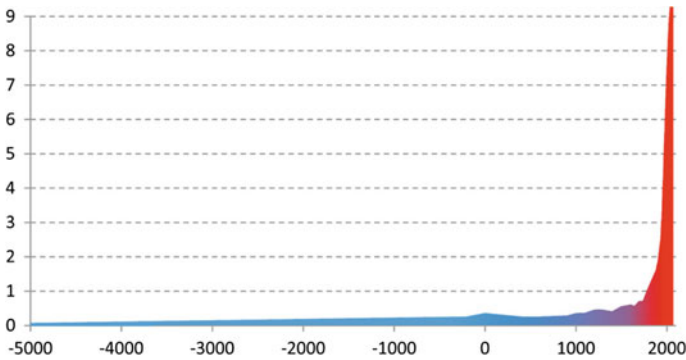
Fig. 6.2 Evolution of global human population (in billions of individuals) and projection for 2050 (lower estimation from MacDevitt et al. 2004)

the demographic explosion has made that behaviors that had little consequence became suddenly problematic and unsustainable.

Jacques Weber, a French economist, biologist, and anthropologist, made an accurate and concise synthesis of the situation, explaining why sustainable development is a current concern:

> Our generation is the first to be aware of its impact on nature, and the last one to still have the opportunity to reverse the condition. (Weber and Barbault 2010)

6.2 Sustainable Development: What Is It?

"Sustainable development" is commonly defined as "Development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (Burton 1987). It is built upon a "3 pillars" model linking environmental, social and economic aspects, all interdependent. As such, sustainable development is a society project, and a political one, that cannot be defined and implemented without science, both because science has to play a huge role in the choice of technical solutions and because science is not disconnected from society. From this point of view, science can contribute to objectivize the reflection on social and economic phenomena as well as natural ones, and to go beyond the opinion debate. This means the scientific approach can help consider the three dimensions of sustainable development with the same level of demand in the reasoning.

At the same time, science cannot pretend to the complete dissociation of facts from values especially when dealing with sustainable development which—as a society project—must be grounded on values and active citizenship.

6.3 Education for Sustainable Development (ESD): Why and How?

In the strategy to achieve sustainable development, the key role of education as a prerequisite for promoting the behavioral changes and providing all citizens with the key competences needed to engage critically with issues has been highlighted (Samuelsson and Kaga 2008). To answer those educational needs, a new approach has emerged, Education for Sustainable Development (ESD), which has been defined by UNESCO in the following terms:

- ESD allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future.
- ESD means including key sustainable development issues into teaching and learning; for example, climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption.
- ESD also requires participatory teaching and learning methods that motivate and empower learners to change their behavior and take action for sustainable development.
- ESD consequently promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way.

ESD may take different perspectives which may give different conclusions. This can be confusing when dealing with the necessity of taking concrete action. Moreover, there is a risk that ESD mainly focuses on encouraging behavioral change (telling people what they should do) rather than also developing the critical skills to engage in discussion of policy and decision making.

6.3.1 A Controversial Approach

Such objectives seem relatively consensual, but they are not. Bob Jickling wrote in 1994 an article entitled Why I Don't Want my Children to be Educated for Sustainable Development (Jickling 1994) in which he argues:

> Education is concerned with enabling people to think for themselves. Education "for" sustainable development … or education "for" anything else is inconsistent with this criterion.

This kind of reaction, comprehensible, illustrates that ESD appears to be a break in the education system, for several reasons: like all the educations "for", ESD is not disciplinary but thematic, which distinguishes it from the standard model of school curricula and raises a legitimacy problem (how are the contents of these teachings validated?). ESD is also closely linked to socially controversial issues that challenge the social representations of teachers, students, parents… and offer a place to the controversy that does not exist (or at a little scale) in the more

traditional teachings. Finally, ESD, as all the educations "for", explicitly targets behavioral change and the adoption of "good practices", in close connection with the appropriation of ethical values, whose cultural roots are important.

For ESD to be fully recognized in the education system, it needs to show that, as with all disciplinary teachings, there are guarantees on contents. This is particularly difficult because the ESD does not really have a formal curriculum, and so no recognition procedure for contents or for teachers.

The legitimacy of the ESD relies on several factors, such as the conviction of the teacher, the ability to lead to concrete actions (which are not themselves consensual!), the scientific foundation of contents (links with physics, biology, geology, economy… are strong: in these fields, the contents are legitimized)… or simply by the political and institutional weight of prescribers bodies of ESD.

Deny the lack of legitimacy can lead to some shortcuts and damaging practices: ESD can then become a moral course favoring political correctness. It is important to keep this in mind and implement pedagogical approaches that give great importance to the debate and the co-construction.

Finally, the growing importance of ESD shows that our societies carry on trusting their school to deal with socially controversial issues and to be able to evolve.

6.3.2 Importance of Interdisciplinarity

One of the risks in implementing ESD lies in the fact that the 3 pillars model of sustainable development often leads educational disciplines to focus investment in one of the three, thus reproducing the compartmentalization of traditional teaching subjects.

Yet, ESD, on the contrary, must encourage more complex and multidimensional approaches, a synthesis of environmental and development education, which may have a number of dimensions: scientific, geographical, economic, political, and social. It requires a change in the mindset and habits of most teachers, especially at Secondary level (because of the subject specialization: many secondary school teachers prudently take refuge within the strict disciplinary lessons to avoid involvement in what they consider as being outside their teaching mission (Lebatteux and Legardez 2011; Urgelli 2012). For interdisciplinarity to become more than a declaration of good intentions, the entire teacher's training program has to incorporate this approach.

More specifically, ESD requires: project-based learning, helping to apprehend the complexity of the issues at stake; collaborative work, including the perception of belonging to a community challenged by the issues; a shift from transmission learning to cooperative problem solving; multi-disciplinary analysis of real-life situations. Learning how to develop and carry out ESD projects is critical for the professional development of teachers.

A quick overview of the ESD projects conducted in French primary and secondary schools (Zélem et al. 2010) reveals that, most often, those projects are limited to the environmental issues and ignore social and economic dimensions of ESD. Economy, when present, is limited to the study of the cost of environmental damages (according to Nicholas Stern, for example, limiting the atmosphere CO_2 concentration between 500 and 550 ppm would cost about 1 % of the global GPD) (Stern 2007).

We think we should rebalance and offer, even to lower secondary schools, educational programs that deal with non-environmental and "purely" economic or social considerations. One example is the growth of inequalities around the world. African population will probably represent, in 2050, 5 or 6 times the US population, but this whole continent will remain, by far, the poorest region of the world. This unsustainable situation may have a lot of social consequences pupils could be aware of. Another example relies on local inequalities.

Figure 6.3 illustrates that 10 % of the richest concentrate 50 % of salaries in the United States. Similar graph showing the distribution of the capital instead of income is even more dramatic, as the richest 10 % own more than 70 %, while half of the population doesn't own anything.

These inequalities tend to be amplified in recent decades, and are expected to increase further during the twenty-first century. Once again, we can imagine that, in a democratic society, people won't accept, on the long term, such inequalities. Social and economic issues are in the heart of the idea of sustainability, and should be present in ESD.

Income inequality in the United States, 1910-2010

The top decile share in U.S. national income dropped from 45-50% in the 1910s-1920s to less than 35% in the 1950s (this is the fall documented by Kuznets); it then rose from less than 35% in the 1970s to 45-50% in the 2000s-2010s. Sources and series: see piketty.pse.ens.fr/capital21c.

Fig. 6.3 Income inequalities in United States 1910–2010 (Piketty 2014)

6.3.3 Importance of the School Environment

Sustainable development is both a societal and an educational challenge. Addressing hot issues, ESD could involve a wide range of players, especially from outside the school itself: scientists, environmentalists, economists, legal experts, local stakeholders, policy-makers, industries.

A school that is connected to such an open environment is a privileged space for developing and applying/implementing ESD. Indeed school can be the place for the articulation of all these stakeholders and at the same time—thanks to its special position in the society and its role of building collective citizenship—pay attention to a view of general interest and not of groups' interests.

6.4 The Specific Contribution of Science Education to ESD

6.4.1 Less Emotion, More Reason!

Every single teacher has noticed that most of the students, even at primary school, are already aware of the greatest challenges of sustainable development: waste proliferation, global warming, biodiversity crisis, etc. Indeed, pupils are exposed, and almost saturated, by such topics in different media: newspapers, television, and Internet. Most often, however, the images, movies or articles they are confronted to focus on the Emotional.

As we saw it, Emotion played a central role in the emergence of environmentalism. It is also a powerful engine for motivation and learning (see Hideaki Koizumi's chapter in this book), and then it has to be taken into account, and used, as a springboard for ESD. But Emotion can also be counter-productive for educational purpose. A research made on French high school students (Simonneaux and Simonneaux 2009) showed that the more "emotional close" the students are to the subject, the more difficult is their scientific learning on this subject (less critical analysis of their conceptions, knowledge appropriation, socio-epistemic reasoning on the knowledge involved…). Although contextualization is supposed to improve learning by "giving sense", we saw here the limits of a too much involving contextualization. Affect overexpression can curb critical reasoning, enhance the resistance of the students and, sometimes, "blind" them.

It is important to provide pupils with an alternative from the "emotion-only" register. School is the place to do it, and, without ignoring values, science should play a key role in helping pupils to acquire the knowledge and understanding of critical issues like climate change, natural disasters, biodiversity, health… and to develop competencies like critical thinking, decisions making, and collaborating.

The heart of inquiry-based science education (IBSE) is drawing conclusions based on evidence children can collect themselves (as well as from other sources).

Developing the first-hand personal experience of children into knowledge and understanding through questioning and inquiry and the consideration of evidence, can contribute to taking good decisions and changing behaviors. This as a progressive process made of little steps in the right direction rather than an immediate capacity to produce fully effective answers.

6.4.2 Inquiry-Based Science Education (ISBE): What Is-It?

Facing the profound changes induced by the impact of science and technology on modern societies and cultures, our times have become more sensitive to the issue of science education for all students, beginning at an early age and no matter their future professional choices may be. It is in this context that science academies, governments, research bodies, national or international institutions have produced, during the last decade, a large body of reports, recommendations or efforts to introduce new goals and policies in science education.

Arguments which underline the necessary development of science education and scientific literacy for all are (Rocard et al. 2007):

- modern economies requires new skills, lifelong learning, understanding of basic principles of science and technology as to provide a broad basis for development;
- citizens must be prepared to understand the contemporary issues on energy, health, climate, population, etc. where decisions have a profound impact on every day's life, as well as on broad issues of global concern and possibly even peace or war;
- ability to use properly reason, developing a critical mind, is a necessary protection against fundamentalisms;
- science, being one of the most remarkable achievements of human culture, is to be shared with all.

Similarity with ESD objectives are gripping.

Successful experimental programs in a number of countries underline a similar set of requirements for the quality of science education:

- education at school should begin very early (age 5 or so), accompanying and developing the curiosity of children;
- inquiry principles should be followed in the classroom;
- to achieve this, proper teacher professional development is the key requirement.

We can find several definitions of "Inquiry based science education" but all of them agree on the following statements: making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results.

As Wynne Harlen explains (Harlen 2010),

> When trying to make sense of new experience, learners start from the ideas they already have; so do scientists when they are trying to explain phenomena and develop their understanding. Ideas 'grow' by being linked to a new experience and tested to see if they help to make sense of the new experience. If a potentially useful idea leads to a prediction that fits the evidence from the new experience, then the idea becomes just a little 'bigger' because it then explains a wider range of phenomena. […] Through these processes there is a change not only in the number of ideas and events that can be understood, but also a qualitative change in the ideas. Scientific ideas that are widely applicable are necessarily context-independent.

6.5 "La main à la pâte" Experience in ESD

In 1996, the French Nobel winner Georges Charpak and the Académie des sciences in France launched a program to totally renovate science education in French primary schools. They had analyzed the status of natural sciences in these schools, and discovered that, contrary to mathematics, natural science had practically disappeared in pre-school and grades 1–5 beyond. The program, named La main à la pâte, had a slow and careful experimental start, then progressively expanded to the whole of France, where inquiry teaching became recommended to teachers by official instructions in 2002, 2005 and 2008. The story of La main à la pâte is found in Sarmant et al. (2009) and its many activities described and available on its website (foundation La main à la pâte 2012).

The common points to various ESD projects made by *La main à la pâte* are:

- a design by a multidisciplinary team, including teachers, scientists, engineers, trainers…
- a validation by top experts, involving scientific, industrial, and institutional partners;
- large-scale class tests to sample the age of the students, the experience of the teachers (and their familiarity with science and/or ESD), the socio-economic context…
- turnkey resources for the teachers: each teaching guide is between 100 and 250 pages long and provides both scientific background and complete and detailed pedagogical progression for the teacher, organized according to a conceptual scenario and composed of detailed sessions (objectives, duration, materials, questioning, investigation activities, conclusions, examples of students handbooks…);
- free access to the resources, online and via print editions;
- and specific teacher professional development activities dedicated to these projects.

6.5.1 Example of an ESD Project Dealing with Health: "Living with the Sun"

In France and many other countries, primary and secondary school teachers as well as education authorities are concerned with health education, often much more than with science education. We believe that the former can greatly benefit from being connected to the latter, in the sense that a child who understands the rationales of health prescriptions (e.g. wash your hands) will respect them better and more than in the opposite case. The project called "Living with the Sun" was launched in 2005. Designed to be used in primary schools (from age 3 to 11), it aims at preventing risks of overexposure to the Sun (Wilgenbus et al. 2004).

Indeed, in developed countries at least, the recent boom in the travel industry and the development of outdoor activities have strongly increased exposures of unprepared children to sunlight. As overexposures during childhood are responsible of melanoma in adulthood, the World Health Organization recommends the development of prevention programs targeting young children. "Solar education" is a bit uncommon in the field of health education. Unlike other health topics such as tobacco or alcohol, the Sun has also beneficial effects: discussing and understanding these effects, without condemning the Sun, helps the study of hazards. Moreover, the Sun is an object of fascination, dream, and imagination, and offers opportunities for science education. During the project "Living with the Sun", the children study the decomposition of white light in colors and discover the existence of the ultraviolet rays, using a reactive paper that gradually changes color when exposed to UV rays. Thanks to this simple and cheap material, pupils can investigate the variations of UV rays reaching them over time, season, latitude, altitude or weather. They model the atmosphere and the ozone layer as a filter whose thickness controls the intensity of UV radiation passing through it (optical thickness of the atmosphere is hinted at, but indeed not formalized).

In Fig. 6.4, a 10 years old student shows, with his own words and drawing, that sunlight passes through a thicker atmosphere in France than near the equator, which explains that exposure to UV is lower in France, since there UV rays are more filtered by the atmosphere.

Understanding why some situations are more risky than others, students can then find out and test strategies to protect their skin and eyes from sunlight, with simple experiments using UV-sensitive paper.

The "Living with the Sun" project has been a growing success with 300 classes enrolled in 2005 and more than 45,000 in 2014! Since 2008, the project is officially labelled by French Ministries (health and education).

The Biostatistic Unit of Languedoc-Roussillon's Fight Agaist Cancer Center and Epidaure, the Prevention Department of Research & Action in Montpellier both led an evaluation with 1500 pupils (cluster-randomizer trial) between spring 2007 and summer 2008. This evaluation showed "a significant progression of knowledge and
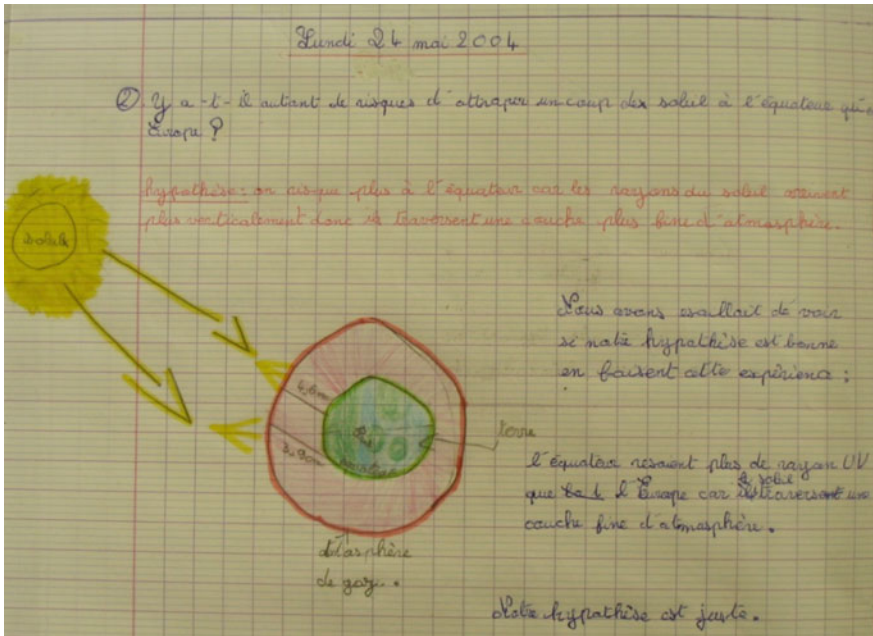
Fig. 6.4 10 years-old pupil's hypothesis, investigation and conclusion (Wilgenbus et al. 2004)

a modification of children's attitudes and behaviors. It seems that the favorable period to communicate messages about excessive exposures to the sun is probably the primary school" (Sancho-Garnier et al. 2012).

6.5.2   Example of an ESD Project Dealing with Climate Change: "the Climate, My Planet… and Me!"

Following the footsteps of the "Living with the sun" project, La main à la pâte launched in 2008 a program called"The climate, my planet… and me!", dealing with climate change (Wilgenbus et al. 2008).

Scientists, reported by the media and NGOs and institutions, agree to consider that climate change represents a major ecological, health, social and economic threat for the 21st century. Since the industrial revolution of the nineteenth century, the energy needs of humanity have continuously increased, and with them the emissions of greenhouse gases. Industry, agriculture, transportation, housing… all sectors are concerned, and the effects of climate change are already being felt: global warming, disturbance of the water cycle, extreme weather events, glaciers regression, sea level rise, endangered species…

Primary school provides a particularly favorable environment to such a project, as climate change is a complex process that needs a multidisciplinary approach. Inquiry-based and project-based pedagogy lead the students to understand the phenomena, to adopt a critical attitude towards the information they receive and gradually progress towards the knowledge they are building together, under the supervision of the teacher.

Learning and understanding are essential components of ESD; but it is obviously on the action that such education must lead. To avoid discouragement or possible guilt of children, the project proposes concrete paths and actions they can conduct in their own environment, family or school. At the scale of a school, for example, we can implement many solutions to limit energy consumption and CO_2 emission: energy saving, waste sorting, organizing public transportation, etc.

In Fig. 6.5, we can see 10 years-old students investigating various parameters allowing to heat water with solar energy: insulation/conductive material, open/closed container, light/dark colored surface, orientation, compactness, etc. Those parameters will then be combined to make a "real" solar water heater.

Some underlying scientific concepts are of spatial and temporal scales very different from those that are used in everyday life. It is then difficult to conduct a purely experimental investigation with students: how to deal with a phenomenon that only occurs at very large scale (that of the thickness of the atmosphere, or the continent, or even the entire planet) or whose consequences are felt on large time

Fig. 6.5 Investigating different parameters in a primary school (Wilgenbus et al. 2008)

scales (years to centuries)? Experiments in the class may be enriched by Information and communications technology (ICT). This is why, in addition to the "classic" teaching guide, La main à la pâte has produced a set of interactive multimedia animations, designed to be used by children 8–14. Another, complementary, approach relies on documentary studies in the classroom, materials being selected so as to alternate the local and global effects examples. Climate change is indeed a global phenomenon, but we perceive its effects (and we can act) locally. The multiplicity and diversity of regional examples help students to bridge the gap between local/short terms to global/large-scale considerations.

To accompany the teachers involved in the project, La main à la pâte set up a dedicated collaborative website which provides access to resources, but also to community tools that allow classes to exchange, help or challenge each other (interactive maps, forums, blogs).

Finally, specific professional development sessions are offered to teachers and teacher trainers. In 4 years, and in France alone, this single project led to dozens of conferences and training sessions, reaching over 6000 teachers, trainers, and school inspectors.

Fig. 6.6 Geographical distribution of the 17,000 classes involved in the project "The climate, my planet… and me!"

The *systematic approach* with free scientific and pedagogical high quality resources (teacher's guide, multimedia animations), online individual accompaniment and training sessions (also freely available), make this project to be very successful: more than 17,000 classes from 50 different countries within a few years (see Fig. 6.6).

6.5.3 Other ESD Projects from "La main à la pâte"

Following the same principles, *La main à la pâte* has set up a dozen of wide-scale ESD projects, gathering more than 100,000 classes during the last decade. There projects are focused on the design and dissemination of turnkey pedagogical guides for teachers, dedicated websites, multimedia animations and professional development on the topics studied. Every resources and services are provided for free to teachers and teacher trainers (Table 6.1).

Table 6.1 La main à la pâte ESD projects

Theme	Project title	Summary
Climate change	The climate, my planet… and I! www.fondation-lamap. org/climat	See details above
		Diffusion: 17,000 classes since 2008
		Target audience: 9–13 y-o
Biodiversity	A school for biodiversity www.fondation-lamap. org/biodiversite	Even though we live daily from it, although we live in the midst of its diversity, while we modify it as we modify our habitats, what exactly do we know about biodiversity? What is it? Where does it come from? How extensive is it on Earth? What is the place of man in biodiversity, and what could be done to minimize our impact?
		The project "A school for biodiversity" aims to address these critical issues. Children are educated to a new way of thinking and every-day life, in which man is but a link in these ecosystems, and a citizen of nature
		Diffusion: 4000 classes since 2011
		Target audience: 8–11 y-o
Housing	My house, my planet… and I! www.fondation-lamap. org/ecohabitat	The increase in population, the depletion of natural resources, climate change: all of these are challenges that impose on us to revise our design of housing. This revision could rely on high tech equipment, as well as traditional (low-tech) techniques and materials
		The project "My house, my planet… and I!" explores the variety of forms of habitat throughout our planet and our history, and their respective impact on the environment. Pupils study energy efficiency, materials, buildings shapes, water management, as well as urban development to design a greener habitat
		Diffusion: 13,000 classes since 2010
		Target audience: 9–13 y-o
Transportation	I am eco-mobile	Mobility is now a key element of social organization, determining access to resources, employment, and leisure

(continued)

Table 6.1 (continued)

Theme	Project title	Summary
	www.fondation-lamap.org/je-suis-ecomobile	activities. With the current population increase, the pressure of transportation on the environment, health, and economy has become a concern. Such is the challenge of eco-mobility, offering to rethink our relationship with the land
		The project "I am eco-mobile" allows teachers to approach the theme of transportation from several fronts: the history of science and technics (from the invention of the wheel to the plane or the solar car); the impact of transportation on the environment, the health, and the quality of life; the current challenges at the individual, family, or community scales
		Diffusion: 5000 classes since September 2014
		Target audience: 9–14 y-o
Ocean	The Ocean, my planet… and I! www.fondation-lamap.org/ocean	The growing threat of global warming, the increasing pressure on biodiversity, the growing scarcity of resources, the increase in exchanges… all of these are reason enough to change our view on the ocean and realize both its importance and its frailty
		The project "The Ocean, my Planet… and I!" will allow pupils to understand the high interdependency between aquatic and terrestrial ecosystems, as well as the crucial role of the oceans in the climate regulation at a planetary scale. Furthermore, they will learn the importance of the oceans in the development of human societies (mineral, energetic, nutritive resources; transportation; natural hazards, and so on) and realize the impact of human activities on this fragile environment. They will discover a whole range of marine occupations and of observational tools (most notably satellite-based)
		Launch date: September 2015
		Target audience: 8–14 y-o
Natural hazards	When the earth rumbles www.fondation-lamap.org/risques	Population growth, urbanization, and colonization of new areas have greatly increased the exposure of inhabitants to natural hazards. A number of recent disasters could have been significantly mitigated if people had been better informed, empowered and prepared
		The project "When the Earth rumbles" combines both local and global approaches to develop a better understanding and culture on risks. It covers three specific natural hazards (volcanoes, earthquakes and tsunamis), and offers a methodological framework for any school to study its own context (floods, forest fires, storms, landslides, etc.)
		Diffusion: 8000 classes since 2012
		Target audience: 8–14 y-o
Health, sun overexposure	Living with the sun www.fondation-lamap.org/vivre-avec-le-soleil	See details above
		Diffusion: 45,000 classes since 2004
		Target audience: 3–11 y-o
Health, nutrition	Eating and moving for my health www.fondation-lamap.org/mangerbouger	Pathologies associated with dietary imbalances or with lack of exercise have surged dramatically in the past years… to the point today that obesity is now considered as an epidemic affecting all socio-professional categories, though not evenly:

Table 6.1 (continued)

Theme	Project title	Summary
		its prevalence is inversely proportional to the level of education
		The project "Eating and moving for my health" teaches children about the importance of a balanced diet and physical exercise for their health, and about the importance of mutual respect
		Diffusion: 7000 classes since 2008
		Target audience: 3–7 y-o
Health, screen addiction	The screens, the brain… and the child www.fondation-lamap.org/cerveau	Screens have become ubiquitous in the daily life of children: TV, computers, phones, video games, tablets, and so on. Despite—or perhaps because of—their massive diffusion, screens generate both enthusiasm and reluctance
		The use of screens makes us exploit cognitive processes, learning strategies and information methods that other cultures, like the one of book reading, for instance, implied little, if at all. This is how digital culture promotes a certain type of memory and attention, influences our interaction with others, allows us to renew our creativity, and arouses an unprecedented attraction for our imagination
		The project "The screens, the brain… and the child" explores the reasons why the screens are so fascinating and captivating, especially for children, while posing a basic scientific look at a "continent" generally little known: the brain
		Diffusion: 4000 classes since 2013
		Target audience: 6–11 y-o

6.6   Conclusion

Children, our today' students sitting in primary and secondary schools, are the one who in 2040–2050 will be adults and live on an Earth with 9 billions inhabitants. They will have to face a lot of new challenges in a rapidly evolving context of globalization, environmental damages, increasing inequalities…

Educating students to sustainability has then become a priority in both developed and developing countries, but this necessity claimed by political authorities doesn't seem the consensus is total in civil society, because of the specificity of education to

sustainable development (ESD): interdisciplinary approach, no formal curriculum, and a collision between "traditional" objectives in term of knowledge and new ones in terms of attitudes and ethical values.

We hope to have shown here how important the role of inquiry-based science education can be in a program for ESD, both because it helps providing the basics for understanding big environmental and social complex issues, and because it promotes and develops competencies like critical thinking, debate and collaboration.

And education for the future should provide an understanding of science and technology in a broader frame, accounting for complexity, encourage creativity and develop an ethical vision of human solidarity.

Since over two decade and in many countries, the constant experience of La main à la pâte has been as follows. Teachers are willing, and even enthusiastic, to enter ESD or ISBE projects, often quite difficult for them at the beginning, as long as they are accompanied, locally and/or at distance, with proper aids and resources. Therefore, as many other organizations in the World, we have dedicated energy and funding to create such accompanying tools, always on an international basis, even if the starting point of our activities is in French schools. Within the broad diversity of the tools we offer, a number of them is related to sustainable development, and meets great success.

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Chapter 7
Evidence Based Education and the UN Sustainable Development Goals (SDGs) 2016–2030

Lee Yee Cheong

Abstract The 17 Sustainable Development Goals (SDGs) 2016–2030 were unanimously adopted by the UN Summit General Assembly on 27 September 2015. Unlike the Millennium Development Goals (MDGs) 2000–2015, the SDGs are holistic, cross-disciplinary and multi-stakeholder in participation. Whilst technology is highlighted as most important to achieve the SDGs, I would like to argue that increasing serious global problems like excessive consumption, religious fundamentalism, military confrontation, terrorism and gun violence, child obesity etc. have not been emphasized in the SDGs. Addressing these issues would require a mental revolution in society the foundation of which is the proper education of our children, especially evidence based education the scientific way.

7.1 Introduction

The UN Summit General Assembly unanimously approved the 17 UN Sustainable Development Goals (SDGs) on 27 September 2015. The SDGs 2016–2030 will replace the UN Millennium Development Goals (MDGs) 2000–2015. They will be the focus of the UN post-2015 development agenda.

7.2 The UN Sustainable Development Goals (SDGs) 2016–2030

The 17 UN SDGs are:

Goal 1: End poverty in all its forms everywhere;

L.Y. Cheong (✉)
UNESCO International Science Technology and Innovation,
Centre for South-South Cooperation, ISTIC, Kuala Lumpur, Malaysia
e-mail: dlyeec@gmail.com

Goal 2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture;

Goal 3: Ensure healthy lives and promote well-being for all at all ages;

Goal 4: Ensure inclusive and equitable quality education and promote life-long learning opportunities for all;

Goal 5: Achieve gender equality and empower all women and girls;

Goal 6: Ensure availability and sustainable management of water and sanitation for all;

Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all;

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;

Goal 10: Reduce inequality within and among countries;

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable;

Goal 12: Ensure sustainable consumption and production patterns;

Goal 13: Take urgent action to combat climate change and its impacts;

Goal 14: Conserve and sustainable use the oceans, seas and marine resources for sustainable development;

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainable manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels;

Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development.

There are 169 targets associated with the 17 SDGs. I would urge all delegates to have a thorough grasp of the SDGs and the associated targets, as any meaningful discussion on sustainable development should use the SDGs and the targets as the frame.

The SDGs are holistic and cross-disciplinary in scope, and multi-stakeholder in participation. They break new ground with additional goals on inequalities, economic growth, decent jobs, cities and human settlements, industrialization, energy, climate change, sustainable consumption and production, peace, justice and institutions. The SDGs boldly proclaim the end of global poverty by 2030.

The SDGs are the outcome of an inclusive consultation involving all UN member states, the entire UN system, experts, civil society, business and millions of people from all corners of the world since Rio+20 in 2012. By December 2014, the multi-stakeholder consultation process was completed with UN Secretary-General Ban Ki-Moon issuing his synthesis report on the post-2015 development agenda entitled "The Road to Dignity by 2030: Ending Poverty, Transforming All Lives and

Protecting the Planet". I would urge all delegates to study the synthesis report in order to understand the consultation process by which the SDGs are finally agreed upon. The synthesis report also contains many useful references.

The UN Sec-Gen synthesis report emphasizes the importance of technology in achieving the SDGs by 2030.

> In two decades since 1990, the world has halved extreme poverty, lifting 700 million out of extreme poverty. Between 2000 and 2010, an estimated 3.3 million deaths from malaria were averted, and 22 million lives were saved from fighting tuberculosis. Access to antiretroviral therapy has saved 6.6 million lives since 1995. — New technologies are unlocking possibilities for sustainable development. The solutions that they can generate, and the levels of access that they can enable, will be crucial to our vision for the world beyond 2015… Large amounts of public resources are allocated to military budgets, while comparatively less is spent on research and development for public good. Public funding often subsidizes private sector research, at times leading to the public being priced out of the benefits through disadvantageous licensing and patent. A transformational and universal post-2015 Agenda is called for, buttressed by science and evidence. (United Nations 2014).

7.3 UN Millennium Development Goals (MDGs) 2000–2015

As the SDGs draws on lessons learnt from its predecessors, the MDGs, it would be well to remind ourselves of the 8 MDGs. They are as follows:

Goal 1: Eradicate poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other diseases
Goal 7: Ensure environmental sustainability
Goal 8: Develop a global partnership for development

In my opinion, the MDGs are unambitious as their target is to reduce global poverty, hunger, chronic diseases etc. only by half. They are also silo-like ignoring important cross cutting issues in development like increasing youth employment, developing sustainable energy, and nurturing small and medium enterprises. Finally the MDGs are government-centric without engaging the private sector and NGOs as direct stakeholders. The reason was obvious as the MDGs were promoted by G7 in the 1990s. They mainly addressed soft development issues like education, health, gender, human right and the environment beloved of the developed world. The MDG targets were constrained by inadequate development assistance funding from the developed world with their caveat to developing countries not to expect more from the MDGs. The MDGs do not provide solutions for the urgent problem

of the developing world, namely poverty eradication through gainful wealth and employment creation. Many developing countries are still off track with respect to the MDGs at the end of 2015.

7.4 From the MDGs to the SDGs

In my view, the drastic transformation from the rather unambitious and silo-like MDGs to the holistic SDGs has been brought about by the dramatic social and economic uplift since the turn of this century by South countries through infrastructure construction, domestic manufacture, industrialization and trade and commerce.

The most striking examples have been China, the Asian Tigers of Korea, Taiwan, Hong Kong, Singapore and then, some ASEAN Countries like Malaysia and Thailand. In fact, the impressive statistics about the alleviation of poverty under the MDGs is mainly due to the achievement of China.

Most SDGs are really infrastructure SDGs. They can be included in SDG No 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation".

In SDG No. 9, infrastructure is linked to industrialization and innovation. Contrary to the widespread belief that innovation is the fruit of R&D in academia, SDG No. 9 affirms that innovations that create wealth and employment happen mostly in industry throughout the world. SDG No. 9 also acknowledges that infrastructure development is the foundation for economic and social development of any country, particularly a developing country.

Propelled by China which is building mega-infrastructure throughout the world at breakneck speed and committing some US $900.0 billion to such projects, I believe the alternate strategy of infrastructure based development will dominate the next fifteen years of the UN post 2015 development agenda. Indeed, infrastructure, industrialization, manufacture and South-South cooperation through institutions like the BRICS Development Bank, Asian Infrastructure Investment Bank and regional economic communities like ASEAN, EAEC, WAEC and MERCUSUR will be the principal engines for South countries and the world to achieve the SDGs.

7.5 Children and Sustainable Development: A Challenge to Education

Coming to the theme of this workshop "Children and Sustainable Development: A Challenge to Education", I would first like to highlight that there is no mention of "Children" in all 17 SDGs.

In the 169 targets associated with the 17 SDGs, "Children" is mentioned only 11 times in total:

SDG No. 1 (Poverty Goal)

By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.

SDG No. 2 (Hunger Goal)

By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round; By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

SDG No. 3 (Health Goal)

By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1000 live births and under-5 mortality to at least as low as 25 per 1000 live births.

SDG No. 4 (Education Goal)

By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and Goal-4 effective learning outcomes; By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education; By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations; Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, nonviolent, inclusive and effective learning environments for all.

SDG No. 5 (Gender Goal)

Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.

SDG No. 11 (Habitat Goal)

By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons;

SDG No. 16 (Justice Goal)

End abuse, exploitation, trafficking and all forms of violence against and torture of children.

As mentioned before, the UN 17 SDGs and the associated 169 targets are the consensus outcome of intensive global consultation involving some 7–8 million people. Yet specific mention of "Children" is found only in 11 of the 169 targets. It thus begs the question whether we should be advocating the importance of "Children" with respect to all the global issues associated with the SDGs in

particular and sustainable development in general. "A Challenge for Education" should really be directed to all policy makers and adults in this world!

As for "Science", it is even worse: only 3 targets out of 169 mention "Science":

SDG No. 9 (Infrastructure and Industry Goal)

Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

SDG No. 12 (Production and Consumption Goal)

Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.

SDG No. 17 (Partnership Goal)

Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.

As an advocate of evidence based education, I wish there is specific quotation in any of the SDG targets of the following statement in UN Secretary-General's synthesis report:

A transformational and universal post-2015 Agenda is called for, buttressed by science and evidence. (*op.cit.*)

This would have been the vindication at the highest global political arena of Inquiry Based Science Education (IBSE) that IBSE advocates throughout the world have been tirelessly promoting for three decades.

But all is not lost. I think the following SDG No. 4 (Education Goal) target sums up what we are trying to achieve here:

By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.

7.6 New Challenges of Inquiry Based Science Education for All

The SDGs 2016–2030 have the prime target of ending global poverty by 2030. As shown by the high income developing countries like China, India and those in Asia Pacific, the premise is that with economic uplift through employment and wealth creation, world peace and sustainability will be nearer to achievement by 2030.

Thus SDGs are all about achieving materialistic success in this world. I used to subscribe to this premise.

However I am profoundly perturbed on the one hand by the current phenomenon of well-educated and middle class youth from the developed world joining ISIL in Syria and Iraq as jihadists. What is even more unimaginable is the willingness to sacrifice their lives as suicide bombers! Developed world are in some fear that many will return home to perpetuate their brand of religious fundamentalism through terror in the West. Then there is also the most unnatural phenomenon of child soldiers as killing machines in Africa.

On the other hand, the developed world continues to develop high-tech weapons of destruction like the killer drone that not only assassinates its intended target but also murders innocent women and children in what the US calls "collateral damage". Even more alarming is warfare from space like the US "Star War" strategy. The West turns her back on democracy by funding street demonstrations or funding military forces to overturn democratically elected governments in South countries. It uses NATO to bypass the UN Security Council. Europe is reaping the refugee whirlwind of the Arab Spring, Afghanistan, Iraq, Syria and Libya!

The prime challenge in education of children in the developing world is not about educating them about the SDGs or sustainable development. Most of these countries in Asia and Africa were colonies of the West with national boundaries drawn in Europe across ethnic, tribal, language and religious divides. Civil wars still erupt frequently, many fuelled by external interests especially in neighbouring countries in defence of their ethnic brothers and sisters. To me, the prime challenge of education of children and (adults for that matter) is to inculcate national unity and national pride by fusing the diverse cultures into a harmonious whole. Without national harmony and social stability, there cannot be any economic development, let alone sustainable development. This is the reason why African and other Asian countries look to Malaysia as the model of development. Malaysia is a multi-ethnic and multi-religious nation that is achieving economic and social development through understanding and harmony.

It has been proved that IBSE Inquiry Based Science Education improves science literacy, numeral literacy and language literacy of students. As Professor Pierre Léna and Professor Yves Queré, the La main à la pâte (LAMAP) co-founders frequently remark,

> IBSE enables students to question and doubt every proposition of the so-called "prophet" unless his proposition is supported by experiment and borne out by evidence. In fact, IBSE trains good citizens.

In the face of "prophets" of excessive military expenditure, of religious fundamentalism leading to terrorism, of profligate consumption as the model of economic development, I still believe that the only effective defence is a discerning and rational global citizenry, nurtured by evidence based education the scientific way.

But I am now convinced that merely being rational, discerning and scientific is not sufficient to solve the terrible irrational ills of the world. IBSE must add moral and spiritual underpinning to the education of children.

In Asia, our developmental success has been underpinned by the virtues inherent in our civilization: "hard work, frugality, investment in education and care for extended family". In Malaysia as we are on the brink of becoming a high income developed nation, we are now grappling of a new education aspiration of putting "soul" into the education of students. I look forward to this Workshop to add relevant elements of spirituality to the above.

The education of children about sustainable development and related moral and ethical issues critically depends on their mentoring in school and at home. Most school teachers are women. The greatest influence at home is the mother. My current preoccupation with respect to the SDGs is actually SDG No. 5.

> Achieve gender equality and empower all women and girls.

The prime aspiration of the SDGs is to eradicate global poverty by 2030. The global poor are the women and children in the world. After centuries of discrimination, it is hard to imagine that gender equality can be achieved by the SDG deadline of 2030. I am proposing that gender equality be made the overarching agenda of all the SDGs. The gender equality action plans of all SDGs are to be monitored through big data collation and analysis so that the strengths and weaknesses will be expeditiously highlighted to facilitate the achievement of SDG No.5. Achievement of SDG No.5 will lead to achievement of all SDGs.

Reference

United Nations. (2014). *The road to dignity by 2030: Ending poverty, transforming all lives and protecting the planet*. UN Sec-Gen, December 2014.

Chapter 8
The Sustainable Planet: Towards an Education for Sustainability

Marcelo M. Suárez-Orozco and Carola Suárez-Orozco

Abstract Our planet is ever more interconnected, miniaturized, and fragile. With the increase in desertification, rising sea levels, erratic weather patterns and climate change, sustainable education becomes an exceedingly important priority the world over. Furthermore, in the age of the "globalization of indifference," as Pope Francis has taught us, the environment we share becomes a powerful point of entry for educating all children and youth to become engaged, ethical, and competent stewards of a finite and frail world. With the alarming rate of environmental degradation and climate change the right to a sustainable environment is urgently becoming the human rights imperative of our times. As the law of disproportionality makes clear, it is the poor, the weak, immigrants & refugees; and the outcastes that are most vulnerable to both cataclysmic man-made environmental disasters and the slow and steady deterioration of environment qualities (i.e., air quality, water quality, and the like).

8.1 The Sustainable Planet or How to Interrupt the "Globalization of Indifference"

Globalization defines our era. Broadly conceived, it is "what happens when the movement of people, goods, or ideas among countries and regions accelerates" (Coatsworth 2004, p. 38). Global, economic, demographic, and cultural exchanges

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Only by participating in the common intelligence and sharing in the common purpose as it works for the common good can individual human beings realize their true individualities and become truly free (John Dewey 1935).

M.M. Suárez-Orozco (✉) · C. Suárez-Orozco
Graduate School of Education and Information
Studies, University of California, Los Angeles, CA, USA
e-mail: mms-o@gseis.ucla.edu

C. Suárez-Orozco
e-mail: csorozco@ucla.edu

have complex and contested histories. The three "M's" of globalization give shape to its most current iterations: (1) *markets*, their integration and disintegration, and the post-nationalization of production, distribution and consumption of goods and services; (2) *media*, the information, communication and social media technologies that de-territorialize labor, put a premium on knowledge intensive work, and stimulate new longings and belongings; and (3) *migration*, the mass movement of people on a planetary scale.

While these dynamics are neither new nor exceptional, the rate and the depth of global change is novel. So is the impact on global warming, rising sea levels, desertification, climatic disequilibrium and environmental collapse in setting the stage for new massive flows of displaced migrants and refugees. Indeed these flows have intensified under the ascendancy of climate change, rachitic and collapsing states, war and terror, and growing inequality. Catastrophic migrations pose new risks to millions of migrants and challenge the institutions of sending, transiting, and receiving nations. Although immigration is normative (Abel and Sander 2014), it has taken a dystopic turn. Worldwide, civil and ethnic wars—often worsened by environmental denigration, structural violence, and growing inequality is the cause of the largest forced displacement of people since World War II. Of the approximately 65 million forcefully displaced, there are over 21 million refugees. Half of today's refugees are children. They are the living embodiment of, in Pope Francis' (Francis 2015) eternal words, *la cultura del descarte* (the throwaway culture).

Global flows and exchanges of facts and artifacts, of populations and cultures are challenging old boundaries and making the aspired-coherence of the nation-state increasingly elusive (Suárez-Orozco and Suárez-Orozco 2001, Suárez-Orozco et al. 2008, Suárez-Orozco 2015). Globalization represents the most significant challenge to school systems since the origins of mass public education. Nowhere is this challenge more obvious than in education for sustainability, a proper branch of civic education more broadly conceived (Banks et al. 2016).

Schools the world over are, or must become, strategic "sites of possibilities" (Fine and Jaffe-Walter 2007) in the mold of the Ross School endeavoring to bring to life humane, environmentally conscious, and relevant youth engagement for the twenty-first Century (Ross, this volume). But there are precious few Ross Schools in the world. More often that not, schools are struggling to find ways to model student engagement that are cognitively guided, ethically meaningful, culturally relevant, sustainable and credible. The challenge is deep and there is a long way to go. Enter into any public school and ask children to complete a simple task: fill in the sentence, "School is ———" In too many settings the world over the answer is "boring." Boredom is the first step in the nihilistic road toward permanent indifference.

In the global era schools the world over are pursuing multiple normative ideals: nourishing the eudemonic flowering of children, instilling twenty-first century skills and competencies; fostering cohesive social relations, and crafting the tools needed for all youth to engage as effective citizens and workers in their societies. Others are endeavoring to disrupt gaps in achievement, language loss, as well as disengagement and alienation in the youth. These disparate pursuits will require re-imagining

and re-engineering education—above all civic and sustainability education for an entirely new era.

In reflecting on the once and future promise of civic and sustainability education we would be wise to excavate the archeology of previous scholarly and scientific work. This PAS initiative coincides with the 100th anniversary of the publication of John Dewey's (Dewey 1916) Democracy and Education (and the 115th anniversary of the inauguration of Durkheim's Chair on Education Science at the Sorbonne) (see also Dewey 1972). Over a century ago Émile Durheim began lecturing as *Chargé d'un Cours de Science Sociale et de Pédagogie* would be teachers on moral values and collective consciousness in Bordeaux. By the time Durkheim was inducted into the Sorbonne's Chair he had found in education the articulation of what would become his enduring conceptual contribution to the social sciences: the sustainable nature of the relationships between the individual and society.

In the Anglo-Saxon tradition, ethics, civics and environment *qua* education were equally weighty. In John Dewey's masterpiece, education mediates between the individual and society—in his ideal of participatory democracy.[1] In a passage echoing Durkheim's general sentiments, Dewey writes, "Education is a regulation of the process of coming to share in the social consciousness;" and in his most famous line "I believe that education, therefore, is a process of living and not a preparation for future living." The process of living is an evolving bio-social developmental journey nested in complex ecologies and environments: the family, the society, the country, ecology and the world.

The context in which free and compulsory public education came to be a century ago—industrializing young nations undergoing rapid urbanization, bears little resemblance to today's world of post-industrial globalization, super-diversity, super-inequality, and environmental dystopia. Indeed as Banks (2016 argues globalization challenges traditional education ideas and ideals based on anachronistic and irrelevant demographic, socio-cultural, and, we can add, environmental assumptions. If fostering engagement and allegiance to the nation-state was the *raison d'être* for civic education 1.0, the 2.0 version requires a paradigm shift towards global consciousness and environmental participatory democracy in Dewey's sense.

Why schools? Zvi Berkerman (2016) cogently reminds us that classrooms are at root spaces where knowledge, meanings, values and identities—ethnic, racial, religious, cultural, civic and environmental are constructed and negotiated and where democratic mores, attitudes, and behaviors are first practiced and enacted. What is knowledge and how it is constructed and weighed is a complex flow of logic, reason, ethics, and data but also power and legitimacy connecting teacher and student epistemologies to classroom interactions and identities. Civic and environmental sensibilities among youth are inextricably inter-linked with developmental factors (age/maturation), religious, spiritual, ethnic, and culturally coded identities.

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[1]"Only by participating in the common intelligence and sharing in the common purpose as it works for the common good can individual human beings realize their true individualities and become truly free" (Dewey 1935).

The negotiation of civic, religious, environmental and cultural epistemologies play out in complex and difficult ways in schools and in classrooms. In educational contexts where cultural, religious, and secular paradigms compete for hegemony, educators must uncover how youths' religious, cultural, and environmental epistemologies are presented and represented in classroom facts and artifacts.

In a normative ideal, teachers must endeavor to foster knowledge and skills necessary for employment in a sustainable global economy; incorporate multiple relevant cultures, languages and environmental epistemologies in the classroom; promote equity pedagogy, and culturally relevant and responsive teaching that is at once engaging and relevant to the students' local environments and realities. To achieve transformative environmental education and to effectively engage within and across the super-diverse communities of the 21st century, students need to acquire democratic, environmental and civic attitudes, sensibilities and identities.

A 21st century environmental education must first be relevant to local concerns while embedded on a larger global ethic of solidarity, equity and care. Second, it must be developmentally appropriate: how a 5 year thinks about air pollution and how a 10 year old thinks about global warming will differ, *inter alia,* by socio-emotional and cognitive readiness to metabolize ideas, facts and artifacts. Third, over the last century the ethnographic record has made clear that cultural memes, sensibilities, and general orientations towards the environment differ substantially across the world. The eminent Harvard anthropologist Clyde Kluckholm argued that the Man-Nature relationship includes divergent ideal types, such as the view that humans should be subordinate to nature, the view that humans should be dominant over nature, and the view that humans should live in harmony with nature (Kluckhohn 1951). The value orientations of a Navaho child, a Norwegian child, and a Nepali child *qua* the environment are incommensurable and curricular and pedagogical interventions should be wise to understand and respect such differences. The future promise of environmental and civic education must be, *inter alia,* do the work of fostering culturally and developmentally appropriate knowledge, values, sensibilities, and practices required to participate effectively within multiple (regional, national, and transnational) environments and communities while understanding and respecting cultural differences. An authentic, organic, and sustainable allegiance to the environment is preordained in the structural inclusion and valuing of all children as agents of environmental stewardship.

White and Meyers (2016) argue that emerging models of education aiming to privilege 21st century skills inevitably come to prioritize critical thinking and problem solving, meta-cognitive skills, communication and socio-emotional skills, as well as intrapersonal skills such as auto-regulation, responsibility, and time/self-management skills. Concurrently, White and Myers suggest that *qua* civic education liberal democracies are striving to develop more inclusive models often animated by the spirit of cosmopolitanism, multiculturalism, and universal human and environmental rights. These are lofty yet elusive ideals. Contested histories, group identities, and alternative epistemologies are often downplayed in an attempt to build social cohesion, nourish solidarity, and minimize group differences. Massive inequalities in wealth and in learning opportunities are translated into

education and schooling with frightening ease. In the United States the zip code a child lives in and her parental tax bracket are exceedingly good predictors of the school she will attend and the learning and non-learning she will experience. Inequality is the irremediably disease behind disparities in human flourishing.

Environmental education is grappling to expand beyond traditional knowledge to prepare students with the skills necessary to participate in the ever more globally connected economy and society of today. But the efforts to build the architectures for more inclusive models inspired by the logic of cosmopolitanism, multiculturalism, environmentalism and universal human rights generate anxiety and push back. Clearly the education *status quo* is not working: in the United States the rejection of the scientific method and denial of climate change are reaching epidemic proportions. For too many, the science is irrelevant, facts are illusions, and global climate change is an hoax. A survey by the Pew Research Center in Washington DC, conducted with the American Association for the Advancement of Science (AAAS), sought to examine the opinions of a cross-section of the U.S. population on various science related matters. It found that "only half of the (U.S.) population agreed with the Intergovernmental Panel on Climate Change view that climate change was mostly driven by human activity, such as the burning of fossil fuels. Nearly half said there was either no good evidence for global warming, or that the recent warming of the Earth was due to natural climate variability" (Pew Research Center 2015). But Exhibit A to make the case of the general failure the *status quo* in civic and sustainability education comes in the perverse form of the Republican candidate for President of the United States, Donald Trump. Mr. Trump has based the entirety of his campaign on an anti-establishment, anti-science, and anti-rationality sensibility in a yearlong campaign of magical thinking in the political life of a major advanced post-industrial democracy.

These and other alarming developments suggest that a new civic and environmental literacy initiative aimed at valuing and nourishing environmental consciousness by means of the scientific method, logic, ethics, and the place of data in argumentation is very much a worthy and urgent challenge. In an ever more interconnected global world, environmental education models that successfully balance multicultural sensibilities and 21st century skills—including intercultural communication and higher-order cognitive and meta-cognitive skills, will lead to positive outcomes. The next generation will need to exhibit strong habits of environmental engagement, civic *savoir-faire,* and responsible civic and political agency *qua* the pressing issues of the day.

8.2 The Sustainable Planet as a Unifying Purpose-Giving Narrative

In his 1996 book, The End of Education, Neil Postman argued that schooling had veered off course by largely focusing on initiating children into the economy as workers and consumers. Instead, echoing Durkheim and Dewey, he suggested that

the purpose of education should be to socialize children by creating a common culture among citizens through the communication of "unifying purpose-giving narratives." Nearly two decades ago, he suggested five possible narratives. At the top of that list was "Spaceship Earth"—a worldview expressing concern over the use of limited resources available on our planet, encouraging all on it to act harmoniously working toward the greater good.

The term "spaceship earth" emerged in 1965 when Adlai Stephenson spoke of it this topic of concern at the UN. Though the term may be a bit dated, the concept is portentous. We suggest that we might readily substitute a unifying narrative of a Sustainable Planet.

As an educational narrative, the Sustainable Planet has many advantages. It builds and expands on children's innate moral sensibilities and curiosities. The Sustainable Planet can provide a sense of connection to peers in one's school but as we witnessed with the children participating in the Holy See Workshop also with children from around the world. At the Workshop, we witnessed first hand how education for sustainable development serves to expand the sense of "me" into the "us" and the "in-group" into the "we-group." It has the potential to be a way for children and adolescent to enlarge their "moral circle" (Peter Singer, this volume).

Second, it provides a compelling moral imperative that can set children on a search for solutions to interrupt the decay of their environment. At the Workshop we also witnessed the moral imperative spurring youth to agency. By posing a series of questions and using the method of inquiry as the pedagogical strategy the Sustainable Planet capitalizes on children's natural curiosity, and helps them develop and refine critical thinking skills. Of course, we are not starting from ground zero. There are excellent models like La Main à la Pate and the Ross School curriculum that can serve as exemplar models to be locally iterated.

Environmental disruptions, climate and global change are destabilizing processes generating disequilibrium, *malaise* and alarm. Global disruptions interrupt the taken-for-granted cultural schemas and social practices that structure belonging to, and membership in the nation state. The institutions of state-making in the modernist era, above all schools in their civic function, have been geared toward producing loyal citizens, workers, and consumers of a nation-state rather than individuals with multiple identities, languages, and global sensibilities. Re-imagining the narrative of belonging and re-calibrating the institutions of the nation-state, and bringing the environment into its rightful place in schools and elsewhere, are a *sine-qua-non* to move beyond the current global environmental and social dystopia.

Indeed we are at a crossroad. Should schools respond to the new global realities of the 21st century by building efforts to nourish in all students a broader consciousness, multiple languages, identities, and belonging as world citizens? Or, should the response be to redouble functionalist efforts to prepare youth for the new, more fiercely competitive workplace of today? How can classrooms and teachers change to better promote relevant and authentic civic engagement and an environmental sensibility predicated on equity, sustainability and access to all?

How we answer these questions will in no small measure determine the collective fate of the planet.

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Part II
How Could Education Evolve
in a Diversity of Contexts?

Chapter 9
Education for Sustainable Development

Margaret S. Archer

Abstract This contribution analyses the Sustainable Development Goals (United Nations Transforming Our World. The 2030 Agenda for Sustainable Development 2015) and their relation to education. In a first part, the conception of education, underlying the UN vision, is criticized, since education must be considered as a structured social institution, where the structure greatly influences the whole education process. The second part analyses the positive role of numerous institutions, not directly aiming at education, but rather at culture, and being part of the digital revolution. This analysis leads me to propose an education for sustainable development which takes advantage of the world's digitalization. Balancing the over-centralized existing systems, the relevance to the needs, the participative character and the adaptability of these tools offer new perspectives for the future.

9.1 Introduction

> We are setting out together on the path towards sustainable development, devoting ourselves collectively to the pursuit of global development and of "win–win" cooperation which can bring huge gains to all countries and all parts of the world.
> (United Nations Summit 2015) Transforming Our World. The 2030 Agenda for Sustainable Development.

These words describe the overall aim of the new Sustainable Development Goals (SDGs), adopted by the United Nations at the end of August 2015. The title of our Workshop referred specifically to 'The Challenges to Education'. I assume that the two are directly related and devote this paper to discussing their relationship.

Although I am a strong supporter of SDGs this will not be manifest in Part I, where the UN expressly addresses education. When it does so, I find (as a Social Theorist whose thought is grounded in Critical Realist philosophy) that the UN presumes 'education' to be something requiring no definition, no acknowledgement that it is a

M.S. Archer (✉)
Pontifical Academy of Social Sciences and Professor of Sociology, Center for Social Ontology, Department of Sociology, University of Warwick, Coventry, UK
e-mail: margaret.archer@warwick.ac.uk

structured social institution, or that its structuring makes huge differences to its intake, processes and outputs. Instead, it is treated as a homogeneous concept, an everyday taken-for-granted notion that everyone uses in the same way. Neither historically nor comparatively has this ever been the case; nor is it so globally today. In fact, the only homogeneity about Educational Systems and their practices in the 21st century derives from those of the developed West having been transferred to 'the rest'. I will try to illustrate that this is exactly what those controlling educational institutions in the developed world have vested interests in happening. However, if this is so, it will run counter to the UN's aspirations for greater 'inclusion' (promoting social integration) and for learning having a positive relationship to 'sustainable development' in developing regions (regional system integration). Far from promoting 'win–win co-operation', imitating developed countries would merely reproduce the 'win–lose' formula, in millennial dress, between the developed and the developing world.

Conversely, Part II will arrive at very different conclusions if we examine other SDGs—ones that are not targeted directly at 'education'—but concern communication, digitalization, and the uses that can be made of the Internet. All of these referents (and the practices associated with them) relate to *culture*. Intrinsically, culture is not, in kind, a scarce social resource. It can only be made so by the imposition of artificial controls (such as intellectual property rights, patents and restricted access). These tactics are, indeed, in full play today, but just as burning books could not destroy ideas in the past, so the digital cloud is proofed against any equivalent of Fahrenheit 451 today. My argument will be twofold: that 'win–win collaboration' can be achieved on a digital basis and that sustainable development can be promoted in different regions and areas if education becomes more computer based. That is, if everyday stereotypes of educational activities cease to be conventional ones involving purpose-built schools and universities (separating instruction for home and community), a uniformly certificated body of teachers (whose professional activities are largely confined to these buildings), set textbooks (limited because of their expense) and a standardized curriculum (that is not uniformly relevant to all areas and their main geographical characteristics, associated types of employment or to their vernacular languages/dialects, or to many enduring ethnic and religious differences). I will seek to uphold my twofold argument, despite the fact that Google, as the world's dominant browser, is known to exercise politico-economic controls selectively in various parts of the world. In Part III a realistic, but nonetheless digital alternative is sketched out.

9.2 PART I: Why the SDGs Specifically Concerning 'Education' Are Too Conventional

Let us start by briefly inspecting these, which are all found in the UN Finalized text for adoption (SDG 2015):

Goal 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

The key priorities are summarized in the concepts of 'inclusivity' and 'equitability', goals that all sociologists of education are only too aware have never been achieved in a single developed country.[1] However, Sub-clause 4.1. aspires to attain these goals within fifteen years:

> 4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes. (ibid.)

4.3 adds the same objectives for quality technical, vocational and tertiary education, including university.

Attention is worth drawing to two other Sub-Clauses, especially if they are juxtaposed with the above. First, the connection between education (possessing the above characteristics) with sustainable development is accentuated:-

> 4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development. (ibid.)

Second, is the admission that as far as higher education for sustainable development is concerned, this will be supplied through scholarships for those in developing countries to attend institutions in developed countries, with allowance for some lateral transfers among developing areas:

> 4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries. (ibid.)

Global partnership sounds thoroughly desirable, but as far as education is concerned, let us be acutely aware that partnering with the educational systems of developed countries would be to collaborate with those that have *failed* not only in terms of cracking the problem of social 'inclusion' and 'equity', but have also been *failures* at promoting sustainable development. Undeniably, some of their research contributions have sought to foster the latter, but these efforts have been completely dwarfed by their promotion of unsustainable development: their assistance to the automotive industry, to aerospace development, to 'big pharma', to morally dubious forms of bio-medical research, marketing technology, data-mining and so forth. In each and every one of the above examples this is attributable to the 'partnerships' that university research in the developed world relies upon with multi-national companies for research funding.

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[1]The history of the Sociology of Education could be written as a quest to explain the sources of exclusion and inequity; what accounts for the persistent socio-economic differences in educational opportunity (access) and educational outcome (achievement)? Hundreds of thousands of books and articles have been devoted to these issues, without making decisive progress.

Historically, this was not the case. Indeed there were certain decentralized educational systems (such as those of England and Denmark) where radical workers or popular rural groups could open their own schools, where teachers could introduce innovations directly into their classrooms and where diverse groups from new industry, dissenting churches, or philanthropists with their own pedagogical visions could transact changes with local schools or colleges, or if not, to set up their own.

Throughout the nineteenth century this allowed for a diversity of views, values and local concerns to find educational expression and services.[2] However, from the 1980s, a move towards the centralized control of all educational systems in the developed world that, regardless of their original structures, began to succumb to the centralization of educational control.[3]

The structure of educational systems has been systematically neglected in the social sciences as a potent cause of who gets into their component institutions, what goes on within them and the nature of their outputs. Nevertheless, centralized systems are the form of education that developing countries are being encouraged foster in order to enter into Global Partnership. In order to answer, 'What's wrong with that?', it is necessary to examine the causal consequences of the structural centralization of education for sustainable development. In the developing world, already suffering from climate change, the capacity for science education to relate to (variable) local conditions in a country, quite apart from appreciating 'cultural diversity and of culture's contribution to sustainable development'(4.7), is crucial. This is because local responsiveness to and representation of cultural diversity, have always been the weakness of centralized educational systems.

It is not difficult to see why this is so if we examine the constraining effect of centralization on demands for change coming from different quarters.

Demands for educational change from civil society were strongly constrained to work through one process of interaction alone if they were to stand any chance of success, namely, 'political manipulation'. This is illustrated in Fig. 9.1. To obtain any further concession entailed *aggregating such demands* with entirely different groups in order to put effective pressure on central government. Yet, the *aggregation of demands spelt their dilution*, if various interest groups were to work together. In turn, dilution meant that, even when 'successful', the changes gained were always insufficiently specific to satisfy the original demands of any group.

There was no alternative to passing demands upwards to the political centre and, if at all successful, reforms were then passed downwards as policy directed changes. The teaching profession itself (usually denied to right to become a professional association for as long as possible) was equally powerless to respond directly to any wishes they countenanced from local civil society because teachers were unable to engage in the 'internal initiation' of pedagogical change, in line with their

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[2]I have traced these developments for England, France, Denmark and Russia in an 800 page book (Archer 2013), but have not space to enter into their history here.

[3]This move is documented in my chapter (Archer 2008).
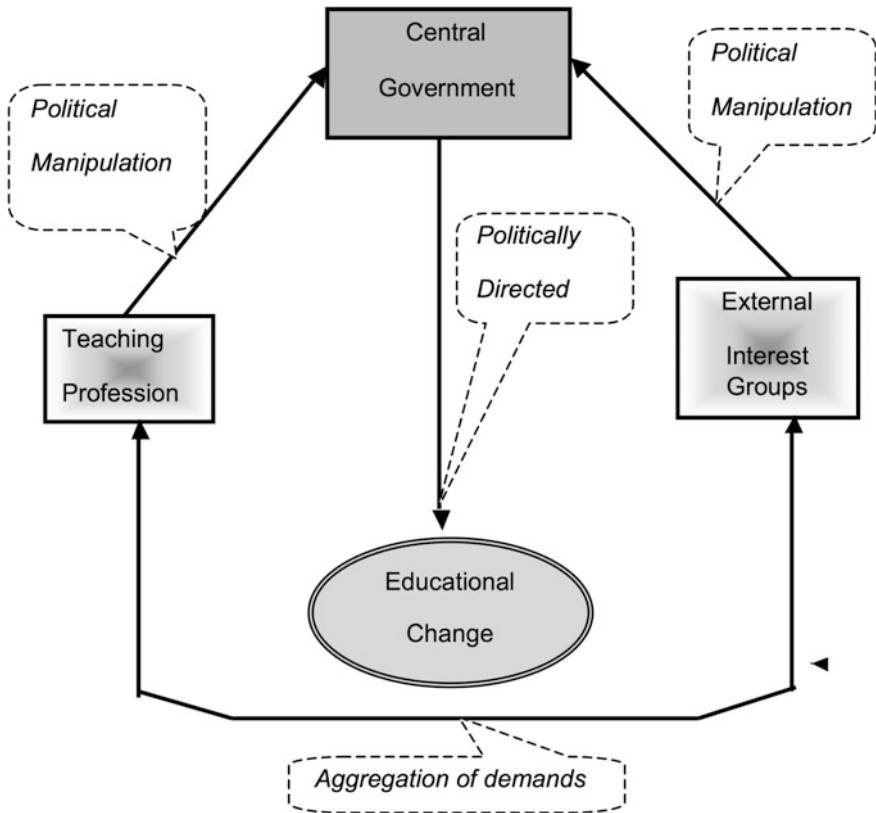
Fig. 9.1 Educational interaction in the centralised system

professional values or sympathies with local community interests. Similarly, interest groups could not engage in direct 'external transactions' with any part of the State Educational System. Instead, they had to go outside education and find allies with whom to exert joint pressure on the political centre. The alternative resort of the re-buffed, namely to use and to extend the private sector, was generally of little use to them because it lacked the independence to offer anything significantly different from provisions defined by the State.

In short, the centralized State Educational System typically had vitriolic critics and, at most, tepid supporters from within civil society. This is why it was prone to periodic outbursts of direct action, usually followed by panic legislation and then by administrative clawing-back of the new concessions obtained (Archer 1996).[4] In short, the 'concessionary' centralised model of education continuously frustrated and frustrates large sections of civil society. It contrasts greatly with decentralized systems where

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[4]I have analysed the 'May events' of 1968 in these terms (Archer 1972).

three processes of change were usually at work simultaneously: 'Political Manipulation' was supplemented by changes introduced directly by the teachers through 'Internal Initiation', whilst external interest groups could also negotiate change through 'External Transactions' by financing new courses or institutions (see Fig. 9.2). These processes, working at the same time though not in concert, served to prevent the accumulation of grievances and the aggregation of demands.

In the twentieth century, as modernity moved towards its climacteric, no State Educational System was suited to meeting *simultaneously* the new requirements of central government and of the modernising economy. The attempt to satisfy both is the main story-line of educational changes in the twentieth century, namely how to give *simultaneous satisfaction to the State and to the Market* as the new imperative for education in the rapidly developing West.

This was because, on the one hand, nearly every State in the developed world had moved (or was swiftly moving) towards some version of representative democracy based upon universal suffrage. They were consequently under increasing pressure, usually from their equally new Parties of the Left, to rectify the abysmally low state of *social integration*—signalled by fears of class warfare—and to extend political concern beyond the maintenance of 'social order'. Thus, democratic governments experienced relentless pressures to reduce the great divide between social classes—viewed as dangerous or iniquitous, depending upon ideological standpoint—by some equalisation of life-chances through enhancing the equality of educational opportunity.

Just as importantly, on the other hand, industrial competition was intensifying and highlighted by the innovative applications of science to production, stimulated by the two World Wars, and by the adoption of Fordist production techniques in the United States as the key to industrial advance—or post-war re-construction in Europe. Together these enhanced the economic role assigned to education in
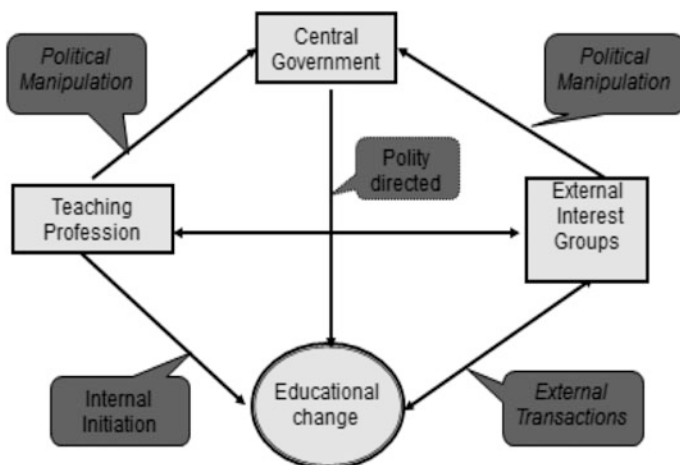
Fig. 9.2 Educational interaction in decentralized systems

twentieth century inter-national economic competition. In turn, playing this role required more science education and more resources for scientific research. In turn, this entailed much more *system integration* between component parts and levels of national education for adequate pupil preparation and progression.

Thus, at the most macroscopic level, the central problem for educational systems in the developed countries of the 20th century was how to align these two very specific pressures for change—greater social inclusion and better services to industry—within the structures of education inherited from the nineteenth century; ones imperfect for either purpose and undoubtedly even more unsuited to realising the two simultaneously.

In the post-war period, the increased *social integration* and *system integration* sought from education by very different interests in society were in perpetual tension. In general, this was contained by the *lib/lab* 'formula'. Donati[5] has analysed the manifestations of this opposition between them as the oscillation between *lib/lab* policies. Politically directed 'lib' changes favoured Market competition whilst 'lab' egalitarianism favoured the stability of society. The final fling of this approach, in which 'half a loaf of bread' was handed out alternately in 'lib' or 'lab' interests, as the two alternated in office, revealed the generic antinomy between them. This was glaring precisely when attempts were made in the last quarter of the century to run *lib* + *lab* in tandem, through the moderation of both Right and Left parties into centrist coalitions or centrism more generally (such as Tony Blair's 'New Labour').

In Britain, within what had historically been a decentralised system, the arrogation of new educational powers to the State was shocking in its speed, thoroughness and systematic nature. The number of Educational Acts (previously rare) increased to almost one per year under the Tories (1988–1996) and the Secretary of State for Education gained over a thousand new powers in the same period. This entirely novel accumulation of educational power at the centre followed a clear agenda. 'While individual freedom, market choice and power for consumers rather than 'producers' of education were extolled, the central state took tighter control of finance, curriculum and examinations, teachers' practice and training. Part of what became a continuing agenda was to remove power from institutions and groups, which were bases for dissent, criticism or independent advice.[6]

In parallel, the expression of French centrism was to allow more specialization and controlled *differentiation* within the centrally controlled system, without fundamentally damaging its centralized structure. The response to the same simultaneous demands for more egalitarianism and instruction more relevant to the economy was tackled by the progressive segregation of different cycles within existing levels. A short and a long secondary schooling, each with its own diploma; a division of the *baccalauréat* into numerous sub-sections, related to different occupational outlets and higher educational inlets; at the higher level, the differentiation of *Instituts Universitaires de Technologie* again replicated the segregation

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[5]Donati and Colozzi (2006), p. 38. See also pp. 110–113.
[6]Tomlinson (2001, p. 35).

of short and long alternatives. The long alternative remained University education 'proper', but was now itself divided into three cycles, each with specialist options and a specific diploma at the end of it. In brief, the meeting of 'lib' and 'lab' demands was orchestrated by the State, thus augmenting its power *vis à vis* civil society, whilst it purported to be serving all sections of society. Centralization was here to stay; educational provisions became more complex in their differentiation and specialization, but always remained orchestrated from the political centre.

Allow me to present a brief and bald summary of why this shift towards centralized educational systems in the developed world is not one it would be advantageous for developing countries to follow, particularly given the new priority that educational growth and elaboration should contribute directly to sustainable development.

- Centralized systems are *unresponsive* to differences in regional conditions and requirements (because of the absence of direct External Transactions). The more geographically varied a country is; the less well national education serves it as a whole.
- They are too *uniform and standardized* because their national curriculum and pedagogy mean that teachers cannot initiate or adapt practices directly through Internal Initiation. The more urgent the crisis faced, the slower and less innovative the educational response.
- Changes are typically *compromise* measures, thus failing fully to satisfy any of the groups who had made alliances prompting them (the effect of Political Manipulation being the dominant process of change).
- Change comes from the *top-down* and not from the *bottom-up*, meaning that even (rare) measures to foster 'inclusiveness' are rarely of the kinds sought by the lowest socio-economic groups or minority sections of the population.

As globalization intensified from one side of the millennium to the other, the shift towards the centralization of all educational systems in the developed world was significantly increased by the 'partnership' emerging between them—one furnishing important warning signals to the developing countries. If the Common Market indicated that European entrepreneurs (administrators, bankers and professionals) had to function proficiently outside national borders, internal investment from overseas (starting with Japan but soon including other Asian 'Tigers'), extended this lesson, and if research costs soared then premiums were associated with inter-European and Euro-American collaboration, but soon became worldwide. One consequence was that 'partnerships', in the first instance, encouraged interchanges between countries of students, professors, research teams and conjoint research funding. In turn, the educational systems in the developed world grew yet more structurally similar to one another (through, for example, the 'Bologna Process', standardizing the length of first degrees and facilitating programmes such as 'Erasmus', enabling a year of undergraduate studies to be taken in another country).

Once developed national systems had become compatible in such ways, they also became comparable, and if they could be compared, systems then became competitive. This began with the Universities and was fast transformed into a global

competition (in fact, into several). Now, all academics and watchful (rich) parents are supposed to be riveted by 'World Listings' and the place of particular institutions of higher education within it. These are now plural and based on slightly different criteria, so obviously their recruitment publicity highlights the one on which they were placed highest. *Caveat emptor*—because these blatantly empiricist indicators, using fuzzy terms such as 'student satisfaction', are unrevealing to, say, the parents of a shy daughter belonging to a minority ethnic group. So hot has the competition become, that 'Consolation prizes' are proffered for special categories. For example, my recent employer the Swiss École Polytechnique Fédérale de Lausanne, exulted in coming first in a 2015 listing for the best Universities founded in recent years (although even its dating is debatable).

The key point is that these competetive antics have both lateral and downward causal effects. Laterally, to be highly rated, is also cash-driven because the entrepreneurial companies as well as financial services and even private Foundations will be magnetised towards the most successful institutions—and 'success' breeds success when we are dealing with multi-billion research awards in any national currency. Downward causation operates simultaneously and the effect upon secondary schooling has been to make the International Baccalauréat increasingly popular, especially amongst those mobile corporate executive families who are uncertain about the location of their next three-year placement. The ties (or should one write bonds) between academia and multi-national enterprises (including financial services) are strengthening. Does this mean that Primary schooling escapes untouched? Far from it, because the main task of the most desirable Primary school is to prepare the maximum number of its pupils for entry to the most desirable Secondary schools.

The reason why I have been stressing this point is not only because such competition encourages further standardization, but even more importantly because these manoeuvres testify to the formation of a global elite; the beneficiaries of current globalized capitalism and the heirs to its future, thanks to current parental educational investments. Now, let us return to SDG 4b and its promotion of indigenous scholarships to enable pupils from developing countries to become students in developed ones. On the best case scenario, this enables more numerous bright and wealthy prospective students to join the ranks of the rich kids in developed countries and head for the kind of university certification from overseas that would enable them, too, to join the global elite. But, does the 'best case' eventuate; does it illustrate a useful Global Partnership, one with a 'win–win' outcome? It is worth a brief examination of international student recruitment and its flows, in order to bring the evidence available to bear on these questions.

With the arrival of the BRICS, the large fast growing economies of Brazil, Russia, India, China and South Africa (all G20 members), the outward flow of their future undergraduates to the USA prompted a headline in the *Wall Street Journal* 'International Students Stream into U.S. Colleges' (Wall Street Journal 2015). This recent and dramatic rise was attributed to two factors: first, by the rise of an affluent class within the BRICS together with the generous scholarships offered by oil-rich Gulf states such as Saudi Arabia; second, by '[c]ash strapped public universities …

aggressively recruiting students from abroad, especially undergraduates who pay a premium'. According to the Department of Homeland Security, the 1.13 million foreign students, mainly enrolled on college-degree programs, represented a 14 % increase over 2014, almost a 50 % growth compared with 2010 and 85 % more than in 2005 (Department of Homeland Security 2015). Coming predominantly from Asia, state university administrators maintained that these higher-paying students served to subsidize in-state students, whilst opposite concerns were voiced that U.S. students were being displaced.[7]

As big businesses themselves, organizations facilitating overseas enrolment, such as NAFSA (National Association of International Educators), emphasize the economic benefits derived by the U.S.: 'The 886,052 international students and their families at universities and colleges across the country supported 340,000 jobs and contributed $26.8 billion to the U.S. economy during the 2013-14 academic year. This is a 8.5 % increase in job support and creation, and a nearly 12 % increase in dollars contributed to the economy from the previous academic year'— according to their 'International Student Economic Value Tool' (NAFSA 2015).

This is also big business throughout universities in the developed world. Almost without exception, each institution has its website inducing overseas enrolment and, significantly, it is the most prestigious universities in the developed countries that lead in marketing themselves: Harvard hosts a site that disingenuously accentuates how cheap undergraduate study *can* be, whilst Oxford claims that it is quite simply 'one of the most international universities in the world. Today, one third of its students, including 17 % of undergraduates, are international students … we welcomed our first international student, Emo of Friesland, in 1190.' (University of Oxford 2015). Obviously, harness all your 'strengths' in marketizing education!

Conversely, compare the above with the counterflow. Whilst most incoming students follow a full-degree, the 1 % of US undergraduates studying abroad do so for one or two terms/semesters, the numbers remain flat and their favourite destinations are still European, despite China having become the fifth preference (IIE 2014). The largest increase was registered among students majoring in the STEM fields (Science, Technology, Engineering and Maths). Overall, three-quarters of those taking up this opportunity were Caucasian.

The emphasis in selling such (short) programs is placed on the cultural dividend reaped—or more crudely, the romance of the cultural heritage overseas. However, a study conducted from 2006–2010 showed that—during a period when only 49 % of the average population of college graduates found a job within 1 year of graduation —98 % of students with study abroad experience had found employment within the same year. Students with study abroad experience reported starting salaries 25 % higher than the general student population'.

There are various ancillary phenomena, such as durable research links between countries or campuses founded overseas, an increasingly popular formula, but the

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[7]Headlines in the Wall Street Journal at the end of 2015 read: 'International student cohort in the US sees biggest growth in 35 years'.

message is identical. Indeed, the preferred partners are ones in other developed counties, for example, the University of Warwick explored setting up a campus in Singapore more than a decade ago—not exactly underdeveloped territory—but backed out probably due to the resistance of British staff. Instead, it is currently exploring California for its new build and already has a Warwick-Monash partnership. The website outlining this strategy is straightforward about repute and remuneration as well as blatantly competitive. Objective 1 is to obtain 'Global scale', including to 'Increase research income by ensuring that we combine investment-ready proposals with an ability to mobilise and exploit emerging funding schemes e.g. *Horizon 2020*'. In other words, the objective is to play the bigger developed world off against Europe, whilst milking its resources. The overall aim is to 'Secure our global position: Optimise the scale, scope and reach of all our activities'. How will they monitor their success? By the rankings of all disciplines in national peer exercises (aiming for all to be ranked in the top ten); by achieving the target institutional operating surplus of 7 %, and by increasing their market share of UK research income. This is corporate finance-speak, entirely unrelated to the Global Partnerships envisaged in the SDGs between developed and developing countries. On the contrary, it is about attaining elite status in the most developed parts of the world. As Warwick puts it, 'it's satisfying to be so good at punching above our weight'[8] —a view shared by other aspirant university contenders.

In case private universities in developing countries retain the aura of the religious concerns that largely prompted their early foundation, perhaps joined latterly by the humanitarian priorities of some NGOs, the list repays scrutiny because the fact that most are non-profit organizations does not mean that most are playing a different and indigenous game. For example, as a relatively stable country, Ghana has witnessed a flood of post-millennial private educational foundations. However, significantly these focus upon similar academic disciplines, 'like Business Administration, Human Resources, Accounting, Information Technology, etc. … The recent discovery of Oil and Gas in commercial quantities has basically influenced the development of Oil and Gas Management courses within the private universities' curriculum' (Private University 2016). Whilst Biblical and Quranic institutions continue, what the 'flood' points to is a country with a good pace of growth doing its best to keep up with the developed world. Other countries with an even better pace have formed joint-partnership private universities with Western universities, such as China's three millennial foundations (two with British universities: Nottingham and Liverpool). It seems important that all instruction is in English because this constitutes a selective requirement privileging students from wealthier families and preparing them to join the national entrepreneurial elite.

To what do these considerations about international student flows, foreign campuses and private universities add up to meaning in the context of the UN's SDGs and their challenges to education? Not, it would seem a 'win–win' formula.

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[8]All quotations in this paragraph come from the University of Warwick's Official Website (University of Warwick 2015).

As far as the students are concerned, since most from developing countries do return home with their degrees, what is being consolidated is a global educated elite: rich kids from poorer countries, now equipped linguistically and through their studies, to take their place in the indigenous or multi-national enterprises of global capitalism where they will doubtless—as a group—be dealing with the likes of their fellow US and GB students! Meanwhile, their presence and payments in the developed world as students had served to subsidize their new found global status.

Nor at the institutional level are the global campuses briefly examined any kind of testimony to Global Partnership in UN terms. In an extraordinarily competitive field, such partnerships are intensely market orientated and consist in manoeuvres that advance or at least confirm the status of universities in the grand world pecking order, as judged universally in commodified cash earnings—and thus promoting further standardization. There were no indications of prestigious, well-endowed universities taking a poorer 'partner' from the developing world 'under its wing' (perhaps as a legacy of post-colonialism) because that would damage their place in market competition. Neither did the foundation of private universities appear to compensate; they were the best that developing counties could do or transact to help themselves.

In all of this, 'sustainable development' has not featured, unless one adopts the cynical view that its referent is to sustaining the position that past history and geography had enabled a given country's higher education to assume at the end of the twentieth century. The sea has certainly risen in educational terms, but it has not lifted all boats—at least towards greater parity. Indeed, this rising sea poses the question as to whether the efforts of developing countries to stay more or less where they were in the rankings of university education have not widened the gap between them and their primary if not secondary schools.

9.3   PART II: There Is an Alternative

The account presented in Part I examined a top-down approach in which governments looked to the topmost level of educational institutions, their Universities, to secure if not advance their country's place in the world economy. Two interlinked consequences were noted for schooling in relation to higher education. First, that downwards causation constrained the definition of instruction in secondary schools to prepare for university entrance, despite the percentage of those entrants being small in developing counties. Second, few robust attempts were encountered that promoted a diversification of schooling in order that parts of it were directly adapted to local conditions; where applied science and technology are closely linked to local sustainability, through the deliberate blurring of boundaries between training and academic preparation. This would be instruction that looked 'outwards' rather than 'upwards' and gained its own status through its indigenous 'use value' instead of its 'exchange value' on the international educational market.

The following discussion is therefore addressed (for consideration) to groups such as the Association of Popular Movements. Its point is to stress that there are

forms of instruction lying between learning-on-the-job (how to operate the machinery of a co-operatively run factory, taken over when it failed as a market enterprise) and those supplying academic credentials, of value mainly for moving up the educational ladder. The suggestion is that such movements themselves would be the engines promoting decentralized diversification in schooling and training related to the immediate needs of local sustainable development. Institutionalisation would come later when groups in a city established certain shared needs for particular skills and techniques and after they had discarded some of their earlier trial-and-error experimental practices.

This entails a bottom-up approach, which is innovative, rather than a top-down reliance on irrelevant trickle down effects that are imitative of the developed world, but only entrap developing countries in the educational standardization of the former as intensified by their market-oriented competition.

Based upon his conviction that a 'poor Church' should give priority to the poorest of the poor first, Pope Francis's response to social reform regularly takes the bottom-up form. This is a challenge to social scientists; when he asks how, for example, *los cartoneros* (the scavengers) can be socially integrated, we are at rather a loss in the absence of a familiar policy framework through which this can be approached, and we are not renowned for our practical, adaptive innovation.

In this context, what I want to explore is starting from a different place from the routine examination of the educational structure and practice in developed countries, on the assumption that these contributed significantly to their success in the global market and, thus, repay imitation. As far as sustainable development is concerned, it would seem to me that the opposite lesson should be drawn, but what is 'the opposite'? Sociologically, it would entail starting from *culture* rather than *structure.* By culture I specifically do not mean folk ways or folk wisdom, nor shared values or knowledge or even embodied know-how, but the entirety of ideas now lodged in the universal digital archive (Archer 1996). (Academic arguments aside, were the relevant information already shared, there would be no need to teach or learn it).

The distinctive property of culture is that it is not a scare resource, unless restricted and rationed artificially, and it does not diminish in value through being shared. As Thomas Jefferson once put it:-

> 'If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of everybody … Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me.' (August 13th 1813).[9]

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[9]Cited in Archer (2015) How Agency is Transformed in the Course of Social Transformation. (2015). In: Archer (2015) (ed) Generative Mechanisms Transforming the Social Order. Springer, Dordrecht.

Literally, it requires 'scavenging' the cultural archive (because no-one knows everything), selecting (for local relevance), systematizing (so that the relevant can be conveyed coherently in sequence) and evaluating it (for appropriateness to local sustainable development). All of these processes are what make it part of education, including that which resembles 'apprenticeship' more closely in form.

On that basis, I will try to substantiate the radical view that *culture can digitally outdo structure,* in the sense that it does not entail the imitation of the 'West by the Rest', is not valued for its capacity to compete in the global educational *concours* but is evaluated by its contributions to problems of 'sustainable development' and 'inclusion' in their local or regional specificity. Neither of these concepts are rigorously defined or used. Here 'sustainable development' will be taken to mean processes in any domain that help a given area to make continuous progress towards a desirable social goal (in education, health care, decent employment etc.) and can be sustained without damaging the natural environment or the attainment of other social goals sought. Every word in that sentence is obviously contentious: 'progress' does not mean tracking developed countries, adopting their criteria of 'advancement', not becoming embroiled in competition on their market terms or assessed by their commodified indicators. An area could make qualitative 'progress' in ways that do not register on such metrics, by making better use of available resources or encouraging the amplification of skills or engendering decision-making processes to prioritise those social goals that are held 'desirable'. These would enhance the quality of life in that area and the relational goods it generates. The key term is the *local area,* be it rural or urban, because this would be the cell of bottom-up development—the only one where some are fully conversant with its human and environmental resources.

Significantly, the new UN SDGs have many sub-clauses advocating the increased availability of the Internet and computer literacy in general. These are admirable goals but their implications for and their connection with educational goals is not made explicit. Nor, importantly is the triangular relationship between Education, ICT and changing environmental conditions, especially those related to climate change. At most, Clause 12.8 specifies rather vaguely that the aim is 'By 2030, [to] ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature'.[10]

Clause 9.c amplifies the above to specify that it entails Internet access that is 'universal and affordable'. Clause 17.8 is more detailed, commits to its accomplishment in only two years, but remains mute about whether this will be by top-down or bottom-up processes:

> Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology. (ibid.)

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[10]'Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries and landlocked developing countries and small island developing states by 2020' (see 9.c in SDG 2015).

There is no doubt about UN commitment to ICT and its conviction that the achievement of the Millennial and the most recent SDGs depends on its universalization. However, most of the WISIS publications are much stronger on national strategies than on means of accomplishing them, especially local ones. The Policy Brief *Towards National E-agricultural strategies* alone is unequivocal in stating that

> A national e-Agriculture strategy should emphasize that ICTs are not direct **solutions** to agricultural and rural development challenges, but instead are **enablers** for those people who will create the solutions. The strategy should promote empowerment and capacity development and contribute to a **cultural shift**—from top down and prescriptive to bottom up and participative. (FAO 2015)

Of course, agriculture is far from irrelevant to the issues discussed here, but what is needed is to spell out the above sentence in relation to education.

The distinction made above between ICTs as *sources of enablement* rather than *ready-made solutions* is vital to advocacy of their expanded role in education at all levels, especially if schooling is to play an enhanced role in 'sustainable development' as defined here. My strategy will be to work from top-down 'objections' to according ICTs a bigger part in schools and colleges, which are well rehearsed in the literature, to countering each with bottom-up 'advantages' that would accrue, even if the empirical basis of each objection were indeed the case almost everywhere. These 'objections' can be broadly grouped under three headings: *Connectivity*, *Cost* and *Competence*, each of which will be considered in turn along with the countervailing 'advantages', when examined in terms of local benefits accruing from local initiatives.

9.3.1 Connectivity

It should be noted that debates about the 'digital divide'—within or between countries are conducted overwhelmingly in empiricist terms. There is a deceptive and immediate slide from the (neglected) consideration of the computer per se to Internet access, as if this in itself usefully opened up the world's archive of knowledge to every subscriber. This focus recommended itself because of the (seeming) ease of measurement of Internet subscribers and diagrams of the 'divide' proliferated accordingly. It transpired not to be easy, if such divides were not measured in terms of simple access but of the existing bandwidth per individual (measured in kbits per capita) (Hilbert 2013). More diagrams followed, intended to demonstrate that the digital divide grew and then shrank after the introduction and slow diffusion of (basically, increased broadband available) with its proportional usefulness to subscribers. This is an elementary empiricist error, comparable to neglecting whether or not the increased sales of flat screen TVs resulted in more informative viewing.

   Another error is to use the presumed 'home subscriber' as the unit of statistical analysis. That betrays an individualism that is unwarranted and militates against the socio-educational advantages that accrue to thinking in terms of local relationality. As E.J. Wilson pointed out, 'the number of users are greatly affected by whether access is offered only through individual homes or whether access is offered through schools, community centres, religious institutions, cybercafés, or post offices, especially in poorer countries where computer access at work or home is highly limited.' (Wilson 2004) Such collective use in public spaces may entail inconvenience but have unconsidered benefits for 'inclusivity', fostering inter-generational mixing and exchange. Young and older males will cluster round a cybercafé screen, debating its content, many of whom would not be drawn into a school, even after hours. Women and young girls can use libraries, community centres and religious facilities in safety and without opprobrium. This is social connectivity; the obverse of the Japanese stereotype of young people alone in their bedrooms with their PCs for the day.

   Furthermore, the direct incorporation of the Internet into schools, fosters standardization if reliant upon the digital textbook, which will have been publicized but not produced in their area. Certainly, such texts include multimedia learning, through embedded videos and hyperlinks and include test materials and grading facilities. Yet, open access can provide a similar multimedia experience at no cost and allow teachers the discretion to select material relevant to the locality and linking to pupils' everyday world. Let us not forget the discrimination involved in the heyday of I.Q. testing, when Brazilian pupils were deemed several points less intelligent than their European counterparts because the tests involved experiences foreign to them (for example, 'How long does it take for a bath to fill if the tap flows at X litres per minute'?) The problem was not the maths but the unfamiliar baths and their taps. This year, South Korea will furnish digitalized texts in all public schools yet already their pupils excel over British ones in maths attainment at various levels. Is digitalization here a symbol of success rather than a means to it and, outside of mathematics, is there no ideological danger in importing textbooks produced largely in the developed world on subjects such as history and economics?

9.3.2   Cost

Low cost was a great attraction of the 'One Laptop per Child' project, which in 2005 produced 'XO' laptops with the aim of providing digital learning and Internet access to children residing in both poor and isolated regions in developing countries at a cost of $100 per computer, to be purchased by governments. Although they turned out to cost rather more (and updating was extra), they contained many desirable features and a manageable solution to the connectivity issue: 'Each laptop is constructed to use as little power as possible, have a sunlight-readable screen, and

is capable of automatically networking with other XO laptops in order to access the Internet—as many as 500 machines can share a single point of access' (ONELAPTOP 2009). Uruguay was the first country to adopt the scheme, in total purchasing 300,000 XOs for all public school pupils between 6 and 12 years old by 2009. There, the cost rose to $260 per pupil, if maintenance costs, repair of equipment, teacher training and Internet connection were included.

The barrage of criticisms, well documented online, include the breakability of the laptops, that Uruguay reported only one fifth of teachers making use of them daily and that in Peru usage declined substantially when the novelty wore off, that those of the lowest socio-economic status had difficulties using them without assistance and that the drop-off of XOs by helicopter constituted 'flying away', although Negroponte's organization supplied learning teams to assist teachers.

Despite the commercial battle that ensued, the 'cheap and cheerful XO' functioned as a stimulus to the development of what we know less than ten years later as the tablet. However, three educational issues also surfaced and ones that cannot simply be reduced to value for money. First, were schools the best, despite being the most obvious places in which to insert digital learning? Others advocated libraries, claiming, as did the Gates Library Initiative, this to be more effective because technical support could be more readily on hand. Second, and more principled, the software uploaded was held to lack a direct relationship to 'the pedagogy needed in the local context to be truly effective' (ONELAPTOP 2009). Third, this was generalized into a second-order critique, sometimes known as the 'production gap' within the digital divide, which 'separates the consumers of content on the Internet from the producers of content' (Digital Divide 2015). In short, the force of such arguments insists that digital learning is over-centralized and must be *decentralized* in order to be relevant, a theme I will return to in the last section.

9.3.3 Competence

If the cost of online digital teaching and learning are prohibitive in terms of a laptop per capita (or tablet and now iphone) if both teachers and learners are easily discouraged, it is valid to question whether or not Internet access is indispensable. After all, a great deal can be done offline with the help of a few USB sticks.

The Wikimedia Foundation (the charity running Wikipedia) have led the field in providing offline facilities for education. Its rationale is based upon 'sustainable development', although that term is not employed. What they accentuate is that approximately 30 % of the population in the developing world is of primary or secondary school age, representing ∼550 million pupils; that 15–24 years olds are more literate than older people; and that children are also more competent and quicker in acquiring new technologies. Updates are delivered every semester or two and new software is supplied annually, content is checked and edited as suitable for

children by staff and volunteers at the charity 'SOS Children's Villages' and these contents are cross-referenced to an index of school subjects.[11] Copies can be downloaded to a USB memory stick and transferred repeatedly and are released on DVD. The project started in 2005 and an updated version of *Wikipedia for Schools 2013* is the latest version, allowing content to be created in local languages.

As a resource, particularly popular in Latin America, Wikipedia beats those available to lower class children throughout most of Europe. However, three problems arise over the *substance of the competence acquired*. The most serious concerns the fact that 'Wiki for Schools' is based on the UK national curriculum. Post-colonialism is not just a spectre; in particular, history and geography will be affected by more than irrelevance and other subjects will in no sense be related to local conditions. Next, this offline product does not offer a means for offline editing, meaning that the above deficiencies cannot be remedied on the ground by those concerned. Finally, although the text is produced under Creative Commons licencing, the vultures are circling and, for example, Google's current support is probably waiting to pounce on the 'Target Market' nicely prepared for them when these children do come online (see Target Market 2011).

9.4   PART III: Distilling the Lessons: Combining Them to Educate for Sustainable Development

'Inclusive Sustainable Development' can be invoked as a meaningless mantra. Effort has been made to avoid this in the text by referring each of the three constituent concepts to 'local areas'. Certainly, a 'local area' is itself an umbrella term with fuzzy boundaries, sometimes more geographically defined (as in Chile's unusual topography: the mountainous, cultivatable and coastal strips running East-West, though not culturally homogeneous) and sometimes approximating to urban zoning in cities such as Rio de Janeiro and Buenos Aires. In between falls every permutation of definitions based upon enduring tribalism, Colonial history, ethnic and religious differences, natural resources and related occupational specialization and the impact of climate change already registered, among others. Because we are talking about 'development', which necessarily implies change, this will unavoidably and continuously be redefining 'local areas'. Hence, the referent itself is not fixed and consequently the vagueness of its definition at any given time is inevitable. If field study demonstrates that some feature or factor, crucial at a given point in time for the delineation of a given 'locality', has been omitted, this can be checked, revised and corrected through using network analysis.

This ontological anchorage is important for the conclusions advanced in linking the foregoing discussion to 'better pedagogical practice'. All of these are predicated upon educational *decentralization* and decentralized delivery and reception if the

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[11]Contents can be checked online at www.sos-schools.org/wikipedia-for-schools.

Table 9.1 The RAP
framework

Goal	Pedagogical condition for its realization
Development	Relevance (local)
Sustainability	Adaptability (to local conditions)
Inclusiveness	Participation (of all in a locality)

digital alternative advocated here is to have any chance of success. What will be sketched is the RAP framework, where each term in 'Inclusive Sustainable Development' has implications for pedagogy that are dependent upon *decentralization* for their realization, as follows in Table 9.1.

9.4.1   Relevance

The goal is for pupils not to take their local environment and social context for granted (because it cannot be, given natural and social morphogenesis), but rather as (1) something to be understood; (2) a familiar resource drawn upon through which to teach the unfamiliar and; (3) a source of problems, present or impending.

1. Involves presenting local ecology in understandable and interlinked ways, engaging children's existing knowledge base and extending it. For example and at the start, if the locality is mainly involved in animal husbandry, what animals are reared, what care do they need, what products do they yield, what use is made of them, by whom, what tools and equipment are used, are there seasonal variations in tasks. One form of extension is to introduce how in other areas different forms of livelihood produce very different pictures of everyday lives and digitalized visual material and animations would help in preliminary recognition. This can be further extended into nutrition, fertilization, animal reproduction, the sexual division of labour—the list is endless, but one consequence is breaking down existing disciplinary boundaries.
2. Introduction to new school subjects, such as maths and natural sciences acquire relevance through practical involvement (Piaget); progressing from counting (whatever is available) to subtraction (each one take one) to division (two of you take one each, then another …) to multiplication (all of you give one, two … more). It could immediately be related, say, to nutrition (If everyone in your house needs to drink a litre of clean water a day …), leading on to Piaget's basic concept of identity, the 'conservation of matter' (Piaget 1967), and discussion of potable water (micro-biology, health and hygiene). Such lessons can be peripatetic, practical, participatory and progressive. All of these basic illustrations can be reinforced by offline computer programmes, but what is then formalized is rooted in the everyday world and much more firmly than by the 'early learning' texts of the developed world.
3. Everyday problems are a learning resource. Videos can convey poignantly and pointedly what happens to livelihoods if and when acidification diminishes fish

stocks, desertification reduces animal fodder, or leeching results from urban land-fills. These offline but computer-assisted lessons, teach that everyday life cannot be taken for granted and introduces whatever measures for preservation can be taken. In short, Primary level pupils will have begun to study the 'integral ecology' of Laudato sí as part of acquiring literacy and numeracy—if the digital archive is 'raided' appropriately.

9.4.2 Adaptability

Fundamentally involves two processes: (1) linking-up and 2) breaking down. Both of these prevent local problems either from being seen in isolation or being regarded as intractable. Their exploration is probably more suited to Secondary school students but, again, is not reliant upon working online, although it may benefit from this.

1. Linking-up means both with other communities (of professionals as well as geographically) for discovering alternative solutions to existing problems or becoming acquainted with 'best practices'. Simultaneously, it reveals that education is directly linked to, for example, health, nutrition and child care that will likely not feature on any standardized curriculum. These linkages do not imply hi-tech resources. One illustration from Uganda illustrates the use of the mobile phone to send SMS messages to health care providers in remote areas, but these could readily have been sent to schools. (World Bank 2012). They included quizzes on health topics and dealt with basic methods of avoiding infection. The result was to improve handwashing practices and was directly transferrable to the school context.
2. Breaking-down tasks that appear formidable can render them tractable. For example, one case study investigated how women and girls in various African countries could adapt their existing skills in garment-making, using sewing machines, to the production of 'Italian' look-alike shoes. This involved learning how to select and insert the appropriate needle and thread and to grasp the tolerances of leathers and plastics; others had to acquire the skills of pattern-making, sizing, packaging etc. But, no-one had to learn all; the division of labour had arrived and, with it, the 'Gucci' bags and 'Versace' shoes on street sale throughout Europe.

As Workers' Movements re-start production of 'failed factories' in Buenos Aires, the same principles apply. Probably very few understand the complete production process, but broken down into parts and harnessing the now unemployed but with previous experience, they can become productive members of the co-operative and take on several school leavers as quasi apprentices.

9.4.3 Participation

Adaptability should diffuse and when it does, it improves social integration. Those working cooperatively in the above factory know their (Durkheimian) inter-dependence on one another, which greatly exceeds those running around cleaning car windows at traffic lights or resorting to individual scavenging. However, integration is also generated on other dimensions; especially by sharing techniques with other factories; by integrating school and work, so that further study is not seen as the sole point of successful schooling.

Sometimes the overall practical task may appear daunting. How, for instance, do kids from the *favelas* learn to service a car, given vehicles become more hi-tech year upon year? This is where Internet access comes into its own; filling gaps, supplying expertise and integrating schooling with NGOs, voluntary associations, government- sponsored projects, charities and professional groups. One way it does so through the UN volunteers (VNU 2015), who volunteer online for several hours per week (unpaid) worldwide. These are the bridges that integrate the global and the local; the locality describes the problem in their area, a list of these tasks to be tackled is published online and the volunteers pick one with which their skills match. Thus, there is a bottom-up impetus defining practical needs, an outward digital search to meet their requirements, and sometimes an upwards linkage to the UN and its SDGs. In Table 9.2, I have tried to illustrate this process from today's list of tasks advertised (12 October 2015) and seeking online volunteer assistance.

Table 9.2 Online voluntary help sought: from most local to most global

Help sought on	Help provided by
Designing video animations and info-graphics for educat …	Noble Missions for Change Initiative
Graphisme et infographie—Concevoir des graphiques et …	Agriculteurs Professionnels du Cameroun
Conception d'une base de données excel pour la gestion …	Fondation Joseph The Worker/Structure Lazarienne
Online auditing and production of financial report	Seeds Theatre Group Inc.
Manejo de redes sociales campañas MY World y Action/2015	Corporativa de Fundaciones, A.C.
Geographic Data Visualization—Production Assistance: …	UN OCHA—World Humanitarian Summit
Gestión de proyecto para juego digital sobre derechos h …	UNDP Democratic Governance Group
Create animations for the Sustainable Development Goals	UNDP Democratic Governance Group

9.5   Conclusion

The argument has been that digitalization can promote *decentralization* in schooling that is not imitative of the *centralization* that is increasingly characteristic of educational systems in the developed world. Its main benefit is that education can remain responsive to the specific needs of local areas within developing countries. The use of offline computing has been accentuated as important in retaining this responsiveness. Nevertheless, online access is a major resource, providing it maximizes links to the Cultural Commons, the voluntary sector and free-giving. These are held to be *socially integrative linkages* that, managed reflexively in relation to the requirements of local areas can evade the *domination by* and *commercialism* of those agencies through Internet hegemony, of which Google is the biggest threat, but so too are the mass of others which provide 'free services' at the expense of exposure to advertising, to data-mining, sale of distribution lists and further targeted bombardment in the interests of still more *monetarization*. Instead, reliance on the Third and Charitable sectors—though not guaranteed to be free from ideological bias—at least offer the potential protection of subsidiarity at ground level. This is also why the social media have not been mentioned, useful as such networking could potentially be, were it not, like Facebook, mounting an assault upon human dignity by the degrading self-presentations it fosters.

It will not have escaped attention that the sketch proffered here for educational development is in close conformity with Catholic Social Teaching. Therefore, I will conclude in an unconventional way with a final Table (Fig. 9.3), in order to illustrate that this is indeed the case.
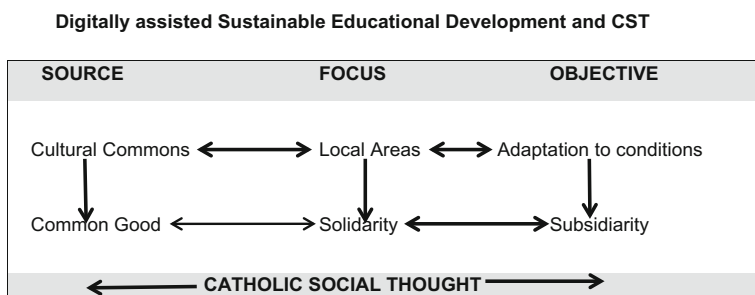
Fig. 9.3 Digitally assisted sustainable educational development and Catholic Social thought

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Chapter 10
Low Attainers in a Global Knowledge Economy

Sally Tomlinson

Abstract This chapter argues that sustainable development goals cannot be achieved unless all children and young people receive an education which assumes there are no limits to their learning. A Western-type of education, exported globally, will not solve global problems. In developed countries the gap between those who have more education and qualifications, and those who have less is increasing. Despite a rhetoric of inclusion, low achievers and those who have learning difficulties, disabilities or are disruptive in schools, are more likely to be excluded from an equitable education and regarded as problematic by governments. There is a creeping resurgence of eugenic beliefs in the inherited incapacities of many young people. Research in schools and Colleges in England, the USA, Germany, Malta and Finland found 25–30 % of students were in low level education leading to vocational education and training associated with lower status work. Education in sustainable economies must lead to a working future for all young people, and respect for those for whom work may not be possible.

10.1 Introduction

There can be no achievement of sustainable development goals unless globally all children and young people are offered an education which assumes that there are no limits to their learning. Basic education for all has come to mean literacy, numeracy, and some understanding of information and communications technology, although this is nowhere near being achieved in many developing countries. While educational inequalities between developing and developed countries exist, inequalities within systems in developed countries and even in developing countries are strong and growing. In global economies educational qualifications are

S. Tomlinson (✉)
Department of Education, University of Oxford, Oxford, UK
e-mail: s@stomlinson.net

increasingly regarded as a form of capital in themselves, and elite and aspirant groups equip their children with the required 'educapital', which goes far beyond basic education. The polarisation between those who have more, less or even no education is increasing. This paper is concerned with the large group of young people who in developed countries, are increasingly defined as being low attainers in tests and assessments and/or having special educational needs or disabilities. This is a challenge to education systems in both developed and developing countries as attempts are made to include all groups of children previously excluded. It is also a challenge to the persistent notions, common in developed countries, that children have fixed levels of 'ability' or limits to their potential.

As Archer (2016) has pointed out, the Sustainable Development Goals adopted by the UN assume that a Western type of education, exported globally, will help solve global problems, but this is debatable. It is more likely that there will be a win–lose result in developing countries. In developed countries there is a rhetoric of 'inclusion' and concern for the disadvantaged, while the reality is that low attainers, and those who have learning difficulties, disabilities or are disruptive in schooling, are more likely to be excluded from an equitable education and regarded as problematic by governments. It would be a tragedy if developing countries embraced the hierarchical, unequal systems that currently characterise some of the world's richest countries. National governments in these countries believe that higher levels of educational attainment and skill are needed for successful competition in a competitive knowledge-driven global economy. But historically and currently, it is the lower social classes, castes and minority groups, who are regarded as having difficulties in learning to ever higher required 'standards', and while governments have a political interest that all young people should be economically productive and not rely on unemployment or other benefits, the social control of these groups is also paramount.

Young people who a 100 years ago in England were described as hooligans, defectives, feeble-minded, delinquent, slum-monkeys, are now often derided as yobs, chavs, NEETS (not in education, employment or training), or scroungers, and each country has developed its derogatory labels (Tomlinson 2013). While in the West the expansion of education systems has led to an expansion of labels and institutional arrangements and resources for these young people, the arrangements continue to prevent their full participation in working for a sustainable world. This is despite a realisation that children, whatever their assumed level of attainment, do have the capacity to help change the world. While there is a paucity of information on what is happening to the young people, the identification, classification and provision for those who do not achieve well in the education system or the job market is a social categorisation of economically and socially weaker groups, who can be treated unequally and often punitively by those with power. There are also historical and current rationalisations for the treatment of these groups. This paper discusses the ideologies which support unequal treatment—notably a 'new eugenics' which has political appeal, and outlines a research study examining definitions of young lower attainers and what sort of education and training was

provided for them.[1] One conclusion from the study was that those labelled as low attainers may actually have more empathy towards others and capacities for bringing about a sustainable world than those regarded as higher attainers.

10.2 Progress

Over the past 25 years education systems around the world have been developing and expanding. In many countries higher level education was for elites, basic education for some and exclusion from education for many. By the end of the twentieth century concern for groups excluded from mainstream education and for those regarded as having special educational needs, disabilities, difficulties in learning and being lower attainers in national and global tests had become world wide issues. In 1990 at Jomtien in Thailand, in 1994 in Salmanca, Spain, and in 2000 in Dakar, Senegal there was a global affirmation of "education for all" and countries were urged to ensure that education should incorporate all social, ethnic and religious groups, including those with learning difficulties and disabilities (UNESCO 1990, 1994, 2000). Universal primary education was one of the United Nations Core Millennium Development goals. However, as Archer (2012) has pointed out, the consequences of this structural expansion of education systems, the conflicts of interest between interest groups claiming control of the expansion, and the consequences of expansion, are all currently areas where much further study is required, and unfortunately it cannot always be assumed that those in control have the best interests of children at heart. In developed countries the international PISA tests[2] of samples of young people cause governments to panic if their test results go down, and in some countries, the USA, and England for example, 'long tails of low achievers' who lowered national test scores, and their supposedly 'failing' schools were blamed for this situation. Governments adhere to the belief that all citizens in nation states are subject to the forces of globalisation and global economic forces and that ever higher levels of knowledge and skills are necessary for successful competition in knowledge-driven economies. All young people, whatever their learning difficulties or disabilities, are thus required to invest in their own human capital, constantly learn new skills and compete with each other in largely stratified education systems and uncertain job markets. Countries, it is claimed, need 'world class' education systems to improve the national economy and allow for successful global competition, although this is not necessarily supported by evidence. Advanced economies employ more young people, including those with learning

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[1]The study was funded by the Leverhulme Foundation and discussions were held in five countries, England, New York and Los Angeles in the USA, Germany, Malta and Finland, with some 77 participants (Head Teachers, College Principals and Administrators) who were interviewed in their schools, Colleges and Local Offices. It is reported in full in Tomlinson (2013).

[2]The PISA tests (Programme for International Student Assessment) are now taken by samples of 15 year old students in some 64 countries.

difficulties, in low-wage, low-skill jobs deemed necessary for the economy. (Holmes and Mayhew 2010). Low-level education becomes a means for profiting from this low skill labour.

10.3 Labels and Definitions

There is much confusion between a wider recognition that some young people with physical, sensory or severe intellectual disabilities may never achieve more than skills for independent living, and the need for the larger groups of those with milder learning difficulties and behavioural problems to be assisted or coerced into learning. This results in what John Richardson has called, a 'punitive benevolence' (Richardson and Powell 2011). Political responses vary between blaming the young people and their families for not achieving required levels of attainment in tests and examinations that are subject to constant raised expectations, blaming schools and teachers for not raising all young people to required levels, and searching for policies that will overcome the deficiencies of those regarded as low attaining, disadvantaged or disaffected young people. Benevolence towards these groups is countered by political, social and commercial interests that all young people should if possible, be economically productive and not rely on welfare benefits, or fall into delinquent or criminal activity. There is also a more recent recognition of an expansion of middle class demands for recognition and resources for those of their children who have difficulty in attaining well in competitive school environments, which has fuelled an expensive "Special Education Needs Industry" (Tomlinson 2012). Parents are driven by anxieties that their 'less able' children may not progress well or find and keep work, although middle class parents are more likely to avoid the placement of their children on vocational programmes. Which young people get labelled as a lower attainer, having special educational needs or a disability depends on current definitions of what constitutes adequate attainment or 'normal' ability. This varies at different historical times, between different countries, between professional groups, and even between religions. Protestant Martin Luther considered that physical and mental disabilities were an indication of divine displeasure and the afflicted people were 'Godless'. Catholicism was kinder, St Vincent de Paul's Sisters of Charity in the early 17th century included the disabled in their hospital at Bicetre, in France, and in England a Catholic asylum for the blind opened in 1841.

In England and the USA social class and race[3] were always markers in deciding who should receive an inferior education and thus achieve less in terms of

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[3]There is a plethora of literature defining, discussing and repudiating the terminology of race, racism, ethnicity and multiculturalism. Here the definition adopted is by Rex (1986:17) "Racial and ethnic groups are groups to whom common behavioural characteristics are imputed rather than having such characteristics…. Racial groups are groups thought to have a genetic or deterministic base, ethnic groups are thought of as those whose behaviour may change". For further discussion see Tomlinson (2008).

acceptable qualifications. Historical definitions were based on beliefs in the biological and cultural inferiority of lower social classes and racial groups—the 'feeble-minded', the 'mentally retarded' and the 'educationally subnormal' threatened society, especially by 'over breeding'. In England current restriction on welfare benefits still reflect beliefs that poorer people should restrict their family size. The Minister for Work and Pensions claimed on a radio programme in December 2014 that he wanted child benefits restricted to the first two children. This would save money and encourage the 'behavioural change' of the poor having fewer children (Toynbee 2014). Those predominantly lower class young people not being in education, employment or training after age 16 have also been subject to scrutiny and any allowances they receive have been cut. All young people from 2016 are now legally required to stay in some form of education or training to 18.

10.4 Old and New Eugenics

In England as soon as the possibility of mass elementary education became a possibility, what could be described as the first wave of eugenic views denigrating the educational possibilities of lower class minds was developed. Francis Galton, second cousin to Charles Darwin, set out to provide a 'scientific' base for selective breeding to improve the genetic inheritance of the human race, worried that the working classes with ineducable minds were 'over-breeding' and reproducing defective people. He advocated selective breeding policies and used the term eugenics, derived from the Greek eugenes—a person hereditarily endowed with noble qualities (Galton 1869, 1883). He argued, as did other medical and political interests at the time, that just as genius and talent were 'inborn' so low abilities, mental defects, delinquency, crime, prostitution, unemployment and other social evils were inherited by the lower social classes. Eugenic theories were embraced by those on both the political right and left and a Eugenics Society founded. A 1908 report in England on the Care and Control of the Feeble-minded (RRCCCFM 1908) emphasised the seriousness of inherited deficiencies, especially blaming 'feeble-minded' women for breeding defective children.

Subsequent interventions especially in European countries and North America aimed to prevent births by forced institutionalisation, sterilization and segregation into labour camps. It has been argued that the subsequent linkage of eugenics with Nazi programmes of sterilization and euthanasia has down-played the links between the massive impact on education and eugenic thinking. Cyril Burt, appointed London's first psychologist in 1913, had met Galton as a child. He developed his mental tests to determine 'intelligence' and it was eugenic concerns and implacable beliefs in inherited 'intellectual ability' that influenced Burt throughout his long career. Despite later claims that much of his research data (on twins) was fraudulent, Burt's influence on political decisions in education during the 1920s and 1930s

in England, and his assertions that IQ tests could separate out children for different kinds of schooling, has cast a long shadow over education in the 20th and into the 21st century (Hearnshaw 1979). The long saga of attempts to demonstrate the mental inferiority of lower social classes and races continued, especially in the USA (Jensen 1969) (Herrnstein and Murray 1994).

In the 21st century the issues have been infused with new life with the completion of the Human Genome project, the creation of massive DNA bio-banks and an expansion in the neuro-sciences, genomics and behavioural genetics. All this matters for education as some people working in these areas are able to influence government policies. Robert Plomin, an American currently working at King's college London, and with long record of twin research currently asserts that children's intellectual capacities are due mainly to heredity and he advocates that children should be fitted with a 'Learning Chip' to inform teachers about the kind of education each child should receive (Asbury and Plomin 2014). He has met the English Secretary of State for Education several times and given seminars at the Department for Education. Although geneticists claim that they have not yet located missing 'cognitive heritability' genes for individual educational performance, some researchers are excited by the possibility that 'advances in genomics may open up new ways to enhance human intellectual abilities' including embryo selection for cognitive enhancement (Schulman and Bostrum 2014). Such claims influence both political and general public beliefs that young people who are regarded as having learning difficulties or disabilities, or are low attainers in school tests, are a problem and likely burden on society and an obstacle to the development of sustainable education. This all illustrates the need for scientists to consider the ethics of their work and its political repercussions.

10.5   Low Attainers in England

In an attempt to clarify which groups of young people were being defined as lower attainers and/or having special educational needs, in 2010–2012 a small-scale research study asked School Heads, College Principals and Administrators in five countries which young people they regarded as being low attainers, what courses or programmes they provided and what they thought the likely future of the young people would. In England replies were as follows:

10.5.1   Definitions of Lower Attainers

- Students not achieving the level of five A*–C in GCSE (General Certificate of Secondary Education) at 16
- Students unable to achieve in a purely academic curriculum
- Students with mild learning problems

- Students who exhibit behavioural problems
- Students who would achieve in a more vocational curriculum
- Students with a Statement/Plan describing their disability (or self-declared at College)
- Students whose parents press for a 'diagnosis' of special educational need
- Students from poorer homes.

There was much evidence that the structural expansion of the system was taking place, not only in an expanding diversity of institutions (maintained schools, academies, faith schools, free schools, special schools, Further Education Colleges, private schools and higher education institutions), but also within the institutions. Asking the system to incorporate larger numbers of young people to 18 who previously would have been regarded as educable only to 14, then 16, has required change in funding, curriculum, qualifications and trained personnel. School and College staff and local administrators accepted that lower attainers and those previously excluded with special needs should if possible be included, although government requirements that schools should focus on 'academic' subjects, with vocational subjects down-graded, has a negative effect on lower attainers. Segregated special schooling had diminished, but some schools were keen to pass on their low attainers or disruptive pupils to other schools or Further Education Colleges. The participants in the study, with variations between local areas, described numbers of low attainer/special needs students as around 25–30 % of the young people they dealt with. Funding was a crucial issue, as the government was keen to reduce the funds paid to schools or to individuals with special needs, and funds for vocational courses in Colleges continue to be reduced. However schools and Colleges were taking seriously the task of including young people and socialising them into the norms of social behaviour and preparation for lower level work. The agenda was very much one of social control and skills valued by employers—obedience, time-keeping self-presentation.

10.6   The USA

In the USA, with a Federal structure of 50 States, the history and treatment of lower attainers and the 'special' is similar to the UK, although the USA was more strongly influenced by the belief that racial minorities are likely to be less educable and a large literature continue to indicate that such students are more likely to be considered as potential lower attainers, drop out of school and receive a less equitable education (Blanchett 2008). There is also a wider separation of general and special education, with the Learning Disabled emerging as the largest group of named low attainers, some 20 % of all students overall in the 50 States. Participants in the study thought about 20–25 % of young people fell into low-attaining/special categories, but were concerned to keep students from dropping out before 18.

10.6.1   Definitions of Lower Attainers

- Students who cannot attain a regular High School Diploma
- Students who may not access regular post 18/19 College courses
- Students who cannot achieve well in standardised tests
- Students who fall into categories of SEN
- Students especially assessed a Learning Disabled
- Students who exhibit behaviour problems
- Students at risk of dropping out of school or College
- Students whose parents press for a 'diagnosis', preferably medical of therapeutic
- Students from disadvantaged and minority homes.

As in England, middle class parents demand special education services for their low attaining children and are quick to move to litigation if demands are not met. In one area parental litigation had almost bankrupted the District School Board. In contrast to England there is a stronger individualistic work ethic and minimal welfare system which encourages the education and training of young people for lower level Community College courses or employment at lower levels. In New York participants noted that low attaining, especially minority students, were being prepared for what Moxley and Finch (2003) had described as the Five F's for low wage and often undesirable jobs:

- Food (fast food outlets, cafes, restaurants)
- Filth (cleaning in streets, hotels or offices)
- Folding (laundry work)
- Fetching (messenger work)
- Filing (low level office work).

In California new legislation now requires all students to attain to higher levels at school before receiving any state funding for Community College courses. This is already affecting poor and minority students and the Chancellor of the Community College System has described this legislation (Student Success Act 2013) as a rationing of education.

10.7   Germany

In Germany as in the USA there is a decentralised system in which 16 Lander (States) function under wider Federal jurisdiction. The system remains selective from 10/11 although some Lander now include comprehensive schools. The Gymnasium, for higher level schooling has only around 11 % of working class children, the Realschule offers a mainly technical education, and the Hauptschule provides a basic education leading on to vocational training. Around 6 % of students are still in segregated special schooling. But Germany has long credited its economic success to the dual-system of apprenticeships with all young people

spending time in education and training post-16. This system has long prepared a majority of young people, many with low school attainment, for an occupation. In this study participants noted that lower attaining young people were more likely to be educated in the Hauptschule (especial Turkish and Kurdish students) and then move on to 'transitional' vocational courses where Colleges would try to prepare them for apprenticeships or employment. The participants were reluctant to put a number on those they considered low attainers but as with other systems it is the category of mild learning disability which includes large number of poor, minority and migrant children. A major difference between Germany and the two countries above is that links are more likely to be made with a shrinking labour market, and lower wages, rather than blaming young people and their families as deficient.

10.7.1   Definitions of Lower Attainers

- Students who leave the Hauptschule without a Certificate
- Students who leave special schooling without a Certificate
- Students on 'transitional' courses in Colleges
- Students unsuitable for the dual system of apprenticeships
- Migrant and minority students with poor language skills
- Students from poor, disadvantaged and minority homes
- Those unable to find work due to labour market deficiencies.

10.8   Malta

The small island of Malta, influenced by it former British colonial status and by the Catholic church, has a long history of selective education. Although there are much smaller numbers of students than in the other countries discussed, the problems of dealing with low attaining students and those with special needs are similar. The middle classes dominate in church and private schools and around 40 % of mainly working class young people leave education at 16.

Malta has embraced the idea of a knowledge economy, but for some early school leavers there is work in the tourist industry, construction and other services at low-wages, and the main provider of post-16 vocational education and training, MCAST, the Malta College of Arts, Science and Technology, aims to organise vocational education on the lines of the German system. As in other countries, it is accepted that all social classes can produce severely disabled children and four special schools deal with these, while the majority of low attaining children are working class, regarded as problematic and liable to be excluded into Learning Centres.

10.8.1 Definitions of Lower Attainers

- Students who do not attain the Malta Secondary Education Certificate
- Students taking a 'second chance' st academic education in sixth form Colleges
- Students with severe disabilities
- Students assessed as dyslexic, autistic or with drug and alcohol problems
- Students with disruptive behaviour
- Students who drop out at 16, especially girls
- Students from lower class homes.

10.9 Finland

Finland, widely regarded as a country where students achieve well and coming high in PISA tests, is distinguished by the lowest quintile of students obtaining higher scores than in any other country! Although the system claims that anything up to 30 % of students will at some time in their school careers receive 'special education', this is in effect, additional education and help rather than exclusion and the aim is to prevent learning difficulties. A major difference with other countries is that the system is openly egalitarian, with the declared aim of disrupting inequalities between generations. There is little choice or competition between schools and no school league tables. There is no government or academic literature suggesting that poor genetic inheritance or family deficiencies are barriers to learning and teachers are possibly the best trained in the world The Finnish system "shows that a consistent focus on equity and cooperation, not choice or competition can lead to a system where all children learn well" (Sahlberg 2015:12). But as in other countries the lower attainers are more likely to go into vocational Colleges for education and training rather than the academic upper secondary schools and there is growing concern for the most vulnerable groups who may not achieve independence.

10.9.1 Definitions of Lower Attainers

- Children assessed in kindergarten who may need developmental help
- Students in the 9 year peruskolu (comprehensive school) who may need additional educational help
- Students receiving special or welfare services
- Students at 16 going on to special vocational College
- Students who drop out before completing vocational courses
- Students remaining unemployed after College.

10.10   Low Attainers and Sustainability

Although this study focused on the practitioners and administrators rather than the students. It was possible to observe the students in all the countries visited, talk to them and ask about their curriculum. It was clear that many of the young people had an emotional connection with others around them and often an ability to question 'what was going on' in their schools and communities that the supposedly higher ability students did not necessarily have Those doing their 'work experience' in children's nurseries, with animals in vet clinics, or in agricultural settings, were empathetic and responsible, and their connections to practical caring activities was removed from considerations of a profit motive. It seemed that there was much to learn from these young people in ways that politicians always concerned with 'raising standards' for competition in a global economy had never considered. It is not the case that low attainers in competitive tests and examinations or those with disabilities are always a 'problem', and a drain on social resources. However, if young people are only to receive a basic education with a narrow curriculum, they have less chance of learning about the need for a sustainable global world.

10.11   Conclusions

The issues facing policy-makers, practitioners and administrators in these five countries were however similar. They did mainly regard low attaining young people in a global economy where low-skilled jobs require some form of qualification as a problem rather than as a resource. All the discussants in this study accepted that low attainers, including those previously excluded or only offered a 'special' education, must continue in education and training, with the expectation that they will take low skill, low-wage jobs, or with application, progress to higher skill levels. The rhetoric of a knowledge economy does not include much recognition that the services of the low skilled will continue to be needed although governments now provide some funding for those who would previously have not been considered worth educating or training. But vocational education and training continues to be associated with lower class, lower status work, and there are underlying beliefs in the inherited capabilities of the young people. These beliefs seemed more obvious in England, the USA and Malta, less so in Germany and Finland. Politicians in all countries except Finland appeared largely unfamiliar with anything other than an 'academic' education, have not yet realised that requirements to include literacy, numeracy and IT skills in all courses actually reduces the split between the academic and vocational, and the influence of a world-wide disability movement means that young people with physical or sensory disabilities now have more opportunities for training and work.

While this small study could not cover the wider issues of labour markets in developed economies the participants were sceptical about government assumptions

that constant exhortations to raise 'standards in education would automatically improve national competitiveness in a global economy, and thought this might actually create more 'failure' among low attaining young people. In many countries splits between the 'have' and 'have nots' in the workplace have increased and economies are blighted by recessions, redundancies, bad working practices, and financial greed. The resurgence of attempts via advances in genomics, and behavioural genetics, to 'prove' once again the intellectual inferiority of some groups of young people, may have far-reaching political consequences and do not bode well for a world in which the talents of all people will be needed for sustainability.

As already noted, some progress has been made world—wide in educating more children, but the number of poorly educated and even uneducated children is increasing. If richer developed countries cannot find ways of educating all their children and young people, especially those regarded as low attainers or having learning difficulties, more equally and with less paternalism or insult, then it will be even more difficult for developing countries. It would be a matter of concern if developing countries imitated these countries in devaluing or ignoring the talents of all children and young people, regarding them as 'less educable', and creating structures that gave superior education to elite groups. Education in sustainable economies must lead to on to some kind of working future for all young people, and respect for those for whom work is not possible. Those with power could learn from young people who are often disregarded or insulted, that life can be lived sustainably and without always seeking material profit.

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Chapter 11
Unequal World, Unequal Education

Bernard Hugonnier

Abstract

- Education inequalities are increasing everywhere:

    - Between developed and developing countries
    - Among developed countries
    - Among developing countries

- The presentation will bring all the evidence of these phenomena
- The presentation will conclude that urgent actions are needed to tackle inequalities in particular among developing countries
- Indeed: not only education inequalities perpetuate income and social inequalities; they also aggravate them
- Three strands of actions are necessary in developing countries
- Strand One:

    - To limit education inequalities in developing countries, exogenous risks factors should be addressed (such as poverty, health problems, hunger, lack of shelter, child labor…). The priority is to reduce poverty, the cause of all problems
    - Intrinsic education inequalities should also be redressed (such school access, dedicated teachers, quality of buildings, availability and quality of learning material…). The priority is to recruit and train excellent teachers

- Strand two:

    - At present, according to the Unesco, public international aid to education "remains inadequate and not well targeted"

B. Hugonnier (✉)
Institut Catholique, Collège des Bernardins, Paris, France
e-mail: hugonnierb@gmail.com

- For instance, while sub-Saharan Africa is accounting for over half of all out-of-school children, aid to basic education in the region accounts for only 33 % of the total and primary education is insufficiently supported.
- In addition, the fourth UN Sustainable Development Goal to be achieved by 2030 (ensure inclusive and equitable quality education and promote lifelong learning opportunities for all) requires additional aid.
- Hence, donors need to raise their aid and to support first the poorest countries.

- Strand three:

  - Could developed countries provide some aid in kind?
  - We have to be careful: exporting our educational systems into developing countries has proved counterproductive in some cases.
  - However, induction based pedagogies such as «La main à la pâte» could help improving performances as they seem to be closer to the culture of some developing countries.

If inequalities have always been an integral part of human society, in recent years the world was particularly interested in this issue, the main reason being, as noted by the OECD, that "Inequality in OECD countries have never been higher since we measured them" (OECD 2015). For the International Monetary Fund " Widening income inequality is the defining challenge of our time. In advanced economies, the gap between the rich and poor is at its highest level in decades" (IMF 2015). This results from the fact that real income but also wealth of the vast majority of the population have stagnated in recent decades while those of the richest (the 1 % and even more the 0.01 % and the O, 001 %) increased strongly. According to some, this trend is historical (Piketty 2013) and has consequences both political and social (Rosanvallon 2016; Allen 2016).

Many causes have been put forward, whether this is the change of power between elites and masses; the tax system and the social acceptance of higher wages (Piketty 2013); the liberalization of financial transactions (Bazillier and Héricourt 2015); the capture of the political system by the wealthy (Stiglitz 2012), and finally education: for example, the fact that digitization gives a significant premium in terms of income (skill premium) to those with skills in this area (OECD 2011). This means that educational inequalities can lead to income inequalities. The intrinsic vocation of education is to correct social inequalities. It is not to perpetuate even if not worsen them, which is unfortunately the case in some countries where, for example, "the most privileged students generally have access to more expensive and better quality training than others; teachers have more seniority, options are more numerous, studies are longer" (Dubet 2014).

It seems therefore important to take an interest in education inequalities to monitor the extent to which they, as well as income inequalities, tend to increase in the world. First we will look at the trend between developed countries and developing ones: then the trend among developing countries; finally, the trend among developed countries.

11.1 Inequalities Between the Developing and the Developed Worlds

In 2000, the Millennium Development Goal for education stated that by 2015 universal primary education should be reached. In 2000, 17 % of children in developing countries were out-of-school in primary education. That percentage went down to 9.6 % by 2013 (that represents 54.7 million children). In developed countries that percentage is much lower (2.7 %). Hence, education inequalities are quite important between the two groups of countries.

One might say that these inequalities are decreasing, as the respective percentages of out-of-school children are getting closer. However, these percentages are merely representing access to school, and access is not the ultimate goal of schooling. Quality education in both primary and secondary education is that goal. The level of student performance measures it.

Quality of education depends upon two series of factors: some that are not directly relating to education (exogenous factors, e.g. poverty, conflict situation) and others are (endogenous factors, e.g. curriculum, school climate).

Exogenous factors listed in Table 11.1 all impact quality of education: for example, a child from a poor family is likely to have poorly educated parents who will struggle to assist in his education; for homeless child, working conditions are difficult at home; for a sick or malnourished child, it will be difficult to concentrate in class; a child at work will not always be in school; conflict situations and risk of human trafficking depart children from school; one parent at home will make the child's education support at home harder, etc.

Clearly, if on one hand some of the factors listed in Table 11.1 may impact developed countries, such as poverty, illness, child mortality, single parent family and child mortality, on the other hand, all the factors in the table may prevail in the developing world and sometimes, if not often in some countries, they can dramatically impact the quality of education.

Hence the world is unequal, and as a consequence education is unequal.

The following figures give an indication of the situation in the developing world (UNESCO 2015)

- Poverty: 1 billion children leave in poverty
- Lack of shelter: 640 million children leave without adequate shelter
- Child mortality: 6.3 million children under age five died in 2013. The risk of a child dying before that age in Africa is about 7 times higher than in Europe

Table 11.1 Ten exogenous risk factors impacting the quality of education

Poverty	Lack of water
Lack of shelter	Child labour
Illness	Human trafficking
Child mortality	Conflict situation
Hunger	Single parent family

Table 11.2 Endogenous factors impacting education quality

Access to kindergarten
Quality of buildings and facilities
Years of initial training of teachers
Procured learning materials
Student/teacher ratio
Teaching language different from mother tongue
Curriculum quality
Use of interactive pedagogies
Use of ICT-based pedagogies
Use of formative assessment
School climate quality

- Hunger: 66 million primary school-age children attend classes hungry
- Child labour: 253 million children aged 5–15 years old
- Conflict situation: 33:8 million children leave in conflict affected countries

The question is whether the importance and impact of such factors are going to decrease over time or not? Some might, such as the first five. It is less certain for the others. Hence, the end result is unclear.

Table 11.2 lists the endogenous factors that can directly impact the quality of education. Let's consider for instance the first factor (Access to kindergarten). According to PISA (OECD 2013), students who have benefited from one (two) years of kindergarten have on the average a performance in PISA in mathematics which is increased by 26 and 37 points respectively (38 points represent 1 year of education). There would not be any education inequalities if kindergarten was equally available in both developed and developing countries. This is not the case: while kindergarten is becoming prevalent in most OECD countries, it is still often limited in many developing countries.

A similar analysis can be developed regarding most of the other endogenous factors listed in Table 11.2: in most cases, developed countries are making rapid progress while developing countries are making slow ones. Hence, the impact of endogenous factors on education quality is raising education inequalities between developed and developing countries.

Accordingly, by combining the impacts of both the exogenous risk factors and the endogenous factors on education quality in the two groups of countries, one have to conclude that education inequalities cannot but increase over time between developed and developing countries.

11.2 Education Inequalities Among Developing Countries

Inequalities can prevail first between regions (e.g. Asia and Sub-Saharan Africa) and second between countries among a given region (e.g. Africa).

Table 11.3 Years of in education

	Rural areas	Urban areas	Poorest	Richest
Somalia	0.95	3.11	0.30	3.80
Congo	6.54	10.05	5.61	10.92

Source UNESCO (2015)

Let's take the first case: in Asia, from 2000 till 2013, the number of out-of-primary school children decreased by 69.2 %. During the same period, in Sub-Saharan Africa this percentage decreased by 25 %. This is clearly an indication that education inequalities are increasing between regions in the developing world.

As far as the second case, let's consider the situation of Somalia and Congo in Africa. Table 11.3 gives the number of years of education according to four specific situations. The differences of years between the two countries measure the inequalities in education: for instance, the inequality for the poorest (column 3) amounts to more than 5 years in favour of Congo.

From this table, one can conclude that education inequalities will have a tendency to rise as long as some countries will develop more rapidly than others, which implies better schooling opportunity for their population than in the lagging behind countries.

The later countries would hence need to be better supported by official development aid (ODA) to their education. However, this aid was in 2014 lower than its peak in 2010 and it is expected to stagnate in the future (UIS 2015). In addition, low-income countries "are expected to fare worst given that most aid increases will be directed to middle-income countries" (according to the UIS "Of the US$5.4 billion in ODA to basic education in 2013, just 39 %, or US$2.1 billion, was allocated to the 34 low-income countries" (UIS 2015).

Combining the results of the two cases (inequalities between regions and within a region), the only conclusions that can be reached is that education inequalities have a tendency to increase among developing countries.

11.3   Inequalities Among Developed Countries

In all countries, student performance is function of inter alia student's family background. When school cannot compensate for social determinism, education inequality rises and education equity deteriorates. Table 11.4 provides the list of OECD countries where this has been the case over the 2003–2012 period (OECD 2013).

As shown in the table, in 16 countries (55 %) out of 29 OCDE countries for which the information is available, education equity deteriorated over 2003–2012.

Table 11.4 Evolution of education equity 2003–2012

Equity improved	Equity deteriorated
Belgium, Hungary, Italy, Germany, Greece, Japan, Mexico, Norway, Sweden, Switzerland, United States	Australia, Austria, Canada, Czech Republic, Denmark, Finland, France, Iceland, Ireland, Korea, Luxembourg, New Zealand, Poland, Portugal, Slovak Republic, Spain

Source OECD (2013)

Another way to measure education inequality is through the evolution of the percentage of resilient students (students in the bottom quarter of socio-economic status who perform in the top quarter): from 2003 till 2012, this percentage has been decreasing in 14 countries out of 29; it stayed constant in 8 and increased in only 7 (OECD 2013).

From these two results, one can conclude that education inequalities have rather a tendency to increase in OECD countries.

11.4 Conclusion

This paper shown that education inequalities are likely to increase between developing and developed countries, among developing countries and finally among developed countries. Such inequalities need to be addressed. If not for human reasons (why should a child born in Peru receive an education, which on average is of a quality 7 years behind that of a child born in Japan? (OECD 2013), at least for economic ones: as human capital is highly correlated to competitiveness and higher education, it implies better job and higher income; as well as for social reasons: better educated people leads to higher civil and civic participation and better health (OECD 2014).

The urgency is to decrease education inequalities among developing countries as this is where inequalities are the most important. In these countries, the emphasis should no longer be on access to education but rather on quality of education. Three strands of actions seem necessary.

First, risk factors exogenous to education should be addressed. The priority is to reduce poverty, the cause of many problems such as hunger, illness, lack of shelter, child labour, child mortality, etc. Simultaneously, factors positively impacting education quality should be acted upon notably by improving the teacher work force, by far the weakest link of educational systems in many developing countries.

Second, and accordingly, international donors need to raise their aid and to support first the poorest countries. Indeed, as already mentioned, official development aid (ODA) to education "remains inadequate and not well targeted" (UIS 2015). For instance, while sub-Saharan Africa is accounting for over half of all out-of-school children, aid to basic education in the region accounts for only 33 % of the total and primary education is insufficiently supported. The situation will get

even more difficult in the future: indeed the fourth UN Sustainable Development Goal states that inclusive and equitable quality education and lifelong learning opportunities for all should be ensured by 2030; this requires massive additional ODA to education. But countries should also make sure that education equity is a reachable objective; at present, too often, in some countries there is still a sort of pro-rich bias in public spending in education (IMF 2015).

Finally, one might wonder whether developed countries could not provide some aid in kind? If this certainly has to be done with great care (exporting educational systems from the North into developing countries has proved counterproductive in some cases), investigation-based pedagogy such as «La main à la pâte» seems to be an approach that could help improving performance as it already did in many countries (LAMAP 2015).

As we have seen economic inequalities are increasing. They affect growth and hence employment; they hamper poverty reduction and they dampen investment and hence fuel economic, financial and political instability (IMF 2015). We are already leaving in a world of inequalities. Everything has to be done to avoid that we would soon be leaving in an age of inequalities. Reducing education inequalities will help achieving that goal.

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Chapter 12
Fe y Alegría and the Educational Challenges and Opportunities of Our World

Luis Arancibia Tapia and Ignacio Suñol

Abstract Fe y Alegría is one of the largest non-profit educational institutions in Latin America and the Caribbean, with its mission also extending to Africa and Europe. A work of the Society of Jesus, Fe y Alegría annually reaches over 1.5 million participants in low-income neighborhoods and rural communities. Recognized as one of the most important Catholic networks working for justice in the world today, Fe y Alegría actively transforms the fabric of society by bringing high-quality education that enshrines the values of justice, participation, fraternity, respect for diversity and solidarity.

12.1 History of Fe y Alegría

Founded in 1955 by the Chilean Jesuit priest José María Vélaz in the outskirts of Caracas, Venezuela, Fe y Alegría was conceived to offer practical, quality education to the most impoverished and excluded sectors of society. Born out of a collaboration between Father Vélaz, indignant university students and Abraham and Patricia Reyes—who generously offered their home as the first school for local community children—Fe y Alegría's mission since its inception has been to "begin where the asphalt ends." (Palabras 2005).

Nine years—and 10,000 students—after opening that initial school in Abraham and Patricia Reyes' humble home, the success of the Fe y Alegría model in Venezuela spurred Father Vélaz to replicate this experience in other Latin American countries over the following decade: Ecuador, Panama, Bolivia, Peru, El Salvador and Nicaragua.

Following another successful decade of growth, Fe y Alegría established in 1984 the "International Ideology of Fe y Alegría" at the XV International Congress in

L.A. Tapia (✉) · I. Suñol
Federación Internacional de Fe y Alegría, Bogotá, Colombia
e-mail: fi.coordinador@feyalegria.org

I. Suñol
e-mail: fi.coordinador@feyalegria.org

Table 12.1 The growth of Fe y Alegría

Country	Year founded	Country	Year founded
Venezuela	1955	Paraguay	1992
Ecuador	1964	Argentina	1996
Panama	1965	Honduras	2000
Bolivia	1966	Italy[a]	2001
Peru	1966	Chile	2005
El Salvador	1969	Haiti	2006
Colombia	1971	Chad	2007
Nicaragua	1974	Uruguay	2008
Guatemala	1976	Madagascar	2013
Brazil	1981	DR Congo[a]	2014
Spain	1985	Guyana[a]	2015
Dominican Rep.	1990		

Source Fe y Alegría (2015a)

[a]As of November 2015 not members of the International Federation of Fe y Alegría

Merida, Venezuela, defining for the first time its international identity and objectives. Most recently, Fe y Alegría has ventured into new frontiers of poverty and exclusion, working with local communities on the African continent to adapt the model to new cultures and languages.

From one unassuming school with a handful of students, Fe y Alegría has transformed itself over the past six decades into an international movement with *3228 schools and centers in 20 countries* (Table 12.1).

12.2 Our Mission

Fe y Alegría is an International Movement of *Popular Education* and *Social Promotion* based on the values of justice, participation, fraternity, respect for diversity and solidarity, working with impoverished and excluded populations, in order to contribute to the transformation of society.

Fe y Alegría seeks to promote the formation of *new* men and women who are aware of *their own potential* and of the *reality* which surrounds them; men and women who are open to transcendence, who are *agents for change* and are *advocates* of their own development.

Through innovative and quality education programs, these new men and women will contribute to the creation of a *new society* whose structures make possible a commitment of Christian faith through works of justice and love.

12.3 Our Model

The Fe y Alegría model is *integral* as it takes into account all dimensions of the human person (physical, cognitive, affective, social, spiritual and moral); it is *liberating* because it seeks to ensure that each person recognizes themselves as protagonists of their own development, capable of having an impact on their surroundings; and our model is *transformative* as it cultivates lifestyles that are committed to the common good and the building of a more just and inclusive society.

This is a model which is committed to working directly with the communities involved, seeking to always make sure that the education provided responds to the context of families and communities where Fe y Alegría is present.

Fe y Alegría works to uphold education as a human right and a public good and therefore, works with States to extend quality, inclusive education, especially for those who need it most. Thus, Fe y Alegría belongs to the public education system and in many countries has developed institutional agreements with national governments in order to provide educational and social services for the poor. In addition, Fe y Alegría encourages private initiatives aligned with its mission to support comprehensive quality educational services in marginalized areas.

At the national level, each Fe y Alegría office operates as an independent non-profit entity, with its own legal status and autonomy to develop programs and lines of action focused at the national level and to mobilize resources from public and private organizations in country or abroad. These national Fe y Alegría offices collaborate together to form an international federation in order to articulate common strategies and to ensure the cohesion of the movement at the regional and international levels.

12.4 Our Proposal: Popular Education

Popular Education is an ethical, political and pedagogical proposal that believes in the liberating and transformative power of education. It is a proposal that recognizes that education cannot be neutral, that is should be based on an ethical proposal, which also promotes the active participation of everyone involved in the education process, building relations of respect and accompaniment.

What Fe y Alegría understands by Popular Education is a *historical and social process* which seeks to support persons and communities in their efforts to become conscious of their potential and their values, to make decisions in their own life and future and to realize their role as protagonists of their own development. This is done by means of genuine integration in the reality of excluded people and a permanent effort to comprehend the precise nature of their needs.

12.5   Our Education Programs

In order to respond more effectively to the multiple demands of its students and communities, Fe y Alegría's educational proposal has been articulated in a *wide variety of programs and services* in order to better response to the educational needs and possibilities of the poor population:

- *Formal Education* Networks of early education, primary and secondary schools, including vocational training centers; Special Education Programs and more recently also Higher education programs.
- *Radio Education and Distance Education* Radio institutes that offer formal basic and secondary education and skills training for youth and adults, and radio programming aimed at promoting civic education and participation.
- *Alternative and Non-Formal Education* Literacy programs in national languages and with an intercultural bilingual approach; Alternative education programs for children, youth and adults; Values-based education
- *Teacher Training* Country level professional development for teachers; international programs for teacher training and classroom management.
- *Social Services and Community Development* Programs to meet basic needs of health and nutrition; community development programming in urban marginal areas and rural indigenous communities. Involvement of local communities is one of the critical elements of the Fe y Alegría model, so the educational centers become a community developer.

12.6   Our Reach

With the recent integration of Madagascar in October 2015 and Italy in April 2016, the International Federation of Fe y Alegría—its International Coordination Office located in Bogotá, Colombia—is currently comprised of *21 member countries* from Latin America and the Caribbean, Europe and Africa. Fe y Alegría has also established presence in *two countries* (Guyana and the Democratic Republic of Congo), which are in the initial phases of implementing programs (Fig. 12.1).

Additionally, Fe y Alegría operates through formal and informal alliances in other countries, such as Cuba—the Conference of Bishops' Summer Course Program for Educators—and the United States—in partnership with Magis Americas for the "Friends of Fe y Alegría in the United States" initiative.

Fe y Alegría in 2014 established a record-high of *1,566,787 participants* in its programs worldwide. Furthermore, the number of overall centers grew from 2957 to 3228—another historic figure (Table 12.2).

After 60 years, Fe y Alegría continues to flourish, developing new innovative programs to walk in solidarity with the world's most marginalized populations.
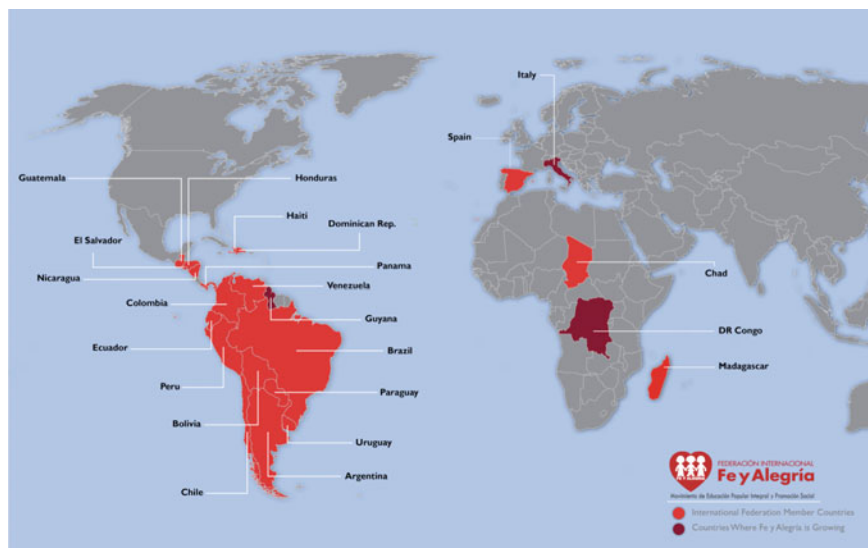
Fig. 12.1 The International Federation of Fe y Alegría. *Source* Fe y Alegría (2015b)

Table 12.2 2014 official International Federation Statistics

Country	Total students	Total centers
Argentina	5491	29
Bolivia	349,226	574
Brazil	20,796	57
Chad	7935	28
Chile	5454	21
Colombia	273,767	368
Dominican Republic	102,128	91
Ecuador	46,223	205
El Salvador	18,491	25
Guatemala	32,759	119
Haiti	5492	20
Honduras	19,365	44
Nicaragua	83,079	171
Panama	6573	54
Paraguay	22,239	317
Peru	213,779	265
Spain	2921	112
Uruguay	5173	47
Venezuela	345,896	681
Total	1,566,787	3228

Source Fe y Alegría (2015b)

[a]Fe y Alegría Madagascar was not a member of the International Federation of Fe y Alegría until October 2015 and as a result does not appear in these statistics

12.7   Initiatives to Face the Main Challenges of Education

Fe y Alegría identifies four main challenges for education from a global perspective: access to education; quality of education; disconnection of education with the real life and the needs of society and economy; and finally, lack of values and citizenship skills and capacities. Some of them are more relevant than others in different contexts, but all of them are present in the countries and the population Fe y Alegría is working with.

12.7.1   Access

Despite a huge increase in the rates of enrollment, several problems remain unsolved after 15 years from Dakar summit on education for all and the Millennium Development Goals, that committed to extend, at least, primary education to all the children in the world:

1. There are still around 60 million of children out of school. In many countries *access to primary education is still a major problem*, mainly in rural areas and in conflict zones.
2. We are far away from universal *Pre-primary and secondary education.*
3. *Specific groups* of population are still out-of-school and demand proactive policies with specific approach, because access to education requires more than availability:

   • Migrants, refugees and internally displaced persons, IDPs.
   • Indigenous communities.
   • Students with disabilities or other special needs.

Facing these challenges, Fe y Alegría response has emphasized some priorities, in particular:

• Moving to the educational frontiers (peripheries). Pope Francis is inviting all the church to move to the peripheries of the world, to the frontiers, to those places that are more in need because there human life is in risk. Fe y Alegría is trying to answer that call, and it is moving to new places in which education is not available yet:

  – New countries such as Haiti, Chad, Madagascar, RD Congo, or Guyana
  – New spots in the most marginalized areas: rural networks in Peru, Pan-Amazonia, new slums in the cities.

This invitation from the Pope should move each of us to a deep reflection and brave action. Catholic educational institutions are also called to question, review and ask ourselves, how, despite the huge number of initiatives that are already in place, can catholic education respond to Pope's call to go to the new peripheries?

- Exploring new ways to ease access to education to specific groups (like migrants, refugees and IDPs; indigenous communities; students with disabilities) such as:

  - Blended education: combining Radio and/or Information and communication technologies with in person education.
  - Increasing flexibility in schedules, classes, methodology…
  - "Going outside of the education center and looking for these groups, instead of waiting them to reach us.

- Advocating for political commitment for education and partnering with governments to reach universal education. Like in the Dominican Republic where the 4 % campaign has forced the government to double the public budget for education.

12.7.2 Quality

Nevertheless, in many countries universal primary education is almost achieved. In those places, a new challenge emerges: quality of education. It is not enough to expand education to all children, but we need to offer them a good quality education that may have a real impact on their life.

1. *More than 250 million students do not learn the basics at school. Low quality of learning* is one of the most relevant challenges, even for developed countries as PISA statistics show every year.
2. There are huge differences of quality within educational systems that reflect deep *inequality in education.*
3. Quality is understood and measured in a *very narrow sense*, as it is identified with academic results. This reduced understanding of quality excludes other dimensions of human being as the artistic, emotional, historic, spiritual or many others.
4. The lack of good quality education is caused by several aspects, but of some the most relevant for marginalized groups are:

   - Teacher that do not have enough preparation, with low motivation and very diminished social recognition.
   - Lack of basic material resources such as tables, chairs, blackboards, textbooks…
   - Curricula not suited to the context. In many colonized countries the official curricula is still very much influenced by the former metropolis tradition and is not enough shaped by local culture and reality. Besides, in most of the

countries the real needs and expectations of the socially excluded groups are not enough taken into account by a system that tends to prepare students for university.

– Pedagogical practices are still very traditional, memory-intensive and too much cognitive-oriented. All of them affect in a particular way to those students more disadvantaged.

Fe y Alegría considers the improvement of quality education as one of the top priorities, as we believe that poor students do not deserve a poor education, but the best one. In order to increase the quality of the education offered to our students we are working on different areas:

- Understanding quality education in a deeper, richer and more comprehensive sense, including all dimensions of human being. From that wider concept of quality, Fe y Alegría has developed its own Measuring and Improving Quality System. During the last 10 years, over 600 schools have gone through this system that includes four stages: initial assessment, improving plan, final assessment and "learning from experience". The system has obtained official recognition and it is being used by many public schools in different countries.
- Teacher empowerment. Teachers are the instrumental element to improve the quality of education. Fe y Alegría is working with them mainly in two aspects

  – Developing teachers training programs that include three basic dimensions: personal developing, pedagogical skills and knowledge, and socio-political understanding. The use of blended models for these programs is very effective and can be easily spread.
  – Caring and attending human dimension of teachers in order to raise their self-knowledge and steam and offer them basic tools for personal developing.

- Curricula locally adapted to the real needs of the populations. A particular mention has to be done to the intercultural and bilingual programs for indigenous communities.

One final insight from Fe y Alegría experience trying to improve the quality of education received by poor people: quantity and quality does not have to be a trade off. Instead of that, taking advantages of being a network is an intelligent way to develop new approaches and experiences to increase quality of education and an effective way to scale up the bests.

12.7.3 Dis-connection with the Real Life and Economy

In many places, even those students who succeed in the education system are not achieving the skills and knowledge needed for a better life in their communities and demanded by the local or national labor market. In particular, students from

marginalized areas are not receiving a relevant and significant education for their context.

Fe y Alegría is aware of this situation, and is trying to change it in different ways:

- Stressing the importance of locally rooted initiatives, in which the involvement of local community in the school life is critical. Parents can be a strong ally for an educational center.
- Developing non formal programs, both for current students in order to complete the education offered by the formal programs (art, sports, faith, community outreach, leadership…) and for young people early dropped out of the system.
- Promoting vocational and technical training programs that help young men and women to get a job or to be entrepreneurs in their local community. Some of these programs are using blended models combing online education (using a common online platform) and in person training. This training efforts are completed with different strategies to ease their access to a job, through pathways that connect education and labor market.

12.7.4 Values, Sustainability and Citizenship

Beyond the lack of access in some education systems; the low quality of the education offered to poor and marginalized communities and the disconnection between that education and the "real life", there is the question of what kind of human beings are the education systems forming: What is the concept of person that is beneath our educational proposals? What values are we promoting in our students? These are basic questions that each educative project should answer itself. For Fe y Alegría, there are two additional concerns particularly relevant in the current situation: Are we educating students to be sustainable citizens? And, are we educating the future change-makers or just preparing youth to be integrated in "the system"?

Promoting critical thinking in students may be a basic tool for their future commitment with creation and the others. Also leadership programs (such as the "youth solidarity network" or "skills for life") can prepare student to become the future leaders that may change their communities and promote sustainability in their local context.

Education is facing critical challenges in this historic moment. Nevertheless, it is widely accepted as the most powerful tool to change the life of people and to promote social justice and ecological sustainability in our world. In Fe y Alegría we have experienced that with good education, every kid may become a future change maker. Let's give them the chance.

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Chapter 13
A Bright Start for Every Child Education in Rural China

Lu Mai

Abstract China has made tremendous progress in poverty alleviation through development. The government is increasing input into and reforming policies of child development by including these policies in its national poverty reduction strategy and in its 13th Five-Year Plan (from 2016 to 2020). To achieve further progress, the China Government is interacting and cooperating with social institutions and non-governmental organizations to explore a new path for child development specific to China. The aim is to ensure equal opportunities for all children and to help them realize their dreams.

With this view of social equity, the China Development Research Foundation (CDRF), a non-governmental organization, conducts both policy research in child development and innovation in public welfare. The CDRF builds bridges between and among government, private enterprises, research institutes, the media, and the public. It adapts interventions along the life-course, from parenting programs, to non-formal preschool education to expansion of national school nutrition improvement and monitoring, and to strengthening of youth's technical vocational skills in poverty stricken areas. The CDRF seeks to elevate knowledge and experiences gained from evaluations to national policy and then to promote and scale up these policies nationwide.

In the quest to shape a global agenda for sustainable development beyond 2015, the global community embarked on an unprecedented, broad, and inclusive consultation leading to the United Nations (UN) synthesis report, The Road to Dignity by 2030 (UN 2014). This report provided the framework for Transforming Our World: The 2030 Agenda for Sustainable Development (UN 2015). The Vatican workshop on Children and Sustainable Development, held in November 2015, focused on the central piece of sustainable development, the role of education, and

L. Mai (✉)
China Development Research Foundation, CDRF, Beijing, China
e-mail: lumai@cdrf.org.cn

159

the organizers of this workshop embraced a laudable goal: "to build, through education, an inclusive society in which all people can have the resources to develop a life project in harmony with their culture and beliefs, transcultural universal values and respect for the environment."

Childhood makes us human. Our earliest experiences, beginning at conception, shape our brain and biological functions for life. Early human development is the foundation for a country's economic development and, ultimately, its human development. Together, our task is to close the gap between rich and poor and ensure that future generations have the capacity to create democratic, pluralistic, and prosperous societies.

This paper describes China's policy and action on education for disadvantaged groups, starting in early childhood. It specifically addresses programs that the China Development Research Foundation (CDRF) has undertaken to leverage translation of policy into action to level the "playing field" for rural children living in poverty.

13.1   Context

Poverty and other deprivations, such as insufficient nurturing and care or limited social interaction and stimulation, have devastating, lifelong effects on young children. Neglect in children's early years is particularly potent and is often manifested as a lack of attachment between children and their parents or caregivers. In our ever-changing and increasingly mobile world, families are being torn apart by conflict, natural disasters, migration, and emigration—all of which take a toll on children's health and development not only in the short term, but also over a lifetime. China offers a prime example, for over the past 30 years; it has experienced the largest rural-to-urban migration in human history—a migration that has resulted in 61 million children left behind in rural areas under the care of persons other than their parents.

The UN's launch of Millennium Development Goals (MDGs) in 2000 accelerated the world's focus on children. Four goals (MDGs 2, 4, 5, and 6), respectively, were aimed at reducing child and maternal mortality and infectious diseases and promoting education. The knowledge base underpinning the emphasis on child survival rested on public health measures such as nutrition, sanitation, immunization, oral rehydration, micronutrient use, bed-nets, and prevention of human immunodeficiency virus (HIV) infection. The emphasis for education was based on access to schooling and provision of inputs. Yet, the latest research evidence calls for a broader and deeper strategy for children and a paradigm shift from children's survival and schooling to their full development and learning through comprehensive, integrated approaches that engage all social sectors—education, family and social protection, health, and nutrition.

The world community has embraced the importance of such investments in early child development (ECD) as a priority—to improve children's outcomes *and* to advance human development across societies. Calls for action come from many different venues. Multilateral donor agencies, such as the World Bank, the Inter-American Development Bank, and the Asian Development Bank, highlight ECD programs in their lending portfolios. The United Nations Children's Fund (UNICEF) focuses on health, nutrition, education, and child protection, as well as water and sanitation, as basic rights of children. In its Education for All initiative, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) advocates for ECD, developing learning outcome measures and monitoring ECD programs in countries. The World Health Organization (WHO) established guidelines for delivering health services at each developmental phase of childhood beginning during pregnancy. And, the United Nations Development Programme (UNDP) focused its Human Development Report 2014 on life-cycle vulnerabilities, beginning in infancy, and the need to promote human capability and protect the most vulnerable (UNDP 2014).

The year 2016 opens with unique opportunities for global leaders and policymakers in all countries to work together to end poverty and to transform the world by meeting the needs of its human populations and economic necessities while protecting the environment, ensuring peace, and realizing every person's human potential and dignity. In 2015, countries across all regions celebrated achievement of MDGs 2, 4, 5, and 6, which reduced child and maternal mortality and gained universal primary school enrollment. A major challenge for the world in the next 15 years is to assure the healthy, full development of all young children as a means to equitable, stable societies.

Progress toward reducing poverty has been remarkable, although uneven. More than 1 billion people have escaped extreme poverty since 1990 (Kharas 2015). The percentage living in extreme poverty has declined over two decades, from more than 40 % in 1990 to less than 20 % in 2010 (Chandy et al. 2015). China offers the most compelling example of the transformation of a society in a single generation. By lifting 439 million people out of poverty, China achieved a historical precedent. As recently noted, "What the world achieved in the space of 200 years, the reversal from fewer than one in five people living above $1.25 to fewer than one in five living below that threshold, China managed in little more than 20 years" (Chandy et al. 2015). Launching and pursuing the MDGs contributed to this progress and teach us how governments, business, and civil society can work together to achieve transformational breakthroughs.

Transformation is the key to unlocking human potential across societies. The UN Secretary-General has called on member states to continue the march of the MDGs and to use them as a "springboard" to lead and embrace change that leads to "a future free from poverty and built on human rights, equality, and sustainability." He goes on to say, "This is our duty and it must be the legacy we strive to leave for our children" (UN 2014).

13.2 Early Child Development Services and Challenges in China

China has long believed that its future lies with its children. Over the past 30 years, China has adopted a development path that is characteristically Chinese and suited to its unique conditions as the world's most populous country. China realized the MDGs ahead of schedule, lifting 439 million rural citizens out of poverty and sharply increasing its human development index. Infant mortality in China decreased from 50.3 infant deaths per 1000 live births in 1991 to 9.5 per 1000 in 2013 with an incidence of low birth weight of 2.44 % (National Bureau of Statistics 2013).

In education, China has fully established 9 years of compulsory education for urban and rural children and achieved a net primary school enrollment rate above 99 % for boys and girls. Compulsory education is guaranteed for nearly 14 million rural children who have moved to cities with their migrant-worker parents. Gross enrollment of 3- to 6-year old preschoolers has reached 67.5 %. And, through education and poverty alleviation policies, nearly 400,000 children with disabilities now have equal access to education (Yuan 2015).

Moreover, the government has increased the protection of children to allow more orphans to benefit from preferential policies in education and medical services by improving the basic living allowance standard for orphans, expanding the scope of assistance, and increasing the child welfare service system's coverage. The government also has improved laws and regulations to protect children by, for example, issuing and implementing The Action Plan for Fighting Human Trafficking (2013–2020); intensifying surveillance of domestic violence, school violence, and pornography; and severely punishing illegal activities against children.

The Chinese government is increasing input into and reforming policies of child development and is interacting and cooperating with social institutions and non-governmental organizations to explore a new path for child development specific to China. For example, China is including child development in its national poverty reduction strategy. And, in addition to two ongoing programs [the National Program for Women's Development (2011–2020) and the National Program for Child Development (2011–2020)], the government has formulated the National Child Development Plan (for 2014–2020) for Poverty-Stricken Areas to provide a full range of services and health and education interventions for children ages 0–15 years in 680 counties in contiguous poverty areas. These policies are evidence that poverty alleviation via human capital and ECD investments in health and education for poor and disadvantaged children are attracting increased attention in China. The aim is to ensure equal opportunities for all children and to help them realize their dreams.

Although China has made great achievements, it is still a developing country with a per capita gross domestic product (GDP) ranked at about no. 80 in the world. China has more than 200 million people living in contiguous poverty areas, about 70 million are in abject poverty, and more than 40 million are children. The country

continues to face many challenges, which include disparities among regions and between urban and rural areas, as well as rapid urbanization. More than 100 million children are affected by migration—36 million are migrants themselves, and more than 60 million are left behind when parents migrate for work. Most of the children come from or live in rural areas. In impoverished areas, the rate of stunting for children under age 5 is as high as 20 % and, for school-age children, 17 %. Survey data show that the rate of stunting for left-behind children is 2 % points higher than that for non-left-behind children (Du and Lu 2015).

Changing the fate and welfare of these children is a matter of equity and fairness. Just as transformation is the key to unlocking human potential, equity is the key to attaining sustainable human development. Equity is the cement that holds together the bricks to build a fair and prosperous society.

In its 13th Five-Year Plan (from 2016 to 2020), China has set a goal to lift its poor populations out of poverty by 2020. This plan builds on China's progress over the past three decades in pursuing a poverty-reduction strategy in impoverished areas. This strategy has three pillars:

- Poverty alleviation through *development*, initiated in 1986 to ease poverty by improving living and production conditions for farmers
- Poverty alleviation through *social security*, by creating a basic social security network that provides a minimum living allowance, establishes a rural cooperative medical service system, and provides free insurance
- Poverty alleviation focused on *child development*, to improve children's educational levels and empower them through compulsory education.

China has made tremendous progress in poverty alleviation through development, attracting wide attention from the international community. It has also made significant progress in poverty alleviation through social security, especially in the decade since 2003, winning heartfelt recognition from farmers. Poverty alleviation focused on child development has "taken off," but still needs to be specified further and elevated as a national strategy.

13.3 Assuring Children's Equitable Development: CDRF Action

Early child development is a powerful equalizer and the basis for a transformative framework of sustainable development centered on people. Indeed, "ensuring healthy lives, knowledge, and the inclusion of women and children" is one of six essential elements set forth in The Road to Dignity by 2030[1] to enable member states to deliver on the Sustainable Development Goals (SDGs). In the 2030 Agenda for Sustainable Development (UN 2015), early childhood development is

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[1]See UN (2014, pp. 20–22).

the common thread across 7 of the 17 SDGs: goal 1 (end poverty), goal 2 (end hunger), goal 3 (ensure healthy lives and promote well-being), goal 4 (promote lifelong learning opportunities for all), goal 5 (achieve gender equality and empower all women and girls), goal 6 (ensure available water and sanitation), and goal 10 (reduce inequality within and among countries). Goal 4 specifically emphasizes lifelong learning opportunities from early childhood development through primary and secondary schooling, including life skills and vocational education and training (UN 2015).

The global ECD community can do more and better. We believe that inequality is a disease that we need to fight at its roots, in early childhood, because it is during this formative period that intervention has been shown to be more effective, more efficient, and ultimately more humane. We do this by putting children first, working toward equality for all, focusing on rural poor, and caring about the life cycle of our youngest citizens to give them a better chance of having a fulfilling and prosperous life.

With this view of social equity, the CDRF, a non-governmental organization, is committed to both policy research in child development and innovation in public welfare. Commitment to China's poverty reduction and rural education is the cornerstone of the foundation. The CDRF builds bridges between and among government, private enterprises, research institutes, the media, and the public. The CDRF learns of and introduces pioneering concepts of ECD from China and elsewhere, adapting them locally, conducting social experiments, and constantly exploring measures of rural education and child development suitable for China's situation. In addition, the CDRF seeks to elevate knowledge and experiences gained from scientific evaluations to national policy and then to promote and scale up these policies nationwide. Once an ECD policy is established, the CDRF oversees its implementation and continually evaluates it to improve its efficiency and fairness.

Through these actions, the CDRF directly helps individuals and communities at the lowest 20 % of income and helps the government create better policies to meet the needs of this population.

13.4   ECD Interventions: CDRF Accomplishments

13.4.1   Five Examples of the Foundation's Accomplishments in ECD Interventions Are Described Below

13.4.1.1   Nutrition Improvement Program in Rural Schools

In 2007, the CDRF launched a pilot nutrition intervention at Du'An County (Guangxi Province) and Chong Li County (Hebei Province) to provide nutritious school lunches for students. Evaluation of the program demonstrated improvements

in students' height, weight, capacity for running, and lung capacity. The program was supported by the central government with a subsidy of RMB3 per student per day for rural children receiving compulsory education. The program has been scaled up to reach 32 million students in 680 counties (nationally designated as poverty-stricken) and is supported with an annual allocation of RMB16 billion from the central government. In November 2014, the central government raised the nutritional meal subsidy in pilot areas from RMB3 to RMB4 per student per day (Ministry of Education 2014).

In 2015, as entrusted by the National Student Nutrition Office, Ministry of Education, the CDRF established the "Transparency in School Feeding" platform (CDRF 2015) This data platform is designed to gather and share information on policy execution and, in a timely manner, to reflect the dining situation of rural students who receive compulsory education. The site serves to monitor local food purchases and prices, analyze nutrients in school meals, publicize policy measures to improve the nutritional status of students in impoverished areas, exchange related experiences, and establish a platform for nutrition and health education and for public donations.

As of November 2015, 10,000 schools in 100 pilot counties participated in this website, and by March 2016, all 680 poverty-stricken counties in China will be included. The website information is available to anyone. Policymakers, parents, donors, and the general public can access the site to find out what lunches were served to children in any of the schools that day and to obtain useful monitoring data in real time. This website is a proactive and efficient approach to reduce child poverty.

13.4.1.2 Village Early Education Center (VEEC) Project

The CDRF implemented the VEEC project to offer free preschool education to rural children ages 3–6 years. As of 2015, the CDRF was operating 798 centers in 12 counties in 8 provinces, with 800 preschool volunteer practitioners serving 20, 328 enrolled children. Regional governments at the provincial level have expanded the program. Based on a model used in Ledu, the Qinghai provincial government has expanded the VEEC project to 15 other counties, establishing 911 VEECs to reach more than 18,000 children. In 2014–2015, in Guizhou, the Tongren municipal government built more than 2060 VEECs to serve all villages and benefit 53,720 children. The next task is to promote the VEEC model for rural kindergarten as a national policy (Du and Lu 2015).

13.4.1.3 Ying Yang Bao (Nutrition Sachet) Program

The CDRF first piloted the Yin Yang Bao Program in Ledu County (Qinghai Province) and Xundian County (Yunnan Province) in 2009. The nutrition sachet, developed by the Chinese Center for Disease Control and Prevention (China CDC)

as a micronutrient food supplement, contains soy flour and nine trace elements (e.g., calcium, iron, zinc, vitamin A, vitamin D, folic acid) for infants. Evaluation of the program demonstrated gains in the infants' nutritional status (e.g., reduced stunting) and reduced anemia (National Health and Family Planning Commission 2014). The health sector [Ministry of Health] has expanded the program to more than 300 poverty-stricken counties, benefiting more than 1 million infants. As requested by the Ministry of Health, the CDRF will be assessing the program, with a goal of expanding it to all 680 poverty-stricken countries.

13.4.1.4 Parenting and Early Child Development Interventions

In 2014, the CDRF launched the China Rural Education and Child Health (ChinaREACH) project for infants and toddlers ages 0–3 years in Huachi County (Gansu Province). The project is an adaptation of a Jamaican curriculum that combines parenting skills and home visits conducted by trained ECD volunteers who visit families once a week. The aims are to enhance parenting skills and promote infants' healthy development. ChinaREACH is a randomized controlled trial, and outcomes will be tracked and evaluated. Another example is the Nurturing the Future, an experimental parenting project under way in Shangluo City (Shaanxi Province) and participating organizations include the National Health Family Planning Commission and several academic groups, which include the Center for Experimental Economics in Education, Shaanxi Normal University; the Center for Chinese Agricultural Policy, Chinese Academy of Sciences; and Stanford University in the USA.

13.4.1.5 Evaluation of Secondary Vocational Education

At the request of the Ministry of Education, the CDRF will evaluate China's Secondary Vocational Education program, which currently covers 19 million teenagers, 89 % of whom come from rural families. In 2014, the CDRF conducted a performance assessment of vocational education. The results showed that although the training is free, and therefore increased rural students' access to it, the quality of the program needs to be improved. Based on the assessment, the CDRF expects to start a pilot program, entitled "Win the Future," in two cities, to improve the quality of education in vocational schools. Equally important is the aim to improve students' self-esteem and mental well-being, as social skills are vital to future success in the job market.

These five examples of CDRF work reflect a comprehensive approach to infants and children that addresses their needs for nurturance, nutrition, stimulation, and education to help them realize their full potential over the life cycle. Through these endeavors, the CDRF is attempting to shift attention in rural child development

from only education to nutrition *and* education, with the understanding that it is difficult to properly educate a child who has a brain that is malnourished. In addition, the CDRF seeks to expand the focus in rural child education from only compulsory education of older children to stimulation and education of the youngest children, ages 0–6 years. China's rural education and poverty-reduction strategies must incorporate a holistic approach when attending to children—that is, start early, assure quality nutrition and education, foster cognitive and non-cognitive development, and promote equity and social well-being. Above all, the CDRF aims to help the most disadvantaged children realize their dreams along the life course "from womb to job".

13.5   Reaching More Children by 2020

To benefit more children in rural poor areas, in 2013, the CDRF proposed "Establishing a National Plan for Child Development in Poor Rural Areas," a policy recommendation based on evaluation findings. President Xi Jinping formally commented on the plan and, in 2014, nine ministries, including the Ministry of Education, drafted the National Plan for Child Development in Poverty-Stricken Areas (2014–2020), which was approved by the State Council on November 15, 2014. The overall goal of the national plan is to improve overall child development levels in poor contiguous areas up to or close to the national average by 2020 (Du and Lu 2015). Three specific goals are to:

- Protect maternal and infant security. As stated, the government shall reduce the maternal mortality rate to 30 per 100,000, the infant mortality rate to 12 %, and the mortality rate of children under age 5–15 % and shall remarkably improve the quality of newborns.
- Protect child health. As stated, the government shall reduce the rate of stunting among children under age 5 to below 10 %, the rate of underweight children to below 5 %, and the rate of anemia to below 12 %. The government shall raise and maintain the vaccination rate of children in villages and towns to above 90 %, improve the constitution of primary and middle school students to meet National Student Physical Health Standards, and improve the welfare and support system for children in need.
- Ensure children's access to education. As stated, the government shall strive to increase the gross enrollment rate for 3-year preschool education to 75 %, increase the graduation rate for compulsory education to 93 %, significantly improve the overall quality and balanced development of education, and increase the enrollment rate in compulsory education for children with visual, hearing, or mental disabilities to 90 %.

13.6 Government Policy: Linking Innovation to Action

Children in China are benefiting from having a proactive and attentive government and a flexible policymaking process. The examples of CDRF's actions and accomplishments described above indicate the government's responsiveness and desire for innovation. China has encouraged experimentation by creating a consultation, measurement, and evaluation structure that, in essence, acts as an "incubator" to fast-track successful pilot programs into policies.

The environment and structure within which the CDRF operates is triangular, with the central government, local governments, and rural populations forming three equilateral sides. Over time, the role of the CDRF has evolved from initially promoting policy research to facilitating the flow of information among the three points of this triangle. As facilitator, the CDRF can ensure that innovation, wherever it starts at any point in the triangle or at CDRF itself, is quickly identified, leveraged, and made into policy for the benefit of China's poor populations. This system is unique to China and holds much promise for the future.

The successful ventures that the CDRF has launched and that the government has scaled up clearly show that with the nation's antipoverty strategy and policies, the intellectual output of Chinese researchers, the strong local government capacity, and the warm support from rural parents, China's rural child development model is not only entirely practical, but also very effective.

13.7 Lessons Learned

Of course, many lessons have been learned in seeking to ensure equitable development of all children in China, particularly those who are poor and disadvantaged, who often live in remote and poverty-stricken rural areas. China is embracing these lessons as they arise. Four main ones, which may have applicability elsewhere, are as follows.

1. *Adapt global knowledge locally*. We, the ECD community, need to pool our global knowledge of and experiences with ECD. There have been numerous theoretical and practical explorations in child development, and the fruits of these research projects need to be utilized. But, their results must be adapted innovatively to local situations, rather than importing and implementing them directly.

2. *Government leadership, policy, and action are essential*. We must interact and work with government to explore and support promising ECD research and practices. Experimental projects in child development simply cannot be undertaken without support from central and local governments. Transforming the experimental findings into national policy is not possible without government's support and financial resources. The role of government is crucial. Philanthropy by itself can help thousands or maybe hundreds of thousands, but

only government policy can truly change the lives of tens or even hundreds of millions of people in China.

3. *Meet community needs and assure quality*. Measures must be simple, services accessible, costs economical, and quality assured. China is still a developing nation, and there is a large population of children in rural poor areas who require many services. Organizers and administrators of child development programs need to respect communities' current level of development. That is, the costs of personnel and facilities need to be affordable and cost-effective, operations should be easy and quick to carry out, and quality must be assured.

4. *Realize the responsibility of all stakeholders*. Child development is not only the state's responsibility, but also the responsibility of society, families, and individuals. All stakeholders must be engaged to ensure success. The success of CDRF projects depends on the participation and collaboration of government, corporations, social organizations, families, and media, all of whom contribute to child development in poor rural areas and help create an atmosphere conducive to the healthy development of children. For example, the CDRF has received corporate and individual donations totaling approximately US$3 million each year for the past 3 years for the five projects described above.

13.8   Conclusion

Child development and education are entering a critical historic moment. For the first time, early child development is on the global development agenda, presented as an essential and integral component in "Transforming Our World: The 2030 Agenda for Sustainable Development." Education is the foremost objective and content and is most realized as a transformative force for humanity and dignity. What we need now and more than ever is caring and far-sighted policy that is built on innovation and exploration of ways that assure human development beginning at birth and even before.

We have now a convergence of evidence from developmental neuroscience, developmental psychology, and the economics of human capital formation which points to the importance of children's early years and their effects on health, learning, and behavior throughout the life course. We are guided by renowned economists James Heckman, Amartya Sen, Joseph Stiglitz, and Jeffrey Sachs who are all actively involved in guiding the work in child development in rural China. They know well that by investing in a child, we could change his or her fate. By investing in a generation, we could change a nation's future and that of the entire world for generations to come. Now is the time to work together to ensure that every child gets a bright start so that all children may realize their dreams and create a more equal world!

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Chapter 14
AmritaRITE: A Holistic Model for Inclusive Education in Rural India

**Prema Nedungadi, Raghu Raman, Radhika Menon
and Karunya Mulki**

Abstract India has made good progress in many of the Millennium Development Goals but a dismal number of children in remote and rural India continue to drop out of school or perform poorly in reading, arithmetic and sciences. Our model for Inclusive Education, called Amrita Rural India Tablet enhanced Education (AmritaRITE, 2016) is inspired and guided by the principle of providing both 'Education for a Living' and 'Education for Life' skills. AmritaRITE integrates traditional school educational goals with awareness regarding moral, scientific, technological, ecological, and social issues. The curriculum includes such topics as health and nutrition, moral values, technology skills, gender equality, child labor and trafficking awareness as well as respect for each other and for Mother Nature to ensure the holistic growth of the child. To achieve these goals, our program utilizes sophisticated multilingual mobile learning aids that are adapted for rural areas to work with low-bandwidth Internet. The methodology evolved through our experiences working in 41 remote villages in 21 diverse states of India over a period of two years; thus, the AmritaRITE program was designed for adaptability to individual community circumstances. School systems and NGOs can incorporate key elements of AmritaRITE's holistic curriculum, models for community involvement, teacher training and e-learning technology to achieve quality and inclusive education in both village and urban environments.

14.1 Introduction

Tomorrow's world will be shaped by today's children. In their tender minds, it is easy to cultivate universal human values. If you walk through a field of soft, green grass a few

P. Nedungadi (✉) · R. Menon · K. Mulki
Amrita Center for Research in Advanced Technologies for Education, AmritaCREATE,
Amrita University, Kollam, India
e-mail: ammasprema@gmail.com

R. Raman
Amrita School of Business, Amrita University, Coimbatore, India

times, you will quickly make a path, whereas, it takes countless trips to forge a trail on a rocky hillside. The teaching of universal spiritual principles and human values should be a standard part of general education.

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Sri Mata Amritanandamayi Devi (Amma),
Spiritual Leader, Humanitarian & Chancellor, Amrita University

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Educational levels play an important role in demonstrating the social, economic and cultural progress of a nation's overall development. In a developing country such as India, the majority of people still live in villages. However, rural India faces many limitations and drawbacks due to lack of awareness, education and literacy. Remote village schools face significant challenges that directly and indirectly influence the quality of education including proper classrooms, educational resources, and adequate teacher training, as well as lack of healthcare facilities, sanitation, toilets, and gender equality.

The inclusive policies of the Government of India, such as the Right to Education Act (2009), monetary incentives for girl children to delay marriage until after the age of eighteen, scholarships for children and free mid-day meals in schools have certainly benefitted schools where these policies have been implemented properly. A number of schools were built in such areas through Government of India initiatives such as Sarva Shiksha Abhiyan (2001) and Operation Blackboard, to supply the minimum facilities to primary schools. Such policies have been designed to increase access and equity, to bridge gender and social gaps and to include girls and other children at high risk of exclusion from education.

Enrollment in schools in India increased significantly after the Right to Education Act was implemented in 2009. Yet despite record enrolments and massive efforts by public and private sectors, the dropout rates remain high at 19.8 % by grade 5, 36.6 % by grade 8 and 47.4 % by grade 10 (MHRD 2014).

In addition, income inequality is strongly correlated with the difference in test-scores (Nickell 2004). The increasing gap between low-income children and those in high-end private schools, including differences in access to schools, quality teachers, and learning materials, contribute to the divide and the disparity. Schools attended by low-income children often lack adequate physical infrastructure, learning materials and trained teachers (Jha and Jhingran 2005; Mehrotra et al. 2005; Kremer et al. 2005).

A common characteristic of education in remote and rural India is the small school. About one third of the 1.25 million elementary schools, primarily in remote areas, have less than 50 children (Mehta 2010). Often, these small schools have only one to three teachers who must deal with teaching children in multiple grades. Small schools play an important role in reaching the last mile to bring high-quality education to rural India. With the right support, these schools have the potential to bring inclusive education to the most disadvantaged sections and provide genuine improvement in the educational and socio-economic wellbeing of future generations.

Clearly, current efforts by themselves are insufficient, and innovative approaches to teaching, teacher training, community involvement, and student motivation and retention are required. AmritaRITE is focused on strengthening education in remote areas for children who, historically, have been left out of the education system. AmritaRITE is partnering with the AmritaSeRVe village empowerment program (AmritaSeRVe 2016), a project of Embracing the World network of Charities (ETW 2016).

AmritaRITE strengthens, in an integrated manner, education, gender equality, health, values and self-esteem for children, youth and girls. We make the case that enabling Inclusive Education, if done in a holistic manner, has the potential to permanently uplift education levels in the villages and achieve many of the United Nations Sustainable Development Goals and can be replicated by other NGOs and school systems.

14.2 Challenges Specific to Remote and Rural Education

High attendance rates are related to improved academic performance among children from all backgrounds (Epstein and Sheldon 2002), and children in remote areas and disadvantaged communities are significantly more likely to have lower attendance (Govinda and Bandyopadhyay 2008). Thus these children tend to achieve lower levels of learning and are at higher risk of dropping out before completing primary school.

Factors correlated to poor attendance include parental level of education, family socioeconomic status, and availability of motivated teachers. The education level of parents and their socioeconomic status affect absenteeism (Dreze and Kingdon 2001). A majority of parents in these areas are farmers or unskilled laborers. Many are illiterate or semi-literate and do not have a clear perception regarding the long-term benefits of sending their children to school. This lack of interest translates to low attendance in school, which then leads to poor performance.

In addition, most rural schools, being quite small in size, have their own unique challenges including availability of qualified teachers. Absent teachers can mean that the school is closed, a circumstance that occurs disproportionately in poor and marginalized communities. Where this occurs, attendance is not a matter of choice for many children (Diwan 2012).

Additional reasons why children absent themselves from school are (a) assisting parents in agriculture (b) earning for their families (c) taking care of younger children (d) health problems due to malnutrition, poor sanitation and lack of access to medical care (e) lack of proper sanitary facilities for girls and (f) customs such as child marriage. This latter problem, which disproportionately affects girl children, originally arose as a means to protect girls.

Although ancient Indian tradition had a culture of respecting women and girls, the custom of child marriage came into practice during India's Mogul invasion in order to protect the girls from being kidnapped. Although the original cause for this

practice no longer exists, the custom continues in rural India in spite of the law against child marriage, thus further exacerbating this problem of education and equity for girl students.

In some villages, an additional community-based challenge includes substance abuse, which can lead to household violence, molestation, and diversion of income from needs of children, creating a home atmosphere that is not conducive to learning. The situation is worsened when children continue the substance cycle, learning the abuse by imitation. Alcohol and substance abuse during adolescence results in underdevelopment of the cognitive area of the brain and can result in severe psychological disorders, as well (De Bellis et al. 2000; Hambrecht and Häfner 1996).

All of these factors and more contribute to poor attendance and concomitant poor academic performance. Once children lag behind academically, they are unable to catch up with the school curriculum and eventually drop out during the primary stage (Pratham 2007; Pratichi 2009).

14.3 AmritaRITE Goals

The overall goal of AmritaRITE is to provide life-changing sustainable development to the disadvantaged and to eliminate the stigma of being illiterate or poorly educated. This holistic approach is designed to minimize community and familial challenges while optimizing motivational factors and educational opportunities. This is achieved through the following sub goals:

- *Enable Inclusive Education.* Focus on children, including girls, disadvantaged by factors such as socio-economy, geography, gender, caste and poverty. This includes motivating dropouts to return school with bridge courses and providing coaching for distance education schools such as the National Institute of Open Schooling (NIOS).
- *Provide Quality Education.* Strengthen primary education so that children successfully progress through grade levels and continue on to middle and high schools. Promote the transition students, based on their capability, to either higher education or to skill development certificate courses.
- *Enrich Education with Human Values.* Integrate values and social and gender awareness and nurture appreciation of local heritage and sustainability education.
- *Engage Community for Empowerment.* Encourage community involvement by mothers, children, girls and youth through Ambassador Programs that discourage the cycle of substance abuse and other activities.
- *Promote Health and Nutrition.* Promote awareness of and resources for nutrition, health and sanitation for the entire community, especially children and girls.

14.4   AmritaRITE Methodology

Children in remote villages with disadvantaged social and economic backgrounds need encouragement, support and good health to learn and stay in schools.

Amrita Education Centers work with low-achieving or out-of-school disadvantaged children directly in their village settings by using after-school tutoring for current students and bridge-courses for dropouts. To achieve these goals, our program utilizes sophisticated multilingual mobile learning aids that are adapted for rural areas to work with low-bandwidth Internet (Fig. 14.1).

In addition, we provide literacy training for adults, an offering which not only enhances overall literacy, but also tends to increase the likelihood that parents and other adults in the community will encourage village children to attend and succeed in school. The integrated model blends innovative tablet technology with time-tested traditional methods including academics, teacher training, computer education, health awareness, cultural and value education.

In order to refine intervention strategies tailored to the unique challenges of each geographical and target group in various regions of India, this innovative model assesses factors directly and indirectly related to academic achievement. The assessment process covers math, reading and writing in both regional language and English, and also includes questionnaires about health, sanitation, nutrition, substance abuse etc. to assess awareness and the prevalence of positive and negative habits. The results then guide development of both educational strategies and community-wide reforms that support not only specific educational goals but also overall village health and wellbeing.

Fig. 14.1 Children in a tribal village in Kerala discovering the joy of learning through tablets

Fig. 14.2 Holistic and integrated model
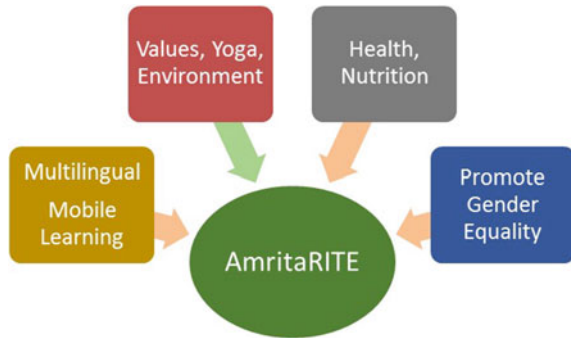
Thus, AmritaRITE attempts to apply a holistic approach at multiple levels, considering the whole child and the whole village with compassion, including an understanding of resources and constraints needed to bring a positive change (Fig. 14.2).

14.4.1 Inclusivity

The United Nations Educational Scientific and Cultural Organization (UNESCO) views inclusive education in terms of including traditionally excluded or marginalized groups or making the invisible visible. The most marginalized groups are often invisible in society: disabled children, girls, children in remote rural and indigenous communities and the very poor. The parent NGO, Mata Amritanandamayi Math has provided fifty one thousand scholarships to children (ETW 2016). Girls and tribal children are given special attention making the program more inclusive. Flexible learning hours accommodate children helping families during the harvest season.

AmritaRITE provides direct educational support to marginalized communities within and outside class hours. The program offers educational centers that partner with the local school in each village. Non-formal bridge courses allow children to get back to school. Furthermore, this integrated model connects school education with nutrition, health, moral values, technology initiatives, gender equality, and respect for each other and for Mother Nature to ensure the holistic growth of the child.

To provide an example of how this approach manifests, in the village of Kodur in the Medak district of Telengana, in Nov. 2015, AmritaRITE provided awareness classes on child marriage and alcohol abuse, two burning issues in these areas.

Ambassadors were chosen from among the village students and trained to disperse this awareness in their respective schools. They learned and presented a dance-drama embedded with videos and presentations on these awareness topics in three schools in the area (Fig. 14.3).

Fig. 14.3 Student Ambassadors from Kodur Village, Telengana spreading awareness against child marriage

Through this effort, the students gained awareness, moral strength, self-confidence, and self-respect, as well as the respect of their peers in their respective school communities, thus contributing to their holistic growth. Later in 2016, two students from this marginalized village eventually scored highest in their respective schools for the 10th grade exams with a GPA of 9.2 each.

14.4.2 Multilingual Mobile Learning

Our findings show that tablet technologies, customized to be culturally appropriate and in regional languages, are effective for rural areas that lack computer labs, electricity and Internet. Children express great curiosity and interest in tables and thus are highly motivated to attend class, which fosters faster learning (Nedungadi et al. 2014). AmritaRITE tablets provide technology-aided instruction in nine Indian languages. Children are grouped into different levels based on assessment scores in mathematics, regional language reading and writing, and English reading and writing abilities (Fig. 14.4). Differentiated instruction in small groups is provided to accommodate the needs of diverse learners. As noted, the centers also provide support to children who have dropped out and to adults in need of literacy and education.

In addition to being multilingual and able to be used for a variety of different class subjects, AmritaRITE tablets are especially adapted for rural India and can work in the absence of consistent Internet or electricity.

Fig. 14.4 Multilingual Tablet Apps (AmritaRITE 2016)

Because the tablet lessons are engaging (e.g., colorful visuals with audio, interactive and customized self-reinforcing capabilities), children and adults show increased interest and motivation. They can learn spatial awareness, matching, left-to-right tracking, phonics and letters, and can also move letters around to/from words and find words in stories; all before they can even hold a pencil or piece of chalk. When we watch young children learning on tablet, the quickness of their understanding is almost like magic. Previously, such learning environments have not been available due the lack of computers, dependable electricity, Internet and availability of multilingual and culturally appropriate content. However, these tablets work with low Internet and electricity connectivity. Lightweight software has also been deployed, making it easily loadable on low-cost tablets. This model can be used in all developing countries, as well as adapted for urban areas.

14.4.3 Schooling and Teacher Training

Teacher training is a key aspect of the AmritaRITE program. Teachers are trained on Information and Communications Technology (ICT) as well as curricular subjects and are coached to offer quality education to children. Teachers are recruited from the villages in order to be able to better understand and deal with the cultural and linguistic diversity. As the classes are multi-grade, training is provided on Classroom Management, Differentiated and Hands-On Learning and Activity Based Learning. Tablets and Hands-on learning materials are provided as part of our teacher-training process (Fig. 14.5).

Fig. 14.5 Teacher training at Amrita University, Kerala—Village teachers being trained to use Tablet Technology and Hands-On Teaching Aids in rural instruction

14.4.4 Awareness and Value-Based Education

Imbibing universal human values are an integral part of developing the whole child as they develop a large part of their character in the primary years. Value-based education in the form of traditional and cultural sensitivity is offered in order to preserve the indigenous communities and cultures of rural India. Universal values and respect for all beings are also inculcated. Awareness education is provided to both children and adults to sensitize them regarding issues of child labour, gender inequality and child marriage.

In November 2015, for example, awareness classes about mobile and internet safety and how these are connected to child labor and trafficking was conducted the tribal village of Komalikkudi, Idukki, in the local Bison Valley School, where the high-school student population is close to 200 (Fig. 14.6). As the classes unfolded, we heard real-life stories of student experiences on these topics, which were an eye-opener to their peers, as well as to us, about the intensity and widespread prevalence of the problem. After the awareness education, children and parents felt they would be more alert to the problem and able to protect themselves.

14.4.5 Getting Girls Back to Education

Often girls, due to various outcomes of gender bias such as child marriage and social customs that prevent travel beyond village boundaries, have historically been unable to continue their studies. Dagara, in Gujarat, for example, has only one village school that runs up to Class 8. Girls from Dagara are not allowed to go to neighboring villages for secondary education. Many girls who wanted to study were not given the opportunity to do so. AmritaRITE first tried to convince the community to send their daughters to the high school in another village by offering transportation but it was difficult to convince the village heads so we sought additional strategies.

Our team found that there was only one young woman in the history of the village who had studied beyond grade 8 and completed high school. She did this by moving to another village and staying with her relatives. She was mentored by

Fig. 14.6 Human trafficking awareness for village girls using 'Smart Decisions', the Amrita Trafficking Awareness App

AmritaRITE and hired as a teacher to tutor the girls. Subsequently, a door-to-door campaign with the families and young women inspired some of them to restart their schooling. This teacher then taught 5 h each day for a complete year with the goal of preparing the girls to pass the State-administered Grade 10 exam (Fig. 14.7). Though thirteen girls expressed an interest, seven girls enrolled in the program initially, and one new girl joined after 6 months. All of the initial seven passed the Class 10 state exam with more than 60 % marks. One young woman, who had a 2-year old child and was resuming education after 8 years, scored 88.8 %.

14.4.6 Participatory Learning: Integrating Health, Social Equality and Sustainability Education

Awareness of health, substance abuse, sanitation, social welfare, gender equality, and sustainability is a key determinant in the empowerment of the community and in success in education. Participatory learning activities dealing with these topics are promoted on Sundays.

The first Sunday of the month is dedicated to parent meetings where the academic progress and attendance of the children is discussed. Following these meetings is an awareness class for parents during which videos and software are displayed using tablets. Topics such as value of education, keeping children in school, equal education access for girl children, need for proper nutrition and other relevant topics are discussed. During these classes, their children present mimes, skits, dances or speeches related to these themes. Often the idea of seeing their children perform is an incentive for parents to attend these meetings.

Fig. 14.7 Recognition for the Dagara girls who cleared grade 10

The second Sunday of the month is earmarked for honoring women in the village (Fig. 14.8). In some states, gender inequality is a major problem with high gender discrimination against girl children. In such villages, a new non-intrusive custom was introduced among the children, where they garland and honor an elder woman of the village.

There has been a gradual change in attitude to women especially among the younger generation with young men joining the group. This change in mindset is important for empowering girls and encouraging parents to promote higher education.

The third Sunday of each month, called the "Nutrition Sunday," focuses on the fundamentals of nutrition and practical ways to enhance it. The importance of nutrition and diseases caused by malnutrition are also covered. A study in Gujarat showed that anemia in adolescent schoolgirls affected cognition (Sen and Kanani 2006). In Bangladesh, a study found that iodine deficiency in children affected reading and cognitive functions (Huda et al. 1999). In addition, children set up or maintain kitchen gardens, help others with their gardens, and harvest their vegetables. The garden is their lab and auxiliary education covers climate change, protecting nature, the plant cycle, water cycle, organic farming, composting, and waste.

Fig. 14.8 Promoting respect for women: students honoring an elderly woman in the village of Harirampura, Rajasthan

Fig. 14.9 Green and clean initiatives

Every fourth Sunday is "Clean Sunday," when students participate in cleaning, composting and recycling activities. The entire village community is trained in solid waste management and best practices for sustainable environment (Fig. 14.9).

14.5   Discussion and Conclusion

The AmritaRITE program is active in 41 rural and remote villages in 21 Indian States and will be scaled to over 120 villages. Tablet technology that has been adapted for rural India is a transformational resource for areas where both quality teachers and learning materials are scarce. The effectiveness of this technology has been demonstrated in controlled studies where students were able to master the Malayalam alphabet in only 16 sessions with AmritaRITE v.s. 30 sessions with conventional learning (Nedungadi et al. 2014). Awareness about the value of education also plays a key role and has helped reduce dropouts, as was demonstrated, for example, at the Ransai village in Maharashtra, where the dropout rate fell from 16 to 1 as a result of AmritaRITE interventions.

The integrated approach provides both Education for Life and Education for Living to children, adolescents, girls, and mothers in indigenous tribal communities and those below the poverty line. A key benefit of AmritRITE learning centers is the non-formal but structured support and mentoring to both communities and schools in providing wholesome education to children and youth. We find that local community members are better suited to tutor in the centers as they are easily accepted by the community and better understand the cultural context. Pre-service and ongoing teacher training along with mobile technology help provide quality education.

Policy implications include use of improved models and enforcement for monitoring teacher attendance and performance in rural areas with community participation. Mobile tablets with relevant content conveyed in local languages should be provided to schools that cannot have computer labs and their usage should be monitored. While the government already offers provisions for free lunch in schools, the quality and availability of these should also be monitored. Health checkups and awareness campaigns may be integrated to the school systems. India's ancient value system of revering Mother Nature and all of creation may be reinforced in school education through real life examples and legends. Sustainability, moral values, health and hygiene and gender equality education can be enhanced with participatory learning practices. Adolescent boys and girls, being the most educated in semi-literate remote and rural communities, can be mentored to be ambassadors to bring positive change in the school and in their village communities.

The AmritaRITE model can be scaled to nearby clusters of villages and is replicable worldwide. The model is sustainable as local community members are trained and engaged, thereby encouraging ownership and self-reliance.

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Chapter 15
The Assumpta Science Center Ofekata—Owerri (ASCO): An Initiative of International University Cooperation with Africa in Informal Science Learning Activities for Sustainable Development

Tobechi E. Anyadike

Abstract This contribution presents the Assumpta Science Center Ofekata—Owerri (ASCO) Initiative and its works as little efforts to enhance science education in Africa and elsewhere through informal science learning activities. The strong point of these activities is that they have students and young people, together with volunteer lecturers and experts from different parts of the world working in synergy with their African colleagues to realize them as principal protagonists. This is done under the guidance of the Pontifical Council for Culture, ASCO's patron Institution. Such contexts of concrete encounter with science and applying it in real life to solve real needs, provide important moments and channels of intercultural exchanges, interreligious and ecumenical dialogue and the all-important dialogue of life between science and faith. The work comments on the recent Pope Francis' Encyclical letter '*Laudato Si*' and science education. It shows how ASCO uses science to create ecological awareness among young people and local communities through for instance, its Clean and Green Enlightenment Campaign in Nigeria. This responds to the appeals of Pope Francis. The presentation will also show some evaluations of the initiative, its constraints and challenges and the socio-cultural context of its interventions.

T.E. Anyadike (✉)
Assumpta Science Center Ofekata—Owerri (ASCO) Initiative for Africa,
Owerri, Nigeria
e-mail: tiaen@yahoo.com

T.E. Anyadike
Under the Pontifical Council for Culture, Vatican City, Italy

T.E. Anyadike
School of Aerospace Engineering, Sapienza University of Rome, Rome, Italy

15.1 Laudato Si and Science Education

We thank the organizers of the workshop, for inviting us to participate and present our Assumpta Science Center Ofekata—Owerri (ASCO) Initiative of International University cooperation with Africa in Informal Science Learning Activities for sustainable development. It is commendable that the organizers of the workshop have identified science education as the crucial field for responding to the twin challenges of sustaining a healthy environment and at the same time advancing sustainable scientific, technological and socio-economic development, as Pope Francis raises in his recent encyclical Laudato Si. In poor developing African or 3rd World nations, and with rapidly advancing innovations (Pope Francis 2015, LS no. 177), this double task of reducing environmental damage and at the same time stimulating sustainable science and technological development for sustainable development (Pope Francis 2015, LS no. 175) as the PAS President Prof. Werner Arber describes it in his introductory contributions, would be achieved through a holistic science and technology (ST) education. That is, an ST education that inculcates into young people (the future techno-science operators) both modern science and technology skills and the broader perspective and values for the care of the environment.

For the take-off of this kind of ST education that Pope Francis advocates, the best is to take to what the president of the Pontifical Council for Culture that is the patron institution of the ASCO initiative, His Eminence Cardinal Ravasi (2012), calls the *paedia* approach in education. That means, the approach of sowing the good seeds (Pope Francis 2015, LS no. 213) of the broader and healthier perspective early in young people, so that they grow exercising and developing it. This is also the ASCO guiding principle that determines its focus on young people. In view of the relevance of the recent Papal encyclical for our theme, we shall observe some of its points that call for response in science education.

15.1.1 Pope Francis Sets Science on Public Agenda

In the encyclical Laudato Si, Pope Francis uses science and scientific argumentation to buttress his message on present environmental problems (Pope Francis 2015, LS nos.7, 15, 17ff, 23). In this way, he uses science to give concrete relevance to religious and ethical teachings and values on these. By so doing, he sets science in society's public and private agenda. This helps a lot to establish significant place and role in today's society for modern science and technology. The efficiency of this gesture, should never be underrated. Experts in the communication of science often compare the model or communication apex of science to be achieved to be equivalent to the Pope campaigning and appealing for science in his general audience. Reasons adduced include the widest global reach of his audience and most importantly, the incredible role of religious elements in generating interest in

public communications of science (Anyadike 2006). Ludwig Wittgenstein has compared the efficiency of such religious elements in generating interest and attention to that of a bomb (Wittgenstein 1967). David F. Noble gives us a detailed elaboration of the role of these elements in providing motivation and interest in aerospace science, technology and exploration, (Noble 1999; Benedict XVI 2009, *Caritas in Veritatis*, nos. 29–31), while Gould (2002) tells us about their roles in creating curiosity and interest for science in general. Perhaps, without really intending it, the works of Carl Sagan in both, print and electronic media (radio and television), show us in practice the use of this technique. Now in Laudato Si, Pope Francis goes beyond just declaration for science in a general audience but appeals for it in his magisterial teaching (Pope Francis 2015, LS nos. 34, 42, 131,164–165). His stint with chemistry in his youth might explain this friendly gesture.

Prof. Werner Arber in his contribution 'Cultural Aspects of the Theory of Molecular Evolution', in one of PAS sessions like this in Arber (2003), has argued that such use of scientific knowledge to address immediate human needs and concerns to facilitate human life, apart from setting science on the public agenda, also makes science become cultural value. At the same time, it enriches and refines worldviews and cultural values themselves. This is important and very necessary nowadays, given the rise in religious extremism, terrorism and killings in the name of religion. While we sympathize with the entire French people for the terrorist attack in Paris the previous night, by religious extremists, the occurrence itself shows us the enormous work still to be done to entrench modern science and technology as cultural value in our society and use it to refine and enrich worldviews and cultural values themselves. They need to be purged of those elements that give birth to religious terrorism and violence. For this to happen, there is need for such continuous setting of science in the public agenda, even for the very progress of ST itself.

Bonincelli (2006) had maintained that "the intensity of scientific information flow and communication is directly proportional to the level of science and technological development in new breakthroughs and applications in a given society." This is why a PAS award to Pope Francis as a friend of science might be suggested.

15.1.2 Returns Science and Technology to the Real World and Society

In *Laudato Si*, Pope Francis also returns modern science and technology to the real world and society. He relinks ST to the dimensions and processes of real life situations of society and its culture where it is made to address real and concrete human needs (Pope Francis 2015, LS nos. 105–108, 110, 112, 116). This return re-injects interest, curiosity and motivation to ST field and the kick it gives to people.

Interest, attention and motivation are important ingredients and requirements for human understanding and also in science education. Curiosity drives scientific investigations (Arber 2012).

Carl Sagan argues in the National Research Council's 1998 book, Every Child a Scientist: Achieving Scientific Literacy for All, that "every student starts out as a scientist. Students are full of questions, ready to suggest possible answers to their questions. Unfortunately, most lose this curiosity as they progress through their science studies. In typical schools they do not see or practice science in any full sense" (Yager 2002). In 2003, Pierre Léna had informed us that the present challenge for an effective science education, is to generate and restore interest, curiosity, fascination and excitement for science which is diminishing among young people (Léna 2003).

The amount of efforts and resources further spent to recruit and retain students' and young people's interest into study and career in science and technology so as to sustain and push the borders of current marvelous achievements in the enterprise, speak volumes on how successful these efforts have paid, even in Africa.

15.1.2.1 Religious and Cultural Roots of Curiosity and Interest in Science and Technology

Human curiosity, interest and fascination in science and technology, ultimately have cultural and religious roots (cf. Habermas 2008). These are not reducible only to the laws of physics and chemistry, but transcend the quantitative categories of the sphere of mathematics and biology. David F. Noble, before he died, elaborately showed this fact with his work on how the religious motivations of the ascent of man are the motor of the marvelous advances in aerospace science, technology and exploration. In consonance with the teachings of Pope emeritus Benedict XVI in *Caritas in Veritatis*, Pope Francis shows us in *Lumen Fidei* and *Evangelii Gaudium*, how religious faith provides motivations that make it possible to make sacrifices required in scientific study and development.

> The gaze of science thus benefits from faith: faith encourages the scientist to remain constantly open to reality in all its inexhaustible richness. Faith awakens the critical sense by preventing research from being satisfied with its own formulae and helps it to realize that nature is always greater. By stimulating wonder before the profound mystery of creation, faith broadens the horizons of reason to shed greater light on the world which discloses itself to scientific investigation (Pope Francis 2013a) (cf. also Pope Francis 2013b).

Such human curiosity, interest and fascination for science and technology spring from that fundamental (for some mythical) dimension of our existence as human beings. Describing this dimension, Goldacre (2009) opines that science and technology hasn't got enough nor more time to consider and learn about it. It is dealt with in history, ethics, philosophy, aesthetics, poetry and most specifically in religious/moral classics and education.

This shows us the importance of broadening perspectives in science education, for one that exposes and familiarizes people in science, both with the methods proper to the experimental sciences, and those of other forms of understanding the non-quantitative dimensions of reality dealt with in other disciplines.

> Observation is the basis of science and preparing a description, like making an accurate drawing, helps to focus attention on an object or event. (But also) writing helps you to observe. (It) is necessary for precise description and is an aid to learning. (Barrass 2001)

Proper religious, moral and cultural formation and prayer life develop attitudes that help us observe. They include the attitudes or spiritual lifestyle of reflective and attentive life, moderation, simplicity, humility, truthfulness, charity and love, silence and listening, that Pope Francis recommends as helpful in ST education and activity (Pope Francis 2015, LS nos. 199–217, 222–227). Silence and listening help us to deeply appreciate the world, people, events, phenomena and processes in it. This helps us to grasp the depth and mystery in them. They help to develop capacity for self-questioning, wondering, observation and reflection in life (Pianniselli 2016). A lifestyle of constant noise and distractions helps less.

15.1.2.2   Youth Crisis

No one can deny the value and contributions of such attitudes and lifestyle that motivate and facilitate greater sacrifices of love and charity for the sustainability of the scientific enterprise. Yet, there are no concerted formal efforts to properly inculcate and develop them in science education. That's why there is the dysfunction and disconnect not only between science and the interest of young people today, but also in society and the environment. It is why we have science without conscience and technology without a soul. In fact, Pope Francis had earlier in 2013 during the World Youth Day in Brazil, affirmed that the crisis young people face today, is nourished by the predominance of the technocratic paradigm. That is, of the dictatorship of techno-scientific rationality and the blind market forces in which young people are trained, but conflictingly shut out from proper religious outlook and value judgments (Pope Francis 2013c, d).

Young people still feel in themselves, even in modern science and technology, hints and invitations to the reality of the transcendent. Before the mystery of the natural world, two urges surge in them. There is first, the kick to explore, study, analyze, understand and solve its challenges in order to master and use it for the exercise of our God given intellectual capacity in science and technology. But there wells up in them also, the inner appeal from it as God's gift to know and serve Him. Thence comes the ecological sensitivity and generous spirit still found in some young people, and their exercise of great symbolic creativity. The younger generations are therefore torn between the approaches, as human beings on the one hand, and on the other, those that the training in society's dominant paradigm hones in them which try to numb the former. Hence their ensuing crisis. The solution lies in reconciling these two approaches and attitudes in ST education. Young people

want science; they also want spirituality (Kresta 2013). They work to satisfy these, as exemplified in the ASCO initiative.

We need therefore to heed the call to accompany training in ST skills with an equally sound education in ethics, culture, religious faith and spirituality.

15.1.2.3 The Emperor Is Really Naked

Science and technology, like every other human activity, is froth with both human strengths, its limits and interests. The Pope's counsel therefrom, of the necessity for ST to recognize and maintain strong and close links to other domains of human endeavor is for its good (Pope Francis 2015, LS nos. 110, 143). We have been taught in thermodynamics to explain the paradoxical difference between a theoretical equation of a phenomenon and its real behavior to lie in missing out essential operative parameters in the former. Rigid solid materials might in their real behavior be far weaker than their theoretical projections. The consideration of the system's internal structure in terms of its global energy balance reveals this incongruence to derive basically from the internal energy fluctuations, imperfections, micro cracks, cavities and creeps of the solid structure itself. These link it to constant interactions within its environment. Though the system appears perfect, it shouldn't be forgotten that in reality the emperor is really naked. It is imperfect and still carries within its internal structures, the imperfections and links to its environment.

This is a good analogy of the abstract images of science and its prestige that blow the power of science as perfectly isolated in its ivory towers, completely removed from its human environment. In reality, ST still carries in its very existence and operation, internal structural links to the strengths and challenges of the real human world.

The corollary is that modern science and technology should drop its hubris (Gismondi 1997), and pretext of going it all alone with regard to resolving complex human problems. It should rather cultivate a dialogical openness to listen to, consider, complement and reconcile their specific contributions with the input and findings of other disciplines. In this way, they can fit in well in society and win the support of its populations who eventually bear the cost of scientific activities. Ziman (2000) explains this on how academic science can integrate itself into society.

The return to the real world, will return interest to the ST field. When science and scientific issues are in the real world and are used to solve practical problems of daily human life, they interest people. They are able to occupy the minds of people, attract and focus attention as important and worth studying and knowing (Goldacre 2009). Because here they are not immune to man's other dimensions and those deep inevitable questions about the meaning and purpose of our human existence to which Ben Goldacre refers (Pope Francis 2015, LS no. 160). Since science is shaping our world and impacting on society, the scientist, science educator, or communicator of science, must attract people, especially young people to science

by putting interest and motivation to it (Barrass 2001). But for the public understanding and engagement with science, 'we must always remember that scientific knowledge Is not received Impersonally as the product of disembodied expertise, but comes as part of life, amongst real people, with real Interests, in a real world' (Ziman 1992). That will entail sensitivity to science's historic, economic, social and ethical aspects and audience needs as full human beings in their whole dimensions.

15.2 Informal Science Learning in Science Centers

Many experts have dedicated lots of efforts and study on how to return science procedures and issues to their real life settings so as to generate in this way and bring back interest, attention and motivation into science education learning (Perrone 1994).

The current focus is to achieve a broadened perspective of science and science education through event-based science education programs for students and the general public, using not just formal classroom teaching, but also the informal strategies of Paulo Freire's popular and dialogical pedagogy (Servaes et al. 1996). These programs provide direct functional science experience—i.e. functional experience of science skills. They aim to enhance effective science learning by developing in the audience the ability to use science knowledge and skills in new situations, not just in the classroom or laboratories (Yager 2002). They focus on creating the proper contexts or cultural background—awareness of the history, philosophy and sociology of or behind given science theme or skills—that make students more interested and involved in learning and understanding them as well as able to apply the understanding gained in new situations (Yager 2002). Emphases are also placed on direct practical experience with students by the use of technology which also interests students, as well as group learning in which the teacher acts as facilitator or animator.

The ingredients and features of such effective science education programs and activities, are the turf of science centers. They design, produce and implement such effective science programs, new science education experiments, exhibits, shows and events, etc., in order to realize the broadened perspective of science education (Yager 2002).

The current trend is to achieve the mentioned broad-based science education, with the hands-on and minds-on event based informal science learning activities of science centers. They provide experiences that return science skills to their real life situations (ibid).

Such centers, and the ASCO initiative that uses them, are needed today to promote science education and growth in Africa.

Let us see how the initiative does this. Its provision of platform for international group experience in such activities in Africa outside one's domestic milieu, is very helpful in cultivating those proper virtues and lifestyle that favor care and protection for the environment. The experience in the African communitarian socio-cultural

milieu, for instance can help generate ideas for alternatives to the prevalent individualistic and consumerist lifestyle which harms the environment. It can mobilize the members of society to become ecological citizens, sensitive to issues that threaten the ecological equilibrium (Ogbeche 2015). (The example of Bill Gate's wife in Malawi Africa, on the issue of water, buttresses this point.)

15.3 So What Is the ASCO Initiative?

The Assumpta Science Center Ofekata—Owerri (ASCO) Initiative consists in the realization and running of science centers across Africa as para-scholastic organs of scientific and cultural exchanges to provide young people and the entire population with direct functional experience of science at work in their immediate everyday life. These science centers with their main branch in Ofekata—Owerri, Nigeria, under the patronage of the Pontifical Council for Culture, will have satellite units in other regions and countries in Africa. The science centers are meant to be formidable platforms of international university cooperation in informal science learning activities and academic exchanges meant to promote the development of ST culture and its dialogue with religious faith for sustainable development.

15.3.1 ASCO Objectives

ASCO science centers are meant to be engines of informal science learning activities that spread and promote science and technological education for ST culture's growth in Africa and other parts of the world. They provide didactic laboratories to support ST learning in academic institutions by adapting educational resources to local contexts and combining them with traditional ones. They use these to mobilize the people's participation in support of science and technological development so that the later will enable them use the continent's abundant resources to improve wellbeing. The centers also provide ongoing training and updating of ST teachers and students. For wider reach and deeper penetration of their activities, ASCO centers use mobile units to reach rural areas and people in other margins of society. They will also be equipped with their own research centers and laboratories.

One important goal is to use local cultural elements and contexts to bring ST nearer to the people's everyday experience, (bring ST to their door steps, as ASCO motto says), in other to challenge the widespread myth in Africa that ST is foreign. These will also be used to create those values that support investment in ST achievements.

The ASCO science centers are also meant to be platforms for volunteer international university cooperation and field experience in Africa, as well as platforms for exchange of know-how with partner institutions.

15.3.2   Target Audience

The target audience of the ASCO initiative are young people in and out of school. But they are also aimed at adults, the aged, stakeholders like government and traditional institutions, public and private organizations, voluntary agencies, religious bodies and in fact, the entire society. The focus on young people is important so as to ensure steady supply of young and rising scientists and gifted experts who will sustain advances in various ST fields and applications.

15.3.3   Who Are the Protagonists in ASCO?

The main actor in the ASCO initiative is the Association for the Assumpta Science Center Owerri (ASCO), a non-governmental and non-profit organization of university students, lecturers, young people and other volunteers from different parts of the world who work in collaboration with their African colleagues, under the patronage of the Pontifical Council for Culture (PCC). ASCO was formed in 2005 and its membership and referents are open to all parts of the world.

It is structured into the general assembly of ASCO member students, young people and other volunteers, the ASCO secretariat with the various departments led by the coordinator that run the ASCO day to day activities, the Scientific Committee of university professors and lecturers that proof the scientific content of its activities. These refer to the ASCO board and honor committee, the ASCO director, the Under-Secretary at the Pontifical Council for Culture that supervises ASCO activities and ultimately the Cardinal President of the Pontifical Council itself (Fig. 15.1). Students and young people from different parts of the world and in collaboration with their African colleagues come together in the name of ASCO to carry out the activities of the initiative, as principal protagonists. They play roles like working as science explainers and animators, science tour guides, teachers or researchers at the centers, as well as other administrative, management, communication, maintenance, production or exploratory duties. This affords them the opportunity to explain, digest or simplify scientific issues and concepts to religiously conscious and active lay audience (population) like the African ones. In this way, the protagonists will grow in their appreciation of the perspectives of both religious faith and modern science and technology, and the cultures of the continents. Such group learning and contextual awareness in the spirit of intellectual charity, will enable them to appreciate together their respective insights, knowledge, abilities, skills and limitations in modern science and technology. It also helps to learn to respect other forms of knowledge.

Most importantly, they will as well strike up bonds of fraternity and friendship among the younger generations, the future elites and experts of the world. This makes the ASCO initiative also a veritable instrument for peace and fraternity. Its engagement of young people and others with science and development work, helps
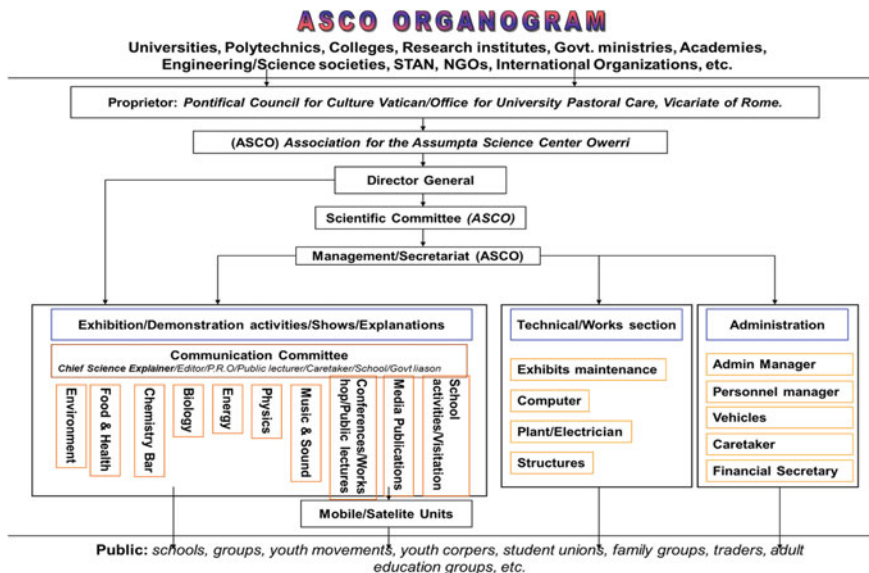
Fig. 15.1 ASCO organogram

to keep them busy and less available to be used as cannon fodders or agents for crimes, violence and wars.

This involvement of students and young people from different climes, is one of the most exciting thing in the ASCO initiative. Let us not forget that Pope Francis in his 1st Christmas Meeting with the university community in Rome, December 2013, had enjoined students and young people not to be mere spectators of life but to be protagonists and actively embark on big projects with gospel courage and fortitude to contribute in resolving current challenges. He has already given his blessing to the ASCO initiative. This international youth dimension also attracts other science centers, experts in the field and other interested people and partners to the ASCO initiative.

15.3.4   ASCO Origins

We could say that the ASCO initiative was launched by Pope emeritus Benedict XVI with his appeal at his meeting with the international university community during the events marking the 1st European-African Day for University Students. This was held at the Vatican in December 2005 and 11th March 2006. At this encounter, he appealed to students and the university community from different parts of the world to undertake concrete projects of scientific and cultural university cooperation with their African colleagues in the field of the dialogue between

science and religious faith, for evangelization and sustainable development. Pope Francis has reiterated the need for this *dialogue between science and faith* both in his encyclical letters Laudato Si and Lumen Fidei as well as in his post-synodal Exhortation Evangelii Gaudium as very decisive for sustainable development (Pope Francis 2013b, EG nos. 132–134;242, 257)

As pragmatic response to these papal invitations, the participant European and African University delegates to the December 2005 and March 2006 events, chose the ASCO initiative as the concrete initiative of international university cooperation with Africa in informal science learning and dialogue between science and faith, to put into practice the noble appeals. ASCO is therefore a living monument of these events.

The idea that inspired the initiative which was presented by the Pontifical Council for Culture, is the fruit of an Interdisciplinary doctoral thesis titled Science, Religion and Mass Media (2005) in Social Communications and Missiology at the Pontifical Gregorian University, Rome after a Masters Program in Science Communication at (SISSA), Trieste, Italy.

15.3.5   ASCO Current Activities

The ASCO science center initiative has already started functioning practically on the ground in Africa. This was after the initial training of young African (Nigerian) student members selected from various tertiary institutions in Nigeria, at partner science centers in Italy. First at the 'Immaginario Scientifico in Trieste' in 2007 and then the 'Città della Scienza in Naples' in 2008. There were also preparatory missions in the locality of Owerri, Imo State Nigeria that would house the main branch, by the ASCO (Italian) team with the partner Science Center IDIS Città della Scienza, Naples in 2008, for feasibility studies. ASCO kicked-off its activities with a successful International Science Festival in Owerri, Nigeria in April 2009, that was declared open by then Director of UNESCO in West Africa/Nigeria, Dr. Joseph Ngu from Cameroun, and then Imo State Government Commissioner for Education, Prof. Jude Njoku. The festival was realized with the support of several sponsors, especially Finmeccanica SpA.

At the moment, ASCO functions on a small scale from its temporary facilities at No. 160 Whetheral Road, Owerri, where it transferred since after the Scifest of April 2009.

As its core activities, ASCO uses modest hands-on and minds-on interactive science exhibits and other facilities from partner science centers, as well as volunteer students, lecturers, etc., to provide direct functional experience of science at work in everyday life. Demonstrations, participative events, shows, etc. are also used to awaken curiosity, interest and involvement of young people and local populations to participate in science. Some of the activities include:

- Training and exchange of students as science explainers together with their foreign colleagues, both in Nigeria and abroad.
- Hosting and Guide to visitors to the science center explaining the science contents of the interactive facilities.
- Visit to schools, outreach activity, especially to rural areas with a mobile unit, etc.
- Exchange and competition programs,
- General advocacy & sensitization activities, etc.

ASCO has also acquired a huge expanse of land for the permanent site of its main branch where it is meant to transfer in Ofekata suburb 18 km from Owerri city center, in South-eastern Nigeria. It needs funds to ensure infrastructural presence and transfer to this site as well as the development of its satellite units in other regions.

15.3.6 ASCO Actions in Ecological Education

15.3.6.1 Using Science to Raise Awareness

Today, modern science and technology help both to develop living standards and the wherewithal to defend against environmental dangers. The best way in which the populations of poor developing African or 3rd World nations could contribute in facing present ecological dangers is to be assisted to develop a modern science and technology with broader perspective and sensitivity to the human environment. That is, ST capacities that would empower them with the skills to employ by themselves, their abundant local resources to serve their needs, combat poverty as well as be able, to protect their environment which they understand best (Pope Francis 2015, LS nos. 93, 94). For instance, ST capacities that will help them develop and use less polluting forms of energy production like solar and wind energy whose sources abound in their environment. This requires a mechanism to give these local populations effective access to modern science and technology education with such broader perspective. This is what the ASCO initiative tries to provide by using science to raise awareness on environmental issues. By promoting understanding on the science involved in the issues, they help put them on the top agenda of public opinion (Pope Francis 2015, nos. 171–172).

15.3.6.2 Scientific Ignorance and Illiteracy Induce Collusion in Ecologically Unhealthy Actions

Scientific illiteracy and the globalizing power of the techno-economic paradigm that Pope Francis blames for the present ecological crisis, are nowadays combining to threaten the precious biodiversity lung and rich gene bank of our planet conserved in

the local ecology of developing African or 3rd world countries. The pressure from both forces are leading to disproportionate consumption of these natural resources. Culprits in this include first of all the local populations themselves who are induced into such acts for economic survival with money from the rich and powerful, but especially because of ignorance and scientific illiteracy. Certainly, bigger faults might be levied on the rich industrial nations who pollute the more with techno-industrial and economic activities, and consumerist lifestyle that cause ecological harm. But they also urge battle to combat the ignorance and scientific illiteracy that often make the majority of the local populations become accomplices with them.

The rabid search for raw materials has led the rich industrialized countries directly or through their multinationals and other powerful companies to operate in poor African countries in ways they would never attempt elsewhere in their home countries (Pope Francis 2015, LS no. 51). For economic survival and gains, local people are induced into tree logging, bush burning or forest fires and to abandon customary practices meant to keep a clean and healthy environment.

To add salt to injury, they are scandalously recommended as remedy to the looming environmental danger to cut their populations and birth rates. Or ridiculously proposed the so-called 'buying and selling of carbon credits' that is equivalent to selling their rights to use similar resources for their wellbeing.

15.3.6.3   The Butterfly Effect

The unjust proposals will exacerbate the damage as it is already being noticed across the globe. Things are connected. As M.I.T.'s Edward Lorenz's metaphor of butterfly effect tell us, an ecological damage to one zone might also produce effects on other zones (Greco 2013). The earth and its goods are common patrimony that belongs to us all. So also are modern science and technology used to exploit the latter.

For balance and fairness, reason demands that the contribution expected from these poor local populations in facing the ecological crisis, should be ones that build in them the capacity to survive and protect themselves and their environment from the crisis. It shouldn't be to debar them from socio-economic growth. This is why Cardinal P. Musengwo, Cardinal Archbishop of Kinshasa, Congo, speaking at an international conference in Rome organized by the Sant'Egidio movement to mark the Synod of Bishops on Africa in September 2009, had made an appeal to the rich industrialized nations of the world who pollute most. He urged that they should stop considering poor developing African or 3rd world countries only in terms of their natural resources, as full of raw materials. They should also see these nations as also full of grey matters (human brains). They should see the teeming population of young people, that promise great potentialities if properly trained, in tackling the present challenges of sustainable development. Investments should therefore be more in educating the youth and entire local population with the appropriate skills to use these abundant resources with care to their environment, not only in exporting them. This is what ASCO does.

15.3.6.4 Inculcating Habit of Caring for Ecological Impact of ST Activity

In its activities, ASCO tries to cultivate this care and sensitivity to the environment in the young people and its audience through various innovative ways. Apart from its trademark hands-on and minds-on interactive exhibits, these innovative ways include, narratives (stories), audiovisuals, films, photos, paintings and other traditional media. Most of all, it does this through providing the young people with occasions for direct contact and interaction with nature and ecosystem of the local environment. This exposes young people and the audience to explore and appreciate the rich biodiversity, resources and beautiful provisions in these local environments. The program can include for instance, an inventory of the rare species and resources in a given locality.

- The event is not finished until the environmentally harmful residues or effects are properly taken care of! This is a basic operational maxim inculcated and observed in each informal or formal science learning event or demonstration.
- Clean and green enlightenment campaign: ASCO also runs a clean and green awareness raising campaigns in schools, local communities and at the center during visits. This promotes clean lifestyle and farming choices. It also involves mobilizing young people and local communities to clean and organize their environments by for instance riding them of littered waterproof (synthetic) water sachets and other non-degradable materials for recycling or appropriate disposals.
- Tree and grass planting campaign: This campaign encourages less polluting and greater greenry attitudes and actions aimed at reducing the emission of greenhouse gases.
- Exhibits and demonstrations of the carbon cycle, etc.

When these activities of ecological education are put in the framework of the ASCO initiative's international university cooperation to promote best ST and ecological practices by young people and society, one better sees how they can stimulate creativity in seeking new ways and solutions with which to respond to current ecological crisis. For instance, how to handle erosion. They also stimulate individual and group initiatives to respond to such challenges (Pope Francis 2015, LS no. 177)

15.4 Evaluation of ASCO Initiative so Far

The ASCO initiative is succeeding in realizing its objectives of promoting sustainable science and technology development in Africa. The direct functional experience with science at work in daily life and demonstrations it provides with its

modest means, to awaken curiosity, interest and participation of the local populations in science and technology, are bringing positive results. This is to the benefit of many young people, students, teachers, etc., both in Africa and elsewhere.

It has helped minimize cases of dropping out of school or unfinished science courses and careers for most participants or people who have come into contact with it. Especially for the non-African participants, the initiative has, for example, supplied ideas, topics and materials for thesis, case studies and exercises, and the opportunities and experience of working with fellow Africans in the field in Africa. For many of the African participants, it has much more given them the opportunity to see, handle, experiment and interact with many of the principles, phenomena, processes, ideas, concepts or scientific reality encountered in their scientific studies, in their real life situations.

This is why the initiative has continued to attract the attention and interest of important public and private institutions, national and international agencies and mass media.

15.5   Constraints and Challenges

As an initiative of international university cooperation in which students and young people are chief protagonists, the high mobility in students' life is not without its difficulties. Many highly gifted student participants who during and after their trainings in the initiative have played key roles in it, will not be there forever. Soon after they graduate and leave for work elsewhere as their careers or professional calling leads them, they leave gaping holes, before new students are trained to replace them. Then there are also official bureaucracies and some political intrigues. Lack of funds, has not helped matters as student participants, especially the science explainers and others who play other roles in the life of the initiative need also to be supported financially with some stipends. When these are not regularly forthcoming, many abandon the initiative. We mentioned above how lack of funds is delaying the development of infrastructural presence and transfer of activities into the permanent site of ASCO's main branch in Ofekata—Owerri, Nigeria, as well as in its satellite units in other regions, which are the most pressing challenges currently facing the ASCO initiative.

This is why the Vatican Pontifical Council for Culture appeals to all people, individuals and organizations of good will, to come to the aid of the ASCO initiative to overcome these needs and challenges. This is so that the many expectations which the initiative has aroused in many people both in the local and international settings, may not be dashed.

15.6   Discussion

We would like to show the need and relevance of the ASCO initiative of international university cooperation in informal science learning activities in Africa and Third World countries, for the kind of broadened science education that Pope Francis calls for in LS for sustainable development. We approach this by discussing the socio-cultural context of such activities.

15.6.1   Religiosity of Developing African Populations

We had mentioned in passing the deep religiosity of the populations in developing African and 3rd world countries, especially sub-Saharan African ones. Pope emeritus Benedict XVI had dubbed them the religious and spiritual lungs of the world today (Benedict XVI 2011, AM no. 13). His successor Pope Francis, highlights the immense biodiversity of the continent that he terms them in Laudato Si, the biodiversity lungs and gene bank of the planet (Pope Francis 2015, LS nos. 38–40). A famous quip by the Cardinal Archbishop of Abuja—Nigeria, Cardinal John Onaiyekan formerly scheduled to participate in this workshop, regarding the African traditional oral culture, readily comes to mind here: "A dead African old man, is like a burnt library". Likewise, a burnt African forest/bush could be likened to a burnt gene bank. The continent thus houses rich gene banks for curing diseases (medicine), meeting other human needs (e.g. food), etc. (Pope Francis 2015) op. cit., no. 41) It also houses cultural remedies for the predominant technocratic or techno-economic paradigm that threatens the environment.

15.6.2   African Poverty

What readily comes to mind whenever Africa, especially sub-Saharan Africa is mentioned today and on which most mass media focus attention, is its scandalous endemic poverty in the midst of abundant human and natural resources. People in the continent are in most cases still subdued by challenges like famine, disease, corruption, wars, low life expectancy, etc. The World Bank's 2004 estimate terms Africa 'the world's main development challenge' (Moyo 2009). Perhaps for this, Pope Francis recommends in *LS* that while considering the current ecological crisis, the priority in such poor developing African or 3rd World nations should be to fight the abject poverty and promote the socio-economic development of their people. Though they should do so with appropriate precautions to avoid ecological disasters (Pope Francis 2015, LS no. 71). Such poverty situations create a cycle that stifles a population's critical capacity and creativity to respond to such challenges including the environmental ones, that aggravate. Poverty in the Western standards of

infrastructure and low income might be widespread in the rural areas. The urban areas in the continent however sprawl with a mixture of poor, middle class, high income people, including the mega-rich businessmen or politicians. The latter who might be wealthier than many rich people in the rich developed nations, exert big influences in career choices, rewards, and peer group/class recognition in the local communities (Servaes et al. 1996). Unfortunately, they have predominant love for foreign opulent and consumerist lifestyle, products and commercial wealth from importing goods and exporting raw resources. This reinforces an overwhelming dependence on foreign aid and foreign goods and services in almost every sector. It helps to instill a certain powerlessness instead of empowering the people to help themselves.

Reflecting on this poverty in the midst of abundant resources in the continent, Benedict XVI had averred in Africae Munus, that illiteracy (we would say scientific illiteracy) is one of the greatest obstacles to socio-economic and political development in Africa today (Benedict XVI 2011, AM no. 76). We say scientific illiteracy because of the big role of science and technology in development. It is its lack that leads to their marginalization in today's world and makes them unable to access and fully participate in current information, knowledge, important choices and decisions of the world as equal members of the international community (Benedict XVI 2011, AM no. 79). Science education and literacy of African populations, especially their young people, would therefore mean making them active members with full rights to contribute in the building up of the human society of today (op. cit., no. 76).

Caritas in Veritate wishes that greater international solidarity and aid to needy populations like those in Africa, should be in promoting greater access to science education. This should be not just only in terms of formal classroom teaching and vocational training (Benedict XVI 2009, CV no. 30; Cf Benedetto XVI 2008, *Gesu di Nazaret*; Cf Pope Francis 2013b, EG nos. 62–64).

> Charity in truth and the bond of fraternity therefore compel us to resolutely confront and eliminate the cause of underdevelopment and poverty in the continent by promoting science education and training for the development of modern science and technology capacity among the people. This is so that they could use these capacities and the resources that abound in the continent to help themselves (Cf. Benedict XVI 2009, CV no. 27)

In Africae Munus, Benedict XVI situates this call in the African setting. What Africa needs is a qualified and holistic education, an educational program that conjugates faith and reason, science and faith and transmits knowledge imbued with truth, a know-how and knowing how to live or be human, that is animated by a Christian conscience (Benedict XVI 2011, AM nos. 78, 128, 130). This will weave in the African society and cultivate in the population right from infancy an education in modern science and technology and in those human African values assumed by those of the Gospel of Christ that help and nourish development in science and technology (Benedict XVI 2011, AM, nos. 134–136).

That introduces us to the subject of the current state of science and technology and ST education in the African context.

15.6.3 Science and Technology Education in Africa

The persistent tendency is to wave-off things having to do with the Southern hemisphere like Africa as unscientific, the domain of culture and old folkloric treatment. Whereas things having to do with the industrialized or post-industrial societies in the Northern hemisphere are the domain of modern science and technology, meriting more scientific approach (Mezzana 1996). Some even take the continent for a ride that none of its sons and daughters has ever won a Nobel prize for work in this sector. Apparently because of difficulty to comprehend and follow the rigors of modern scientific and technological method. However deficient and wanting these views are, as we shall see, the truth is that Africa still lags behind in this important sector that is the engine of development today. It is not that the continent has not got very capable and performing sons and daughters in the field, both within and outside the shores of continent who have been contributing greatly to developments in the field, sung or unsung. They have not however, reached the critical mass such as to use science and technology (ST) to drive development and regenerate the continent. Like in most climes, modern science and technology is yet to effectively take root among its populations where it still lives an isolated formal existence hung in the ivory towers of academic institutions. It has not penetrated and been integrated into the socio-cultural fabric of everyday life in the continent.

15.6.3.1 Missionary Schools Provide First Contacts and Exposure to ST Culture

Initial contacts, exposure and interaction with modern ST have been had and are ongoing with scholastic institutions, and via ST products and gadgets with certain excitement and enthusiasm among the population for ST and ST gadgets. They have been apt to recognize in it, the value and potential its field offers as a means to improve and strengthen their daily life, work and wellbeing. But there is widespread unfamiliarity among the population of the ST behind the gadgets beyond what their young wards learn in scholastic institutions. As in most Third World societies, most of such institutions that provided the first exposure to and encounter with modern science and technology are missionary schools built by the Christian missionaries (Awa 1996), though most have later been taken-over by the state.

A former secretary to late Pope St. John Paul II, Archbishop Kabongo from Congo, and Rev. Fr. Charles De-Hemptinne, the 2nd son of Prof. De-Hemptinne of Belgium, tell the story of how the first study of nuclear physics/science in Africa was introduced by Jesuit missionaries from Belgium. They did so through a team of experts led by late Prof. De-Hemptinne at the then Catholic University of Congo Kinshasa. Here they also built the first ever nuclear reactor in Sub-Saharan Africa.

Today, much of such academic institutions are often overpopulated and insufficiently equipped to provide satisfactory exposure to and encounter with science. This partly explains the bewildering fact that the initial fascination for ST fast gives way to indifference, negative attitude of learned helplessness towards the field, or drowned by other trends like the unbridled pursuit of immediate commercial wealth (cf. Stuart and Bery 1996).

15.6.4 The Myth of Learned Helplessness of Black Africans in Alien Science and Technology

From the communications point of view, it is not just the superficial reasons hinted above, like inferiority or laziness on the part of the population that accounts for this failure to achieve the critical mass of the population that participate in the cultural skills of modern science and technology in the continent. The most important reason has to do with the socio-cultural context of presenting ST to the people. In these institutions and other occasions, the ST often presented in foreign language, is set in the socio-cultural context of foreign Western societies with little reference or no link to the immediate, local socio-cultural context with which the people could easily identify (Servaes et al. 1996).

The strategies and activities to cultivate and pass on the science and technology cultural skills are mainly that of textbook formal science learning with a didactic style and top-down vertical model (Fig. 15.2). The learner student community with their indigenous culture and cognitive frames are presumed empty in scientific knowledge about the subject matter. The teacher from the supposedly more scientific culture of foreign industrialized Western societies, possesses all the knowledge coded in these foreign contexts. The framework of rallying symbols,

Fig. 15.2 Vertical, top-down didactic model for science in overpopulated schools and textbooks
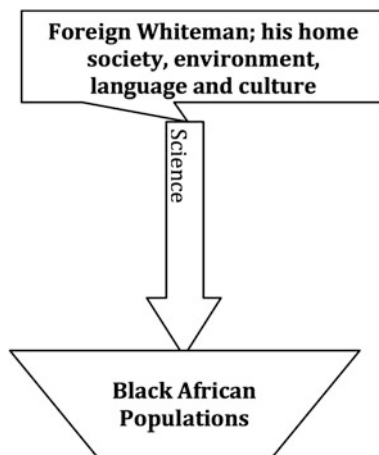
codes, and personalities with which the people legitimize their activities in the daily struggle for survival in their local contexts are brushed aside as unscientific and are not addressed in their lay man's language. Hence the difficulty in the immediate practical applicability of science learning contents in the local conditions (Mezzana 1996). An interaction and incorporation with the categories and concepts of the indigenous cultural knowledge system, of insights, beliefs and practices garnered through years of dealing with nature, could produce better results.

People tend to reject or ignore messages when they have nothing to do with their immediate expectations and needs, or when they are unable to connect its language, conventions and values as attuned to their own (Pradip 1996). This didactic style has therefore generated in the local populations who abandoned the sector to the foreign white people as their reserve, the prevalent repulsive myth and attitude of learned helplessness regarding the sector (Awa 1996). According to this fatalism, modern science and technology is alien, from foreign white people's culture and society. Black Africans are therefore inherently incapable of doing science productively. Associated with this is the myth that science is against religious faith. The constraints of the time and energy consuming daily struggle for survival in prevalent situation of poverty, would leave little or no room for the luxury and patience of pursuing science out of pure curiosity and completing formal ST careers in academic institutions (Awa 1996). This rhymed with the influences of colonization and neo-colonization that have already stimulated and developed taste for the importation of foreign Western goods and favored commerce of crops and services. The new elite, the cosmopolitan professionals—civil servants and urban experts often joined by expatriate contingents from the colonial countries—esteemed modern science and technology so high as to regard it as the only legitimate knowledge system. All other cultural perspectives were dismissed as primitive and inferior to it (Awa 1996). This ran into the hands of the neo-nationalists and reinforced the conception that modern science and technology is something of foreign Western culture, and that participation in it tantamount to abdication to the colonizing power, a supreme prize to pay. Populist and nationalistic trends emerged that employ the concepts of the preservation and promotion of indigenous cultural identity, values, norms and practices and self-reliance, to resist excessive external influence of foreign values and practices. With such arguments that legitimize the traditional status quo, the tendency is spread that resists modern science and technology education and activities as foreign Whiteman's magic.

On the margins of these institutions however, all kinds of indigenous and non-indigenous (mixed) pedagogical, production, organizational and communication systems, institutions, symbols, contents, forms and networks exist and maintain their influences. These informal sectors are employed by these populist nationalistic champions to spread the myths.

15.6.5   Scourges of Boko Haram and Similar Movements on Science and Technology Culture

The conveners of this auspicious workshop have noted among other things in the presentation, how progress in science education is slow, despite the efforts to promote it.

> In many countries, especially developed ones, anti-science movements arise questioning the ability of scientists to arrive at some truth about natural phenomena, showing a poor understanding of the nature of scientific reasoning and a lack of confidence in the scientific institutions which disseminate the results of research. In other countries, parents and maybe official agencies, basing themselves on religious principles, oppose scientific evidence to the detriment of children. In both cases the lack of understanding, by the general public, of the nature of science is evident: it has not been transmitted by a proper education pattern. (Pontifical Academy of Sciences 2015)

The menace of the Islamic terrorist Boko Haram sect in Nigeria and other parts of Africa that are paradoxically opposed to Western education and science and technological culture as evil though they use its knowledge and products, is symptomatic of this. Other alternatives, still intent on preserving the traditional cultural values, encourage the borrowing and use of elements from modern science and technology, to forge and develop local adaptations (including pseudo-scientific ones) which are claimed to be more conducive to the peculiarities of the local socio-cultural environment. We need not mention witchcraft and attempts to resurrect and re-populate popular imagination and thinking in Africa with the superstitious beliefs and practices of the primitive deities earlier checkmated by Christian evangelization. For instance, the divinization of the earth and nature, killing of twins, albinos, etc. Benedict XVI had noted in Africae Munus, that: "Witchcraft, which is based on the traditional religions, is currently experiencing a certain revival. Old fears are re-surfacing and creating paralyzing bonds of subjection. Anxiety over health, well-being, children, the climate, and protection from evil spirits at times lead people to have recourse to practices of traditional African religions that are incompatible with Christian teaching. The problem of "dual affiliation"—to Christianity and to the traditional African religions—remains a challenge. Through profound catechesis and inculturation, the Church in Africa needs to help people to discover the fullness of Gospel values" (Benedict XVI 2011, AM no. 93). Such practices recreate bonds of awe that cripple or prevent study, research and work in ST.

15.6.6   Argument of African Students in Diaspora: The African Child Is an Expert of His Local Environment

The most effective mobilizing principle for these extremist religious or cultural movements across national boundaries and societal contexts, consists in their

grass-roots bottom-up approach and ability to latch up popular slogans and expressions. These slogans, like 'boko haram', root their appeal to the local socio-cultural values of kinship and especially religion. These still influence life and practices in the society.

Majority of the local population follow the offers of these informal sectors predominantly for reasons of language and cultural affinity, values and inexpensiveness. Because of this, the myth of learned helplessness regarding ST has taken root among the population with the concomitant underestimation of its own capacity, loss of self-confidence and dependence on foreign aid when it comes to ST. The African university students in Rome, of the African University Service, ['Servizio Universitario Africano (SUA)'], Rome, regard this cultural inferiority complex and underestimation of their ability due to the alien socio-cultural context in which ST contents are set, as the crucial factor that causes African underdevelopment in this sector and their inability to be creative in it. Pierre Erny in his book titled 'The Child and his Environment in Black Africa: Essay in traditional education', has noted how the African child is an expert of his local environment, with a mastery of all the flora and fauna, and the like natural phenomena and processes (Erny 1981). The students argue that for science and technological development to determine and support sustainable socio-economic development in a given society, it must itself be well adapted to the socio-cultural and natural environment of life in this society. Therefore, a realistic science education program at the service of sustainable ST development in Africa is needed. One that will enable the people, especially the youth, to develop scientific and technological capabilities without losing their cultural identity. This is what the ASCO initiative is striving to provide.

15.6.7 Is Science and Technological Reasoning Truly Alien to Africa?

The premise on which the foregoing myth is built, that science and technology is alien to the indigenous African population, is questionable. As Edigin (2010) notes, there was once

> the African mind that build the empires, the great moats and ramparts and the pyramids. That mind atrophied alright but it can be resuscitated to its earlier heights and enervated from its decline through a carefully crafted program of research into African's philosophical thoughts and its underpinnings and evolving training in creative thinking and more importantly in lateral and generative thinking so critical in patterning, freedom, abstractions ability to conceptualize, to re-examine ideas, to restructure old ideas, to reject ideas intelligently or reshape new ideas-ideas that could create modern day visions and values to remake and generate Africa. (Edigin 2010)

Benedict XVI has earlier warned that

> Technologically advanced societies must not confuse their own technological development with a presumed cultural superiority, but must rather rediscover within themselves the oft-forgotten virtues (and values) which made it possible for them to flourish throughout their history. Evolving societies must remain faithful to all that is truly human in their traditions, avoiding the temptation to overlay them automatically with the mechanisms of a globalized technological civilization. In all cultures there are examples of ethical convergence, some isolated, some interrelated, as an expression of the one human nature willed by the Creator. (Benedict XVI 2009, CV no. 59)

The point is that modern science and technological reasoning is not totally alien to indigenous Africa. What is foreign to it is the attempt to remove God from this worldview or pose it against the religious. Traditional African cultural and technological intervention on reality has consisted mainly in being in tune with and respecting nature by receiving and utilizing only the possibilities nature or things offer, rather than forcing them to do what we want. Indigenous African scientific and technological efforts incorporate nature and culture. Yes, Africans are a people close to nature. They live in harmony with nature, using their ancient and tested cultural values that create the right attitude and commitment to nature-oriented development (Arber 2012). The African cultural worldview incorporates not only religious/spiritual aspects but it knows also of the science and technological dimensions of reality (Benedict XVI 2009, CV nos. 27, 40, 58–59), Cf (Benedict XVI 2011, AM no. 69). What has happened, as Pierre Erny, points out, is that they opted to emphasize the metaphysical. However, now that there has arisen the need forced by the present ecological crisis to emphasize a science and technology with a broader perspective, this African approach could provide a model. They could become a model to people, who want to escape the environmental and cultural malaise caused by a modern science and technology with narrow focus on the material/quantitative dimension and the correspondent mindset of a consumerist lifestyle, which doesn't mind the moral and spiritual dimensions. There is therefore the need for a science educational program that could generate modern day visions and values that would regenerate Africa to contribute her share for sustainable human development.

For this to happen, Benedict XVI teaches that true charity requires also that such science education should be with "appropriate pedagogical method and resources that enable people in needy populations to realize their full human potentials in this sector" (Benedict XVI 2009, CV nos. 30, 61).

15.6.8 Socio-Cultural Approach to Science Education in Africa for Sustainable Development

It should be obvious that the development of modern science and technology itself, rests on cultural bases. Cultural values play very vital roles in the process of its development (Benedict XVI 2009, CV nos. 29–31, 56, 69ff). The history and study

of its emergence in the industrialized world as well as its journey and sojourn in other climes show that traditional Judeo-Christian religious orthodoxies, the values and ethics they created, played significant role in the magnificent scientific and technological achievements of the scientific revolution (Tipler 1997; Cf Kresta 2013; Collins 2007). The Medieval insistence on monotheism and especially Christian doctrine on Creation by a supreme, omnipotent creator God and lawgiver, embedded into the cultural worldview and life of its society by medieval Christian preaching, teachings and popular literature, were active in these. Their derivative beliefs, values and rules of conduct, like those of the uniformity of natural intelligible laws, the dignity of man and his capacity to understand God's work and laws as well as the Christian command of love and compassion, gratitude, charity to the weak and the poor, were exceptional in these (Kresta 2013).

Many have therefore proposed a socio-cultural approach to stimulate and ensure adequate development of ST in Africa to power its sustainable development. That is, a countercultural revolution and renaissance of the indigenous African humanism, its culture of human values that animated and motivated the African minds that generated the great feats of yesteryears, so that it will make the continent to recover its feet and even grow more rapidly in modern science and technology. The rediscovery and re-inculcation of such African customs and values that gave leverage to such developments are reasoned to equally spur this development. The values include: solidarity between nations and people, hospitality, concern and respect for the dignity of the whole human being in his/her spiritual and the material dimensions and not insisting only on the material while ignoring the spiritual, moral, etc. dimensions.

15.6.9   Need for Informal Science Learning Initiative in Africa

However, what has been lacking in all this, are informal efforts to offer and support the proper contents and efforts in the academic formal science learning, with a bottom-up countercultural offensive to rekindle among the people, especially the young ones, keen interest and confidence to do science or support its growth. That is, a carefully crafted science education program that uses the method of popular education of Paulo Freire (Servaes et al. 1996; Cf Arnst 1996; Pradip 1996; Freire 1996). One which, with appropriate cultural stimuli and values, would mobilize the cultural background and local society of the populations in favor of ST. To create such a socio-cultural scenario that with its values and virtues, favorably supports sustainable ST development in Africa, this science education and literacy program would not be only formal classroom one. It ought rather to be a qualified scientific and holistic education that teaches science and technology as well as values and virtues that promote ST development (Benedict XVI 2011, AM no. 134). It ought to use informal science learning activities, adapted to the human and natural skills,

socio-cultural and economic resources of the benefiting populations in order to fully involve them in the process. It must also inculcate early into the African populations and young people from childhood, experience with ST knowledge, and the habit of reconciling science with religious faith.

We are talking of informal learning's multidimensional focus on broader socio-cultural contexts, grass-roots resources and especially multilevel minds-on and hands-on interactions of participants. The program should use these to integrate science learning in the real life setting of the people considered as a system comprising their environment, indigenous cultural beliefs and practices to which ethos, they still pay allegiance (Pradip 1996). Stephen Jay Gould has argued in 2003 that: "Practically, in societies with central influence of religious belief, if people come to believe that science stands against their spiritual convictions, then science is screwed." The best strategy according to him, is to respect these convictions (which many scientists also share) and continual insistence that science poses no threat to these central pillars of life (Gould 2003).

15.6.10 ASCO Initiative Answers to This Need

It is such informal science learning program that the Assumpta Science Center Ofekata—Owerri (ASCO) non-profit initiative of international university cooperation with Africa in Informal Science Learning Activities, a small effort promoted by the Vatican Pontifical Council for Culture, tries to provide among developing African and 3rd World populations. As an alternative popular organ/media, ASCO supports and complements formal science learning offered in academic institutions. But it mainly uses popular education strategies and religion to challenge the prevalent myth that science and technology is the preserve of foreign white-man and that the black Africans or 3rd world people cannot have equal prowess in the field. Using the participatory approach and informal science learning activities, the program directly involves the people through their children and wards (both talented and non-talented) in collaboration with their foreign counterparts, to realize the demonstrations and presentations of science in its activities. This strengthens their confidence in their capacity as a people to do science, and so demythologizes this myth that it is the exclusive reserve, or 'juju' of foreign white people (Cohen 1996). The international cooperation breaks their young people's isolation in the sector, opening them to the network or alliance of active collaboration in the field with other agencies at the local, national and international levels. The program teaches these populations to value what they have with respect to facilitating the development of science and technology. Namely, their culture, their human and natural resources. That is a way of encouraging their growth in ST cultural competence in order to use these to improve the people's wellbeing (Benedict XVI 2011, AM no. 77).

15.7 Conclusion

In spite of its challenges, the ASCO initiative with its little structure and resources has so far helped raise substantial public awareness and interest in the sector and ample participation of people in its activities. With its activities, it is helping to inculcate values that facilitate sustainable ST development. Through its activities, it is helping to arouse the community's and stakeholders' interest in fostering growth and development of ST culture, especially among the younger generation. The ASCO initiative could be an adequate platform for the broad based science education that Pope Francis calls for in Laudato Si, in order to checkmate the current ecological crisis.

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Part III
Children, Students and Teachers

Chapter 16
Formative Childhood
from a Neurobiological Perspective

Wolf Singer

Abstract The human brain is extremely susceptible to epigenetic modifications of its functional architecture because its development extends over two decades. This developmental process is characterized by a continuous making and breaking of neuronal connections. Which of the newly formed connections are removed and which eventually become consolidated is determined by the patterns of neuronal activity. Hence the developmental remodelling of the basic, genetically specified architecture is critically influenced by interactions with the environment. As all cognitive and executive functions of the brain are determined by its architecture this implies that experiences made during the first two decades of life have a strong impact on behavioural dispositions. Different networks are susceptible to epigenetic modifications during different critical periods of development. Thus there are distinct windows of opportunity for the shaping of specific functions but once these windows close, induced modifications become irreversible. I shall discuss how it is conceivable that widely differing behavioural dispositions coexist in a single system as highly integrated as the brain and review educational and societal attempts to bias the expression of these dispositions.

16.1 Introduction

Currently the neurosciences are instrumentalized by a number of disciplines in order to extend their empirical foundations. Examples are neurophilosophy, neuroeconomics, neuropsychoanalysis and neuropedagogic. These trans-disciplinary projects are challenging, in principle highly welcome but great caution is required to avoid unjustified generalizations of neurobiological findings, in particular as many of them have been established in animal models. With this caveat in mind I wish to investigate the extent to which results of neuroscientific investigations

W. Singer (✉)
Pontifical Academy of Sciences, Max Planck Institute for Brain Research,
Frankfurt, Germany
e-mail: wolf.singer@brain.mpg.de

might be relevant for education. One important source of potentially relevant insights are developmental studies. These indicate that the development of the human brain is extremely protracted, is segmented into a sequence of critical periods, is highly susceptible to epigenetic modifications and is controlled by intrinsic mechanisms that regulate attention and motivation. Another important notion derived from studies on cognition is the remarkable dependence of perception on a priori knowledge that is stored in the brain and has been acquired both during evolution and ontogeny. The resulting idiosyncratic nature of human cognition has consequences for the education towards tolerant behavior. Finally there is the insight that the cognitive abilities of our brains are constrained by evolution and unable to cope with complex systems exhibiting non-linear dynamics. Not only our brains but also the systems into which we are embedded are complex, have highly non-linear dynamics, exhibit qualities that cannot be deduced from their components and cannot be steered in a goal directed way by intentional interventions. In conjunction with the notion of limited cognitive abilities this has deep consequences for the way in which children need to be prepared for their role of responsible agents in a complex world.

Before providing evidence for these notions it might be helpful for the non-specialists to briefly recapitulate what neurobiologists belief. It is commonly held that all knowledge available to an individual about itself and the embedding world resides in the functional architecture of the brain. Unlike in computers there is no functional specialization in brains into storage devices for data and programs and a central processor that executes the computations. In the brain there are only complex networks of excitatory and inhibitory neurons that interact in a highly specific way and it is this functional architecture that serves as store for all information and at the same time determines the programs for the computations underlying all cognitive and executive functions. The basic layout of this functional architecture is specified by the genes and, therefore, reflects "knowledge" that has been acquired during evolution. This blue print is further modified during ontogenesis by experience dependent epigenetic modifications that adapt the functional architecture to the actual conditions encountered by the developing organism. Another highly consequential and empirically supported notion is that all cognitive and executive functions (perceptions, feelings, decisions, action plans) are the *consequence* and never the cause of neuronal processes and that the latter obey the known laws of nature, including the law of causality.

16.2   Epigenesis, Cultural Evolution and the Role of Education

Although the genetically specified blue print of our brains still closely resembles that of our cave dwelling ancestors because of the slow pace of biological evolution our cognitive and instrumental abilities have considerably changed. The reason is

the embedding in an ever more sophisticated socio-cultural environment that refines the functional architecture of our brains through epigenetic modifications. Some of these modifications are due to practice and to imitation. These modifications occur also in the animal kingdom. When animals learn to walk or to fly they internalize a model of gravity or aerodynamics in their brains and use these models for the adjustment of adapted motor programs. Male songbirds learn their specific courtship songs from their peers and human children acquire knowledge about their embedding environment in very much the same way. They acquire knowledge about physical laws of gravity, ballistics and causality and use these models for the optimization of their motor programs. They imitate the gait patterns of their peers and the prosody of the language used in their environment. And even part of language acquisition depends on imitation and non-supervised extraction of the statistical properties of languages. In this way, knowledge acquired by experience can be passed on to the subsequent generation through epigenetic shaping of the functional architecture of their brains. However, in humans this transgenerational transmission of acquired knowledge is substantially amplified by intentional instruction, i.e. education, an ability that is not observed in the animal kingdom and is one of the factors that enabled cultural evolution.

The mechanisms through which experience shapes brain architectures during development have been studied in great detail in animal experiments and are well established. At the time of birth most of the neurons in the brain have already been generated but a large fraction of them, especially in the cerebral cortex, is not yet connected. The subsequent maturation of brain functions is due to the progressive outgrowth of myriads of nerve fibers that assure communication among neurons. This proliferation process continues until adulthood which in humans is reached around age 20–25 years. However, new connections are not only formed but a substantial fraction of them, amounting to at least 30–40 %, disappears again in the course of brain development and this making and breaking of connections is controlled by the activity conveyed in the neuronal networks. Connections between neurons that have a high probability of being activated in a correlated manner become consolidated while connections between neurons that seldomly or never exhibit correlated activity get destroyed and adsorbed. "Neurons wire together if they fire together". Thus the anatomical architecture of the developing brain is shaped by activity and since this activity is modulated by sensory experience and interactions with the embedding environment, knowledge about the world gets imprinted in the brain through structural modifications. An important aspect of this epigenetic shaping process is that the windows of opportunity during which particular brain regions are susceptible to such epigenetic modifications differ for different brain regions and once they close, no further changes in architecture can be induced. This is the reason why one talks about critical periods of brain development. In regions subserving elementary sensory and motor functions these windows of opportunity open and close early in development. For the acquisition of basic visual functions the critical period lasts only from birth to about 4–5 years, for the acquisition of the mother language windows are slightly longer but also tend to close around the beginning of school age. Critical periods for the acquisition of

social functions which are realized in late developing brain structures open and close around puberty and adolescence and finally, in the adult, structural changes at this scale are no longer possible. There is no further outgrowth of neuronal connections and under non-pathological conditions there is also no large-scale destruction of connectivity. Adult brains are of course still capable of acquiring knowledge but this adult learning is solely based on activity dependent strengthening and weakening of the existing connections. The rules that govern these experience dependent modifications of the efficiency of coupling connections are identical to those that govern the developmental selection of pathways. The major difference is that the architectural changes occurring during development become irreversible once the respective windows of opportunity close while the modifications in the efficiency of connections that are associated with adult learning are to some extent reversible. Connections can be both strengthened and weakened if experience changes and new programs have to be installed.

A particularly impressive example for the importance of experience for the development of cognitive functions and for the irreversibility of epigenetic shaping processes beyond the end of the respective critical periods come from research on the acquisition of vision. If animals or human babies are deprived of vision from birth because of disturbances in the optical media of the eyes and if this deprivation outlasts the critical period for the development of vision which in kittens lasts only 3 months from birth, the deprived subjects will suffer from an irreversible loss of vision. The reason is that architectures in the cerebral cortex required for the interpretation of retinal signals cannot develop appropriately in the absence of experience and once the critical period is over even extensive exposure and training becomes futile. The loss of function cannot be recovered. For review see (Singer 1995).

Although much research is still needed in order to determine the windows of opportunity for higher cognitive functions, especially those subserving the regulation of social interactions, it must be assumed that the underlying processes are very similar. This can be deduced from the evidence, that in human beings there are still massive changes in the density of connections between neurons at least until age 20 in regions of the cerebral cortex that mature late in ontogeny and have appeared late in evolution, some of them actually existing only in human beings. It is of course difficult to determine in detail to which extent particular functions are due to the autonomous expression of genetic programs or to epigenetic shaping because the effects on brain architecture are very similar. In most cases it is impossible to know whether a particular connection is absent because it had not been foreseen genetically or because it had been destroyed through epigenetic mechanisms. However, it is save to state that both factors are equally important for the expression of both cognitive and executive brain functions. Although, it is common knowledge in the field of pedagogic that there are windows of opportunity during which brains of children are ready to acquire particular functions the very notion of the irreversibility of critical periods should be sufficient motivation to protect the developing brains from the deleterious effects of deprivation. The developing brain knows which information it requires at the various stages of

development and actively searches for this information. However, it the required information is not available, the respective functions cannot develop. Thus, it is one imperative to provide a rich environment from which the developing brain can choose what it needs for the full development of its genetically specified potential.

Providing a rich environment is however not sufficient. It is well established, that the experience dependent epigenetic shaping of brain architectures is controlled in very much the same way as adult learning by systems regulating the activation state of the nervous system, its attention, motivation and reward expectancy. The adult brain learns only if it is in an activated state, can focus attention on the content to be learnt and is motivated to acquire knowledge. The same holds true for the optimization of brain architectures during development. This process is gated by the same modulating systems. Again care takers and teachers are intuitively aware of this fact but knowing about the irreversibility of missed occasions should be a strong incentive to do whatever is possible to not only offer a rich environment but to also nurture the curiosity of children, to allow them to focus their attention and to motivate them to exploit their potential.

Another important and fairly recent discovery is, that developmental learning—the epigenetic shaping of architectures—requires consolidation during sleep just as is the case for learning in the adult (Rasch and Born 2013). Another imperative is, therefore, to give the developing brain sufficient time to rest and to sleep. Environmental enrichment is necessary but if the developing brain is over stimulated, focusing of attention gets impaired and the highly regulated sequence of distinct sleep phases gets disturbed.

Before closing this chapter on experience dependent shaping of brain architectures during development the question needs to be addressed, why nature runs the risk to expose brain development to the hazards of epigenetic shaping, given that deprivation leads to irreversible impairments of brain functions, some of which could undoubtedly have been realized by genetic instructions alone. Numerous species acquire quite sophisticated cognitive and executive functions without relying on experience dependent optimization of their brain architectures. Research on visual development has revealed that certain functions such as the fusion of the images arriving from the two eyes and the ability to extract from the comparison of these images stereoscopic information cannot be realized alone by genetic instructions but requires functional comparison of the activation patterns arriving from the two eyes during development. By extrapolation one has to assume, that the same reason holds for the development of all the other often specific human abilities that get expressed only due to epigenetic shaping. These functions are nearly all related to communication and social competence: examples for communication skills are of course language competence but also the ability to express oneself non-verbally through differentiated mimics, gestures, dance and the various forms of musical expression. Whether social skills such as empathy, fairness and altruism or cognitive abilities such as developing a theory of mind are inborn and mature without experience or whether these traits and abilities are installed and refined by epigenetic shaping and if so to which extend is still a matter of active research (Klimecki et al. 2014; Singer 2015). The mere fact, that brain development is so

protracted in humans and lasts until these specific human traits are fully developed does suggest that their expression is strongly dependent on epigenesis as well. If so it seems likely that nature runs the risk to expose the developing brain of humans for such a long time to the hazards of epigenetic influences because it allows the brain to adopt its structures to the conditions of the complex socio-culture environment and to thereby realize functions that outweigh the risks of deprivation and that could not have been implemented without epigenetic shaping. In this respect it is noteworthy that the genetic disposition for such protracted development and the concomitant susceptibility to massive epigenetic influences must have evolved already rather early in the evolution of mankind and long before adaptation to a sophisticated civilization could become a relevant fitness factor.

16.3   The Constructivistic Nature of Perception and Concepts of Tolerance

There is broad consensus in the community of neuroscientists that our perceptions are the result of a constructivistic process (Friston and Kiebel 2009). Sparse sensory signals are compared with a vast body of stored knowledge about the structure of the world, are interpreted accordingly and then transformed into spatio-temporal patterns of distributed neuronal activity that correspond to what we perceive. Usually we are not aware of the fact that what we perceive is the result of a knowledge-based reconstruction. The reason is, that we are not aware of the processes that take place in our brain and of the implicit knowledge that we use for the reconstruction of our percepts. As already mentioned in the preceding chapter, a substantial amount of the knowledge that is stored in the architecture of our brains has been acquired during evolution, is stored in the genes and then expressed in functional architecture of the brain during development. Hence, this knowledge is implicit, it is a priori knowledge. We are not aware of having it because we were not around when it has been acquired. The same holds for knowledge acquired during early child development. This knowledge too remains implicit and is not accessible to conscious recollection because of the phenomenon of childhood amnesia (Tulving 2002). During the first years of life structures required for the establishment of episodic memories, of memories that register not only the learnt content but also the context in which learning has occurred, have not matured yet. The consequence is that we learn during childhood, form models of the world that complement the models acquired during evolution but are not aware of having this knowledge and of exploiting it for the reconstruction of our percepts.

With respect to the perception of the pre-cultural world to which our cognitive apparatus has become adapted during evolution, the constructivistic nature of our perception usually poses no problems. We share the knowledge required for the interpretation of the respective sensory signals with all other humans and even with animals as the conditions to which organisms had to adapt throughout biological

evolution were rather similar. Non-human primates use exactly the same Gestalt criteria for the segmentation of scenes, for the definition of objects, for the attribution of intentionality and agency as we do. Therefore, there is usually broad consensus among subject's perceptions when they are exposed to conditions that existed already prior to the onset of cultural evolution.

Problems arise however for the perception of social realities, of immaterial realities that came into the world only once human beings started to engage in social interactions and symbolic communication. Examples for such realities are the contents of belief-systems, agreements, concepts such as altruism, fairness, justice and honor and attributions to our self-models such as autonomy, freedom, responsibility, intentionality and morality. All these immaterial realities owe their existence to the reciprocal interactions between agents endowed with the cognitive abilities that distinguish human beings from all other organisms. These realities are of course as causally effective in our lives as is the case for tangible material objects whether in-animate or animate.

By extrapolation one has to assume that the perception of these social realities depends to the same crucial extent on the body of a priori knowledge as is the perception of material objects. However, most of the a priori knowledge necessary for the perception and interpretation of social realities cannot be inborn but must have been acquired post-natally. And here comes the problem. The sources of the knowledge required for the perception and interpretation of social realities are culture specific and hence very likely to differ substantially between individuals raised in different cultures. Accordingly, the same sensory evidence, provided for example by a particular social interaction, is likely to be perceived very differently by persons from different cultures. As we are not aware of the constructivistic nature of our perceptions and are forced to take for granted what we perceive—just as we continue to perceive a red surface as red even if told that the true wavelength composition should be perceived as a green color—it is impossible to change one's mind on the perception of a social reality if told that one is victim of a misperception. In case of the red surface it is possible to provide objective measures of spectral compositions and to prove that the percept of red is not reflecting the true composition of the light reflected from that surface but is the result of color contrast, an effect that Mondrian has exploited in order to induce the percept of colors that do not correspond to the spectral composition of the reflected light. However, even in cases were objective measures unravel that what one perceives is the result of an inference, the percept does not change and has to be taken as one's truth. In case of social realities such objective measures are not possible and this has profound consequences for concepts of tolerance. The perception of a social reality cannot be reversed by argument and has to be respected as the perceiver's truth. This respect has to be reciprocated and cannot be overwritten by majority votes. Thus, educational curricula should be designed to raise awareness of these cognitive constraints. This is not difficult because there is a host of psychophysical experiments that exemplify in a very convincing way the constructive nature of human cognition. Once this notion becomes common good respect and tolerance become natural consequences of a more realistic self-model.

16.4   The Fallacies of Complexity

As mentioned above evolution has adapted our cognitive abilities to the conditions of the pre-cultural world. One of the most important functions of nervous systems is to learn about the rules that govern processes in the world relevant for survival and reproduction and to internalize a realistic model of these conditions. This model can then be used to make predictions and derive appropriate reactions in order to cope with anticipated challenges. However, there is a limit to predictability that depends on the complexity and the dynamics of the systems. Predictability is high for simple systems with linear dynamics and it goes towards zero for highly complex, highly non-linear dynamical systems. Even with well adapted heuristics and sophisticated mathematical calculations it is in principle impossible to predict over longer stretches of time how such non-linear systems will develop even if all initial conditions are known. It is probably for this reason that our ability to develop an intuition for complex systems with non-linear dynamics is only purely developed. There was no selection pressure for the ability to imagine high dimensional systems with non-linear dynamics because their future trajectories cannot be predicted anyway. Developing internal models of such dynamics would not have been very helpful.

As long as we were living in a pre-cultural environment or in small social groups, this posed no problem because linear models were sufficient to cope with the interaction dynamics that were of low dimensionality. This changed once humans initiated cultural evolution and generated complex societal and economical systems. Highly complex systems with non-linear dynamics did of course exist already in the pre-cultural world. The weather system, large ecosystems, organisms and in particular their brains are prime examples for highly complex systems with non-linear dynamics. However, the limited tools available to early humans prohibited any intentional causal interaction with these systems and therefore it was sufficient to develop some simple heuristics for adaptive behavior. However, in the course of cultural evolution complex societal, economical and financial systems emerged that exhibit non-linear dynamics and owe their existence to human action. The communality of all those complex systems is that they consist of agents that interact with one another through a dense network of reciprocal connections. A serious problem arises once one becomes an active part of such a system, a node in the network as is the case for our socio-economically systems. Our actions keep these systems alive but it is impossible to predict the future trajectories of such non-linear systems, leave alone to control them. Because we have no intuition for the dynamics of these systems we succumb to the illusion that carefully planned interventions will have well defined long term effects—as would be the case in linear systems. However, there is empirical and mathematical prove that goal oriented steering of such systems is very, very difficult if not impossible.

The problem is that our model of the world according to which we act is no longer valid for the systems that we have created and are now sustaining by our actions. Many of the problems that we presently encounter, the financial crises, the

drifting apart of the have and the have-nots and our inability to responsibly manage our ecosystems are a direct consequence of false assumptions and intuitions about the processes that we have brought forth and constantly interfere with. One of the frequently applied escape strategies was the attempt to create simpler and hence easier to control systems. Examples are totalitarian political systems or strictly hierarchically organized economies. However, these strategies are bound to fail as well because they destroy much of the self-organizing capacities that alone are capable of stabilizing complex systems. The number of agents and variables to be controlled are simply too large in modern societal systems. By preventing horizontal interactions between the nodes and relying on top down control, i.e. highly variable competence of governments and CEOs, the self-organizing mechanisms that make complex systems resilient cannot become effective. Hence, these systems become extremely unstable and tend to collapse sooner or later.

Future generations will be increasingly forced to cope with the non-linear dynamics of systems with ever increasing complexity, systems that they keep in action, cannot escape from and at the same time have to manage. This requires a profound change in attitudes. Children will have to understand that they are embedded in a world that they cannot really control but that requires from them to act in a responsible way. They will have to develop confidence in the resilience of complex systems. We know that the complex systems that have been optimized by evolution can be extremely stable and self-healing provided that their interaction architecture allows for the stabilizing forces of self-organization. The principles favoring resilience in self-organizing systems can be studied in living systems such as individual organisms, ecosystems and hyper-organisms. The respective rules concern both the requirements that have to be met by the individual nodes of such networks and the layout of the communication channels that mediate the interactions between the nodes. Once more is known about these rules they certainly should become content of future curricula. The rules that need to respected by the nodes of such self-organizing resilient systems would be part of a secular ethics that can be grounded empirically. Some of these rules have of course already been discovered by trial and error and became implemented in our moral and normative systems. And it does not come as a surprise that these bear great resemblance with the Ten Commandments. One important rule is for example that information about the state of the system must be distributed without distortions. Nodes must not lie. Members of the evolutionary optimized self-organizing and remarkably stable hyper-organism all respect this rule. If bees fly out and find a particularly riche source of nectar they return and reliably and unselfishly report to the rest of the community where the rich resources are to be found.

However, at present we have only insufficient knowledge about the factors that render self-organizing systems resilient. All that educational systems can and should achieve in the moment is to prepare the next generations to realize and accept that each individual is embedded in an uncontrollable system in which each figures as a active node in the self-organizing network. This will by itself entrain the humility and the responsible solidarity needed to overcome the challenges of the future. In order to convey an intuition about the behavior of complex

self-organizing systems with non-linear dynamics there are numerous examples both from the in-animate and animate world that can be used for educational purposes. Experiments with such creative but non-controllable systems should therefore become an integral part of the curricula of future generations.

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Chapter 17
"I Hold Your Foot:" Lessons from the Reading Brain for Addressing the Challenge of Global Literacy

Maryanne Wolf, Stephanie Gottwald, Cynthia Breazeal, Tinsley Galyean and Robin Morris

Abstract In this chapter we describe the theoretical and technological principles that underlie an innovative application of cross-disciplinary work in cognitive neuroscience, linguistics, child development, education, and technology: The global literacy initiative, Curious Learning. We will delineate the basic principles about the reading brain from cognitive neuroscience that guided the content of our work, and the principles from technology that guided design, implementation, and data collection. This initiative represents our ongoing efforts to develop and implement a comprehensive, tablet-based digital learning experience to help children learn to read on their own, particularly those children who either possess no school or whose schools are so inadequate that the children never achieve functional literacy.

> One day Abba Arsenius asked an (unlettered) old Egyptian monk about what he was thinking. Someone said: "Abba, why is a person like you, who has such a great knowledge of Greek and Latin, asking a peasant like this about his thoughts? He replied: "Indeed I have learned the knowledge of Latin and Greek, yet I have not learned even the alphabet of this peasant."
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> *The Wisdom of the Desert Fathers* (Ward 2006)

M. Wolf (✉) · S. Gottwald
Center for Reading and Language Research, Tufts University, Medford, MA, USA
e-mail: maryanne.wolf@tufts.edu

S. Gottwald
e-mail: steph.gottwald@tufts.edu

C. Breazeal · T. Galyean
MIT, Cambridge, MA, USA
e-mail: cynthiab@media.mit.edu

T. Galyean
e-mail: tgalyean@curiouslearning.org

R. Morris
Georgia State University, Atlanta, GA, USA
e-mail: robinmorris@gsu.edu

Although the students certainly faced challenges, the teachers faced at least as many if not more… There were no books. The children were reciting from memory a story that they had read with their teacher over and over….I prepared to read them a story…To my delight, Joe said, "Let me try." Try he did, and with sheer determination, he succeeded. The look on his face was one of pure joy as he loudly proclaimed, "I can read!" My joy matched or probably even exceeded his.

I Hold Your Foot: The Story of my Enduring Bond with Liberia (Tucker 2015)

The connecting theme in this paper and indeed in our collective endeavors is that literacy transforms the lives of everyone who learns to read. Like the wisdom expressed above by the Desert Fathers, we do not minimize the unique ways of knowing that characterize many non-literate societies, and indeed were embodied in Socrates and some of the wisest figures in human history. Yet like the wisdom expressed by Sr. Leonora Tucker of the School Sisters of Notre Dame in Africa, we know full well the extraordinary contributions that literacy brings. It is our species' penultimate platform for increasing knowledge and discovery both in the individual and in a society. As Galileo Galilei described centuries ago, among all the great inventions the species has created, nothing has had more significant, life-changing, enduring sequelae than the invention of literacy. Indeed, little has had more impact on the intellectual, social, emotional, and spiritual advancement of human kind than the mind hewed and honed by literacy. For, the acquisition of literacy changes the very circuitry of the brain, which permits whole new avenues of thought that were never available before and that become an expanding foundation for the ever new forms of knowledge that come next.

It is within that context that we will describe in this paper one of the most innovative applications of cross-disciplinary work in cognitive neuroscience, linguistics, child development, education, and technology: A global literacy initiative we call *Curious Learning* (2016). This initiative represents our ongoing efforts to develop and implement a comprehensive, tablet-based digital learning experience to help children learn to read on their own, particularly those children who either possess no school or whose schools are so inadequate that the children never achieve functional literacy. Thomas Edison was known to say that invention without execution is hallucination. As discussed in this paper, we are as committed to understanding how to *implement* our approach, as to understanding how to improve it, iteration after iteration.

Before we describe this initiative and its most recent iterations, however, we want to begin with a much earlier set of related efforts by the School Sisters of Notre Dame. It may be the case that few other teaching groups have done so much for the education of children in "out of the way" places as the Sisters of Notre Dame, whether in the US or in places like Western Africa. It is the case that the first author, who grew up in a tiny town in the heart of the rural Midwest, could never have achieved any step of her later education (from St. Mary's College and the University of Notre Dame to Harvard University), had it not been for the School Sisters of Notre Dame. This order consciously chose to send their teachers to two-room schoolhouses like the one in Eldorado, Illinois and similar, under-resourced places in rural and urban US. In schools like these, these teaching

nuns attempted to change the lives of the children of miners and farmers and the occasional businessman, like the author's father, first through literacy, and then through catechesis and the foundations of a classic education.

It is just that spirit that led the School Sisters of Notre Dame to send teachers like Sr. Leonora Tucker and her group to Liberia and Western Africa, where they strove to bring their pupils through literacy to higher forms of learning. Sr. Lenora Tucker wrote one of the most delightful memoirs about the work of an educator in Africa. Called *I Hold Your Foot: The Story of my Enduring Bond with Liberia*, it is based on an endearing expression used in Liberia, "I hold your foot" (Tucker 2015). The expression means "I beg you", or "I plead with you". In her touching, often side-splittingly humorous account, Sr. Leonora Tucker described how the mothers of young children would use this expression on their knees before her and the other courageous teachers there. The mothers used this phrase—along with every other possible means—to ensure that they could get their child into "school". We use this phrase as the title to our paper to honor the work of Sr. Leonora, all her fellow teachers, and the aspirations of those parents.

We understand the perspectives of both teachers and the parents of these children. There is little more important than giving all our children their best chance to lead a good and productive life. Such a life begins with education, which begins with literacy, and continues with a changed literate mind. Nevertheless, there are more than 200 million children in this world who will never attain full literacy. For most of these children there are few or no books or paper, few prepared teachers, and very few adequate schools. Whether they are called "pastoral children" in remote rural environments, or "street children" in dehumanizing urban areas, no picturesque language can hide the life-demeaning poverty in which most of them live out their unfinished lives with their unfulfilled promise. Pope Francis goes straight to the core: He calls them the "disenfranchised children of the world". Over the last years Pope Francis confronts the world with the unconscionable realities of these children and their families and asks each of us the moral, contemporary version of Kant's questions: What do we know? What can we do? What do we hope?

Our initiative directly embodies the first two questions with our group's very particular twenty-first century questions: first, can we translate both knowledge about the reading brain's development and innovations in technology into a digital "learning to read" experience? Second, can relatively inexpensive digital materials —from tablets to cell phones—be programmed with our particular approach to literacy to help the disenfranchised children of the world learn to read in the absence of trained teachers and adequate schools? We do not speak of replacing print or teachers with technology. Far from it. There is little better for the learning of children than the well-trained and resource-prepared teacher. But in that teacher's absence or the school's lack of resources, can we direct the great potential of technology to help children learn? In sum, we seek to use our society's most advanced knowledge bases about the development of the reading brain and the development of digital learning to redress and contribute to the amelioration of illiteracy in millions of children.

17.1 Background

The initiative began when the first author was approached by MIT technology scholars Cynthia Breazeal and Nicholas Negroponte to consider the possibility of applying her group's collective knowledge about the reading brain and reading impediments to the creation of a digital learning experience for non-literate children who have no schools. Breazeal sought to understand whether research by Wolf, Gottwald and their team at Tufts University, particularly on reading intervention with struggling readers in the United States, could be applied in the design of digital tablets for children who would never otherwise become literate.

The collaboration that emerged included members of the Tufts Center for Reading and Language Research; Nicholas Negroponte and Cynthia Breazeal from the MIT Media Lab and their teams, including Matt Keller from the earlier technology-based initiative, One Laptop per Child, whose foundation funded the beginning of this initiative. Soon after, Robin Morris, an eminent methodologist from Georgia State University who was also part of the original team conducting research on reading intervention, joined the collaborative. Technology expert and designer Tinsley Galyean replaced Negroponte some time later.

We have told the unlikely story of our efforts in other published papers, two of which were sponsored by the Pontifical Academy of Sciences (Wolf et al. 2015, 2014; Wolf 2016; Breazeal et al. 2016). Here we want to provide some of the underlying principles in neuroscience and technology that undergird our efforts. In addition, we will describe some of the newer directions in our ongoing work. It is our hope that this combined information will be of help to other educational initiatives, especially the emerging collective of groups committed to the children and youth that are becoming organized by Scholas Occurentes, under the auspices of the Pontifical Academy of Sciences.

17.2 Principles from Neuroscience and the Formation of the Reading Brain

Principles derived from the formation of the young reading brain provided the basis for our approach to literacy, and principles of social constructivism informed our approach to children learning alongside other children. To begin, our first and guiding principle was to find ways to reverse engineer the components that make up the young reading brain circuit and to use these components as the basis for content development and design. It is essential to note that the reading circuit is a relatively new, culturally based circuit in the human brain that has no pre-set, or genetically pre-determined program that unfolds in a child's development. In this way written language is very different from oral language which has a genetic basis for its development in the child. Rather, the reading circuit utilizes, rearranges, and

repurposes component parts of those older circuits in the brain that already exist for oral language, perception, cognition, and affect.

Our task was to emulate what the young brain needs to know in order to build a model of the reading circuit that could be used in designing a digital learning experience. For example, for children to read, they must first develop high-quality neuronal networks for each of the circuit's major component areas (i.e., language, perception, cognition, and affect), and then over time, learn to integrate information from all these areas in extremely rapid fashion. More specifically, children must learn to automatically identify the visual patterns in letters (or characters) and to connect this visual information to the auditory sounds (called phonemes) that correspond to each letter or character. To accomplish this, children need to build up both a visual repertoire of their writing system's letters or characters, and an auditory repertoire of the phonemes in their language.

The ability to connect the letters and their corresponding sound information is the foundation of the alphabetic principle and must be practiced over and over until it becomes automatic. This process takes both multiple exposures to letters and sounds, and also the conceptually complex, two-fisted epiphany that a visual symbol can represent a sound, and that our words are made up of those sounds. It is nothing short of cognitive miracle when children tacitly grasp that the invariant patterns of lines and circles symbolize the sounds in all the words they know, and more besides.

That said, the alphabetic principle is useless without an understanding of the words and the grammar of the language that is to be read. The other major area of development in the reading brain circuit, therefore, involves the steadily increasing knowledge that children gain about the words themselves: what words mean; how words work in sentences; how words embody concepts about the world; how words possess associations and connections to other words ad infinitum, and also to feelings. If the first half of the reading circuit is about connecting letters to sounds and learning to decode, the other half of the circuit is about connecting these newly decoded symbols to the storehouse of knowledge about the words themselves.

We conceptualized our overarching task as re-creating this beautifully complex experience of learning to read in a digital format for children between four and eleven years old. Towards those ends we began to curate, and/or create apps and activities that would target each of the important contributing areas in the reading brain circuit—letters, sounds, word knowledge and place them on an engaging mobile device for children. We chose apps, therefore, that provide knowledge to the children about the *words* (what they mean and how they function in sentences), the *letters*, and the *phonemes*, and the concept of bringing all three together, one step at a time. In other words, our goal was to mimic the typical development of young brain when children begin to learn to read with one huge caveat: we sought to do this on a tablet!

To implement this overarching set of goals, we first developed a conceptual *app map* which depicted both the component parts or processes in the reading brain circuit and their developmental sequence over time. For example, to help the child learn to identify visual patterns in letters, letter patterns, and common words, a

developmental series of letter identification apps was conceptualized that began with apps with very low-level demands (e.g., an app with letter blocks which, when touched, announced the name of the letter) to very sophisticated apps that displayed words composed of difficult letter patterns and morphemes in English. In the tablet's first iteration, however, we emphasized largely pre-acquisition content. Thus, we selected theoretically-curated and designed apps that develop children's critical, precursor skills: i.e., alphabetic knowledge, vocabulary knowledge, the most basic letter knowledge, and letter-sound correspondence rules. We also included several apps that introduced early reading skills of blending and decoding using basic vocabulary words. E-books and videos were added that corresponded to these basic words and that reinforced print knowledge, vocabulary, and new concepts.

In our first iterations we erred in providing far more apps and E-books than were needed, or than were used more than once or twice by the children at their stage of development. Our present collection of about 70 apps in English includes multi-level interactive games, E-books, and videos that foster discrete components in the early developing reading circuit, while maintaining engagement. In addition, we include some videos and creativity apps (e.g., drawing, music) that elicit different kinds of participation and learning.

Thus at the present time this iteration of our tablet provides a good introduction to the precursors of reading. We look forward to the next phase of our efforts in which future apps and activities, either curated or designed by us, will begin to fill the developmental lacunae that our app map makes clear for later stages of reading (a topic we will return to in the section on future directions).

17.3 Principles of Technology Development, Design, and Implementation

Our technology design goals were based on a starting point of *no exposure* by the population to any form of technology. We knew the children would have never seen a pencil, much less a tablet, and that there were no literate adults in their village. Indeed it is the case that there are few literate adults in the remote regions that need literacy most. We did not know whether the children would be able to teach themselves and each other on a mobile device with no adult instruction or help. Further, because we knew the conditions would make internet connection difficult, we had to able to support deployments over time and across varied children's needs.

Our starting point, therefore, was that these children who have no exposure to any form of technology or electricity would have to become computer-literate at a basic level for any digital learning to occur. Based on these conditions and factors, the following design principles characterize our system (see also Breazeal et al. 2016).

- There must be an easily installed platform that can be remotely monitored and adjusted to provide educational content appropriate to the learners and different populations.
- It must function without an Internet connection by buffering data and providing alternate transmission paths.
- It must support remote administration including the ability to monitor device health and remotely update content.
- It must permit technical and non-technical local support personnel to maintain and administer deployments.
- It must provide a path to scalability of a large number of sites and tablets.
- It must provide the ability to constrain the usage to educational content, thus reducing risk of theft and exposure to content that would be developmentally inappropriate for the children.
- The overall architecture must be agnostic of any mobile device.

Our current work is based on these collective principles and uses android tablets because of the accessibility of the open-source operating system and their less expensive availability to our populations. The current price (under $70) provides economic incentives, compared to traditional costs of education. Developing countries like Ethiopia typically spend an average of $100 per/year on education, while the USA spends $10,000 a year. Our present intervention can be delivered for less money over time than either figure, and provides continuous efficacy data.

17.4   Data Collection

An important aspect of our initiative's implementation involves the collection of usage data for the tablet (e.g., battery level, accelerometer data, etc.), educational apps (e.g., app launches, time used), and specific response data within apps (e.g., words touched, performance, repetitions of activities, patterns of exploration). Deployed tablets are outfitted with our data collection software for automatic logging of usage data, and thus they are not reliant on an Internet connection. The system is based on the Funf Open Sensing Framework which runs on Android devices without user intervention. It consists of software on both the mobile device side and on the server side. Data probes report on periodic data (collected at a set frequency, on a timer) or episodic data (collected in response to an event). Software on the devices register and log the data events, store them, and transport them back to the server when Internet connection allows.

Our administration tools allow us to remotely manage our deployments and to understand how the devices are used by children. This allows us to evaluate different types of content and iterate rapidly to improve the intervention content and the learners' experience. More specifically, when data are uploaded to the server, processing scripts are applied to incoming database files in order to organize and parse the data streams into a central database. An administrative web interface helps

to monitor and organize tablet information online (e.g., frequency) and allows for web-based remote commands to be sent to tablets (e.g., concerning tablet health, updated content), all while they are in the field. These are important features when conducting remote field research.

17.5   Overview of Deployments

The children who are part of this initiative live in sites that are all under-resourced communities that have been chosen to investigate efficacy in different educational contexts (see Table 17.1). The sites include places where there are no schools, preschool settings, and elementary schools where the ratio of teacher to pupil ranges from 1:50 to 100.

- *Deployment 1.* Children in Ethiopia with no access to teachers or schools; specifically, Wonchi and Wolenchete. These are described elsewhere. At the present writing, only Wonchi exists as a deployment site, because the drought in Eastern Africa recently caused the entire village of Wollenchete to disperse. The loss of this village is another indication that the poor and disenfranchised members of our world are among the first to be affected by climate change.
- *Deployment 2.* Children in a South African school with at 50+:1 student–teacher ratio.

Table 17.1 The platform currently supports three kinds of deployment scenarios

Type of use	Example of context	Description
Disconnected-remote tablet groups	Ethiopia in villages with no schools	No or very infrequent Internet connectivity on site. Data stored on tablets (e.g., SD card). Manual intervention for data collection is required, aggregating the data at a central, connected workstation, and uploading data to the server
Directly-connected remote tablet group	Rural USA schools in varied pre-school settings	Wi-Fi or cellular connectivity to regularly contact central server to upload data and receive updates. Frequency of uploads can be monitored
Indirectly-connected remote tablet group	South Africa, school-home use in schools with 1:50 to 100 pupil/teacher ratio	Strong but intermittent Wi-Fi or cellular connectivity. Tablets make high-speed connection to local server cache, which trickles data to center server through more stable connection. Meant for deployment protocols in which tablets return to central location for charging and data uplink

- *Deployment 3.* Preschool children in underserved, pre-school setting in Ugandan urban areas.
- *Deployment 4.* Children in at-risk, underserved, rural communities in the United States.
- *Deployment 5.* Children in two underserved areas in India.

17.6 Summary of Preliminary Evidence

17.6.1 Literacy Data

Our data from the various assessments to date (described in more detail in Wolf et al. 2015, 2014) document the emergence of important literacy precursors in disparate groups of children who have never seen symbolic text, but who are motivated to learn. Each deployment represented a first-of-its kind effort. There are very important differences among the sites.

In the Wonchi site in Ethiopia, the villagers speak a dialect of Oromo and have very rarely heard English or seen written language. At the time of our implementation, there were no appropriate apps or digital activities available in the children's native Oromo language. That said, learning to speak and read in English was and continues to be highly aspirational for these families, because of improved employment opportunities in the future for English speakers. Most children in Wonchi learned the alphabet and many words and concepts in English. A few learned some basic sight words, but none have achieved true decoding to this point. This site exemplifies both the power and the present limits of this approach. On the one hand, children gained almost immediate skills in the use of digital technology and a very important foundation in the precursors of literacy. On the other hand, only time will inform us if the children can advance to decoding with the next iterations, or whether an adult's presence can facilitate children's move into the next steps of literacy and learning. It is a central question in our work across remote settings.

The Ugandan and rural US deployments, where there are adults in the preschool environments, also demonstrate the efficacy of this approach for literacy precursors. In our most recent study, we compared tablet use in different preschool-age conditions in the rural US sites. We found that the children who made the most progress in critical precursors like letter identification, when compared to their same cohort without tablets, were in the all-day preschool. Each of the groups who were given tablets made more progress than those without tablets in the highly predictive letter tasks, except for children receiving Headstart.

The South African deployment took place in a primary school outside of KwaDukuza of KwaZulu-Natal. This deployment involved school children in classrooms that ranged from 50 to 99 per single teacher. Results showed that those who had access to tablets attained higher scores on letter identification and vocabulary, both of which are key predictors of later reading in every language.

17.6.2 Engagement

Across all educational contexts, children quickly learned to turn on and utilize the tablets, and to open and explore all apps. Thousands of openings occurred in each deployment site. An important question for us is whether tablet use impacts specific changes in early literacy knowledge. The simple index we used was the number of apps that children opened. In US deployments there is a significant systematic relationship (r = 0.43) between the number of apps opened and the number of uppercase letters learned over the study period for these groups of children. Such results suggest a potential relationship between tablet use and impact on early literacy abilities. Although results like these to date are encouraging, given the limitations of our samples, we do not wish to over-interpret the impact until more data are available.

We also examined engagement data across different tablet-use groups to see how engagement level with tablets might change over time. In particular, we used "*dwell time*"—that is the number of seconds a child keeps an app open—as a proxy measure of engagement. As the children's mean "dwell time" increased, children began to switch less often between apps, and became more focused on a single app. We consider this shift from more scattered to more focused attention an important aspect in their learning.

We believe that the cumulative literacy and engagement data provide evidence for the potential of this platform to benefit students across diverse under-resourced educational settings. We are encouraged despite the distinct challenges faced by each study population (i.e., no access to schools or schools with 1:50–100 teacher: student ratio in developing countries; low SES at-risk communities in developed countries). Our particular literacy precursor and vocabulary pilot data suggest that children in our deployments perform better overall in two essential reading precursors: letter knowledge and basic vocabulary, when compared to similar aged children who did not have access to the tablets. As mentioned, these two precursor skills are two of the best predictors of later reading achievements across all languages.

While encouraged by these preliminary findings, we are entirely realistic about the range of challenges presented in this work. We conceptualize the principles described in this paper and the lessons we have learned to this point as the critical foundation for future iterations and advances by us and by the growing number of initiatives by colleagues and organizations around the world.

There are new collaborative, scholarly efforts that are indicative of a more universal movement towards global literacy. For example, our group has participated in several of the Pontifical Academy of Science meetings on education and the UN's Sustainable Development Goals, as well as in recent international meetings for neuroscientists, policy makers, and educators organized at Haskins Laboratory at Yale by Ken Pugh and at the Netherlands Institute for Advanced Studies by Ken Pugh, Ludo Verhoeven, and Charles Perfetti. In addition, the

well-known X Prize will commit millions of dollars in its most recent competition, whose goal is to bring non-literate children to literacy, numeracy, and coding through digital devices. The momentum in all these initiatives is testimony to the deep significance of global literacy for the next generation and indeed the intellectual development of our species.

17.7 Lessons We Have Learned for Other Initiatives

It is our goal that the principles described in this paper about content and technology will have implications for the success and scalability of many future initiatives, not only our own. We have found that our outcomes vary, depending on the varied resources available, the context and location, the number of children, and their background. Several aspects of our work had particularly important influences on the outcome of our projects. For example, having well-organized and established, on-the-ground deployment partners increased the credibility with community adults and facilitated a productive relationship with community leaders. Such relationships facilitate the often difficult, but critical consent processes within communities where literacy is limited. We discovered that the need to train local facilitators in the necessity of recording responses within consent procedures created an unexpected, important investment by the community in the intervention.

It is axiomatic that assessment is essential in documenting impact, but it is almost impossible to achieve in many sites using the conventional methods of testing from developed countries. The first author has documented (Wolf 2016) the extraordinary clinical testing conditions in the Ethiopian sites where the entire village watched her test each child, waiting to clap after every response! Flexibility is pivotal, but so also are new ways of assessment that involve being built-in within the apps. We are, therefore, embarking in new directions aimed at the development of new literacy and cognitive assessments that can be seamlessly integrated into the tablet experience. These built-in assessments will supplement traditional pre- and post-testing by trained personnel and provide far more cost-efficient and time-efficient ways of evaluating children. In addition, these new forms of assessments can generate both longitudinal and finer-grained evaluations of engagement and learning performance. These, in turn, provide data-driven improvements in both tablet content and activities in next iterations.

Finally, by capturing longitudinal data on individual learner's usage and behavioral outcomes, we can leverage these data to build adaptive learning frameworks in the near future. These frameworks scaffold the individuals' learning with apps that are based on the learners' previous performance, engagement data, and needs, while preserving the children's capacity for choice. Such a model fosters exploration and curiosity for learning, while providing updated content based on theoretically derived developmental principles and individual learning needs.

17.8 Next Iterations and Directions

17.8.1 Content Expansion

As suggested, there are clear and exciting opportunities for data-driven improvement, and for the refinement and expansion of content. Additional apps need to be developed to support literacy beyond the early reading skills focused upon here. Based on our cognitive neuroscience-based app map and the existing data, significant content lacunae exist in phonological, semantic, early decoding and blending processes that, when addressed, may propel children's reading acquisition further, and ultimately contribute to their deepening comprehension abilities.

One of the still discomfiting aspects of our work concerns the lack of high-quality, evidence-based apps for literacy, particularly for the stages of reading beyond the initial acquisition phase. Guernsey and Levine (2015) provide an exemplary evaluation of what they call the "Wild West" of app design and bemoan the relative paucity of apps that have had any expert in literacy involved in their design. Our intention in the near future is to work with scholars in neuroscience and literacy intervention to propel the development of the next iteration of high-quality literacy apps that are both theoretically based and tested for engagement.

Furthermore, educational developers can introduce new content areas to our existing open-source platform, both to other academic subjects (e.g., STEM), as well as to provide resources concerning daily life (nutrition, health and hygiene, ethical development). In addition, we hope to add a new direction in our work. We would like the design of future apps to have content that will help to develop the moral imagination of our children. We are hoping, for example, to integrate moral dilemmas in the first stories to instill a greater understanding in the young readers of those whom they have been raised to consider "other".

We are working, therefore, towards what we are calling the "literacy of ultimate concern" in which learning to read incorporates a compassionate stance towards "others" and the ability that the theologian Dunne (2006) refers to as "passing over" into the lives of others. In so doing, such a foundation for learning prepares the children of the next generation to appreciate and to participate in the increasingly interconnected nature of our world. It is our particular hope that such new content will usher in greater connections among children around the globe.

17.8.2 Facilitating Peer Learning

Toward those ends, our current work has emphasized peer-peer learning among children within our different deployment sites. In the not too distant future, we hope to connect children across sites through the tablets—where children's curiosity about each other, and their desire to communicate with others across the world can motivate self-expression and sharing through reading and writing. From a research

perspective, a wider range of deployments across even more diverse sites, and the resulting rich and standardized data provided by the platform from each will make future cross-site and population analyses possible. The work to date has already produced the beginnings of a unique cross-cultural database that can help researchers and practitioners better understand both peer learning and the efficacy of different content emphases. The resulting insights will help educators and families, as well as their communities to better evaluate the particular features that sustain learners' attention and engage them over time with the content and with each other.

17.9 Summary

In the last analysis, reading is the ultimate connector: between reader and author; between reader and "other" people, ideas, and epochs; and between the solitude of the self and the connections reading gives to the rest of the world. Just as Proust described a century ago, "reading is that fruitful miracle of a communication in the midst of solitude" (see Wolf 2007). Within this context we hope to help bring to every non-literate child a platform for communication and connection to our increasingly boundary-less world.

In sum, with this beginning initiative in global literacy, we hope to help bring the world's attention to the vast potential within every child that is released through becoming literate. We hope to underscore the profound waste when children do not become literate, do not become educated members of our society, do not develop their unique contributions to our world. Like Pope Francis, we look at the care and development of our young as a "diagnostic sign" of the health of our society. Like Sr. Lenora Tucker's mothers' plea, "we hold your foot".

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Chapter 18
Scientific Learning and Education for Human Security and Well-Being

Hideaki Koizumi

Abstract Scientific-evidence-based-approaches are extremely important in pedagogy as subjectivity is not uncommon in the field of education. Further, scientific-evidence-based education should be the basis of human sustainability since education is the crux in determining our understanding of major components such as equity, safety, ethics, freedom and growth, leading to human security and well-being. I propose Evolutionary Pedagogy (a theory of education that is based on human evolution) in which brain-science-based education, evolution sciences, bio-sciences, psychological sciences, physics, anthropology and paleontology are trans-disciplinarily bridged and fused in conjunction with the history of spiral education, as one useful scientific-evidence-based-approach. Although Jean Piaget, psychologist and partially paleontologist, noted this point, he did not emphasize it, perhaps due to the fact that Ernst Haeckel's recapitulation theory had been severely denied at the time. Recent advances in science have shown that a parallel relationship can be observed between human evolution and human development even after birth. Evolutionary Pedagogy therefore, could provide a novel and more appropriate spiral education curriculum together with brain-science-based education. Another important priority is to nurture a scientific mind-set and warmheartedness—especially from the viewpoint of values. While a scientific mind will guide us in objective judgement, warmheartedness will provide the compass of compassion leading to harmony in the world. Warmheartedness could be the basis of ethics that is the human dignity.

18.1 Introduction

The brain is created via the interaction of genetic information and the environment. The biological definition of *learning* is the process of establishing a cerebral neural circuit by receiving external stimuli from the environment and that of *education* is

H. Koizumi (✉)
Center for Exploratory Research, Hitachi, Ltd., Hatoyama, Saitama 350-0395, Japan
e-mail: hideaki.koizumi.kd@hitachi.com

to control and supplement such external stimuli to facilitate learning. To enable a scientific and objective approach, the concept of education related to the sense of value should be positioned outside the domain of the biological concept of education and be discussed separately as ethics (Koizumi 2000a, 2004).

The observation of brain development after childbirth reveals a period of synaptic plasticity occurring chronologically on a neural circuit according to genetic information. Such plasticity includes micro plasticity such as inter-neural connectivity (synapses) mainly of sensory circuits, pruning and myelination, or the membrane coating of unmyelinated nerve fibers, and macro plasticity such as primitive reflexes, which are an important sign of next-stage nervous system development. Sleep rhythms, which are important throughout a human's life, are nurtured during infancy according to changes of light from daytime through nighttime. Based on the affectionate relationships formed between an infant and his/her nurturers, the infant's early-stage will (or desire) is manifested in such forms as reaching and crawling (Koizumi 2000b).

During infancy, rationality, sensitivity and precursor functions leading to social skills are nurtured, as well as a neural foundation for warmheartedness or compassion, which becomes the foundation of ethics. Scientific learning and education pursuing "Human Security and Well-Being" help control unethical actions and develop a neural foundation to make passionate efforts to contribute to not only one's self but also others. To nurture children with a rich mind and ensure a positive future, education is a fundamental core (OECD 2002a).

Figure 18.1 is a schematic illustration of the concept that education lies at the core of human security and well-being. The goal of our society is "Human Security and Well-Being," of which the concept of "human security" has been used by the United Nations ("*Ningen-no Anzen Hosho*" in Japanese). Although ensuring
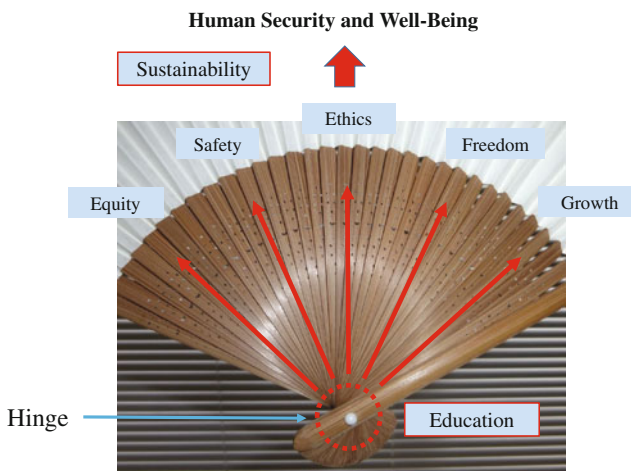
Fig. 18.1 Education is the hinge of sustainability standing with equity, safety, ethics, freedom and growth

security and safety is important, security and safety alone do not necessarily mean that people can feel the joy of life and be fulfilled in their lives. Therefore, I believe the goal should also include Quality of Life (QOL) and Well-Being, which is akin to a sense of happiness.

The elements for the sustainability of human society include equity, safety, ethics and growth. At the OECD Forum 2002, heated discussion took place on the basis of the fundamentals—Security, Equity, Education and Growth. The author, who attended the forum, keenly recognized at the time that each of the four simultaneously held sessions concluded that education is the ultimate solution for global-scale issues related to these fundamentals. The OECD Forum 2002 also included a highlight session titled "Brain & Learning: A Revolution in Education for the 21st Century?" (OECD 2002a, b, 2007). An OECD international collaborative project, "Learning Sciences and Brain Research," was initiated in 1999 mainly by Drs. Jarl Bengtsson and Bruno Della Chiesa, among others.

In 2003, the Pontifical Academy of Sciences (PAS) in Vatican City celebrated its 400th anniversary with a commemoration symposium titled "Mind, Brain and Education." The conferences at the symposium set the direction for the subsequent global approach to "Brain-Science-Based Education" (Battro et al. 2008). At that symposium, Pope Saint John Paul II stated that

> …scientists themselves perceive in the study of the human mind the mystery of a spiritual dimension which transcends cerebral physiology and appears to direct all our activities as free and autonomous beings, capable of responsibility and love, and marked with dignity. This is seen by the fact that you have decided to expand your research to include aspects of learning and education, which are specifically human activities. (ibid)

In 2007, the first issue of the Journal of Mind, Brain and Education was issued, and it became a platform for this new field (Fischer et al. 2007). In 2015, the first issue of the Science of Learning was issued as part of the Nature Partner Journal series (Nature Publishing Group 2015).

Meanwhile, Japan's research on learning and education based on brain science has a long history. In 1974, the book Brain and Child-Care by Tokizane (1974) was published posthumously; Dr. Tokizane, a professor at the Faculty of Medicine at the University of Tokyo, was a leading brain scientist. Dr. Jushichiro Naito, director of Aiiku Hospital; Ms. Kimiko Saito, founder of the Sakura-Sakurambo Hoikuen, who dedicated her entire career to onsite child care and care for handicapped children; Dr. Shoji Ijiri, who was a paleontologist, thinker and philosopher; and Dr. Shigeo Miki, in the field of comparative anatomy, among others—"legends" in their respective fields from the current perspective—cooperated beyond the borders of their disciplines and occupational positions to create the core of the concept of Brain Science and Education.

In 1995, a transdisciplinary forum was held based on brain function measurement, where scientific technologies expected in the twenty-first century were discussed beyond the industry-government-academia framework (Koizumi 1995). In 1996, an international transdisciplinary forum was held on sustainability-based issues related to the global environment. A nighttime session at the forum, titled

"Interaction of the Brain and the Environment" (Koizumi 1996, 1998), led to an international transdisciplinary forum in 2000 concerning education based on brain-science (Koizumi 2000b) followed by the implementation of Japan's large-scale national "Brain-Science and Education" project, which was launched in 2001 and lasted approximately 10 years (Koizumi 2010a, 2012).

In this paper, as a step toward the next stage, I would like to propose Evolutionary Pedagogy as a new concept of education and provide my opinions with regard to "Children and Sustainable Development: A Challenge for Education," which was a major theme of the most recent PAS workshop (2015).

18.2   The Idea of Evolutionary Pedagogy

Figure 18.2 shows typical fossils of organisms that lived until the mid-Paleozoic era. These fossils reflect the history of life. In the more than 3.5-billion-year history of life onE, organisms have continued transforming in line with the fundamental laws of nature such as the laws of physics, and information on such transformations has accumulated in the genes of species that have survived by successfully adapting to the environment, which is one type of long-term learning. Oxygen in the atmosphere, a major reason for the significant transformation of life forms, is considered to have been brought forth by the photosynthesis of cyanobacteria (blue-green algae). Actually, according to recent isotopic analysis using accelerator mass spectrometry on stromatolite formed by cyanobacteria, fossil remains of the algae mat (stromatolite formed by cyanobacteria) that lived 3.43 billion years ago were found to contain sodium carbonate and sulfur originated from organisms (Bontognalia et al. 2012). In the ancient atmosphere of the Earth, which consisted mainly of carbon dioxide (CO_2), oxygen was produced by algae, which evolved from anaerobic Archaebacteria. The composition of the atmosphere was transformed by organisms because the atmosphere that is attached to the surface of the Earth by gravity is a thin film. And such matter is ultimately linked to the major theme of this paper—sustainable development. Half of the mass of the Earth's current atmosphere exists within only 5.7 km of the terrestrial surface. To help people understand why we should not pollute the air, it is necessary to educate children, at young ages, to know such an important physical fact, showing the importance of education. I repeat that education is the key to "sustainability" as shown in Fig. 18.1.

Haikouella lanceolata and Pikaia, are considered to be the ancestors of Chordata, which evolved into the modern vertebrates with an endoskeleton, including human beings, and it has been confirmed from fossil remains that they lived in the Cambrian period 500 million years ago. (The Trilobites shown in Fig. 18.2 also emerged in the Cambrian period.) A species similar to *Haikouella lanceolata* and Pikaia and still surviving is the *Branchiostoma lanceolatum* (Chordata), and an analysis of its 21,600 genes was compared to an analysis of all the genes of a human (approximately 22,000 genes), resulting in the discovery that
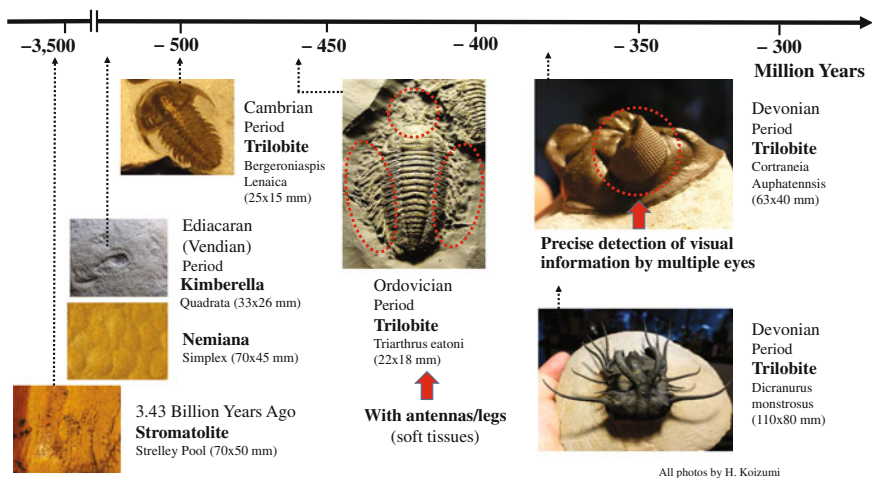
Fig. 18.2 Evolution of life in the Proterozoic Eon and the Paleozoic Era

approximately 60% of the genes of the *Branchiostoma lanceolatum* were of the same type as humans' (Putnam et al. 2008). The genes of modern humans, which are still in the process of transformation, reflect a long history of life forms. Moreover, based on research on the fetuses of vertebrates, many mentioned similarities between the process of human development and the tree of life, "The Evolution of Man." A major example was Ernst H.P.A. Haeckel's recapitulation theory to the effect that ontogeny recapitulates phylogeny in shorter time frames. The ontogeny and phylogeny of the brain also have many similarities if the time frames are shortened and synced for comparison. Some aspects have been seen showing that not only during the fetal period but also after birth the past evolutionary process is repeated.

Although Haeckel's recapitulation theory to the effect that ontogeny recapitulates phylogeny is well-known, the theory was long discredited due to the suspicion of fabrication by Haeckel of the comparative illustrations of ontogeny and phylogeny. Even relatively recently, this suspicion of fabrication was reintroduced in a Science magazine article (Pennisi 1997). On the other hand, a science history researcher recently concluded (Richards 2009a) that the allegation of a fabrication by Haeckel involved errors (Richardson et al. 1997). Although a biological causal relationship that becomes a reason for recapitulation has not been fully uncovered yet, part of such a causal relationship has gradually come to our knowledge such as different species' homeobox genes, which are substantially alike. In addition, recent gene analyses have produced a clear result showing that the period of the pharyngeal embryo has the highest similarity among different species' genes (Irie and Kuratani 2011). Haeckel's concept of evolution has started to be understood more accurately (Dayrat 2003) (Richards 2009b).

On the other hand, some organisms that were optimized in the ecological niche do not show any evolution—with no change in more than 100 million years, as if
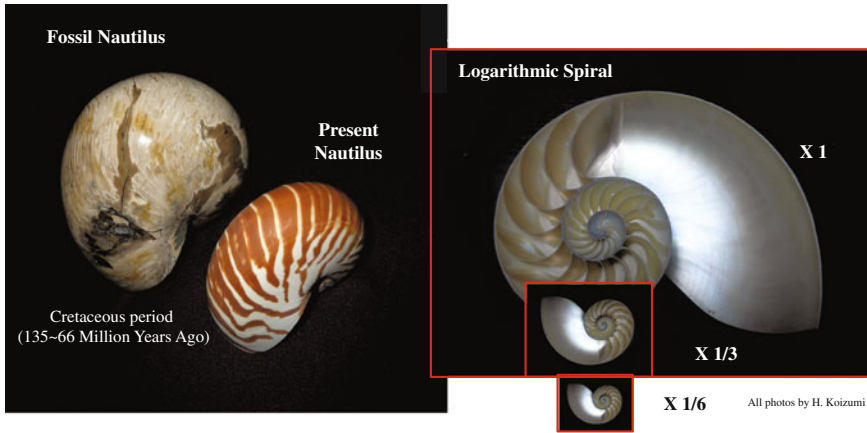
Fig. 18.3 Comparison between a fossil nautilus and a present nautilus (*left*). The cross-section of the present nautilus shows a logarithmic spiral (*right*)

time had stopped. A typical example is the Nautilus shell shown in Fig. 18.3 (left). The right of Fig. 18.3 shows a section of a still surviving Nautilus shell, the spiral curve of which is an accurate logarithmic spiral. Although the convergent point of the logarithmic spiral can be shown mathematically, it takes an infinite approach to reach the convergent point. Cosmic nebulae (e.g., the Galaxy) and a huge low pressure such as a typhoon are typically in the form of a logarithmic spiral. Furthermore, the spiral-shaped horns of organisms are also a variation of a logarithmic spiral.

Moreover, concerning the local functional areas of a newborn's brain, the empirical knowledge of which had been completely nonexistent, actual measurements now have become possible. A new brain function measurement method called optical topography enabled safe measurements of a newborn's brain functions (Koizumi et al. 1999, 2003; Koizumi 2008; Maki et al. 1995). Through collaborative research with domestic and overseas cutting-edge research organizations, the existence of local functional areas was partially but clearly seen on the brains of newborns less than four days old and the brains of early infants (Peña et al. 2003; Taga et al. 2003). Before optical topography, controversies had been incessant between the theory that a newborn's brain is just like a blank slate, or tabula rasa, restated by John Locke, who advocated empiricism, versus nativism, which believes human beings are born with innate brain functions that are universal to all human beings, or Noam Chomsky, among others, who believe that we are born with a predisposition to learn language (Pinker 2007). Further measurements of a newborn's brain resulted in, I believe, somewhere between empiricism and nativism. That is, local functional areas were observed in the newborn's brain, whereas there was a possibility that the baby learned the intonation of a phonetic language during the fetal period and the inclination toward liking natural language was observed. This result helps us think about neural evolution (Fig. 18.4).
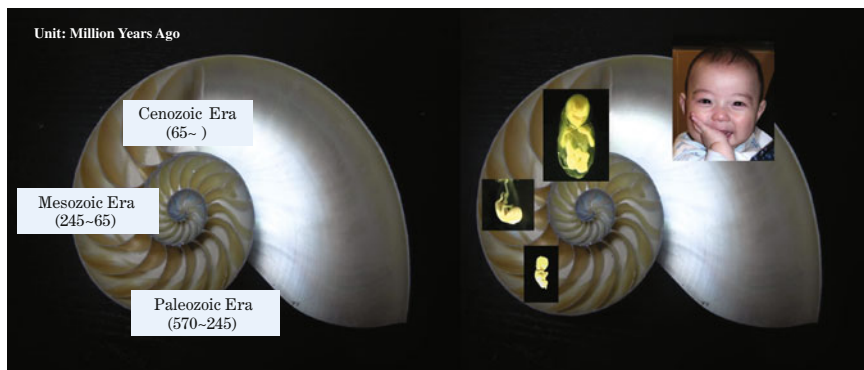
All photos by H. Koizumi (For fetuses, courtesy of Univ. of Chicago)

Fig. 18.4 The concepts of ontogeny and phylogeny on the logarithmic spiral of a nautilus

Furthermore, based on recent knowledge in physics, paleontology and neuroscience, the author has come to believe that it is possible to establish "Evolutionary Pedagogy" as a new educational theory for the future of "Brain-Science-Based Education" (Koizumi 2007, 2014a, b).

18.3 What Is Evolutionary Pedagogy?

18.3.1 Perspective of Physics to Understand Evolution

I repeat that Fig. 18.2 shows the transformation of bacteria to soft multi-cell organisms and the eras up to the Paleozoic era, when multi-cell organisms with a rigid exoskeleton emerged, using major fossil remains. About 3.5 billion years ago, the massive proliferation of algae, a kind of bacteria, occurred in shallow seas and left many fossil remains in the form of mat, which is considered to have brought oxygen into the Earth's atmosphere. In the Ediacaran (Vendian) period (635–541 million years ago) soft Cnidarians appeared at the sea bottom (Fig. 18.2). Although this era was previously considered a period without a predator-prey relation, therefore dubbed the "Wonderful life" by Gould (1989), the recent discovery of fossil remains with a trace of *Kimberella* crawling and a trace of *Dickinsonia* preying on other organisms has raised the possibility that a partial predator-prey relation existed.

Movements have a physics-based inevitable relation with morphological symmetry. With regard to the *Kimberella* in the Ediacaran (Vendian) period, with the emerging possibility of mobility for prey, the right and left sides of its body are almost symmetric (Fig. 18.2). From the perspective of physics, the velocity vector is determined, on a two-dimensional plane, by the velocity and the directions of right and left. To change the direction of movement, the velocity of the right side and left side of the moving body needs to change. This is the same mechanism as that of

CAT® tracks of snow vehicles and construction equipment. The principle for direction control is the right and left nervous systems and the so-called ladder-shaped nervous system that connects them. The Mollusca also complies with this physical principle. In a predator-prey relation, agile control of the velocity and direction of movements is crucial. Leg strength is a determining factor for the velocity of movement because the animal kicks the sea bottom or the ground and moves forward using the ground reaction forces. Furthermore, because repetitious leg movements are necessary to move forward, mechanical impedance needs to be improved. Discussion on direct current (DC) does not need an imaginary unit, whereas the theory of alternating current requires an imaginary unit that expresses the phase. Hopping just once is not enough to jump high. By repeated hopping with good timing (adjusting mechanical impedance), one can jump high. Many animals on four legs can run faster than humans walking upright on two legs. The evolution of humans walking on two legs can be considered to be ongoing. Recent Olympic and Para-olympic track records are becoming closer. Soon, the record of a Para-olympic gold medal runner with two artificial legs will be better than that of an Olympic gold medal winner, proving that mechanical impedance is a key to evolution.

18.3.2 Process of Evolution that Corresponds with Development After Birth

A newborn's primitive reflexes serve as a precursor or a foothold of functional development, and many of those reflexes reflect the history of evolution. The sucking reflex is a reflexive action of a newborn, which is common among mammals, to suck something protruding. The grasping reflex is a reflexive motion of a newborn to grasp tight if one's finger touches the newborn's palm, which could be reminiscent of apes' long-term life on a tree. The walking reflex also emerges naturally in the movement of locomotion (walking or running by alternating hands and legs instead of moving back and forth both hands and legs together at the same time). Many of these primitive reflexes, which disappear during infancy, have been used for the diagnosis of developmental disorders. However, an educational method could exist to facilitate the development of hands and legs by utilizing primitive reflexes (Takei and Seki 2010). As mentioned later, it is possible to conduct research that links primitive reflexes with agile and precise grasping sum and finger motions that humans acquired for the first time via genetic mutation (Alstermark et al. 2011).

As shown in Fig. 18.5, apart from the neural pathway for fingers' strong grasping motion, a separate neural pathway evolved for precise grasping motion by dexterous sum and finger movements (Feix et al. 2015; Ehrsson et al. 2000; Lawrence and Kuypers 1968). Furthermore, it has come to our knowledge that human-specific fast and precision finger movements such as movements for piano, violin and other musical instruments resulted from the evolution of a completely new motor area (Li et al. 2010). This human-specific new motor and somatosensory areas have
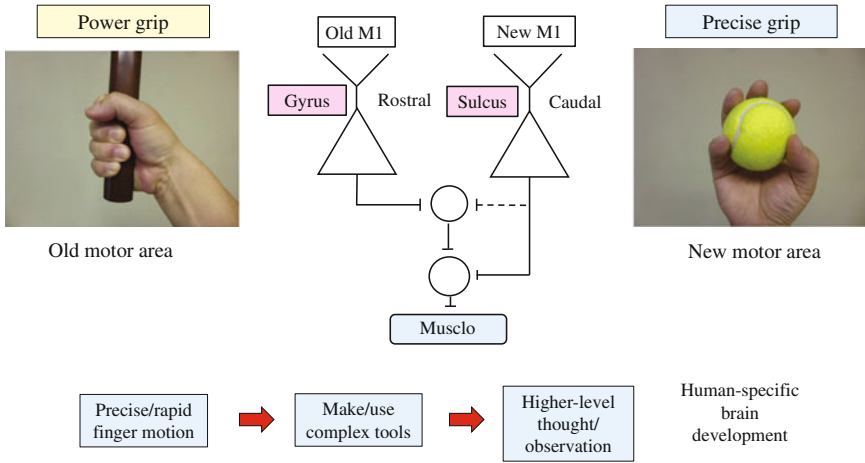
Fig. 18.5 Comparison between the old motor area for a power grip and the new motor area for a precise grip. It could be the origin of human cognition

evolved not in the gyrus but deep in the sulcus where the motor area and the somatosensory area are close to each other. Chimpanzees and bonobos, which are the species closest to humans, do not possess these new motor area and new somatosensory area. No progress was seen in Neanderthals' tools, which might be because this new cerebral area did not evolve in their brains. On the other hand, *Homo sapiens* (modern humans) dexterously developed stone tools and various types of complex and convenient tools. The author believes there is a possibility that the thoughts that were required for the design and production of such tools should help develop the human-specific brain with the SNPs in FOXP2 gene that will be mentioned later.

Language ability is a sophisticated function that humans acquired. Although it has been known that chimpanzees and bonobos are capable of communication by showing one simple word after another using a sign language, only humans possess a hierarchical grammar. Recently, the Max-Planck Institute for Informatics was successful in the analysis of genes of the fossil remains of the bone marrow of Neanderthal, releasing interesting results. Compared with modern humans (*Homo sapiens*), a different nucleic acid sequence was found in the FOXP2 gene, which is called the language gene, on the seventh chromosome (Maricic et al. 2013). Research by putting the FOXP2 of Homo sapiens into the brain of a mouse is under way at MIT. Various new knowledge and insights have been announced concerning the possibility that this single nucleotide polymorphism (SNP) endowed modern humans with various special abilities. Although no significant advance has been seen in Neanderthal's ability to make stone tools, remarkable progress was seen in modern humans' stone tools for each usage. Furthermore, the possibility that the SNP led to a hierarchical grammar in modern humans was clearly validated in 2001 in research on families with an agrammatism member. Future research is awaited.

What is important here is the high possibility that the evolutionary process, from chimpanzees to Neanderthal to modern humans, might repeat after our birth. There is a possibility that the period from birth through infancy until entering elementary school, during which remarkable development is seen in language ability, could correspond with this period of evolution.

Although chimpanzees at a certain age can pass a marking test (i.e., a mark is put on its face while sleeping and when it wakes up, looking in a mirror, it can recognize the mark on its face), chimpanzees' development of the theory of mind (ToM) is far behind. The absence of proactive educational activities might have something to do with chimpanzees' underdeveloped ToM. Without understanding others' feelings, it is difficult to have warmheartedness—caring about other people's minds and understanding others' situations. To nurture ToM is extremely important for our future world.

18.3.3 Development of the Neural System and Corresponding Process of Evolution

As mentioned at the beginning of this paper, the biological definition of *learning* is the process of establishing a cerebral neural circuit by receiving external stimuli from the environment and that of *education* is to control and supplement such external stimuli to facilitate learning. In 2000, new inter-neural connectivity (synapses), which occurs at the time of learning, and the efficiency of the connection itself were addressed, and recent experiments using mice confirmed that the myelination of nerve fibers connecting the elements of a central neural circuit was facilitated by learning. Given the special sequence of magnetic resonance imaging (MRI), which helps verify the myelination in living humans, research on myelination at the time of learning can be expected.

Hypotheses have continued to be submitted to date to the effect that the myelination of nerve fibers that transmit information might enable saltatory conduction of electric signals, thereby significantly improving information transmission speed, leading to acceleration of the processing speed and increasing the processing volume. These hypotheses are based on the tremendous efforts made more than 100 years ago by Flechsig, who clarified the order of myelination (Flechsig 1901, 1920). The process of myelination in ontogeny is parallel with the process of phylogeny. As shown in Fig. 18.6, the transmission speed of nerves is improved significantly—by a digit or by double digits—by the myelination of somatic sensory areas and motor and auditory sensor areas during the fetal period.

As shown in Fig. 18.6, the order of myelination is almost parallel with the order of evolution. Especially intriguing is that some modern human–specific sophisticated brain functions undergo myelination even after coming of age (Yakovlev and Lecours 1967). Although future research is awaited, even now we can tell that if an educational method that requires a post-myelination function is attempted before
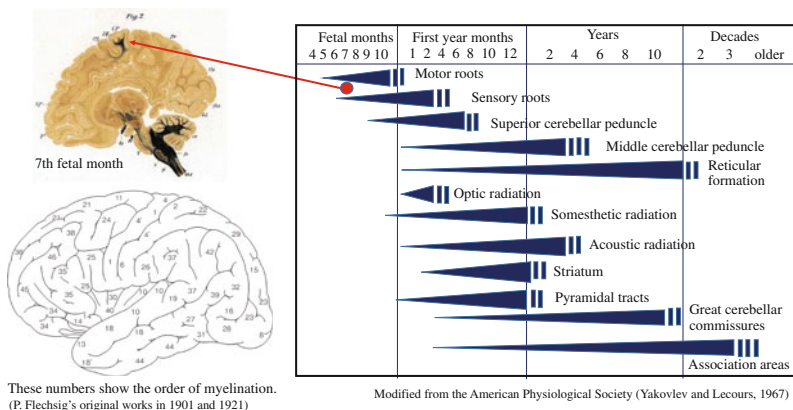
Fig. 18.6 Evolution-related myelination order in human brain

myelination, such a method might be impossible to execute or extremely poor in efficiency. Therefore, this matter needs to be taken into account when scientific education and learning curricula are formulated.

18.3.4 Influence of the Recapitulation Theory

The influence of Haeckel's recapitulation theory on society as a whole was investigated by Stephen J. Gould, who provided details of the impact in Chap. 5, "Pervasive Influence," of his book Ontogeny and Phylogeny (1977). Despite the recapitulation theory's wide range of influence, few clearly supported the hypothesis as it had been discredited with the alleged suspicion of fabrication. However, it cannot be denied that many scholars referred to Haeckel's recapitulation theory for their own theories. Many acknowledged a partial parallel relation between ontogeny and phylogeny even though they did not clearly support Haeckel's recapitulation theory. From among the results of the investigation by Gould, some items that I think are important are shown below.

Jean Piaget, a developmental psychologist born in a French-speaking region of Switzerland, first learned paleontology, as a paleontologist, and wrote a dissertation on Brachiopoda, which lived in the Jurassic period, by examining fossil remains (the "Jurassic period" was named from the Jura Mountains, forming a natural border between France and Switzerland, where fossil remains of the Jurassic period were discovered). In a publication he wrote late in his life, he again referenced the importance of a parallel relation between ontogeny and phylogeny.

> The fundamental hypothetic of genetic epistemology is that there is a parallelism between the progress made in the logical and rational organization of knowledge and the corresponding formative psychological processes. With this hypothesis, the most fruitful, most obvious field of study would be the reconstituting of human history—the history of human thinking in prehistoric man. Unfortunately, we are not very well informed in the psychology of primitive man, but there are children all around us, and it is in studying children that we have the best chance of studying the development of logical knowledge, mathematical knowledge, physical knowledge, and so forth. (Piaget 1969)

Piaget further mentioned, as Gould also mentioned, a parallel relation between the process through which children acquire logical and mathematical knowledge and history of Western science.

> It may very well be that the psychological laws arrived at by means of our restricted method can be extended into epistemological laws arrived at by the analysis of the history of the sciences: the elimination of realism, of substantialism, of dynamism, the growth of relativism, etc. all these are evolutionary laws which appear to be common both to the development of the child and to that of scientific thought. (Fiske 1975)

The author insists that it is possible to establish Evolutionary Pedagogy including Evolutionary Child Care because, different from the age when Piaget lived, with recent significant advancements in molecular biology we are at an entry point for detailed gene analyses of fossil remains of Neanderthal. A significant change is about to occur to the situation described by the aforementioned Piaget phrase: "Unfortunately, we are not very well informed in the psychology of primitive man." At least, we can objectively track the changes in modern humans over the past 50,000 years or so. In other words, we are at the dawn of new education with a bright horizon ahead, capitalizing on the genetic analyses of human evolution. The new education will address not only the child care of the newborn and infants and children but also the process of development of the mind when growing from adolescence to adulthood.

Sigmund Freud evolved to clinical psychology from comparative neurology. He researched neurological evolution using Agnatha and released a related thesis, which was before heated debates between Santiago Ramón y Cajal and Camillo Golgi because the central nervous system itself was not clearly known. Freud showed clear and direct support for Haeckel's recapitulation theory on many occasions. For example, in his publication "Introductory Lectures on Psycho-Analysis," he stated that "each individual somehow recapitulates in an abbreviated form the entire development of the human race" (Freud 1916) and further went on to say that "ontogenesis may be regarded as a recapitulation of phylogenesis, in so far as the latter has not been modified by more recent experience. The phylogenetic disposition can be seen at work behind the ontogenetic process" (Freud 1905). Also, it seems that he thought that underneath the human consciousness lies the history of evolution (Koizumi 2011). With regard to the parallelism of ontogeny and phylogeny, many predecessors in the field of early education such as Pestalozzi, Froebel and Herbart showed interest (Gould 1977).

18.4 Theory of Spiral Education

In 1861, Herbert Spencer emphasized the following:

> If there be an order in which the human race has mastered its various kinds of knowledge, there will arise in every child an aptitude to acquire these kinds of knowledge in the same order…Education should be a repletion of civilization in little. (Spencer 1861)

In the 1870s and 1880s, Tuiskon Ziller (1817–1883) of German Herbartianism (led by Johan Friedrich Herbart) set a general formula of "Kulturhistorischenstufen (theory of culture epochs)," which is a basic theory of Recapitulatory curriculum. Formulating the primary school's curriculum based on the formula was prevalent at that time (Gould 1977).

> The mental development of the child corresponds in general to the chief phases in the development of this people or of mankind. The mind-development of the child, therefore, cannot be better furthered than when he receives his mental nourishment from the general development of culture as it is laid down in literature and history. Every pupil should, accordingly, pass successively through each of the chief epochs of the general mental development of mankind suitable to his stage of advancement. (Seeley 1906)

At the Woods Hole Conference held in the United States in 1959, part of the theory of spiral education was revived (Bruner 1960). The spiral education theory is being further deepened and outstanding actual educational activities are ongoing at the Ross School in the United States (founded by Courtney Ross in 1991) (Suarez-Orozco and Sattin-Bajaj 2010). In 2011, the Ross School celebrated its 20th anniversary, sending out human resources nurtured under the new educational theory to society (Koizumi 2010b).

18.5 Nurturing a Scientific Mind-Set

I would now like to discuss science education for children. The *La main à la pâte* ("putting one's hand to the dough") project, which started in 1996 and is led by Professors George Charpak (†2010), Pierre Léna and Yves Quéré of the Académie des sciences (French Academy of Sciences), has produced significant fruit in science education for children. This campaign nurtures the scientific mind-set, or passionate minds, to discern various facts from objective and neutral standpoints through experience in general education via meaningful activities that can substantially contribute to human society.

In Japan, under the Sony Preschool Education Program for Children, which encourages educational activities to "Nurture a Scientific Mind-Set," initiated by the Sony Foundation for Education in 2002, science education has been targeted at kindergarten and nursery school students ages 0 to six before entering elementary school (Koizumi et al. 2006). Largely different from so-called early education, this program does not develop elementary school-level science education for younger

students. As shown in Fig. 18.7, with the "Scientific Mind-Set" summarized into five items, this program attempts to nurture an essential scientific mind-set from the moment of birth. The number of entries of research papers submitted from kindergartens and nursery schools nationwide to propose new educational content and report the results of such practices has reached 1000 in this decade. The author, who has served as the chief examiner of this program for many years, has learned many things from the initiative. Although this activity started for preschool education, the program is now influencing science education at elementary schools. The clear step-by-step development of the scientific mind-set is beginning to be recognized in children, especially among those ages 0–5, which, linked to "Brain-Science-Based Education" and "Evolutionary Pedagogy," will contribute to future science education.

18.6   Conclusion

The "Scientific Mind-Set" nurtures future scientists and minds that objectively understand the environment where humans exist, leads us to value ourselves and others, and develops in human minds an appreciation for the life within nature (Fig. 18.7).

The education that nurtures such a mind-set helps us anticipate a new mind-oriented horizon beyond conventional politics and economics. Education has the potential to correct the current economic gaps and reduce the strife and conflicts driven by infinite greed and hatred. Education of the mind, reflected in the ancient Eastern philosophy of "Know one has enough (pleasure unrelated to material affluence)," has the potential to change the sense of value of the world. The author believes that such an educational principle can be derived from neuroscience,
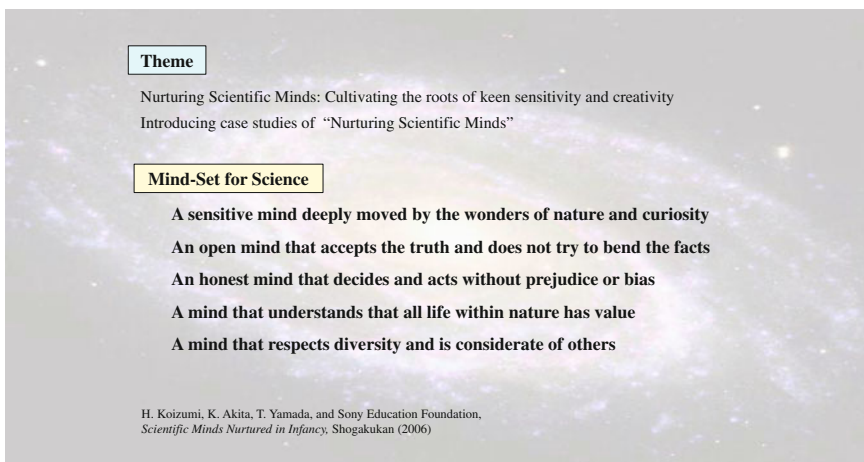
Fig. 18.7 The Sony Preschool Education Program for Children received more than 1000 project proposals in the past 10 years
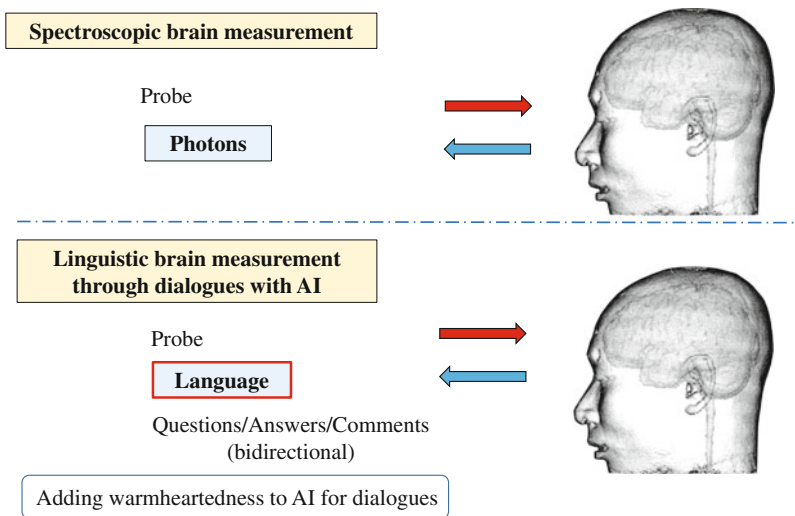
Fig. 18.8 Brain imaging versus linguistic measurement through dialogues

paleontology and physics, linked to religion and philosophy. Without such a direction, it would be difficult for many lives to cohabitate happily within the thin membrane-form biosphere, which is attached to the surface of the Earth.

An accurate understanding of the human brain is the core of scientific learning and education. While learning, the volume and thickness of the corresponding functional area of the cerebral neocortex changes. Furthermore, a recent discovery via experiments on animals has revealed that learning leads to the myelination of nerve fibers that connect the functional areas (McKenzie 2014). Ongoing future research is much awaited.

Basic brain functions include not only the governing of sensory, kinesthesia, memory and emotions but also the decomposing and integration of information for parallel distributed processing (PDP). It has been determined that the chronological development of various brain functions is important for education. Human-specific abilities that do not belong to other animals include language functions, the concept of a future and prediction, surmising others' thinking (the theory of mind) and ethics. In observing brain functions, it is gradually becoming possible to deeply understand humans' fundamental nature including hatred. It might be possible that scientific analyses could help deter the chain of hatred for the first time in our history.

An important function that humans acquired at a late stage of evolution was language. The author believes that a measurement methodology using the language function will be a next-generation measurement method for humans. This measurement concept utilizes language as a probe to measure the human mind (Fig. 18.8). Actually, thanks to the rapid development of artificial intelligence (AI), debate based on a dialog between a human and AI is becoming possible (Sato et al. 2015). Facing the emergence of such a new measurement methodology, something

Pali	Pali meaning (~BC 500)	Chinese
metta	unconditional loving kindness such as that in the gentle heart of a good friend or a mother	慈
karuna	the ability to share another's pain as if it were one's own	悲
mudita	the altruistic joy in another's good fortunes	喜
upekkha	equanimity is a balanced state of mind with no strong attachments to things and self	捨

<Ethics>

Warmheartedness (compassion) ➡ **Human dignity**

Fig. 18.9 From an ancient Indian philosophy outlined in the Vedas (knowledge/wisdom) long before BC 500

Photo by H. Koizumi with permission

Fig. 18.10 Warmheartedness or compassion (The Pieta by Michelangelo in St. Peter's Basilica, Vatican City)

that we need to address again is ethics. Our history has shown that behind a powerful technology exists the yin and yang of its application.

Figure 18.9 shows four extremely important mind-sets that have been passed down orally for more than 3000 years in old Indian philosophy (Vedas) and were recorded in the ancient Pali language around B.C. 500. These were later adopted in Buddhism and are currently known as Shimuryoshin ("unmeasurable broad mind"). The meaning of each mind-set written in Pali is described in Fig. 18.9, all of which basically link to warmheartedness, being able to think of others' situation. The final publication by Dr. Hajime Nakamura, who was called Japan's top scholar of old Indian philosophy and ancient Buddhism, was "Atatakana Kokoro: Toyo-no Riso (Warmheartedness: The Ideal of the Eastern World)" (1999). However, such a way of thinking is not limited to the Eastern world. In "The Metaphysics of Morals" written by Immanuel Kant late in his life, what he wanted to say with regard to ethics was, according to my interpretation, the importance of compassion—not just thinking of one's self, it is important to think about other people's situations and care about others. I believe that warmheartedness should be positioned at the origin of education.

Lastly, presenting the Pieta at St. Peter's Basilica in Vatican City in Fig. 18.10, I would like to conclude this paper.

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Chapter 19
Children Facing Screens: An Educational Project for Helping Children Develop Their Critical Thinking Skills

Elena Pasquinelli

Abstract The sciences of the mind, brain, and behavior can be powerful allies of science education. During the last three decades these sciences have developed rapidly, providing a progressively deeper understanding of why certain concepts and attitudes come naturally to the human mind, why other require greater effort—not because of their intrinsic difficulty, but because they conflict with our intuitions, natural knowledge. This understanding has the potential of helping educators enable the next generations to face the challenges ahead with empathy, reason, and a scientific understanding of the natural world.

19.1 Introduction

> Education is neither writing on a blank slate nor allowing a child's nobility to flower. *Rather education is a technology that tries to make up for what the human mind is innately bad at.* Children don't have to go to school to learn to walk, talk, recognize objects, or remember the personalities of their friends even though these tasks are much harder than reading, adding, or remembering dates in history…
>
> (Pinker 2002, p 222)

The workshop on Mind Brain and Education held at the Accademia Pontificia delle Scienze in 2003 lies at the beginning of a new era for the establishment of a new dialogue between the sciences of the mind, brain, behavior and education. Pierre Léna—who successively co-edited the volume dedicated to the Educated brain with Antonio Battro, member of the Accademia Pontificia, and Kurt Fischer, director of the Mind, Brain, and Education program at Harvard Graduate School of Education (Battro et al. 2008)—brought this revolution at La main à la pâte. La main à la pâte was created exactly 20 years ago, by Pierre Léna and two fellow scientists of the French Academy of Science, Yves Quéré and Georges Charpak. Its aim has been

E. Pasquinelli (✉)
Fondation La Main à La Pâte, Paris, France
e-mail: elena.pasquinelli@fondation-lamap.org

since its beginnings—and still is—the improvement of science education, by creating tools, situations and spaces for thinking, aimed at favoring a more inclusive educational system. Science education is an aim in itself. Not only science education helps children build their vision of nature and humanity, but science is an integral part of human culture. Science education is also a mean for preparing young human beings to deal with the challenges ahead—a growing informational landscape, human societies engaged in non-linear interactions with nature—and for developing a necessary sense of responsibility towards the future of the anthropocene.

Since 2003, the awareness has grown—within and outside La main à la pâte—that the sciences of the mind, brain, and behavior are powerful allies of science education. These sciences have developed rapidly, providing us with a progressively deeper understanding of what comes naturally to the human mind, of the predispositions and mechanisms that make it possible to learn about nature and to reason in terms of objets, spaces, quantities, agents, social groups, norms and moral laws, to feel and think empathically. We've also learnt to anticipate that some concepts are harder to grasp, not because of their intrinsic difficulty, but because they conflict with our intuitions, natural knowledge and with the very predispositions that prepare our mind for learning. These concepts need dedicated efforts. The sciences of the mind, brain, and learning have recently turned their attention towards the understanding of the natural and cultural bases of teaching, and of the tools and strategies that favor social transmission of cultural knowledge. All these different strands of research can help building a better science education, for a better world. With this contribution I would like to illustrate with two examples the children's (and even infants') preparedness to learn—a precious basis for education—and at the same time briefly discuss the limits of the natural, non educated understanding of nature; illustrate with a practical example how cognitive science can intervene in education, namely for favoring critical thinking, social, emotional skills and well being, and propose a framework for fruitful interactions between cognitive science and education.

19.2   Children's Preparedness to Learn and the Limits of Natural Knowledge. Two Examples

The world longs to improve the education of its children. … But the discussion of how to improve education… has not kept pace with the commitment. While most of the proposals offered are reasonable, they are not substantive. Substantive changes depend on content, not on the size of the class but on what is taught there. Content depends on a theory of education that can be derived only by understanding the mind that is to be educated. … *What has evolution prepared the child to learn? Of the topics for which the child is prepared, are there any that are overlooked? Or are not taught at all? Are there topics for*

which evolution has not prepared the child but which must be learned nevertheless, and could be more readily learned if they were linked to topics for which the child was prepared? Finally, is evolution as flawless as the impression given, or has it failed on occasion, and endowed the child with false intuitions that need to be corrected? If what the child is taught is based, not on tradition, but on what evolution has prepared the child to learn, the cultural process of learning will come far closer to the process biology has itself provided to every child. (Premack and Premack 2004)

19.2.1 Social and Moral Skills

From the first days of their life, children assign other human beings a special place in their minds: they seek their gaze, they are tuned to their voices, can distinguish between familiar and unfamiliar individuals. Relatively quickly, they learn how to interpret their doings, to assign thoughts, desires, preferences in a quick and robust way (Bloom 2014a; Gopnik 2009). They develop a capacity of selectively trusting the sayings of adults, to gauge their expertise and trustworthiness (Harris 2015). They imitate, learn from others in variety of ways (Gariépy et al. 2014). Very early in life, they distinguish between an adult trying to teach them something, or just showing some aspect of reality (Csibra and Gergely 2006, 2011). Social skills follow a specific path of development, are not necessarily directly and explicitly taught, and can be specifically disrupted by different pathologies (Frith and Frith 2012). These capacities form thus a cluster of skills—or of predispositions to develop the relative skills—and motivations, which can be at least partially separated from other skills and predispositions: in cognitive terms, they constitute *modules* (Barrett and Kurzban 2006). Early social predispositions are accompanied by equally precocious and natural moral attitudes. Moral attitudes take different forms. First, form of moral judgment and sensitivity for "good" and "evil" (manifested, for instance, by the infants' attitude that consists in selectively preferring "helpers" and disliking "hinderers") (Bloom 2014a); second, empathy, compassion (Singer and Lamm 2009); third, an ability and motivation to cooperate with other individuals, a predisposition to care for others and to give help to others in need, including a predisposition to teach (Tomasello 1999, 2009, 2016); fourth, the imposition of social, conventional norms to others, especially to members of the inner group—while both in-groups and out-groups are submitted to the same moral judgments and moral norms (Koymen et al. 2013).

Education has too often forgotten to deal with these issues, or has tried to forge moral attitudes by forcing principles from the outside. Cognitive science suggests that we might start from the inside: by exposing young children, including pre-schoolers, to situations where they are required to attribute mental states, to interpret and identify emotions, in situations that are progressively more and more difficult, we might be able to sharpen and ensure the development of crucial social skills (Premack and Premack 2004). Education has also forgotten to deal with

empathy. Empathy is a force that dissolves the boundaries between us and others, and thus favors altruism, the helping of others. Sustainable, fair development depends, among other things, on the acquisition of a more inclusive attitude: on the establishment of cognitive and emotional, rational and empathic connections that go beyond kinship and shared culture, that extend towards others at large—that is, on the capacity of expanding the circle of empathy and compassion beyond what we nromally consider to be our in-group (Singer 2011; Pinker 2011). However, even if cultivating empathy looks like a (morally) good thing, it certainly has its limits. The benefits of empathy are easily embraced, and seem too obvious to require justification. But this vision might be too simplistic. Empathy, especially emotional empathy is in fact biased and narrow.

> Empathy is biased; we are more prone to feel empathy for attractive people and for those who look like us or share our ethnic or national background. And empathy is narrow; it connects us to particular individuals, real or imagined, but is insensitive to numerical differences and statistical data. As Mother Teresa put it, "If I look at the mass I will never act. If I look at the one, I will." Laboratory studies find that we really do care more about the one than about the mass, so long as we have personal information about the one. (Bloom 2014b)

A rational attitude allows us to rise above our pettiness and limited vision: to appreciate that the horror that strikes 1000 is worst, in terms of social policy, than the horror that strikes 1. Our empathic brain does not necessarily make the difference, and even, it tends to identify with the one fellow human being we happen to know, to the closest neighbor, not with the tens of millions of lives who strive to survive somewhere else, far from our immediate reach and familiar circle. Rationality, critical thinking and the control over emotions must be cultivated in education no less than empathy, if we are motivated to build a better, more inclusive, more compassionate world. At the opposite of empathy, compassion does not put us in resonance with others—it does not make us feel what other people feel, which is the very definition of emotional empathy, or imagine and understand what other people feel. Compassion is a rational state of valuing others' people lives and well being, and of rationally deciding of helping them. Compassion, as much as empathy, can be educated. The results of training compassion (training the capacity to respond to others' suffering with care, without experiencing their distress directly) are even more striking than those that result from training empathy (training the capacity to experience or feel others' suffering): compassion training can lead to increased altruism and positive emotions, without exposing to the risks of emotional burnout (Singer and Bolz 2013).

19.2.2 The Natural Understanding of the Biological World

As much as they are precocious social and moral beings, children are in a way natural born scientists: they possess the necessary curiosity and start up tools that are required in order to devise causes and other relations between events, to forge

explanations, to put them to the test (Gopnik et al. 2001). They also possess core knowledge systems that predispose them to learn in particular domains, to devise general laws and to develop expectations about objects, agents, numerical quantities, spaces and geometry, the physical and the biological world (Spelke and Kinzler 2007). To children, and even to infants, the physical and the biological world do not look the same (Carey 1985; Keil 2007, 2010). Children distinguish between animate and inanimate objects on the ground of basic laws of motion and the observation that agents perform self-initiated movements (Keil 2007). They identify patterns of growth and regrowth as common to animals and plants, and have ideas about fundamental characteristics of living organisms; e.g., animals have "something inside". Children attribute an essence to living organisms: for children, living organism are what they are because they have something in them that makes them behave as they do; the essence is transmitted and runs in families—e.g., a pig adopted by cows will still behave like a pig, it will not moo or love grass like adoptive parents (Gelman 2003). Children equally attribute a special form of teleology to organisms: at the opposite of artifacts, living organisms are not designed with a function, but their parts have functions (e.g., maintaining life), and teleological explanations are preferred to mechanical ones (e.g. for preschoolers plants are green because green is better for plants, but emeralds are green because they have tiny green parts in them). A sort of vital power keeps vital processes going on, and food is required in order to take in vital force, which is for living (Inagaki and Hatano 2002, 2004). Children use analogies between humans and other living organisms, and tend to attribute characteristics of the first to the latter. But it is now largely admitted that naïve understanding of biology is precocious and separated from naïve psychology—children do not export their observations of how human beings behave towards the rest of biology, but have a specific understanding of the latter as a proper domain of nature.

> This early acquisition of naïve biology is not surprising from an evolutionary perspective; the survival of early humans required some knowledge of animals and plants as potential foods, as well as knowledge about bodily functions and health to protect themselves. (Inagaki and Hatano 2006)

In particular, it appears that children and adults, even in the absence of formal scientific education, apply to the biological world taxonomies that share important similarities with those adopted by scientists.

> There is evidence for universal folk-biological principles that are trans-theoretical, transcultural, domain-specific, and complex in design. In particular, it appears that people in all societies parse local biodiversity into taxonomies whose fundamental level is that of the "generic species," that is, the level of oak and robin. In no other natural domain of human understanding does there appear such a unique and fundamental partitioning of reality into mutually exclusive groups that are further organized into mutually exclusive groups within groups (Darwin 1883:363) (Atran et al. 2001)

Naïve or folk biology is a natural basis for science education and for the development of more sophisticated and correct biological concepts and theories. Scientific biology education should acknowledge the existence of natural conceptions, interests, predispositions, and identify their effect on the acquisition of scientific concepts. E.g. vitalistic explanations might hinder the understanding of the role of germs in illness, and thus reduce the capacity of taking up the correct practices. Essentialism is a positive ground for the understanding of similarity within species, and of heredity, but can hinder the understanding of variation as a fundamental component of the Darwinian theory of natural selection upon genetic variation. On the contrary, teleo-vitalism can favor Lamarckian explanations, through the idea of organs that adapt in order to maintain life (Weisberg and Bloom 2007).

19.2.3   The Role of Experience in the Understanding of Biodiversity

Cognitive science research makes us also aware of the role of direct experience and cultural framework for the development of this kind of folk understanding of biology. Cognitive anthropologists such as Scott Atran and Douglas Medin have compared folkbiological cognition of young children and adults across different cultures (Medin and Atran 1999). They have pointed at the fact that psychological research tend to sample populations that are "close at hands" of major research laboratories. This might represent a particularly biased sample for the study of folkbiology, since populations living in urban settings are susceptible to experience poor contact with and limited cultural exchanges about the biological world—apart from contact with other human beings. In fact, Atran's and Medin's research teams have noticed the following: while urban USA children tend to reason anthropocentrically about the biological world until they are 7–10 years old (and to progressively shift towards a more correct model), Yukatek Maya children and Menominee Indian American children do not show the same bias. The latter in particular see humans as one animal among many. Previous studies had shown that USA college students tend to parse biodiversity not at the level of the generic species (as expected) but at a superordinate level: rather than preferentially using categories such as trout, robin, maple tree, they tend to adopt life-form level categories such as fish, bird, tree. Further studies confirm that urbanized citizens (Euro-American college and university students) might be enduring a devolution of folkbiological knowledge, which correlates with impoverished experience of nature: while still recognizing the generic-level as the basic level for inferences, their inferences are hindered by a lack of familiarity with different species and of names for labeling them. In practice, they tend to identify tree and bird species only as trees and birds.

> Despite Western's science historical origins in universal principles of folkbiology that are found in many different cultures, among people in globally mobile, technologically oriented societies there is marked deterioration in common-sense understanding of the everyday living world. This impairment affects people's practical ability to interact sustainably with the environment: a person who cannot distinguish a kind of bird or tree from another cannot respond appropriately to changes in the ecological balance among these living kinds. (Atran et al. 2004)

These observations suggest that direct experience of the biological world and cultural exposition (language, discourse, interaction with adults) have an impact on the kind of naïve view adults will develop. Despite the universal predisposition to develop a form of folkbiology, experience and culture can make a difference in the capacity of identifying, and thus making inferences about, biodiversity. Atran, Medin and colleagues, have also observed that in certain cultures (e.g. Menominee Indian) a view based on ecology, on the relations between organisms, is more developed and precocious. Such cultures see human beings as being part of nature, and experience difficulties when faced with the classical Western scientific attitude, which consists in studying nature as external and objective; but they more easily appreciate the complex relations that exist among the different components of a natural environment, and the impact of local changes on the entire system. Children, and adults, are thus not all equal as for their views and attitudes towards nature, and these differences are partly influenced by cultural views, partly by experience. Two lessons are to be taken from these studies that hold for science education. Science education cannot be neutral in respect to cultural values and variations. When Menominee children enter the Western school system, science is the school matter they are better at. Maybe their experience with nature, as compared with their fellow USA pupils, helps them for a good start. But soon, science becomes difficult for them, more than for their fellow pupils. They are required to think about nature and living organisms as being something separate, objective, external, and this vision does not fit with their values. What if science teaching could anchor on their grasp of ecological relations, rather than presenting these ones only at the end of the curriculum? The design of educational curricula should not ignore the importance of direct experience, of rich cultural exposition (e.g. vocabulary), and it should not undermine cultural differences either. Education for all does not mean same education for all: we must understand "how to best design science curricula for non majority, non-urban children" (Atran et al. 2001).

A better understanding of children's minds can help devising better courses of action for coping with unprecedented challenges: (a) by building on infants' and children's natural knowledge, social and moral skills; (b) by correcting this knowledge, whenever the ideas of modern science collide vigorously with it; (c) by helping them expanding their social and moral attitudes; (d) by linking the competences for which the child has no preparation to the one or ones he or she is prepared to learn.

19.3 Education and Cognitive Science: Favoring Critical Thinking, Social, Emotional Skills and Well Being

19.3.1 Screens, Brains, and Children

In 2013 La main à la pâte has produced a lesson plan called "The screens, the brain, and the child", a project aimed at developing a critical attitude, favor the child's self awareness and decision building capacity in relationship with challenges represented by the growing information landscape, educate social cognition.

Through 20 lessons—dedicated to different cognitive functions, such as memory, attention, the feeling and expression of emotion, communication—children are guided by their teachers to investigate some questions that emerge from their daily experience: Can one pay attention to two things at the same time, at no cost? Certain things come automatically to the human mind; can we inhibit, control them? How good are we at estimating time spent on an activity? How do we read and communicates emotions, desires, thoughts to others? How close to reality is our perception? Each of these questions is related to the interaction children have with their world, and with a special part of their world: the screens—computer screens, videogames consoles, mobile phones, tv… In practice, the teacher sets the initial situation, susceptible of starting children's questioninig; he or she then invites the children to practice inquiries, discuss, in order to develop a better understanding. Successively, children use the understanding they've developed for reflecting about choices and behaviors—on the screens, their use, for oneself and for others. Rather than passively receiving instructions, they produce recommendations, for themselves and for other children, about good ways for dealing with screen habits. More precisely, at the end of each lesson children synthetise their results and reflexions: what they have understood about the human mind's functioning, and the kind of strategies that seem to be suitable in order to use screens in a wise, intelligent way. The reflexions take the form of a list of recommendations about wise use of screens. A fundamental message the activity wants to convey is in fact that it is possible, and desirable, to seek for knowledge and understanding in order to make better choices. The recommendations can then make the object of exhibitions, fairs, and the children thus become mediators of science. They share their knowledge and attitude with their families and communities, become teachers. In a recent follow-up of the project, we've addressed some 50 teachers and classes from disadvantaged socio-economic areas in France and we've explicitly asked to involve the children's parents in the project, by inviting them to observe what happens in the classroom, participating to the final exhibitions, answering questionnaires.

19.3.2 Cognitive Science and Education: How to Favor a Fruitful Encounter

Cognitive science can be an ally for science education for a better world, built on more empathy, greater understanding and reflexivity. But in order to achieve this objective, it is necessary to build a suitable framework that favors fruitful interactions between the two domains. Cognitive science can intervene in education at different levels: (1) as a compass, orienting pedagogical actions in directions that are respectful of the timing, mechanisms, processes of natural learning, providing methodological tools for defining clear limits to what works in education, without pretending to dictate education its objectives, but serving the purpose of helping education achieving its aims; (2). as an object of education in itself, for favoring in the children a better awareness of their own tools for thinking and for dealing with reality.

At La main à la pâte we try to develop both strands, by exploiting stabilized knowledge and collaborating with cognitive science laboratories. We develop teaching activities that exploit children's intuitions, value them, while helping children develop a view of nature that is conducive to a deeper understanding and wisdom. In order to achieve these objectives, we have established strong alliances with cognitive science research laboratories. Together, we develop teacher's training activities in the domain of cognitive science and produce suitable resources for fostering teachers' understanding of current research and providing them up to date, relevant knowledge about the mind and brain. Meanwhile, we participate in research activities aimed at identifying the cognitive mechanisms involved in science learning and in children's scientific thinking. Finally, as in the example of Screens, brains, and children, we collaborate with scientists and educators at the production of lesson plans that aim at deepening children's understanding of their own cognitive processes, to develop social and emotional skills and critical thinking. We hope in this way to contribute to a better educaiton for a better world.

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Chapter 20
What a Child of the XXI Century Should Know About the Origin and the Evolution of Man

Yves Coppens

Abstract To help, in the next decades, children and students to understand the issues of sustainable development, it is advisable to expose them to the long story of the emergence of matter, life and mankind, and to male them realizing the slow process of evolution and hominisation.

The very first title of this symposium was: Children Facing Tomorrow, and I must say that I liked it very much. It's because I am giving, from time to time, talks in schools, which means opportunities to meet children of different levels, that I had the idea to talk to you about what they should know about the Universe, the Solar system, the Earth, Life and Man. It is something easy and fast to tell and consequently to learn, and this scientific way to teach human genesis would give to the children large enough space to think about and try to better understand what is man, where he stands, why he is like he is, what has been yesterday and what could be tomorrow. And I am sorry to say that, most of the time, wherever it is, their professors are not giving them any idea or, at least, enough ideas about the depth of time, the antiquity of Man, his specificity, ethics for instance as the Chancellor was speaking about, and the keys to weight today and to anticipate tomorrow; except in a few institutions around the world like the Ross School and Institute.

I will briefly list the logic succession of data that the children should have for me to think about. Man is a living being which means that his history is a part of the History of Life which is a part of the History of the Earth, which is a part of the History of the Universe. As soon as this obvious simple statement is settled, the frame is drawn ad I am not sure that even such evidence is clearly established in our children's minds. It gave, in one sentence, the true dimension of the question of our origin; if you add that, as far as we currently know, the first perception (and not the origin) of the Universe has been dated around 14 billions years, you have fixed the limits of what you would tell and the limits inside which your children have to think. But Science is not a statement. So you have to give a demonstration of this

Y. Coppens (✉)
Pontifical Academy of Sciences, Collège de France, Paris, France
e-mail: yves.coppens@college-de-france.fr

data. Then you can give some descriptions of the sky; sky is always marvelous and mysterious. You can talk about galaxies where stars are produced, and stars are like us, they are appearing, living and disappearing, they have birth, life and death which is also an interesting matter of thought, especially after having tell the children that the Sun, our sun, is a star!

You may laugh about my statements and my progression but I can tell you that all these evidences for you, are, most of the time, not at all evidences for children. Whatever country they are from and it is only because these sorts of simple and essential data are not in the school program. Some exceptions do exist (the Ross School) but, unfortunately, usually not.

You should then introduce the Milky Way, and the birth of the Sun, of the solar system, of the Earth, 4.6 billion years ago. This is an important second figure that the children should engrave in their mind and it is not easy, I must say, to figure out 4.6 billion years could mean. You have absolutely to describe, at that level, an Earth, almost naked, without much gas and water. But tell, immediately, to the children, the fact that gas is coming from the Earth itself, as well as from other objects falling on the surface of our planet, as well as water is coming mostly from comets, bringing to our Earth in about 500 million years her atmosphere and her oceans. The imagination of children is strong enough to visualize the Earth empty, only mineral, and the Earth with air and water. "Half a billion years to do that" is less easy to catch.

Then the great chapter of Life is coming. You have of course to talk about the origin of Life, of beings, in the water, as soon as 4 billion years ago. And clearly tell and show that this beginning is documented by fossils. The demonstration is always important to bring into the picture, fossils are very simple first, very tiny, but numerous, because they can reproduce themselves, they can have children, which was not the case before, and it is one of the characteristic of Life.

And as soon as this stage of teaching of description of this world is reached, it is important to point out the extreme diversification of Life according to its environment, to explain what an environment is, to explain what an adaptation should be, to explain consequently what Transformism, Evolution, means to tell how admirable are the inventions of Nature for the beings to survive as an obsession in environments which are changing all the time and consequently adaptations which have to change as well.

Here, as you know, it is the notions of permanent changes, which is essential to point out. Everything is changing all the time, the weather (good example), the temperature (good example), the continents, the oceans but also the environments (more difficult to believe), except if you try to give the examples of transformation of the trees, according to seasons, the transformation of flowers into fruits, of butterflies, of frogs, the transformation of any of us from a child to an adult. But the understanding of this concept of transformism, of evolution, is essential to go further. So the keywords are: change, adaptation to survive, transformation of the shapes and of the ways they worked.

As soon as the children have understood, and more or less admitted the transformation of beings and their filiations, it is easier to go from reptiles to mammals,

inside the mammals to Primates, inside the Primates to the common ancestors to Chimpanzees and Men and, from these grand-parents, to describe the Human way starting by their odd transformation of the posture, from quadrupedal to bipedal as soon as 10 million years ago, in tropical Africa. The standing new posture means a change in the position of the skull, the curves of the vertebral column (the rachis), the shape of the pelvis, the dimensions of the forelimbs (shorter) and the hindlimbs (longer) and consecutively the change of the brain and of the behaviors. This is the time of the well-known Lucy, sometimes useful to propose an example. She is easy to imagine, small, exotic, female, with an easy name for quite a lot of children, standing, walking and climbing, with a sort of modulate language but not articulated speech yet. And she looks a bit like a friend, not completely animal, not completely human, a bit like a pet that she is not of course.

Then comes the main piece! Man. But it was so well prepared that it becomes easy to bring him, us, into the picture, descending from beings looking like Lucy. Man, the true Man, is appearing 3 million years ago, in tropical Africa. Why are we calling this new "chap", Man? because, to adapt himself to a climatic change (a drought), he changed his locomotion (he is not climbing any more, he changed his teeth, less fruits and roots to eat, he starts to hunt and to eat meat), he changed his mind (as he remains small, the more open country is becoming more dangerous for him; he cannot be hidden by the trees and the bushes anymore; so he was developing his brain for better thinking of what he could do to escape, when a carnivore would come to eat him!

And this is the beginning of our thinking. As Man had a better mind, bigger, more complicated, with more blood feeding it, he thought better, understood better life, the past and the future, made tools for using them; Man, thanks to his new mind, becomes free, free to do whatever he wants but responsible for what he is doing, even of this freedom. According to what he will do freely, and for the first time, he will have to think alone about the consequences of what he decided to do; he has a body like animals but a brain much bigger allowing him to think, to anticipate, with the responsibility of his decisions, this responsibility, for me, is his soul.

Following the paradoxical couple "diversity-heredity" with the natural obsession of survival of the species, we add the new paradoxical couple "freedom-responsibility" with, for the first time, the obsession of survival of the Person; it opens up the way towards cognition, technology, curiosity, intellectuality, esthetics, ethics, spirituality, dignity, respect of everyone, anyone, friendship, empathy, compassion and all these facets, characteristic of Man. The main ideas can be summarized as follows:

Man is coming from animals; he is evolving in the same way, for the same reasons. But thanks to the unique development of his mind, he is conscious of what he is, where he comes from, where he is going to (more or less), conscious that he will die. There have been 100 billion of people in 3 million years since the very first one. And all of them are coming from the same cradle, have the same origin, are brothers. From their cradle, they peopled the Earth, developed tools and techniques, increased their demography and are ready to people other planets.

You will tell me, that I would be very naive to believe that I will be able to teach this scientific odd story to everyone, everywhere; I am very conscious about that but I will tell you an anecdote which happened to me, in Paris, a few days ago. I was quite far from my house, so I took a taxi, the driver was north-African, Muslim, and, after a while, he said to me: "Monsieur Coppens, I recognized you, and I am very happy to have you in my taxi. If you agree, I will call my sons in Algeria, to let them talk to you, because they know you through TV interviews and movies and liked very much to hear what you say…" He has a smartphone connected to the car, so, after a few minutes, I was in contact with his two sons in Algeria. And these young guys (I guess around 18–20 years old), said hello, told me how happy, how proud they were to talk personally to me, and that they like me, liked to listen to me, and how they admire me, and so on… and so on…. I was very impressed. And then, one of them said "we are listening what you usually say, it is interesting, it makes us think about that and we like that but we don't believe you". I was at the same time, amazed, and happy. I reply "Thank you, I respect what you believe in and I thank you for listening to me". I will tell you something. I, of course, believe in my scientific approach of the genesis; but in my own family, my grandmother, my mother's mother, catholic, used to tell me: "if you, my grandson are descending from the Apes, me surely not!" And my grandmother was, at the same time, wrong and right. She was wrong, for me, because I believe in the scientific way to demonstrate our descent from the Apes; but she was right because she tried to defend the dignity of Man. I did my best to tell her that science and spirituality and dignity of Man are not in opposition, but I don't think I have been successful. So thank you, and go on listening to my talks, even if you don't believe what I say. I respect what you think and what you believe, and I like you as you like me.

Chapter 21
Teacher Power

Sidney Strauss

Abstract In His Encyclical Laudato Si': On Care for Our Common Home, Pope Francis presents three kinds of harmony, those between: people and their creator, people and their environment and among people. He argues that all three are intertwined and tattered in the present state of humanity. This chapter addresses harmony among people and suggests that teaching has the potential to encourage it. Much academic work on teaching emphasizes cognitive aspects of teaching. For example, it has been shown that teaching is a natural cognitive ability on the part of humans. It appears at age 3½, and a case is made for it having cognitive precursors at age 1½. As a departure from the cognitive, the emphasis in this chapter is on interpersonal relations found in teaching. In particular, the spiritual nature of teaching is explored. From the inherent asymmetry of knowledge states between the teacher and learner, interpersonal ties can be forged. When teaching goes well, respect, empathy, sharing, commitment and friendship can come to the fore. It is argued that teaching can foster these forms of harmony among people, even when very young children are teachers. In this sense, Pope Francis' entreaty to strengthen humanity's frayed interpersonal ties could be addressed at early ages by encouraging young children to teach others.

21.1 Pope Francis' Encyclical Laudato Si': On Care for Our Common Home

This is a short chapter about one of the most remarkable of human achievements: teaching. It is not an academic paper where I mull over various theories and interpretations of what is found on these pages. Rather than write a scholarly treatise, I decided to state what my ideas are without the usual academic trappings of presenting debates about various points and theories. What I write about is filled with intellectual minefields. I am aware of most, if not all of them.

S. Strauss (✉)
Tel Aviv University, Center for Academic Studies, Or Yehuda, Israel
e-mail: sidneystrauss@yahoo.com

What I will be writing here is related to Pope Francis' inspiring Encyclical Laudato Si': On Care for Our Common Home. In it, Pope Francis fixes our gaze on the importance of three kinds of harmony: harmony between people and their creator, harmony between people and their environment and harmony among people. His Encyclical shows how, in modern times, all three are badly damaged. But, with a guiding hand, he also points to ways to restore them.

A theme of Pope Francis' writings is that one reason the world's poor, our collective disenfranchised people, are in their extremely difficult situation stems from a frayed spirituality of communion. Community has, at its core, a sense of belonging.

And, with that belonging could come a sense of responsibility towards others. At the deepest spiritual levels, we may feel responsibility for the physical, psychological and social welfare of others. This is felt most strongly for those in the inner core of family and friends. It could extend to people we don't know who are from our neighborhood, our city, our country and those who share our religion. Most people feel a belonging and commitment to groups of people almost none of whom we know.

At the heart of Pope Francis' Encyclical stands the vision of spirituality that unites all people, not only one's family, friends, countrymen and co-religionists. This engenders the sense that we are all part of a large family, the family of all men and women. In this view, we must treat all equally and with respect for their dignity and rights.

Where could this sense of universal equality, dignity and rights come from? What could its origins be? I believe the core of this sense is grounded in people's everyday experiences with those in their inner circles: family and friends. The extension of this kind of harmony to wider circles that are further from the center is based on our sense of harmony at the center, i.e., with those who have been part of our grounded experiences. I suggest that to feel a sense of community with people we has never seen is possible when we have had a sense of harmony between us and people in our everyday lives.

As mentioned, Pope Francis' Encyclical elaborates on the harmony between people and their creator, between people and their environment, and between people. In his view, all three are intertwined. It is me who is emphasizing the harmony between people.

The present chapter addresses harmony between people in their everyday experiences where teaching is seen as having potential to foster harmony in human relations. When it works well, it engenders friendship, responsibility, a spiritual communality and more. I show how this may be the case.

In this chapter I present: ideas about teaching being a natural cognitive ability on the part of humans, information about what we know about the development of teaching from infancy through adulthood, and the spirituality of harmony between people as it gets expressed in teaching.

21.2 Teaching as a Natural Cognitive Ability

Young children teach. Indeed, they do that naturally and spontaneously all the time from an early age. They are natural-born teachers. They do not need teacher training courses nor do they need to be licensed to be teachers. They teach, and do so at a remarkably early age. They have learned how to teach as part of their cognitive, emotional and social makeup with which they enter the world.

Even a cursory attempt to describe all that is involved in teaching indicates that it is extraordinarily complex. And much of teaching is invisible to the eye. The decisions a teacher makes when teaching cannot be seen by the learner. They can be inferred when teaching acts are performed, but the decisions that led to this teaching strategy or that are unavailable to the learner. In addition, it is unlikely that youngsters are taught how to teach. They are taught but not taught how to teach. Yet despite this complexity, opacity and not having been taught how to teach, children age 3½ teach. All of this suggests that teaching is a natural cognitive ability on the part of children. They teach spontaneously and effortlessly.

21.3 The Development of Teaching from Infancy to Adulthood

Research and theory-building I have done with my colleague, Margalit Ziv (Strauss 2005; Strauss et al. 2002; Strauss and Ziv 2012; Ziv et al. 2016), supports the idea that teaching is a natural cognitive ability for humans. As mentioned, children age 3½ already teach, and they do it mostly through demonstrations with explanations accompanying the demonstration; children age 4 teach contingently, meaning that they adjust their teaching to the learner's changing knowledge state that changed because of the teacher's teaching; and children age 5 teach mostly through explanations with demonstrations accompanying the explanations. For a review, see Strauss and Ziv (2012).

In and of itself, it is remarkable that children age 3½ teach. But teaching is unlikely to appear magically at age 3½. It almost surely has preparation before that age. Very few researchers have studied teaching among children below age 3½, and that may be due to a possibly hidden assumption that teaching requires language. However, children at age 1 year who are preverbal (they do not speak but they understand language) do communicate socially, and they do that by pointing.

Research conducted by Liszkowski et al. (2006, 2008) indicates that preverbal 1½-year-old infants have some of the basics of teaching in their command. They recognize a knowledge gap; they act to close it; and they correct mistakes and even anticipate others' mistakes and act to ward them off before they have been made (Knudsen and Liszkowski 2012a, b).

Briefly, regarding recognizing a knowledge gap and acting to reduce it, Liszkowski did the following. He showed an array of objects on a table to a

preverbal 18-month-old infant and talked about each of them. He then inadvertently (but really on purpose) knocked one off the table, say a key. The infant saw it falling to the floor. After a short time, he looked around and asked the infant where the key was, and the infant pointed to its location.

You might think that nothing extraordinary happened here. After all, the experimenter didn't know where the key was, and when he asked the knowledgeable infant where it was, the infant pointed to it. At first glance, nothing much of importance seems to be happening here. But notice that there is a knowledge gap. The infant knew something that the experimenter (presumably) didn't, and the infant acted to reduce the knowledge gap by pointing to it. So as to test this idea further, the experimenter dropped an object and saw where it fell. When the experimenter asked infants where it was, many fewer infants pointed to its location. That may be the case because there is no knowledge gap here because both the infant and the experimenter knew where the object was.

Much more research is needed to understand what teaching's precursors are in infancy, from birth to age 3½, when actual teaching begins. For the moment, it appears that there are cognitive precursors for teaching among preverbal infants age 1½, and there is reason to believe that prior to age 1, infants have other precursors, such as eye contact, joint attention and more that are not unique to, but are a part of, teaching.

The developmental trajectory extends through adulthood. Strauss and his students have shown that adults have a way of understanding how learning happens in learners' minds (Strauss 2001, 2005, 2012; Strauss and Shilony 1994). Their understanding is a direct transmission model where the teacher is a source of knowledge and learners are the recipients of that knowledge. The main task of teaching is conceived as an engineering problem, i.e., how does knowledge that is outside the learner's mind enter the mind and remain there?

This developmental trajectory lends credence to the idea that teaching may just be a natural cognitive ability. Having made this point, we are now in a position to address how this natural ability can be helpful in advancing other children.

21.4   Children as Teachers

Part of Pope Francis' Encyclical Laudato Si'. On Care for Our Common Home laments the extreme poverty in which hundreds of millions of children live around the globe. These children often do not attend schools because there are none where they live and when there are schools, they are woefully over-crowded with few books available and poorly-educated teachers.

Regarding over-crowded schools, as a yardstick, the average number of children per classroom in OECD countries is 21. In comparison, in sub-Saharan countries where there was data, more than half had an average of over 50 children per classroom. The range of average number of children per classroom runs from 24 in Seychelles, to 44 in Togo, 75 in Tanzania and 90 in Malawi (UNESCO 2015).

Most likely as a consequence of both poor teacher preparedness and over-crowded schools, research conducted in 2008–2009 showed a deeply disturbing finding in Africa and other continents: after 2 years of schooling, large percentages of the children tested could not read one word in their language (Gove and Cvelich 2011). For example, in the Honduras, the figure was 29 %; in Gambia, 54 % could not read in the language of instruction (English), and in Mali, 84 and 94% of the children could not read in Songhoi and French, respectively.

I recently suggested a different way of viewing the over-crowding of schools (Strauss 2016). Rather than despair at the massive numbers of children in class-rooms, say the 90 per teacher ratio in Malawi, given the view that teaching is a natural cognitive ability on the part of children, we can change our perception. We can now see that we have 90 teachers in that classroom.

Furthermore, I presented the idea that children with good subject matter knowledge and skills could supplement teachers. For example, in schools where the vast majority of the children cannot read after 2 years of being in school, were we to bring children who already know how to read to those schools, we have the possibility of encouraging literacy and numeracy for those who don't have it. And we don't have to teach these young teachers how to teach. They know how to by virtue of teaching being a natural cognitive ability.

The benefits to the learners are clear. But it should also be mentioned that there are benefits that accrue to these young teachers (Strauss 2016). They become empowered in their new position and gain prestige from it. They also learn the material to-be-taught better because teaching that material forces them to organize it for their pupils to learn and that enables them to have a deeper understanding of what they are about to teach. And their teaching seems to impact brain functioning (their executive function) that is responsible for cognitive and emotional self-regulations. For an elaboration of these ideas, see Strauss (2016).

As I am writing these words, I am having the enormous privilege of working with a dedicated staff of teachers and curriculum developers, led by Bhavani Rao at the Amrita University in India. They are working in India's poorest villages where illiteracy rates are very high, especially among village women. They are also working in model schools in the state of Andhra Pradesh where the number of schools involved in the program is now 4 and will scale to 400 by the end of 2016 and 4000 at the end of the following year.

I present here some anecdotes about peer teaching where children teach each other in classrooms and where adults teach each other.

Regarding children teaching each other, initially the adult teachers viewed this as a distraction. But, after discussion, they began to see their pupils as a teaching resource and from that moment on, classroom situations have been set up in such a way that encouraged children to teach each other. The resultant enthusiasm on the part of the child teachers and learners has been palpable. Studies that test children's knowledge as a result of peer teaching will be conducted to indicate whether or not there were knowledge gains.

A second anecdote, which apparently is typical in Indian villages, regards the "unit" being taught. In the villages the following scenario is not uncommon.

A course, on masonry and construction, is aimed towards village women. A woman attends school on the first day of class. The following day her daughter attends the class and the next day, one of the woman's sons shows up to class. Then the mother of these children returns to the class. At first the adult teachers of the course found this to be problematic, in part, because they saw teaching as being directed to individual pupils, i.e., the village women. That was the learning "unit" they had in mind. However, it could be the case that when the mother returned home after school, she taught her children in the knowledge that they will be at school the following days. When her children came to school, they came with the knowledge that the mother brought home to the family. Instead of seeing that mothers not coming to school the following day as a sign of absenteeism, the adult course teachers began to see that the "unit" of who teaching is directed towards the family and not just one individual of the family. This insight could have significance for understanding how the family gets involved in learning.

A second kind of peer teaching has adults teaching each other. In the West, there have been public policy cases where governments have decided to eradicate illiteracy in their countries. Among the many examples, two that are prominent in campaigns to eliminate illiteracy come from the former Soviet Union and Cuba. The teachers who taught adults to read and write were literate adults who knew how to read and write. They were without teaching experience in schools and had no teaching certificates. They taught those who were illiterate and this peer teaching led to the rapid elimination of illiteracy in those two countries.

In the case of India, village women, who are often illiterate, are taught skills, such as making indoor plumbing. People with expert knowledge in the areas needed to teach the women how to build, among other things, indoor toilets, are brought to the villages. Unfortunately, because the experts live far from the villages, they often do not come to their appointed lessons. An idea being mulled these days is that if the course takes, say, 3 months, the women who have learned the material for the first month's content can become teachers of that material for the incoming cohort of village women who are beginning the next 3 month course.

What I have been writing about pertains to children teaching children and adults teaching adults. Let me present several areas that may be familiar to some, but not all, where children have taught adults with some effect. One comes from the West and is related to smoking. Children learn about the detrimental effects of smoking on the health of smokers and those in the vicinity of the smokers (passive smokers). These children often confront their parents and beseech them to lead healthier life styles by stopping smoking. In this sense, children can be agents of social change.

But how does this work in villages in India? Here is an anecdotal observation about children teaching adults. In a particular village, where hygiene is problematic, children were taught a jingle about washing hands before preparing food and before eating. When illiterate women in the village wanted to know what the village children had learned in school, the children taught them the jingle. Those jingles have become part of the village everyday hygiene.

These above examples need rigorous research to determine if peer teaching and children teaching adults are more than anecdotes. Until the evidence is in, we

cannot know. But the examples I gave, and there are many others, are suggestive, which is something that should surely encourage us to study these ideas.

Another gain on the part of young teachers comes full circle to where this chapter began. Teaching has the potential to enhance harmony between people and foster spirituality of community.

21.5   The Spirituality of Teaching

Teaching has the potential to foster qualities of interpersonal relations that are fundamental to the spirituality of harmony between people. In the academic world, teaching is generally understood as what transpires between teachers and pupils in classroom situations. Strike (1988), a leading scholar regarding ethics involved in teaching, describes ethical dilemmas in classroom situations. They get at how ought one best, say, teach one's pupils. For example, should one spend more time teaching academically slower children or should academic abilities not be a factor in deciding how much time should be spent with them? Whatever the teacher's decision, the dilemma remains, given the alternative possible solution. With this in mind, there have been calls for creating a code of ethical practice in school teaching (Campbell 2000).

But this is not what I have in mind. Despite the important and interesting work in this area, ethical behaviors in classroom situations may have little bearing on tutoring situations in informal teaching. In the situations I described about children teaching other children, even if the teaching takes place in classrooms, there are no trappings of formal education. For example, no grades are assigned by the child teacher to the pupil she is teaching.

Despite the differences between formal and informal teaching, the latter is replete with situations that deal with harmony between people. I mention several so as to give a flavor about what they could be. Although my frame of reference is informal tutoring, what I present here can apply to formal teaching in schools.

Teaching begins with a situation of asymmetry. The teacher knows more than the pupil about the topic at hand. The goal of teaching is that over time, symmetry is achieved so that the pupil's knowledge is close to that of the teacher's. The pupil no longer needs the teacher for that knowledge. In this sense, teaching's purpose is to help pupils to gain independence. It allows emancipation.

When teaching, there is a need to have empathy. When a pupil is struggling to understand the material at hand and is becoming frustrated, it is important for the teacher to be able to put herself in his shoes and find ways that could help him learn better. This suggests that, above and beyond the passing of information and understanding to the learner, teachers need sensitivity to understand and modulate the learner's emotional and motivational states.

A fundamental part of teaching involves a willingness to share with others, including those who know less. This sharing has an altruistic bent to it. It doesn't always happen, of course. For example, among adults, a person may be working in

a department of a company, and he has considerable knowledge about his role and tasks he performs there. If a new person is hired in the department, it is possible that the knowledgeable employee may sense potential competition, and he might not pass on all the knowledge he has so as to keep the newly hired person at a disadvantage in the potential competition. But this example notwithstanding, at the heart of teaching is the potential to encourage sharing among people.

Teaching also involves a commitment to others. Teachers have the role of fostering learning in pupils. Teachers and pupils team up in a bond of mutual commitment to advance a pupil's learning. This is the role that teaching encourages in the relationship.

Teaching is also a profound act of friendship on the part of the teacher. The teacher has knowledge the learner doesn't. When good teaching occurs, the learner trusts the teacher that this asymmetry of knowledge will not be abused and that the teacher will act towards him with dignity and respect. These aspects of friendship are inherent in teaching.

At the end of the day, when teaching goes well, it encompasses empathy towards the learner and is propelled by a sense of altruism to help another person where their mutual commitment forges a deep friendship. Teaching among children can foster these qualities which are part of the harmony that exists between people. And if it is the case that feeling a sense of brotherhood and sisterhood towards others we have never met is based on our experiences of trust, faith, commitment to others and friendships we forge with those close to us in childhood, then encouraging teaching among children has the potential to foster one of the three relationships Pope Francis pointed out in his latest Encyclical: a spiritual communion with other people.

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Chapter 22
Professional Development of Teachers at the Science Learning Centres in the UK

John Holman

Abstract Professional development of science teachers has been a strong focus of efforts in the UK since 2006, in order to improve the quality of science learning by primary and secondary school students. Lessons have been learned from this effort, which are here applied to the particular goal of science education in the context of sustainable development and climate change. Beyond transmitting knowledge, the challenge for teachers is to introduce their students to the very nature of science and scientific thinking processes, as well as to ethical questions.

Being in the situation of presenting my own contribution after a number of important ones, I wish to modify my original title ("Professional development of teachers at the Science Learning Centres in UK") to examine the implications of what we have already learned, regarding teachers' professional development. I have been particularly interested to hear what was proposed by the young people, who stated as first principle their right to receive an environmental education: this is not a privilege to be granted to a few, but a right that we adults have the responsibility to make available to all, because it is global. My second point is a universally recognized fact, namely that the quality of teachers is the determining factor of the quality of an educational system. And I am convinced this will remain true for the many decades to come. Whatever happens with automation and the digital world, that will remain true.

Education for sustainable development and climate change is an essential and broad goal to prepare young people for the challenges of the future. Here, science education plays a special role, since most of the issues, choices and rationales for sustainable development are related to science and technology. Making science education evolve is an undertaking which has mobilised efforts in the last decades, and revealed how critical is the role of teachers.

J. Holman (✉)
University of York, York, UK
e-mail: john.holman@york.ac.uk

Above all, the top performing systems demonstrate that the quality of an education system depends ultimately on the quality of its teachers (McKinsey 2007).

They are, and will remain, the key to any substantial and positive change in this novel direction.

22.1 Why I am Optimistic

Thirty years ago, we were very concerned about education standards in London. They were lower than in the rest of the UK. It was difficult to get teachers, and standards in many schools were low. In just 30 years, London has become the highest-achieving place in England in education, as measured by literacy, numeracy and other core factors. Why? Many people have stepped forward, arguing this was the result of their particular action. But analysis of the facts gives the main reason: that is immigration (Burgess 2014). London has a higher rate of immigration than almost any part of UK. Incoming people are diverse, but they are young and motivated, they value education for themselves and for their children. This is the reason for the progress of the last decades in London. And now looking across the world to the countries who have rapidly developed a high quality education system, I observe that the main reason of their success is cultural: people there value education, even if they do not have all the facilities. I used to be the principal of a school near London, serving a group of very diverse communities: more than twenty-six languages, a variety of religions and cultures. I knew very well that some cultures valued education more highly than others, and in those young people would succeed well.

The PISA survey of OECD has been mentioned several times, and here is an interesting piece, from the 2006 PISA results in science (Fig. 22.1). It positions each country whose students are participating in PISA tests with the interest for science of these students (vertical axis) and the achievement in the tests (horizontal axis). It shows a curious negative correlation. In the bottom right corner appear countries like Finland or The Netherlands, which attain very highly in scores. In the top left corner are Mexico and Turkey, where students show a great interest for science despite the lack of good scores. So we have a thirst for knowledge, and the thirst is the highest among the ones who do not have access to it: this is why I am optimistic, because these are the people who will make the difference, and these are the people who will seize the chance if you give it to them, even if they are incomplete chances, not as good as what we could offer in the UK.
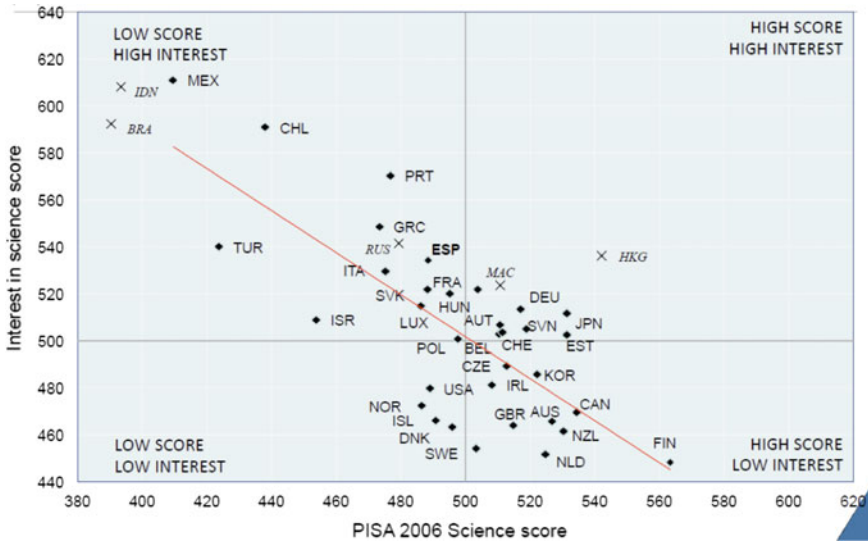
Fig. 22.1 Scores in the PISA tests on natural sciences (2006), compared to the student's interest in science, as declared by them. Each *dot* is the position of a country, participating at PISA 2006. From Dirk Van Damme (Unesco 2015)

22.2 The Need for Teachers' In-service Professional Development

If one wants teachers to adequately cope with an education for sustainable development, they have to be helped to fulfill this new goal. I would like to outline the needs that this implies for their professional development, taking climate change as an example. This is of course an enormously important topic, which young people need to understand. Climate change has been very controversial, but today we are moving to a point where the substantive scientific evidence is settled. Scientists agree that climate change is happening, and is related to human activities and mostly to CO_2 production. This is the settled side. But there is more on the unsettled side: we do not know what the temperature rise will be, what the effect on the sea level will be, on the extreme climatic events. Then, we have the question of what we should do about it, which is an ethical question. This ethical dimension is constantly acknowledged in our exchanges. Who will carry forward the ethical teaching? Should it be addressed by one teacher, or by several? In many secondary schools in my country, there is a separate subject, which is teaching about ethics, about personal responsibility, by a separate teacher. Should that be the way, or when a school teacher teaches about climate change, should he, or she, include the ethical dimension? I think there are good arguments for the ethical dimension to be part of the science teaching, because it arises naturally. But this gives us some challenges.

We all acknowledge what Barack Obama said beautifully:

> [Science] is more than a school subject, or the periodic table, or the properties of waves. It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world… (The White House 2015)

Science is a way of thinking, as well as a body of knowledge, and this is very important for the training of teachers. So, what are the needs of teachers? First they need basic knowledge and skills around science, which can be split in three aspects: content knowledge, the facts, for example what is carbon dioxide, what does this formula CO_2 mean? Then we have what may be called process knowledge, the methods of science. People must understand that science is never certain. Einstein said: No experiment can prove me correct, but one experiment can prove me wrong. And this is the very nature of science. Science moves by trying to disprove what has already been established. People need to accept this intrinsic uncertainty of science, and one difficulty is that often people draw the conclusion *These scientists can never agree*. Nevertheless this is what has to be taught in schools, because it is the nature of science. Finally, if we agree that the ethics around the scientific issues should be part of science lessons, this is also part of what teachers need to be prepared for.

Now, how do we teach these three elements of science lessons? What are the pedagogical skills needed? In David Wilgenbus's presentation, we heard that some of these are topics teachers feel uncomfortable with, considering they lie outside their competency. All the evidence I have points to including all these aspects in the professional development of teachers.

22.3 The Science Learning Centres in the UK

In March 2006, the UK Prime Minister, Tony Blair, inaugurated the National Science Learning Centre, created in York, to become the node of a network spread over England and Wales, funded by the Wellcome Trust—a major charitable foundation in UK—together with the UK government and the UK industry (companies like BP, Rolls-Royce, GSK) in a very interesting three-way collaboration. It aims at all teachers teaching science, primary and secondary, as well as vocational, and critically the professional development is free, teachers do not have to pay. The building is beautiful, and quite luxurious, and this is what I wanted. When we began the project, I wanted science teachers to look at it, and be amazed saying *This is for me*! *What I do is important, and this place has been built for me*! But of course one centre cannot do everything, and this is part of a network of science centres around the country (Fig. 22.2).

We now have been running these for nearly 10 years. When we began, the model was the National Centre at York, and nine distributed centres. Since then the model has developed and today (Fig. 22.3) is made of a large number of learning partnerships, based in schools—an important point.

Fig. 22.2 The original network of Science Learning Centres. The National Centre node of the Network (*red dot*) is in York

Fig. 22.3 Moving from the initial scheme to the current one, with a distributed network of learning partnerships (*grey points*) in schools

What have we learned about professional development? We know it must be relevant to the teachers who come, to matter to them for *their* school and *their* children, something which differs from school to school. It must be followed up in school, there is no point in learning something and not using it. And it must be sustained, it is no use giving one professional development experience and leaving
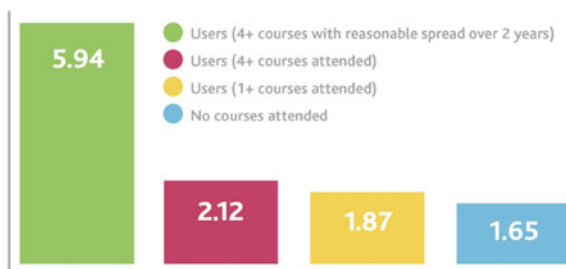
Fig. 22.4 The impact of professional development of teachers on the students' scores, within the Science Learning Centres. *Vertical axis* improvement in percentage achieving Level 4 at KS2 science (grades 3–6), average 2012–2014. *Horizontal axis* the number and spread in time of the courses attended (2015)
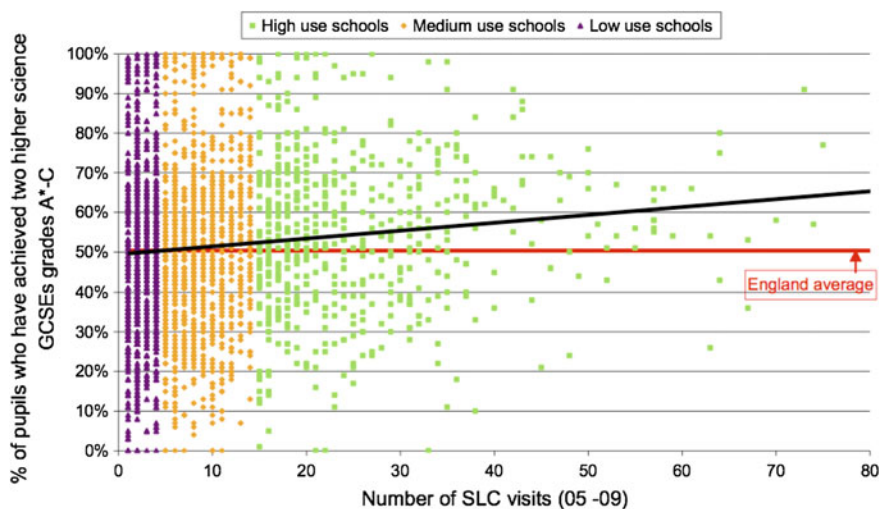
Fig. 22.5 Schools that make greater use of Science Learning Centres (SLC) achieve better results in national examinations

it. This point is illustrated in Fig. 22.4, which shows the difference between a professional development spread over 2 years, or given at one time.

We have a number of very convincing pieces of evidence about the impact of the Science Learning Centres, for example on the students' scores (Fig. 22.5).

To illustrate the kind of content, here are four programmes, connected to sustainable development and distributed in the learning partnerships schools, where all teachers can attend: food security and agriculture (secondary, biology), biodiversity (secondary, biology), climate change (secondary, chemistry), sustainable science (secondary, physics, chemistry and biology). But in our country, it is very important for such programmes to be linked to the national curriculum: this is why, for

example climate change is articulated to the secondary chemistry curriculum, since teachers are under great pressure to deliver the national curriculum.

Finally, I would like to question whether the system we have been fortunate to establish in the UK would work in other countries? The answer is no, the exact model would not work, since there such a diversity of countries in the developed and developing world. But there are some things we can learn, coming back to my three points about successful professional development: relevance, follow-up in school, sustained. These three aspects are crucial for any professional development of teachers, anywhere. Secondly, we should learn from the evolution of our network, which moves from physical centres to partnerships based in schools, close to the grassroots. Margaret Archer's contribution reminded us that centralized solutions do not work. I think one does need some centralized aspect, a central organisation. But the more we can implement the professional development in the school, locally, the better. This rule in my opinion applies to all countries.

To conclude, I like to reflect the great quotation from Goethe:

Science and art belong to the whole world and before them vanish the barriers of humanity.

I have spent most of my career in science education, and I have been very privileged to attend gatherings like the present one, with colleagues from around the world. What I now realize is that science education is a universal language, and the problems we face individually are the problems we face together.

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Chapter 23
Qualifying Teachers for Science in Latin America

Jorge E. Allende

Abstract To learn science, one must do science. This principle guided the program of portable laboratories which is presented in this contribution. The program aims at high school students in biology who, in most of the schools in Latin America, are not doing experiments, therefore not discovering through inquiry how science progresses and scientific concepts become elaborated. The focus of the program is on biology teachers, to empower them and make them able to focus on four fundamental concepts of modern biology, dealing with genetics and Darwinian evolution. The four selected concepts are illustrated in a portable laboratory which has been developed and is serving today many schools in several Latin American countries. Evaluation proves the success among teachers and students, and opens new ways, either in other countries, or for other science subjects.

Several of us in this meeting have had the privilege of living in a large part of Golden Age of biology which in the last 60 years has achieved an amazing progress in our knowledge of the living species that populate our "common home" as the Pope Francisco calls it. In this 60 years, we have moved from not knowing how genetic information could result in the beautiful and surprising diversity of life forms that occupy every corner of our blue planet, to the present position in which we can virtually guide the evolution of living beings on earth. Molecular biology and biotechnology are key sciences which we will have to use to solve the very serious threat that we are experiencing today as a result of human action and also of lack of action.

The rapidity in the progress of knowledge of biology in the last 60 years has been phenomenal and, for those of us in this area, it has been a very difficult task to

J.E. Allende (✉)
Faculty of Medicine, University of Chile (1), Corporation of the Latin
American Network of Biological Sciences (RELAB) (2),
Independencia 1027, Santiago, Chile
e-mail: jallende@uchile.cl

keep up with the advance of the sub disciplines in which we have specialized. We can understand, therefore, the impossible task that secondary school biology teachers are expected to accomplish in preparing their students in all of biology before they enter tertiary education.

We, that work in Universities of many countries, find that students that register to do undergraduate work lack a solid understanding of some of the fundamental concepts of biology and other related sciences and, even more seriously, also lack the practice of using the critical thinking that is the basis for science. This situation is related to the fact that in many countries only small numbers of the students are taking the option of studying sciences for their life careers. This contrasts with the fact that we are clearly now in a period in which knowledge and its generation through science are the main ways that humanity has to overcome the grand challenges that we face in our world.

It is clear, therefore, that we must try very hard to improve science education and practice in all the levels prior to the University. One of the most serious short-comings of science education in most Latin American Countries is that it mainly concentrates on theoretical lectures that require students to memorize long lists of strange names and formulas and equations that the students cannot relate to their everyday experience. Very little of science education is dedicated to doing science, which for us means doing experiments—to learn science, one must do science. It is common practice to give as an excuse for not doing experiments in primary and secondary schools, the reason that laboratories and their equipment are too expensive for our schools. The recent introduction of Inquiry—Based Science Education (IBSE) modules designed to teach basic concepts of primary school science with extremely simple and inexpensive materials that allow the children to do hands-on experiments has completely eliminated that excuse and has demonstrated in many countries that science classes can be entertaining and that children enjoy very much learning about themselves and the surrounding universe by doing experiments.

Secondary school science, especially in the last years, just prior to the entrance to the University, is more sophisticated and the equipment necessary to do experiments is more expensive. The other important consideration that hinders the performance of experiments at that level is that secondary school teachers of science receive their initial training in institutions that do not carry out much original scientific research. For that reason their scientific training includes very little experimental work and they lack expertise in the designing of experimental protocols and in the handling of scientific equipment.

The Latin American Network of Biological Sciences (RELAB) started in 1975 as a Regional Project of UNDP and UNESCO, which had the main objective of strengthening postgraduate training in biological sciences in the Latin American countries. This project was responsible for a large series of training courses that included teaching of the theory and practice of new techniques of molecular biology to postgraduate students.

During the late 90s we started organizing theoretical and practical courses to teach secondary school biology teachers some fundamental aspects of molecular

biology. In 2001, I had the honor of participating in the meeting organized by the PAS on the "Challenges for Science Education for the Twenty-First Century", In that memorable meeting I presented a lecture titled the "Problems and Promises of Science Education in Chile" (Allende 2002). At that time the biological revolution was reaching the schools, and we found that the biology teachers were ill prepared to transmit its important concepts to their secondary school students.

In page 91 of the 2002 book of the PAS meeting, I reported about our efforts of training teachers in molecular biology but, what I did not say, was that the teachers liked very much these courses but were frustrated by the fact that they could not carry out the experiments with their students which were the most exciting part of the course. To solve this problem, 14 years ago I already mentioned an idea that we had. This idea was to use portable laboratories.

I quote directly from text:

> We have the project of developing a mobile DNA laboratory that can visit schools and let the students carry out experiments of genetic engineering (Allende 2002)

My presentation today demonstrates how slowly we have moved in implementing this idea.

In 2011, 10 years later, RELAB applied to the Wellcome Trust in the UK, which at that time had a Program to link the life sciences to Society. In this project we had the participation of 3 countries through their main public Universities: Mexico (UNAM), Costa Rica (University of Costa Rica) and Chile (University of Chile). The project proposed to conduct training biology teachers in theoretical and practical courses of Molecular Biology and Genomics in each of the three countries. The secondary school teachers that approved these courses could request the University in that country to send a portable laboratory with all the equipment and materials necessary for a group of 30 secondary school students to do the same experiments that the teachers did in the University.

In 2012, the Wellcome Trust approved this project providing RELAB with USD $48,000. This project had the following objectives:

23.1 General Objective of the Courses for Teachers

To contribute to the improvement of the teaching-learning process in molecular biology and genomics through theoretical and practical professional development of secondary school biology teachers. These courses are designed to develop four fundamental concepts of molecular biology and genomics. This approach provides the teachers with access to equipment and materials used in modern biology research so that the teachers can share their experience with their students through the use of the inquiry methodology. It also creates a connection, a partnership, between scientists and science teachers.

23.2   Specific Objectives: Four Fundamental Concepts

- *Fundamental Concept 1*: The genetic identity of species and individuals is determined by the information present in the structure of DNA of the species and individuals. Phenotype comes from Genotype.
- *Fundamental Concept 2:* Most cells of multicellular organisms contain the same genetic information as the total organism and yet cells have different morphology and function and express different proteins. This is achieved through the regulation of gene expression.
- *Fundamental Concept 3:* The genetic code that is used to translate the genetic information to generate the proteins present in cells is practically universal for all organisms that live in our planet and the translation machinery present in different organisms is also very similar. These two facts are the basis for modern genetic engineering since genetic material that is introduced into a living cell of a different species can be correctly expressed in the cell that receives it.
- *Fundamental Concept 4:* Darwinian evolution can be observed at the molecular level through the study of the sequences of genes and their corresponding protein products in different related species. Molecular genomics can provide information regarding the time scale in which the different phylogenetic branches emerge in this evolutionary process.

We agreed that in the 3 countries the course for secondary biology teachers would be an intensive 5 days course that consisted in: 8 lectures taught in the morning of the first 4 days. These lectures describe the ideas and the history of the discoveries that resulted in the formulation of those 4 concepts. In the afternoons of those days, the students performed experiments that demonstrated the validity of those concepts. The last day of the course, we dedicated to an evaluation of the course carried out by a written test followed by an oral discussion. Also in that day, we discussed with the students how the concepts are now being applied to the solution of health problems, to the improvement of agriculture and for the preservation of the environment. Also, we demonstrate some simple applications of the inquiry method to learn some other important aspects of molecular biology. Figure 23.1 shows that the portable lab used in Chile is really portable since all the equipment fits easily in two suitcases with wheels and can be transported in the trunk of a normal vehicle.

We have also used the example of the GK-12 Program of the National Science Foundation of the United States (NSFGK12 2010). This NSF program financed a large number of Fellowships to support postgraduate studies at the M.S. and Ph.D. level in Science, Technology, Engineering and Mathematics (STEM). The individuals that were selected to receive these fellowships were required to dedicate 15 weeks during the year in the activities directly involved in STEM education of primary and secondary schools.

On learning about this NSF program and its very positive evaluation, our own National Research Council in Chile (CONICYT-Chile) in 2013 started requiring all the doctoral students that received fellowships from this agency to spend at least

Fig. 23.1 The Portable Lab

100 h in activities of pre-university education. This was considered a way in which these fellows could pay back to the country for the fellowships received. One of the ways in which this retribution can be made is for Doctoral students to accompany the portable laboratories to the secondary school and collaborate with the teachers in the setting up the experiments and in the discussion with the secondary school students about the results obtained. The interaction of these two types of students has been a big success in our program because it has made secondary school students aware that young Chileans are opting for careers in science and that these young scientists are contributing to international scientific progress. For many of the secondary school students this has been a very unexpected revelation.

I will briefly describe the experiments we carry out to demonstrate the validity of the 4 fundamental concepts that the course covers. The first concept can be expressed in simple way: the characteristics of living organisms are the result of the genetic information present in that organism or the phenotype is determined by its genotype. The students are given to taste a paper impregnated with PTC (phenyl thiocarbamide). To most people this compound tastes very bitter but approximately 25 % of human populations cannot detect any taste in these papers. We have, therefore, a characteristic in which human populations differ (tasters and non tasters are phenotypes). Following this test, the students are asked to wash their mouth with a saline solution and to use the wash to prepare a sample of their own DNA which can be rapidly achieved. Previous work has demonstrated that the capacity to taste PTC depends on the gene of a Taste Receptor (TAS 238) (Kim et al. 2003).

The person that has a wild type receptor has a sequence in a part of this gene

140   145   149
| G | G | C | G | G | C | C | A | C | T |

This receptor can bind the PTC and detect the bitter taste. However, a significant part of the human population has a mutation in base 145 having the sequence

140   145   149
| G | G | C | G | G | G | C | A | C | T |

This change of one letter can be detected using a restriction enzyme Hae III that has the capacity to cut the 2 strands of the DNA when it finds a sequence

Hae III   145
_____GG↓ CC_____
_____CC ↓GG_____
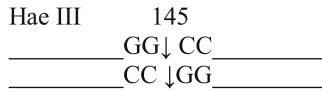
However it cannot cut the DNA of the mutated gene which has base 145 mutated to a G.

We can use the polymerase chain reaction (PCR) to amplify a fragment of 221 nucleotides in length of the taste receptor 238 gene which includes base 145.

This fragment obtained from both the tasters and the non tasters can then be treated with the Hae III restriction endonuclease. As shown in Fig. 23.2, the fragment amplified from the tasters and treated with this enzyme will yield 2 fragments one smaller and faster running in electrophoresis of only 44 nucleotides in length and the other slower moving has 177 nucleotides in length. The gene of the non tasters cannot be recognized by the Hae III restriction endonuclease which, failing to cut, maintains its fragment length at 221 nucleotides in length.

Some of the tasters, however, are heterozygous for this mutation and will show three fragments which should be 221, 177 and 44 nucleotides in length. This experiment has, therefore, demonstrated that "the taster" characteristics is based on the structure of the TAS 238 taste receptor gene which only differs in the mutation of base 145.

Two other fundamental concepts can be demonstrated with a single experiment in which the pGLO plasmid is used to introduce foreign genes into the bacterium *Escherichia coli*. The pGLO plasmid (Fig. 23.3) is a small circle of DNA that has an origin of replication (ORI) which means that every time the bacteria divides, this plasmid also replicates. In addition, this plasmid contains the gene that codes for a beta lactamase enzyme (bla) that renders the bacteria that contains the plasmid resistant to the penicillin antibiotics. Therefore, growing the bacteria in the presence of this antibiotic, only the bacteria that have incorporated the plasmid will survive. In addition, the plasmid contains the gene GFP that codes for a green fluorescent protein which was obtained from a sea medusa. This gene, however, has a switch which does not allow the expression of the GFP gene because the protein coded by the gene "Ara C" turns off the switch of the GFP gene blocking the expression of
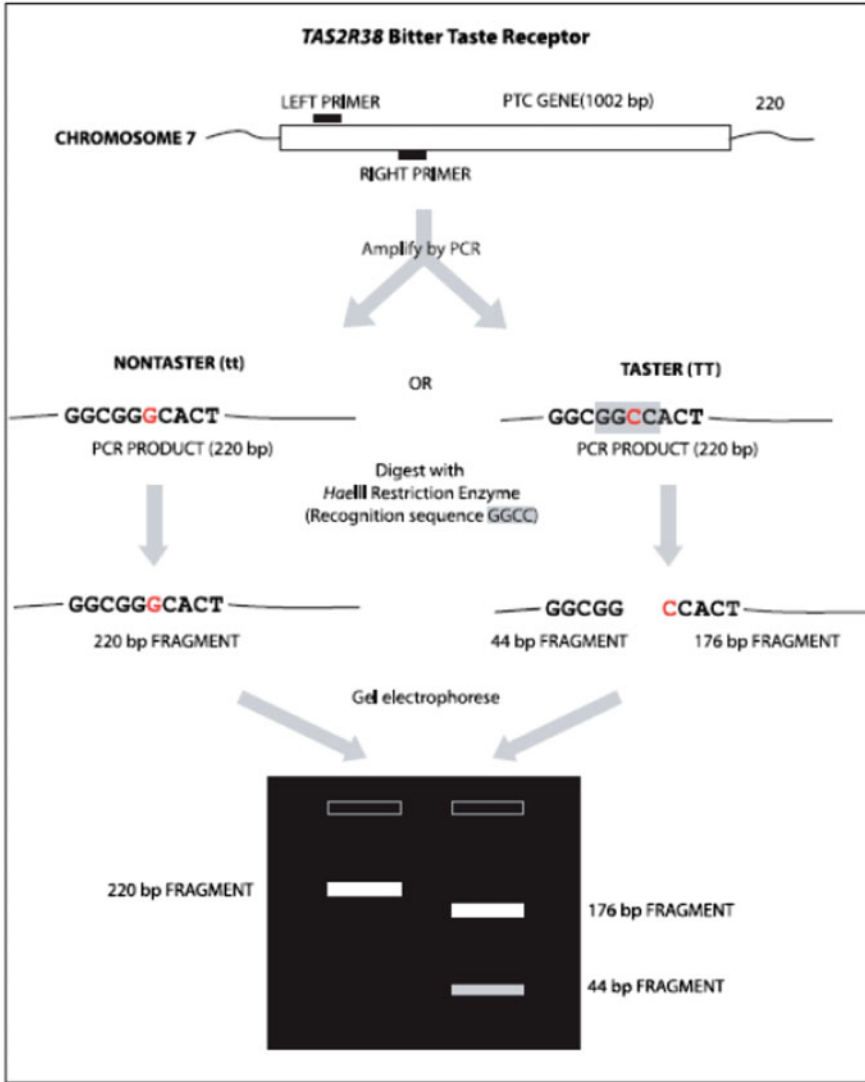
Fig. 23.2 From Phenotype to Genotype: the taste receptor for PTC. A part of Taste Receptor 238 is amplified both from PTC Tasters (T) and (t) non-taster homozygous to yield a 221 base pair fragment. This fragment is then exposed to the Hae III restriction enzyme which cuts both strands of the DNA which contains the sequence GGCC involving bases 143–146 in T DNA but cannot cut the homozygous non taster DNA (t) that has GGGC sequence a this point. Gel electrophoresis can separate the DNA fragments generated by the digestion of the T DNA into a 177 base pair fragment and a 44 base pair fragment but cannot hydrolyze the t DNA which remains the original 221 base pair size

Fig. 23.3 This plasmid pGLO is transfected into *E. coli* which are grown in a medium with Penicilin and in some plates with arabinose and without arabinose

Fig. 23.4 When GFP is expressed the bacterial plates light up with a *green* glow when arabinose is present

the GFP protein. However, if the bacteria are grown in the presence of the sugar arabinose, this sugar binds the Ara C protein and neutralizes its negative effect and the GFP is expressed allowing the bacterial plates to light up with a beautiful green glow (Fig. 23.4).

This experiment demonstrates very clearly how the expression of genes can be positively or negatively regulated by signals that are in the extracellular medium (Second Fundamental Concept). The expression in the bacteria *E. coli* of the green fluorescent protein which was present originally in a sea medusa clearly demonstrates that due to the Universality of the Genetic Code, living species of bacteria can correctly read and express genetic material that was present in a completely

different living organism (the Third Fundamental Concept of the course). This capacity makes genetic engineering possible.

To demonstrate the fourth fundamental concept, we can use computers connected to internet that can search the millions of gene sequences that codify for proteins that are present in data banks.

If one puts a sequence of amino acids of part of a protein, containing 30 or 40 amino acids, there are programs that can search all the protein data in the bank and provide us with the sequence of all the proteins that are very similar in sequence to the one you originally searched for. In Fig. 23.5 we see such an experiment in which the amino acid sequences of the alpha sub unit of the enzyme CK2 α in humans is compared to the sequence of a similar enzyme that is present in Rat, Chicken, the frog *Xenopus laervis*, Zebrafish, and the yeast *Saccharomyces cerevisiae*. It is possible to see from the sequence presented in Fig. 23.5 that the human enzyme is very similar to the rat enzyme (the dots indicate that the amino acid in that position is identical to the human enzyme). Both are mammalian species. This simple comparisons of the sequences can tell us that it is possible to order the species whose sequences have been analyzed in the following order of relatedness in the evolutionary process:

Human—Rat—Chicken—Frog—Zebrafish—*S. cerevisiae* in which the yeast is clearly very distant in evolution from the other species which are all vertebrate animals. There are computer programs that can carry out this evolutionary genomics analysis further to construct more detailed evolutionary trees or maps.

Also this simple comparison of protein sequences can tell us that there are regions of the gene that are exactly the same in humans and in yeast. For instance the portion of the human gene that codes for amino acids 145 to amino acid 165. This sequence is identical to a sequence present in the yeast gene that codes for this enzyme. We can surmise that these regions highly conserved in the evolutionary process must play key roles in the function of the protein. Any change of amino acids caused by a mutation would probably result in a loss of function of the enzyme. This decrease in functionality of the gene product would compromise the viability of the descendents that carry this mutation and the mutant individuals would be at a disadvantage in the populations and consequently would be selected out. This interpretation can now be tested by artificially generating mutations in those conserved regions and studying the properties of the protein mutants.

We have conducted three courses for secondary school teachers in which approximately 70 teachers have passed the final exam. Approximately 65 % of them are from the Santiago Metropolitan Area. In 3 years we have visited 26 secondary schools in the Santiago Region and one school in San Carlos in the 8th Region.

The total number of secondary school students that have used the portable laboratory to do experiments is approximately 750 (55 % girls and 45 % boys). Of them, 80 % studied in public municipal schools in which tuition is free.

As part of our assessment we have gathered the opinions of the main groups of participants: secondary school biology teachers that took the course and later received the portable laboratory in their school; the secondary school students that

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Human      MSGPVPSRARVYTDVNTHRPREYWDYESHV-VEWG-NQDDYQLVRKLGRG   48
Rat
Chicken    ..................................................
Xenopus    ..................................D...............
S. cer.1   .KCR.W.E.....NI.KQ.TE..I....NT..ID.ST.TK..EIEN.V...

Human      KYSEVFEAINITNNEKVVVKILKPVKKKKIKREIKILENLR---------   89
Zebrafish  ..........................................---------
Rat        ..........................................---------
Chicken    ..........................................---------
Xenopus    ..........................................---------
s. cer.1   ......QGVKLDSKV.I.I.M................TD.SNEKVPPTTL

Human      -----------------------------GGPNIITLADIVKDPVSRTPA   110
Zebrafish  -----------------------------........L..I.........
Rat        -----------------------------.....................
Chicken    -----------------------------.....................
Xenopus    -----------------------------.....................
S. cer.1   PFQKDQYYTNQKEDVLKFIRPYIFDGPHN.HA...H.F..I...I.K...

Human      LVFEHVNNTDFKQLYQTLTDYDIRFYMYEILKALDYCHSMGIMHRDVKPH   160
Zebrafish  ...................S..............................
Rat        ..................................................
Chicken    ..................................................
Xenopus    ..................................................
S. cer.1   ....Y.D.V..RI..PK...LE.....F.L.....................

Human      NVMIDHEHRKLRLIDWGLAEFYHPGQEYNVRVASRYFKGPELLVDYQMYD   210
Zebrafish  .............................N....................
Rat        ..................................................
Chicken    ..................................................
Xenopus    ..................................................
S. cer.1   ......KNK...............VNM.........F..........R...

Human      YSLDMWSLGCMLASMIFRKEPFFHGHDNYDQLVRIAKVLGTEDLYDYIDK   260
Zebrafish  ............................Q.....................
Rat        ..................................................
Chicken    ..................................................
Xenopus    ..................................................
S. cer.1   ....L..F.T.......KR......TS.T....K.V.....S.FEK.LL.

Human      YNIELDPRFNDILGRHSRKRWERFVHSENQHL-VSPEALDFLDKLLRYDH   309
Zebrafish  .............................................T....
Rat        ..................................................
Chicken    ..................................................
Xenopus    ..................................................
S. cer.1   .E.T.PRE.Y.MDQYI-..P.H..INDG.K..SGND.II.LI.N......

Human      QSRLTAREAMEHPYFYTVVKDQARMGSS-SMPGGSTPVSSANMMSGISSV   358
Zebrafish  .A.....G..D.....PI....G.GAPAAG.AAS......SSL.A..AL*
Rat        ......................................-..AG.A.................
Chicken    .................PI...........N.............S.......
Xenopus    .T........D.....PI....S..AALICPVAAHPSVAPV*
S. cer.1   .E....K...G...W.APIREQIEK*

Human      PTPSPLGPLAGSSVIAAANPLGMPVPAAAGAQQ*                  391
Rat        ...................S..I.*
Chicken    ...............S.TTT............*
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Fig. 23.5 Predicted amino acid sequence of zebrafish CK2 α and alignment with sequences of human, rat, chicken and *Saccharomyces cerevisiae* CK2 α. Numbering system refers to the human CK2α sequence. *Dots* represent identical amino acids (Daniotti et al. 1994)

used the portable lab to do experiments the secondary school teachers, and finally the graduate students of our University that acted as monitors to the secondary school students that performed the experiments. These opinions are published in the web page of the project (Laboratorios Portátiles 2013). Since these are all in Spanish we have selected and translated a few of them.

23.2.1   Opinions of Secondary School Students

Question How did you like the experience of learning molecular biology by doing experiments in your school in the portable laboratory?

Answer Truthfully, when I heard about doing this laboratory, its not as if I hadn´t paid attention but, I thought to myself, just another thing to do! But after I arrived and I saw so much activity and interest in participating in the laboratory: there were people from the United States, Northamericans, Cubans, stuff like that, and they came to teach us! I became very interested, mostly because we could "apply" the science; because we did experiments on ourselves, taking samples of saliva, and also samples of cells. Then we made samples of bacteria… I liked it very much, … and all the rest was very good. (student)

Question Do you think this approach helps you to understand better some of the discussions in the news about transgenic organisms, stem cells, relations between mutation and cancer?

Answer I think it helps a lot because doing the experiments is much better than theoretical classes and allow us to understand better (student).

Question How did you like learning concepts of molecular biology by doing experiments with the portable laboratory?

Answer I think it was a beautiful experience to be able to use all the knowledge that they taught us in the school is very satisfactory. In addition it is great to learn the new techniques that are now been used (student)

Question Do you think this approach should also be used to teach other experimental sciences?

Answer It would be great. This is good for biology but other students may be more interested in chemistry or physics. This approach would generate an integral approach to all of the sciences which share the same method (student)

Question What recommendation do you have to improve the effectiveness of the portable laboratories?

Answer You should look for more financial support from the government so that you can purchase more equipment so that you could expand this program to reach other parts of the country and other areas of science (student from the National Institute)

To the question "Have you ever met in a person a scientist or a doctoral student in science?", more than 85 % of the students answered no. This explains why so few choose a scientific career. They lack of role model to relate with.

500 or more opinions expressed in Spanish can be found in "OPINIONES" (Laboratorios Portátiles 2013).

23.2.2   *Opinions of Teachers*

Increased Interest in Science The students participate more now (after the portable laboratory course) in biology classes, they are more interested in scientific subjects and the idea of doing research on their own. (teacher)

Consider Science as a Possible Career One of the effects of the portable labs has been a greater interest in considering a career in the area of molecular biology or biotechnology (teacher)

Better Grades in Students that Had Taken the Course The students show a better command of the material, they presented better work in the assignments (…) Its curious that one student had failed six subjects up to this date and then after the portable lab experience, he had better grades in both of his regular school biology courses, the general and elective courses. (teacher)

About the Course for Teachers at the University It was a wonderful week for me and it changed my 'switch' as to how I was working in my classroom: I was working for my salary like everyone else, but suddenly I was thrilled, this week I was rubbing elbows with real scientists and it was wonderful! One of the 'plus" sides, as the doc says, after one finishes the university one can take (postgraduate) courses and contact other scientists doing science and then one can teach science directly from contacts with scientists. (teacher)

About the impact of the Doctoral Students in the School The doctoral students that came here to the our school to do the portable labs were bombarded with questions: what is that? (the doctorate) and: what kind of career is that? They would chat together and see that it was possible (to be a scientist), perhaps they wouldn't buy a new car with the first salary but on the long run, they would have many other benefits. (teacher)

23.2.3 Opinions of doctoral students

Question Do you think that it is positive for Doctoral and Master Students to participate in an activity such as this? Will it be a useful experience in your future career?

Answer 1 I firmly believe that the future of science necessarily depends on its value for society. For that reason any person that wishes to continue in the world of research should, at least once, have the opportunity to approach other people and transmit to them the relevance of what they do in science. If we lose contact with society, science will stagnate.

Personally I have enjoyed very much this work. I like the possibility of contacting the secondary students and to transmit to them my vocation and listen to their commentaries and to watch them enjoy what we do. My intention, every time that I go to one of these classes is to go beyond the technical knowledge. I aspire to transmit to them the enchantment, the beauty of science and what science can do for us. Sometimes the time is too short but I like to believe that I have achieved something, although it may be little. For the same reason I hope that this project can last a long time, so that it will be accessible to all the students that wish to participate (doctoral student- Camilo Allende).

Answer 2 I would like to suggest that participation in this project as monitors could be opened to others, not restricting it to graduate students. In my personal case, I already have received the Doctor's degree and I am no longer a student, nevertheless, I would like to continue participating in the coming years.

I want to add that this initiative should not be stopped. It must continue progressing reaching more schools and more regions of the country. If you accept me, I am willing to continue helping in this marvelous initiative (Dr. Sofía Sepúlveda)

The opinions are unanimously positive in the sense that the possibility of carrying out experiments is very helpful for the understanding of the concepts that are being taught. These very positive responses have prompted us to consider the scaling-up of this project in several respects. One of the dimensions of this scaling is by increasing the coverage of the Chapters of Biology that can be included.

With the support of UNESCO, RELAB and CONICYT—Chile we have organized two international workshops to generate new modules on "Proteins and Enzymes" and on "Fertilization and Early Development of Animal Embryos". These workshops brought together scientific specialists from 3 or 4 countries together with educators working on curricular definitions of Ministries of Education of Several Latin American countries in secondary school biology. These groups identified fundamental concepts in each chapter and from this they derived the content of the theoretical classes and the set of experiments recommended to be able to teach these concepts. A list of equipments and reagents necessary to carry out the experiments also included for each module. These modules were tested in courses that were used to update secondary school biology teachers. This test made it clear that to fully take advantage of the module on proteins and enzymes, a

pre-requisite of having approved a course of one semester of organic chemistry seemed necessary.

The scaling up of this pilot project also is occurring in an international dimension because in addition to the original 3 countries (México, Costa Rica, Chile) 3 other countries have started to introduce this innovation, Uruguay, Brazil and Panamá. All of them have acquired a portable laboratory and ran courses for teachers. It is expected that they will soon start visiting secondary schools with their portable laboratories. The Peruvian Government has also shown some interest to initiate a similar project in their country.

Locally, in Chile, we have agreed with the Ministry of Education to scale up our project by incorporating eight other Universities that will have portable laboratories in Molecular Biology and Genomics and will be training teachers and visiting secondary schools in seven of the fifteen Regions of our Country.

This effort will be supported by Ministry of Education and the Allende Connelly Foundation.

We are hoping that the very positive effect that we have seen with this educational innovation can allow us to expand this approach to other experimental sciences such as chemistry, physics and astronomy. We sincerely hope that this will attract more young men and women to the beauty and the adventure of science and with this new capacity, our countries of Latin America can be better able to solve the huge problems that compromise our future.

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Chapter 24
Formation of Schoolteachers in Haïti: The TEH Program

Jacques Blamont and Morgane Leprince

Abstract In a country where 85 % of the school teachers have received no formation (education Minister, Laroche 2014) the TEH program, developed with cooperation of France and financing by the Inter-American Development Bank (BID), experiments a reform of the teaching methods in the first fundamental cycle for the Ministry of National Education and Professional Formation (MENFP). Contents are elaborated in France with the active pedagogy system *La main à la pâte*, and adapted to the Haïtian programs and language particularities by a group of Haïtians teachers in Port-au-Prince. Then they are presented inside the ministerial network of EFACAPs (Center for pedagogy recycling of teachers) by local "counsels in pedagogy" (CP). Today TEH impacts about 1100 teachers, 200 schools and 55,000 school children. The Ministry works on an extension of the method to 2,000 schools.

24.1 Quantitative Data on Education in Haiti

Haiti is one of the poorest countries in the world. In 2015, according to the Haitian Institute of Statistics and Informatics (IHSI), the population counted 10.9 millions; they will be 16 millions in 2050 (IHSI, Jackson 2012). The average income per year and per day is 2.2 dollars (Banque Mondiale 2015a); half the population has an income inferior to 1 dollar per day (France Diplomatie 2015).

The country is plagued by natural disasters: earthquakes, hurricanes, floods. One major disaster strikes every 4 or 5 years, with many casualties. The consequences

J. Blamont (✉)
University of Paris VI, Paris, France
e-mail: jacques.blamont@cnes.fr

J. Blamont
Centre National d'Etudes Spatiales, Paris, France

M. Leprince
Fondation pour l'éducation à la science La main à la pâte, Paris, France
e-mail: morgane.leprince@fondation-lamap.org

are more severe than in adjoining countries, because of the inadequacy of the infrastructures and the deficient preparation of the population.

Five years after the 2010 earthquake, 65,000 people are still homeless (Haïti libre 2015).

24.1.1 The Pupils

In September 2015, 3 millions children had to enter schools. 0.2 million of them staid excluded from the education system (Banque Mondiale 2015b).

The average age for entering school is 8–9, compared to 6 in Europe. A typical phenomenon of Haitian school children is the *overage* (20-year-olds can be found at the end of the primary cycle). Overaged pupils are thought to number hundreds of thousands.

- Only 33 % of the children entering school reach 7th grade.
- Only 1 % of the children entering school enter university.
- 43 % of the Haitian population is illiterate.

24.1.2 The Teachers

The number of 1st cycle teachers is about 60,000. Only 400 receive a formation each year. However, the number of teachers hired had each year by the Ministry of National Education and Professional Formations (MENFP 2012) is 48,000.

From a declaration of the Minister to us:

- 85 % of the school teachers have received no formation;
- 30 % below 9th grade level;
- Salaries are frequently inferior to 200 dollars per month.

24.1.3 The Schools

The MENFP manages only 17 % of schools; the remaining 83 % are privately owned and managed (Joint 2007).

- 70 % of private schools have no habilitation from MENFP;
- 56 % of schools are accommodated in "precarious" quarters;
- 77 % of schools have no electrical power.

In 2014, 417 schools have shown 0 admission in 6th grade and 800 admitted less than 20 % pupils.

The operational plan of the MENFP, defining the refundation of the education system for the years 2010–2015, presents this system with three characteristics:

- Insufficiency and inequitable repartition of the offer of schools with a high predominance of the private sector.
- Poor quality of the offer and weakness of the internal efficiency causing a high rate of failure and repeats.
- Weakness of the governance of the education system.

All official documents insist on the poor quality of the teaching, caused in great part by the current lack of formation of the teachers.

24.1.4 A Declaration of President Michel Martelly (08-08-2014)

The hour is grave because of the situation prevailing in our education system since decades. The bad results observed at the national examinations are a constant line, but this year they explode in front of us because they are now known school by school.

No leader can be satisfied when 25 % of the students in the 6th grade, 28 % of the students in the 9th grade fail at national examinations. The situation is worse in the secondary cycle since, year after year for more than 30 years, 70 % of the students in Rheto (Bac 1) and 50 % of the students in Philo (Bac2) do not succeed (President Martelly 2014).

24.1.5 The Major Issue in Haïti

- The Constitution stipulates that Haïtian citizens are bilingual: French and Creole.
- 93 % of Haïtians speak only Creole.
- 100 % of the business of the country (political, economy, administration, education) use only French.
- As a consequence, the majority of the population stays a stranger to the national system with major effects on civic attitudes.
- After 13 years of primary and secondary formation, the majority of the students entering the first year of University are found not to master sufficiently the French language to grasp the nuances of the concepts and to start scientific studies.
- Many cannot formulate adequately their thoughts nor write the result of their reflexions as an understandable presentation.

24.2 The TEH Program

http://teh.fondation-lamap.org/teh/

24.2.1 Origin

- Initiated as relief after the destructions of the Jan 12th, 2010 earthquake

  - 85 % of schools destroyed in Port-au-Prince and vicinity.
  - 85 % of schoolteachers killed in Port-au-Prince and vicinity.

- Initial idea was to propose modules prepared in France and use satellite or fiber links to distribute them in schools (tele-teaching).
- Program approved by *MIRH* (French government's Mission Interministérielle pour la reconstruction en Haïti).
- Collaboration between French Institutions (Académie des Sciences, Centre national des études spatiales) and MENFP (Ministère Haïtien de l'Education Nationale et de la Formation Professionnelle).
- Deployment on sites called EFACAPs (Ecole fondamentale d'application – Centre d'appui pédagogique).

24.2.2 Definition

Confronted with the constraints encountered, TEH has quickly become an experimental program, devoted to the formation of the schoolteachers, and the idea of tele-teaching was placed on a slow-burner.

It has now for objective to strengthen the teaching capacities of school teachers and specially to transform the repetitive methods regularly in use in Haïtian classrooms, into active teaching.

- 11 EFACAPS equipped with power supply, computer hardware and Internet links;
- 2 teachers per school spend one day per week at their EFACAP for TEH (translates to about 40 trainees per EFACAP); that is 120 h per year per head;
- Total of about 400 trainees per year for the TEH program;
- Content: Six disciplines adapted to the haïtian context, each formatted into a module;

  - Science
  - Mathematics
  - French
  - Health and hygiene
  - Inclusion to schools
  - Information and communication technologies (ICT)

- Method: Active pedagogy, group work, following the practice *La main à la pâte* (LAMAP).
- Basic idea is that the trainees use immediately in their classes the knowledge they acquire in THE séances.
- Funding:

    - In France, CNES, DREIC.
    - In Haïti, Inter-American Development Bank (BID).

24.2.2.1 Themes

For each discipline, only a selected slate of themes is presented in TEH as a successive serie of lectures:

- Experimental Sciences: Water, air, human body, seisms (outside official program).
- Mathematics: Numeration, operations, polygons, capacities, grid patterns, measures, geometry, mental computation.
- French: Oral communication, creative writing, phonology, work on image.
- Health: Water.
- General teaching: Starting a lecture, individual and group activities, institutionalization of knowledge, scholar inclusion.
- TICE: Treatment of text, electronic mail, Internet navigation.

24.2.3 The EFACAP Network of MENFP

- Objective: To complement the formation of trainees.
- 38 EFACAPs exist all through the country.
- Each EFACAP is a building situated not too far from 20 to 40 schools and is a center of formation for the teachers of all these schools.
- 40–50 teachers per year formed by each EFACAP.
- Each EFACAP hosts 2–3 pedagogical counselors (Conseillers Pédagogiques or CP) in charge of training schoolteachers.
- Not all EFACAPs have electrical power.
- Not all EFACAPs have fiber link.

24.2.4 The Four TEH Principles

24.2.4.1 Humility

- We are not imposing our culture, our words nor our methods.
- Local needs define the program.
- Trainees participate in the elaboration of the message.
- Contents and methods are in permanent evolution.

24.2.4.2 Iteration (Fig. 24.1)

First loop

- MENFP define overall program.
- French educationalists prepare contents in France following the MENFP official program and indications, then send powerpoint data to the iteration cell in Haïti.
- Iteration cell in Port-au-Prince (100 % Haïtians) digest and «haïtianize» contents.

    - Adapt vocabulary.
    - Propose modified presentations of concepts.
    - Prepare material for class experiments.
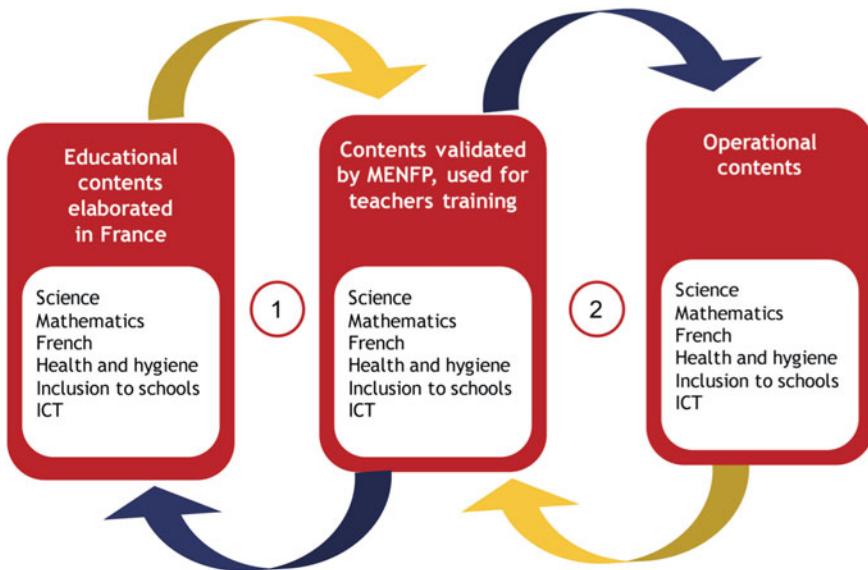
Fig. 24.1 Iteration loop

- Digested products returned to French authors for eventual modifications.
- End product sent back to Haïti for use in EFACAPs.
- Training by CPs with modules in EFACAPs.

   Second Loop

- Trainees go back to their schools for teaching with the TEH rules.
- Reaction of children to teaching.
- Next week, return of trainees to EFACAP: discussion with CPs and colleagues.

   Conclusion

   The voice of children (vocabulary limited to 200 Creole words) is heard through all the process.

24.2.4.3   Appropriation

Objective: The haïtian system has to absorb our contribution into its own practice.

- PCs become cognizant.
- Trainees use immediately the material in their classes.
- No teaching, no training by French personnel.
- PCs to create new modules: this has not yet happened!

24.2.4.4   Investigation

- Active pedagogy *La main à la pâte.*
- All children participate by asking questions.
- Group work.
- Very simple experiments for introducing concepts.
- Development of language.

24.2.5   *The Flow of Operations*

- Conception of modules (120 h/2 years) by French educationalists.
- Adaptation to haïtian context by a team of CPs and MENFP staff.

- Training of CPs in Haïti at beginning of academic year by French education-alists (1 week).
- Training of trainees by CPs from 1st to 4th year of primary cycle simultaneously in 11 EFACAPs (Each trainee follows the cursus for 2 years).
- Trainees use what they have learned immediately in their class.
- Observation, supervision and evaluation in classroom by French and Haïtian educationalists.

24.2.6 TEH in 2012–2013–2014

- Present in 11 EFACAPs and 5 city schools in Port-au-Prince (Fig. 24.2).
- 31 CPs.
- 1100 trainees.
- 55,000 school children impacted.
- Results of the 2013 internal evaluation:

  - Evaluated trainees had acquired 50 % of knowledge after 2 years of formation.
  - Result similar to general LAMAP tendencies deduced from international experience (50 % assimilation in 2 years, 70 % after 4 years).

Fig. 24.2 The EFACAP Network of TEH

24.2.7 Teaching Resources

24.2.7.1 Teaching Resources (1)

The fabrication of modules is not the only mode of action in the cursus. TEH provides also, and it is an essential part of the program, a series of iterated documents which are made available to all trainees:

- Master's guide (help to the trainees for the preparation of all lessons).
- Trainer's guide (for the CP to help trainees to understand the master's guide).
- Iterated knowledge (for the trainee to digest content of lessons).

  Each guide has two versions: one for level 1–2F and one for level 3–4F

- Data sheets for supervision and observations in classrooms.
- Data sheets for the preparation of lectures (initiated in 2015 by CPs; each develops sequences of one or many seances following a learning progression).
- Videos.

24.2.7.2 Teaching Resources (2)

- Videos present a lecture taught in real conditions by an haïtian teacher following the TEH active teaching method.
- Benefits:
  - Visualize the progress of a lecture.
  - Put teachers at ease with their own teaching ability.
  - Observe a teacher in action.
  - Find new ideas.
  - Identify good or bad practice.

    For the shooting of the video, the trainee receives before being recorded a script provided by the French author of the module and the master's guide corresponding to the seance. A French audio–video specialist and the TEH team proceed to the shooting in the school where the student teaches.
    Data are processed in France and delivered to MENFP/DEF

24.2.8 A Year of Transition: 2014–2015

- DEF/MENFP carries on an in-depth study of the TEH strategy.
- Second year of formation for 2013–2014 class.
- Elaboration of new resources by CP (Classbooks for Maths, French and experimental sciences).

- Enlargement of the *iteration cell* to a *teaching expertise cell* with members of MENFP staff.
- External evaluation.

24.2.9 The 2015 External Evaluation

The activity of TEH between January 1, 2011 and December 1, 2014 was evaluated by the consultants GENINOV, on request of the INTER-AMERICAN DEVELOPMENT BANK (BID) which is funding the program.

The report concludes:

- The TEH program has provided a considerable contribution to the education system by generating a pedagogical model through 11 EFACAPs.
- A number of fundamental aspects not taken in consideration by the project will have to be included.

Among the recommendations of the report:

- Modify certain modules for better adaptation to the standard of trainees and to the MENFP programs.
- Apply TEH to all disciplines in the primary first cycle.
- Extend TEH to all EFACAPs.
- Check the adequacy of exemples included in modules.
- Expand communication in Creole.
- Offer complements to CPs.
- Determine the standard of entering trainees and provide help to weak students.
- Organize regular internal evaluations of TEH.

24.2.10 Perspectives

- The MENFP
  - Works on adopting the TEH model for large scale implementation (10, 000 classrooms).
  - Wants to use resources developed by TEH (modules, practice, evaluation).
  - Intends to develop new resources (classbooks, teacher's books) in order to help access to the license (permis d'enseigner).

- The DEF (Direction de l'enseignement fondamental)
  - Concentrates on the elaboration of teaching resources (books).

- The DFP (Direction de la Formation Professionnelle)
  - integrates the formation of the 1st cycle teachers in PE.

Conclusion

The TEH method should form the basis of the formation of the schoolteachers in the public system of primary teaching.

24.2.11 *Immediate Action*

- December 2015
  - Formation of 30 *Trainers of trainees* by a French team using modules developed in preceding years and TEH videos (1 week).
- Early 2016
  - Formation of 600 *Proximity trainers* by the 30 *Trainers of trainees* (with a ratio of 2 Trainer of trainees for 40 trainees) (1 week).
- TBD (2016?)
  - Formation of 9, 600 teachers (1st cycle) and 2, 400 schooldirectors by the 600 *Proximity Trainers* (1 *Proximity Trainer* for 20 teachers coming from 4 schools: 1 director plus 4 teachers per school).
- TBD
  - Elaboration of Competence certification procedures for PE cursus.

24.3 Extension of the Program

- If indeed the government acts, 10, 000 schools only out of 60, 000 will receive the necessary formation of teachers.
- Then 80 % of schools will be left with teachers having received no formation.
- A reform program as TEH has to be introduced in private schools.

An introduction to the top level management of the catholic schools in Haïti is requested, followed by (Figs. 24.3 and 24.4):

- Adoption of TEH practice.
- Formation of a coordination committee.
- A plan.
- A budget.

Fig. 24.3 Group work on health and hygiene

Fig. 24.4 Experimenting

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Chapter 25
Addressing the First Teachers: Education and Sustainable Development for Children, Families and Communities Through Vocational Education, Technology and Life Skills Training for Women

Rao R. Bhavani, Srividya Sheshadri and Laura Aswati Maciuika

Abstract Supporting children's education and development has long been a focus of institutions and non-profit organizations in developing countries. Mounting evidence from developmental psychology and neuroscience continues to point to a child's environment, including resources and quality of caregiver interaction, as critical to healthy development in childhood and into adulthood. Since mothers most often serve as a child's first teachers in shaping a child's cognitive-emotional learning and values, empowering women also can support higher quality development for children. Amrita University's AMMACHI Labs addresses children's first teachers through empowering women with a multidisciplinary, computerized approach to vocational training and skill development, including life skills training, and personal and community development. This paper presents a case study of AMMACHI Labs' WE: Sanitation Project with rural women in India, supporting sanitation, skills, and increased capacity through skills training in toilet building, hygiene education, and life skills training, leading to increased participation in the family, community and economy.

R.R. Bhavani · S. Sheshadri (✉) · L.A. Maciuika (✉)
AMMACHI Labs, Amrita University, Amritapuri, India
e-mail: srividya.sheshadri@ammachilabs.org

L.A. Maciuika
e-mail: aswati.maciuika@ammachilabs.org

R.R. Bhavani
e-mail: bhavani@ammachilabs.org

25.1 Introduction

On December 2, 2014, Pope Francis convened a gathering of world religious and spiritual leaders, where each signed a universal Declaration Against Human Slavery and Trafficking (Barrett 2014). One participant was spiritual leader and humanitarian Mata Amritanandamayi, or Amma, who directs humanitarian initiatives worldwide, and who also serves as the Chancellor of Amrita University in India.

Amma's mission is the education and upliftment of humanity, especially of the poor and disenfranchised in India and across the globe. Of all people, children are naturally the most vulnerable, and yet are foundational to the future of the world. Amma often emphasizes the importance of values-based education and training for children, so that they can develop into citizens in harmony with themselves, with each other, and with Nature.

Reverence towards Nature is highly regarded within India's fundamental value system, especially among rural, tribal and coastal communities. Traditionally, values and norms that promoted a sense of respect and a sustainable outlook towards nature were passed through an oral folkloric practice. For instance, to discourage children from the practice of open defecation in the river, mothers would recite stories to their children, depicting the river as their own mother, which taught the children to honor and maintain the river's purity (Amritanandamayi 2014).

Developmental psychology has long described the importance of a child's early environment for his or her cognitive and emotional development and capacity for learning (Kagan et al. 1995; Bowman et al. 2001; Scott-Little et al. 2003). Recent advances in brain science have demonstrated the importance of interaction and cognitive stimulation to early brain development in children when neuroplasticity is at its peak, as well as the deep interdependence of nurture and nature for children's overall development (Walker et al. 2011; Britto et al. 2013).

Evidence from these related and converging fields of neuroscience, genomics, developmental psychology, and molecular biology suggest a child's early experiences are in fact built into the body as memory, shaping future development for either better or worse, not only throughout childhood, but into adulthood as well. Therefore, to promote adequate or optimal physical, cognitive, emotional and social development, it becomes critical to consider and develop stable and nurturing environments for children that are also physically safe and free from toxins, and in which caregiver and community capacities can promote both health and development in children (Harvard Center on the Developing Child 2010).

The growing field of epigenetics has also offered insights into the importance of a child's environment to gene expression. There is mounting evidence that suggests factors within a child's environment, including the quality of parenting, can affect genetic expression. As such, the quality of parenting may well affect not only the current generation of children, but also multiple generations still to come (Meaney 2010).

In her humanitarian work, Amma has also emphasized mothers as their children's first teachers. They both actively and passively become their children's first

teachers of information, as well as of cognitive and emotional development as their children's first models of behavior, relationships, and values. Taking this simple fact seriously in developing sustainable education and development programs for children, it becomes critical to consider ways of empowering and uplifting the women who give birth to them. The most recent scientific evidence suggests this may also be the most effective way of positively impacting children now, as well as supporting the more successful development of future generations.

This paper will elaborate on this concept of addressing children's first teachers through training and empowering women, with the aim of improving not only the women's lives, but also those of their children, families, and entire communities. A case study will be described in which a multidisciplinary approach uses technology and life skills training with rural Indian women in an effort to address and empower children's first teachers. This model seeks to enhance the women's personal and professional development, thus also enhancing their capacities as individuals and also as teachers and role models for their children, with the promise of positively affecting the next generation and beyond.

25.2 Background—Amrita University and AMMACHI LABS

In her role as Amrita University Chancellor, Amma emphasizes the practical application of research, technology and knowledge to solve real world problems and to educate and train those who might otherwise not have those opportunities. In India the challenge of providing education and training for the disenfranchised is vast, as over 70 % of the population lives in rural areas.

In accord with the Chancellor's directive, several Amrita University departments and institutes focus on combining research, technology and sustainable development for applied, scalable projects, particularly working with populations in more isolated, rural regions.

One primary research center at Amrita University taking on this mission is AMMACHI Labs (Amrita Multimodal Applications and Computer Human Interaction). Established in 2009, AMMACHI Labs is a multidisciplinary group of 85 people from various backgrounds including engineering, design, psychology, anthropology, and videography, all of whom are focused on combining advances in technology with human development to provide applied models of skill development as well as capacity building.

Women in rural India face a number of challenges as individuals and as primary caregivers. Poverty and a lack of education affect women's health, physical and emotional development, and economic standing, all further affecting women's capacities as primary caregivers. Sons may be preferentially fed over daughters, reflecting regional gender biases. With little education including basic reading skills, many rural women are unable to provide their children with even a

rudimentary education, and are less likely to emphasize the importance of formal education. Poor sanitation and health practices in many areas inhibit women's health, further affecting their children. With malnutrition often exacerbated by poor sanitation, and both affecting children's capacity for learning, addressing sanitation directly becomes a potentially powerful way of supporting both better health and better education.

Skill development opportunities are also scant in India; where vocational training has been available in rural areas, only 6.3 % of those trained have been women (ISST 2012). The lack of vocational skills further undermines women's capacity for supporting their children's successful physical, emotional, and cognitive development. Researchers in India have noted the common inter-generational challenges of poverty, poor health and sanitation, malnutrition, and lack of education, which then create patterns of poor health and development and worse learning outcomes for the next generations (World Bank 2004).

Through creating opportunities for skill development, particularly in more rural areas, this inter-generational cycle can be broken more easily and effectively. Women and their families can develop the capacity to not only survive, but function well in a changing world, no matter what their gender, caste,[1] or level of formal education or training. At AMMACHI Labs, these efforts are being focused initially on empowering rural women, children's first teachers, as an efficient way to provide positive change for the next generation.

25.3 Overview of AMMACHI Labs' Women Empowerment Approach

In beginning to address women's skill development in India, the use of leading-edge technology in vocational training was explored as a way to bridge the lack of education in general and the lack of vocational skills in particular. In India, less than 7 % of rural learners who have received technical vocational education and training (TVET) are women (ISST 2012). A variety of challenges specifically facing women learners in rural areas needed to be understood and addressed—from the general lack of education, to the lack of specific experience with computers or technology, to developing confidence and a sense of agency. The primary research areas within AMMACHI Labs therefore included haptic simulators for motor skill learning, human motor skill learning, and robotics and automation for closing skill gaps and creating new skills.

Beginning in 2009, AMMACHI Labs developed a computerized vocational education and training tool (Amrita cVET), specifically designed to address the needs of more marginalized learners such as rural women in India. The Amrita cVET tool included four components:

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[1]Caste is a form social stratification that is observed in India.

1. Video classrooms;
2. Interactive exercises and immersive learning scenarios;
3. Virtual skill development workshops that simulate practice hands-on learning through haptics and simulation technology;
4. An assessment component so that the learner can self-evaluate her own progress.

The Amrita cVET tool made it possible for fewer live trainers to be required for vocational training, while at the same time supporting the transition from vocational skills theory to their practical application.

In addition, the Amrita cVET model incorporated Life Enrichment Education (LEE), which introduced the women to topics such as health, family relationships, and basic financial literacy through group sessions including games, discussions, and video presentations. The Amrita cVET plus LEE model was piloted extensively in India through 2012–2014, including through a partnership with the United Nations Democracy Fund called the Women Empowerment (WE) Project (Transtec 2014).

The Amrita cVET model of supporting personal and community development while simultaneously training in professional skills addressed capacity building on both the professional and personal levels. It promoted the development of life skills including decision-making, problem solving, the building of confidence and self esteem, including greater participation in community discussions and projects (Sheshadri et al. 2015).

Over 4000 women within Kerala and Tamil Nadu and other Indian states have received the cVET and LEE training, primarily in handicraft skills such as making jewelry or soap, or fabric painting. Recently the cVET and LEE approach was developed further to address specifically the complex sanitation and open defecation problem in India through a similar combination of professional skills training, capacity building, and personal and community development (Sheshadri et al. 2015).

25.4 Case Study—WE: Sanitation Project

In India, close to 600 million people live without access to a toilet, and therefore practice open defecation. This is the greatest proportion of a population practicing open defecation of any country in the world (World Bank 2015). This disproportionately affects women and girls in rural regions, as they often have to walk long distances to the defecation areas, and are vulnerable to suffering violence and sexual assaults, especially at night. For these women and girls in rural areas, open defecation practices do not simply affect hygiene, but also have direct effects on safety, health and socio-economic wellbeing. These in turn affect the overall health and wellbeing of children, the community, and society at large (Fisher 2006).

One important aspect of these challenges is that rural women in India make up both the largest disenfranchised population without access to better hygiene, and at the same time make up the largest group of India's unskilled workers. The lack of skills more generally is also evident in many rural women's lack of knowledge regarding how to build or maintain a toilet, in addition to lacking accurate information about hygiene, or the effects of open defecation on the water supply, and their own and their families' health. This is one example of how a lack of skills makes an already daunting problem even more serious (Sheshadri et al. 2015).

Further, children's health and education are both affected by poor sanitation. Without proper toilets and sanitation practices, children suffer from waterborne illnesses such as parasites and diarrhea, with worms in particular causing malnutrition due to malabsorption even when adequate food is available. Disease and illness due to poor sanitation and hygiene, coupled with a lack of toilets in many schools, cause girls to drop out of schools at a higher rate than boys. The majority of school-aged children not in school are girls (Unicef Wash 2015).

The problems of open defecation and sanitation therefore affect women's health and security, as well as bringing forward the basic issues of distance, privacy, and dignity in sanitation practices. It also has a direct effect on the safety, health, development, and education of their children, disproportionately affecting girls.

India has a stated national goal of ending open defecation by 2019. Given the sheer numbers of people practicing open defecation, the goal is daunting. Previous toilet-building attempts in rural areas through both non-governmental and governmental organizations, while extensive, have had limited success (Coffey et al. 2014).

A recent survey of over 3000 households in villages throughout northern India on people's sanitation preferences and practices underscored that building toilets alone is not enough. A large percentage of people with new, working toilets were found to practice open defecation due to a lack of awareness or appreciation for the benefits of using a toilet (Coffey et al. 2014). Families sometimes ended up using the toilets as storage space, or as a garbage container. The study authors conclude that what may be just as important as building more toilets, is developing the demand for toilets by increasing education and awareness about the health and environmental impacts of open defecation (Coffey et al. 2014).

Amrita University took on the challenge of addressing these issues surrounding open defecation and sanitation using AMMACHI Labs' method of women empowerment through skills training and capacity building. By combining skills training with capacity building while focusing on the issue of sanitation, rural women would have the opportunity to not only enhance sanitation and hygiene practices, but also become more skilled and knowledgeable in the functional building and maintenance of the toilets, with the added benefit of becoming skilled workers and participants in the local economy. This integrative approach became the Women Empowerment (WE): Sanitation Project.

In the early phases of WE: Sanitation, Amrita University explored how this integrated approach to skill development might transform the problem of open defecation into an opportunity for economic enhancement, personal empowerment

and community development. By training women to build their own toilets using the Amrita cVET model, multiple areas are addressed at once: the challenge of access to vocational training, the problem of accessing nearby safe, clean toilets, and the opportunity for enhanced personal, family, and community development. This then creates a collaborative engagement of entire communities working towards better sanitation, enhanced overall hygiene, and personal and community development (Sheshadri et al. 2015).

25.5 Approach

As WE: Sanitation aims to positively impact children's development through the empowerment of their first teachers and the surrounding environment, the project adopts an intricately woven and integrated methodology, as depicted in Fig. 25.1.

In providing the trained women with vocational tools, professional and economic enhancement opportunities, and personal development, the goal is to ultimately impact the child's development outcomes. This model seeks to enhance the women's personal and professional development, thus also enhancing their capacities as individuals and as teachers and role models for their children and the next generation.

The WE: Sanitation model addresses six interrelated areas in its integrative approach to vocational training and capacity building: Awareness; Training; Implementation; Maintenance; Community Development; and Behavioral Change (Fig. 25.2). As depicted in the diagram below, the WE: Sanitation model is nested within AMMACHI Labs' overarching LEE framework, which addresses Personal
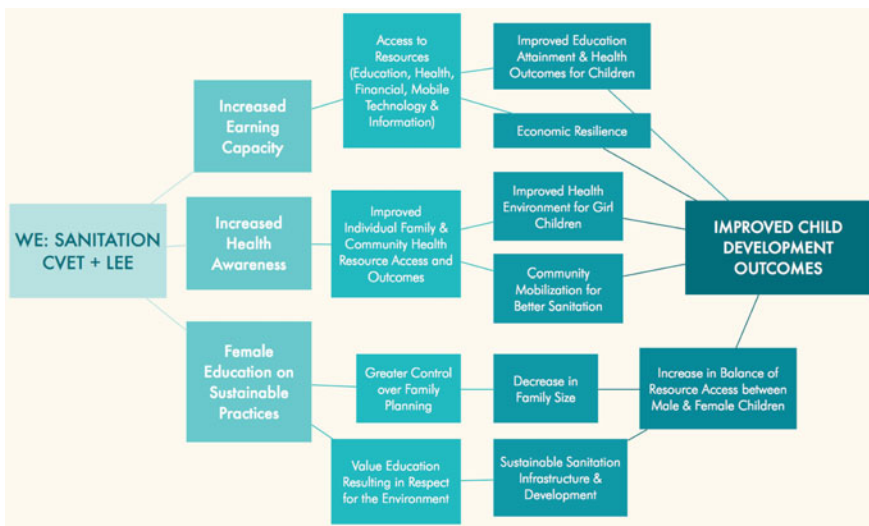
Fig. 25.1 Integrated methodology

Fig. 25.2 LEE framework

and Community Development, Awareness of Infrastructure and Services, Information via Computing and Mobile Technology, and finally, Sanitation and Safety. The following section will elaborate upon each sub-process, as depicted in Fig. 25.2.

25.6 Awareness

Initially, when entering a new community, the WE: Sanitation project holds community meetings. These meetings serve as part of a needs assessment, and as an opportunity to raise awareness about sanitation and hygiene in general, and toilet building and the vocational training involved in particular.

These outreach meetings also include an induction into what Amrita cVET entails, with a description of the technology involved, and how this vocational training program differs from other, more basic skills training. The three general areas of training are described to the community members, including the computerized section of the vocational training via laptops (including demonstrations and training in how to use the laptops), the practice section of learning the trade with the support of a resource expert, and the LEE group sessions on hygiene, sanitation, health, and community problem solving.

As part of the Awareness section of the WE: Sanitation process, the women take part in a facilitated "Ideal Village" Exercise, which allows them to discuss both the challenges and the opportunities with sanitation, safety, and health within their villages. Overall, one of the most persuasive arguments that the women have widely

Fig. 25.3 Awareness through community outreach

taken to is the description of how open defecation has ill effects on children's development, including mental health and intellectual development.

Children are also welcomed to attend these events, and are constantly observing (Fig. 25.3). The children are often the ones who most quickly take on the sustainable practices being taught, and often end up teaching the adults. These dynamics set the stage for individuals of all ages to begin participating more in the community, and often leads to the community developing as a whole. Among the 200 women trained to build toilets through the WE: Sanitation Project thus far, providing a toilet for their children stands as one of the highest motivations women cite in their reasons to enroll in the rural toilet building course.

25.7 Training

The Training section of WE: Sanitation includes teaching individual women the specific vocational skills needed for toilet building and maintenance, as well as the LEE topics and skills taught in group format. The Toilet Building vocational training course covers an array of allied skills/fields, including masonry, plumbing, plastering, and soap making. These skills are taught using the cVET tool, with practical application overseen by a topic expert.

Through cVET, the women are taught with a combination of video lectures, illustrations, interactive games, individual assessments, and a 3D glossary. This model of blended learning has been found to address women's learning successfully whether they are literate or rely exclusively on visual representations. The specific vocational skills courses are either loaded onto tablets, or can be accessed online.

During these trainings, while the vocational training was being given to the women officially, the classes and sessions often would draw entire households, with

the children arriving first, and later the men. After school, in many places children would help with the practical application sessions, or sit and listen during the tablet studies. In one example from the training in Haryana, a boy who was a school dropout and considered "dull" began to come to trainings, sitting at the back of the class every day. Gradually, he not only began picking up the trade being taught, but also taught himself the alphabet at the same time.

In several instances where the WE: Sanitation Project is being implemented, the children of women taking the toilet building course have adopted their mothers' tablet-based classroom sessions as their after-school activity. Children watch as their mothers engage in new tasks such as skilled construction work and the use of sophisticated technology to learn and play games focused on sanitation awareness. The outcome is that children begin to recognize the importance being paid to better sanitation and hygiene at a community level, and demonstrate an interest to practice better hygiene themselves. In response to the children's eagerness to learn, separate awareness sessions just for children have been arranged.

25.8   Implementation

During the Implementation phase of WE: Sanitation the women move into applying the knowledge and skills learned through the cVET tool by practicing the physical construction of toilets (Fig. 25.4). In some villages, the goal becomes to have a newly constructed toilet in each home, all built by the women who took part in the vocational training program.

In addition, through the LEE group sessions, the women are encouraged to share the information about hygiene with their families, neighbors, and friends. This often leads to community development through new community actions. For example, in the village of Byse, the women taught their children some of the basics of sanitation, how diseases can spread, and the importance of toilet use. The children then presented an awareness play to the entire community. In the village of Malcopon, a LEE session connecting personal health and the environment prompted the women to mobilize a cleanup drive in their village. In the Orissa village, discussions of alcohol use and abuse prompted the group of women students to create an Alcohol Awareness Campaign in their village, which included a public march with adults as well as children participating, holding signs and pictures. In light of their heightened awareness of environmental sanitation and hygiene, the youth in the Orissa village also led a massive village clean up campaign, to promote the proper disposal of waste in their village.

The participation of children in the anti-alcohol rally sent an important message to the adults of the community, that they understand and condemn the ill effects of excessive liquor consumption.

The Implementation phase therefore includes practical application both of the vocational skills learned, and also of the awareness and education discussed in

Fig. 25.4   Training and implementation of vocational and life skill development

groups. In addition, the Implementation phase includes Assessment and Certification in each participant's particular vocational trade.

25.9   Maintenance

The Maintenance section of the cVET and LEE training prepares the women to be able to maintain the toilets they have constructed, as well as the toilet pits (Fig. 25.5). The trainees learn the skills needed to maintain and repair the newly

Fig. 25.5 Training in maintenance of sanitation systems

constructed toilets and toilet pits. They are also introduced to inventory management in order to track the needed supplies and tools for adequate maintenance. Within this section, there is additional monitoring and evaluation to make sure the skills are well learned and can be applied successfully. These skills included learning toilet maintenance through environmentally friendly methods to instill sustainable practices, such as planting banana trees near the soak pit, using EM,[2] and lime as a disinfectant.

25.10   Community Development

The WE: Sanitation project is in great part an enhancement of infrastructure for the villages involved. Part of the Community Development aspect involves identifying and supporting some of the women involved in the training to develop themselves as leaders. This occurs as some women are selected and supported in becoming facilitators in the many community discussions required. These facilitators then lead the community discussions and planning of toilet construction, as well as water resource management, additional tracking of resources, and ongoing problem solving.

In several villages where the WE: Sanitation program is being implemented, entire communities have grown to respect the steps women trainees have taken to challenge existing norms (e.g. masonry being a male-dominated profession). In turn, women trainees have demonstrated greater confidence to address

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[2]Electro Micro-Organism (EM) technology is claimed to enhance sustainable practices in farming, composting, and reducing environmental pollution.

community-wide issues as a team. In the Andhra village, women trainees led the effort to clean the streets so their children could attend school on time instead of having to navigate through dirty and trash-filled roads, which often deterred school attendance. In the Orissa village, women toilet building students championed the return of electricity to their village by collecting the necessary support from village residents, in turn positively impacting their access to clean water.

Supportive technology is also used: a Village Wiki is available online to help facilitators and communities track the states and villages within India in which the training has been implemented, the number of trained people available, and the numbers of toilets constructed to date.

Another part of Community Development follows naturally from the women learning needed vocational skills and trades: the opportunity opens up for them to become entrepreneurs and start their own businesses. Within the Community Development section of the cVET training, there are group discussions about the basics of starting a business, whether it is in constructing toilets, making bricks, or making soap. The women are supported in forming Self Help Groups (SHG's), in which they learn together and also develop the community support to help them as they move toward starting their own businesses with their newly acquired vocational skills.

25.11   Behavioral Change

The final section of the WE: Sanitation program is the observable behavioral change of individuals, families, and entire communities and villages in many cases to date. In some villages in which cVET was delivered, the villages embraced a goal of Community Lead Total Sanitation (CLTS), which included not only the use of the newly constructed toilets, but the installation and use of hand-washing stations, and greater awareness of hygiene put into practice by the entire community.

Overall, the most dramatic changes were often observed in the children first, in terms of new sanitation practices and maintenance. The children often became catalysts for additional behavioral changes in their families and communities. Having learned the connection between clean hands and malnutrition through awareness sessions on personal hygiene, children in the Andhra village, for instance, immediately and enthusiastically adopted practices such as daily bathing and grooming, maintaining clean hands and trim fingernails.

The LEE groups and the Self Help Groups facilitate the creation not only of communities of learning, but also communities of practice. The behavioral change on the level of women's participation in their communities is often profound. Women become more active participants in general, often included in discussions for the first time at a community level. The women take a more active role in decision-making in their communities, including in infrastructure and resource management, and raise awareness among their children and often the entire community about issues of hygiene, sanitation, safety, and health. This raising of

Fig. 25.6 Modeling behavior change

awareness often inspires community action, leading to additional community development and positive behavior change (Fig. 25.6). In one village, women trainees of the WE: Sanitation Project conducted an awareness session on the value of proper toilet use to individuals in the community that already had toilets, but were not using them due to a lack of awareness.

Finally, while not every woman who has gone through the cVET training has expressed an interest in starting her own business in the construction trade, some women have started their own businesses, or have constructed additional rooms such as kitchens for themselves and their neighbors. Empowering women in skill development through the cVET and LEE model, which at the same time creates communities of learning and practice, is proving successful at individual, familial, and community levels to date (Transtec 2014). The simultaneous training in vocational skills and personal and community development seems to be creating empowerment on personal, family, and community levels, and shows great potential in continuing to do so.

25.12 Conclusion

The WE: Sanitation Project is an example of an approach that combines capacity building through skill development with personal and community development based on sustainable practices that also transfers those values to the children. Focusing on the women in rural areas, the project so far shows great potential in empowering individual women, families, and entire communities. It also has demonstrated great effect in empowering children directly, who then often take on the role of being catalysts of ongoing positive changes. Addressing the first teachers in this case so far has proven to have great potential for increasing the wellbeing,

economic and social participation, and personal development of the women involved. They in turn, along with their children, become ambassadors for change in their communities, and in their homes. This holds great promise for positively affecting the adults in these communities, as well as the children of this generation, the next generation, and beyond.

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Part IV
The Voice of Children and Teenagers on Sustainability and Climate Change

Chapter 26
Contributions of Students and Debate

**Antonio M. Battro, Pierre Léna, Marcelo Sánchez Sorondo
and Joachim von Braun**

Abstract In order to demonstrate the value of Children Empowerment, an international group of young students, age 12 to 18, has been invited, during an oral exchange, to contribute to the Workshop and its conclusions.

26.1 Introduction

A panel of students from schools in the United States, Italy, France, and Germany was invited to participate in a workshop titled "Children and Sustainable Development," hosted by the Pontifical Academy of Sciences at the Vatican.

Presented by students from: Ross School, East Hampton, NY, USA; United World College Robert Bosch, Freiburg, Germany; Lycée Charles-Peguy, Bobigny, France; Istituto Comprensivo "A. Volpi," Cisterna di Latina, Italy; Liceo Scientifico Statale "U. Dini," Pisa, Italy; Liceo Scientifico Statale "A. Labriola," Naples, Italy; Istituto Comprensivo "R. Viviani," Naples, Italy.

The names and affiliations of the Educator Facilitators, the Educator Participants and the Students are given in Part VI, Annex 3.

A.M. Battro
Academia Nacional de Educación, Buenos Aires, Argentina
e-mail: abattro@ross.org

P. Léna (✉)
Observatoire de Paris, Université Paris Diderot, Paris, France
e-mail: pierre.lena@obspm.fr

M.S. Sorondo
The Pontifical Academy of Sciences, Vatican City,
Holy See (Vatican City State)
e-mail: marcelosanchez@acdscience.va

J. von Braun
Center for Development Research, University of Bonn, Bonn, Germany
e-mail: jvonbraun@uni-bonn.de

These students, aged between 12 and 18, were representing more than the four countries where they are currently studying. Providing a lively image of globalization, immigration, migrations, refugees in today's world, they were issued from fifteen different countries and cultures: China, Colombia, Ecuador, Germany, Italy, Nigeria, Palestine, Philippines, South-Africa, Sweden, Syria, Turkey, Ukraine, United States, Zimbabwe.

Their participation illustrates the concept of Children Empowerment, which was developed in several contributions to the Workshop.

26.2 Students from Ross School, East Hampton, NY, USA

Students from Ross School in East Hampton, New York, spoke about our moral obligation to maintain the environment (Fig. 26.1).

Shanshan: We all understand that old habits are extremely hard to change. Especially those from thousands of years ago. Yet it's time to change our way of thinking. This shift for an environmentally friendly life should not be a competition. These endeavors should be a collaborative effort, and not a challenge for wealth gain. Once we realize the impact of our actions, and how they have negatively affected the environment and our future generations, then we can work on finding solutions for our problems.

Fig. 26.1 Students from Ross School, East Hampton, NY, USA

Malik: In order to find solutions, we must understand that natural resources are limited. If we don't sustain the use of resources, they will become extinct. Think about the trees that provide us with fresh air and shelters, the water that supports life, and the creatures in the ecosystems. Humans would not survive without any of these resources. Therefore, we should be mindful of what we are taking from them, in order for our posterity to have an equal chance of enjoying the world.

Shanshan: Sustaining the natural resources is also about giving back. There's an old Chinese saying, "The warm fragrance stays in your hands when you give roses." We always get happiness when we are contributing to someone else's. As we are enjoying the resources with gratitude, we should also think about what we can give back to maintain the health of our living system.

Malik: For some of us, it is difficult to imagine how much damage is caused by our actions. Because resources are so accessible, we ignore the fact that they're limited and extremely valuable. We don't experience what the poor and vulnerable are suffering from, such as polluted air and water, deforestation, and overexploitation. While larger and wealthier countries are creating the problems, smaller countries have to bear the disproportionate burden, helplessly watching their homes and living environments being destroyed. These countries need our help in order to develop and thrive. To face the environmental issues, we must all come together.

Shanshan: We can see how one society's action can cause another society's suffering. We need to understand that everything is connected in the living system. The health conditions and biodiversity of the ecosystems are deeply connected to human survival. During the first civilizations, humans tried to separate society from the nature. For instance, the city of Uruk, during the Mesopotamian civilization, built 20-foot walls to distinguish itself from the nature. However, it is a wrongdoing to separate them, because society's culture, economics, and politics are intertwined in this ecosystem. As we understand this concept, we need every field to get involved, to get an integrated approach for the issues that we are facing.

Diego: Imagine if there are no future generations. If there were, they would most likely have a miserable life. Who would want a miserable life? Is a miserable life even a life? If there is no more hospitable land, people will move to the places where there is, but then the hospitable land's resources will diminish and the circle will start again until there is no more arable land to live in. All of us would become extinct.
            The ecosystems and environments are changing so fast, we can barely catch up. If we don't adapt fast enough, we will surely suffer—not only us, but so will all life on Earth, including plants and animals. Their death will be on our hands.

We need clean energy so that poor countries can develop, so that their citizens have a chance to rise from poverty. Don't we all deserve that chance? When the UN meets, the wealthier countries say, "We all need to stop using so much energy," when it is actually them using all of the energy. Developing countries feel like a ladder is being taken away from them.

When animals and plants go extinct, it disrupts entire ecosystems, creating hardships for all species in that system. This is happening on a global scale, as well as local and regional. Only bad things will come from the loss of resources. Famine will increase. Disease will spread rapidly, especially for the poor, because the powerful and the wealthy will have access to what they need to survive. War will be like it has never been before. Treaties will mean nothing, since we will all be fighting for resources. Without a change in our mindset, people will do to their new land what they already did to their homeland. The circle will just keep spinning until there are no more resources for anyone.

The poor and the vulnerable will suffer the most from all of the things that are to come. All of what I just said explains what will happen to them, except they will suffer the greatest. Right now, people profit off of their suffering. For example, big corporate companies pay developing countries so that they can dump harmful chemicals in their countries. Sometimes the people don't even get paid. This affects their economy and ecosystem. If food becomes more expensive, which it probably will, the poor will be hungrier. Already they have less access to needs like safe shelter and water. This will only get worse if we don't act urgently. It may seem like the consequences of the things that we are concerned about sound very similar or are exactly the same. But this just goes to show how interconnected everything is, and if one of these things happened, it would set off a chain reaction or domino effect that will set off all of the other things that we are concerned about.

Isabella: People are finally realizing the damage we have done to our environment. This inspires us to work hard on solutions. Eco-friendly and innovative alternatives of polluting substances are being pioneered every day. At the Ross School, we live sustainably amidst nature. Our role and responsibility to the planet is clear. Our Core Value system gives us a baseline of how to live our lives as active participants: cooperation, courage, gratitude, integrity, mindfulness, respect, and responsibility.

Through our Field Academy, we have the luxury to meet and visit with the less fortunate in developing countries who, as the Pope points out, suffer the most. Pope Francis says, "We are faced not with two separate crises, one environmental and the other social, but rather one complex crisis which is both social and environmental. Strategies for a solution demand an integrated approach to combating poverty, restoring dignity to the excluded, and at the same time, protecting nature." His

interdisciplinary approach towards fixing the world makes the solution seem clearer.

Seeing poverty inspires us to change our habits so that we will all live in improved conditions. People in Bangladesh should not be forced to leave their homes because of flooding caused by glacial melting. Fishermen in New York should not lose their livelihood due to toxic waste.

In the Ross classroom, we are taught to think outside the box, innovate, explore, and help. This gives me hope for the future. No one wants to see the world destroyed. Future generations deserve the same gift from the Earth we were given. That means we have to preserve it not only for our children, but also our children's children. The time to act is now, as these problems can't be ignored. As Ross students, we are empowered to do so.

Kwazi: I want you to think of the droughts in Africa, the floods in India, the melting ice caps in the poles, and the naked forests in Indonesia and Brazil. We all know that this is partially our fault. However, unfortunately, climate change still ranks at the bottom of issues that people are even concerned about, or ever take action about.

But imagine if we could change how people perceive their world. Imagine if we could change the society's mindset. Although it may seem a completely daunting and impossible task, it still is possible. It doesn't mean that it cannot be done. We can have a cultural shift.

Environmental change is not only about planting trees and saving habitats. It requires a greater demand within ourselves. It requires that we do more than just our personal best. It requires that we do more than just try to reduce our carbon footprint. Yes, because together we destroyed it, so together we will fix it. Hence, a global collective response is necessary.

Andrew: How do we most effectively help? We mobilize together. In times of crisis, entire cultures have shifted by rethinking their values and taking action. We have the moral obligation to mobilize against this climate crisis and save the planet. After all, there is no planet B.

Our choices and activities have a direct effect on people and the environment. Climate change is on track to cause the extinction of half the species on Earth, devastating droughts, famines, displaced people, and failed states and pandemics. If this horrific destructive force is to be abated, it will be due to a cultural shift and a mobilization of people alive today.

Current adults have a moral obligation to act quickly and immediately for the sake of younger generations—kids like us. But we are not only morally obligated to act today, we are also morally obligated to continue acting tomorrow, and the day after that, and so forth. It would be a moral failing not to act.

26.3 Students from United World College Robert Bosch, Freiburg, Germany

Students from United World College Robert Bosch in Freiburg, Germany, spoke about the need to provide equal access to sustainability education for all children and the importance of spreading the message that individuals can take action (Fig. 26.2).

Iryna: The urgent challenge to protect our common home includes a concern to bring the whole human family together to seek sustainable and integral development, allowed to see it all does. UWC Robert Bosch College in Germany is an international college. Two hundred and six students, 88 nationalities, many different religions, and one goal. UWC makes education a force to unite people, cultures, and nations for peace and a sustainable future. It's the main point of our mission statement and the main purpose of studying there.

Both parents of my college friend Selena, from the Marshall Islands, died because of a storm. Increasing average temperature on the planet of 0.4 °C will cause Selena's home to disappear forever. That is what concerns me. This situation makes me think about why people in different regions of our planet have different rights, especially for life? The situation makes me take action and do small right choices. Should I go by plane or by train? And remember, the main things that allowed to see it all does, "Climate is a common good, belonging to all and meant for all."

Jonas: What is also very concerning is the fact that there are many people in this world, who still do not believe in climate change. For example, I have a friend. I spoke to him a couple of weeks ago, and he told me that he doesn't believe in climate change, simply because of the fact that he thinks

Fig. 26.2 Students from United World College Robert Bosch, Freiburg, Germany

companies just make it all up to sell sustainable and environment-friendly products and therefore earn more money. It is very hard—I tried to persuade him, but I just couldn't do it. It is very hard to persuade those people.

Jay: Yes, I agree with that and for that, I personally want to say my experience related to what concerns me about the climate change is, 5 years ago, there was a dense forest around my village. But 2 years ago, it was deforested and now we don't receive rainfall in time. Nobody knows the reason we don't receive rain in time. Even I knew it was reason of climate change when I came to Germany. So the concerning part is, they don't know about the climate change and how they're going to take action to solve the problem of climate change and sustainability.

Natali: Social inequalities. Social inequalities in the world is my main concern. As we know, not all people have access to their rights. One of these rights is education, which is the main way to know about sustainability and its necessity to gain the sustainable lifestyle. This lack of awareness is coming from the social inequality that results through lack of education for many people in many countries. Thank you.

Jay: What inspires us to do the work for the climate change and the sustainable development—we can take example of the person who are working and worried about the climate change, like Felix Finkbeiner, who is a 13-year-old German guy who started the organization Plant for the Planet at 9 years old to plant one million trees in Germany. He recently got the target. I found the number of trees yesterday in the Internet is 15,202,290,811 trees are planted now, and his organization is going on 131 countries. So he's a child, and he got the education related to climate change and applied it for the sustainable development. We are also children, so if he can, why can't we? It's the question.

         The other we can take example of is a child labor activist. He's working for the child labor and improving the education of the children for the social sustainability, which we can take furthermore, and take those children as a way to change the mind of people about the climate change and work for the sustainable development of the Earth and people living on Earth.

Jonas: That's all very well, but why should we act? What obligates us morally to resolve the problems of climate change. I think that this question can be answered in simply one word: life.

         There is a moral obligation towards preserving the life of every single being on this planet. The things we are doing now, we are responsible for. Things like deforestation, or polluting the oceans and the air—all that causes the death of animals, plants and humans, even whole species. So our behavior is lethal. There is nothing whatsoever to justify this destructive attitude. Everybody has a right to live out of multiple reasons. Additionally, our behavior is not only destructive, but self-destructive.

Basically, every human being should feel the urge to fight climate change simply because of their natural survival instincts. And as a side effect of that, we would save everybody and everything else, also future generations, who have the right to have the same possibilities and resources we now have the privilege to use. So our obligation now is to raise awareness for that and thus set the survival instinct into motion, so that people start to comprehend and therefore to take action.

Natali: Our main goal and mission is highlighting the importance of education, where everyone gets equal access to the education that could help us to gain a sustainable life, regardless of race, ethnicity, or gender. We should also change our way of teaching about environmental issues. Teaching should not be based on fear. Students shouldn't only feel the responsibility or duty, but the love to the nature and the desire to give, not only to give in.

Therefore, contribution from all societies and individuals is required and needed to change the current situation and to raise the awareness of the importance of getting the sustainable development. Fear is rejected. We need to put our wants aside and to leave a world that future generations will live in peacefully. What's needed is love for nature and the passion to move forward and achieve the dream: sustainable life. Thank you.

26.4 Students from Lycée Charles-Péguy, Bobigny, France

Students from Lycée Charles-Péguy in Bobigny, France, addressed the need for both youth and adults to take responsibility for preserving the environment, and spoke of how little acts can make a difference in sustainable development and protecting the environment (Fig. 26.3).

Eda: Today we will tell you about the education at France. About issues and ideas related to sustainable development and climate change.

Jeanne: Today, we can't deny, due to emissions the pollution of water and air, the deforestation, the disappearance of animal and plant species, and poor waste recycling practicing. So we must find a solution to all these issues.

Eda: First, we must make people aware. The most important thing is the organization of the population, because since the end of the twentieth century, there have been warnings about sustainable development, but only today are people beginning to be aware of it.

Fig. 26.3 Students from Lycée Charles-Péguy, Bobigny, France

Jeanne: In order to warn the population, politicians are including discussion in their speeches, but as the word "speech" means, it is just words. Making changes actually happen is longer and more difficult.

Eda: As these issues become more and more pressing, the population is beginning to understand that we have to find solutions. So environmental culture exists in several countries, because parents are mentioning sustainable development when they raise their children. Family is the place where we learn everything. There are also schools which participate in that education. The media with documentaries or interviews contribute to this movement.

Jeanne: Laudato Si was a summary of the world rights situation. Moreover, the Pope is a leader for part of the population. He is listened to everywhere, inspires confidence, and he has no vested interest in the process. So if he wrote a book about sustainable development in the context of climate change, it means that it's important because as it's written, Earth is our home. God gave us Earth as a gift, so in return we must take care of it. It feeds us, it shelters us, it makes us live.

Eda: We take part together in the same family. Our actions have consequences. Maybe not on us, but on our brother and sister living in the next room. For example, developed countries pollute without noticing bad consequences, but their little brother, poorer countries, they are affected by these consequences. That shows us there is a relation between religion and caring for the environment.

Jeanne:	Second, we must feel concerned. Awareness is only the beginning. We must also feel concerned by climate change. In fact, destroying the Earth would have consequences on our own life or on our children, because there may not be the resources to fulfill everyone's needs.
Eda:	To know the consequences, we must be informed by real examples, not theoretical ones, because otherwise, people feel that issues are always exaggerated. When disaster happens in our country, near our home, we are shocked, so there's more impact on us, and we feel more concerned.
Jeanne:	In France, we see climate changes when some days we mustn't take our cars because there is too much pollution is Paris.
Eda:	Or sometimes, there are floods in the south of the country.
Jeanne:	Or in the French islands, there are typhoons too.
Eda:	We also feel the multiplication of heat waves.
Jeanne:	But sometimes it can be worse in other countries, like China, where jogging or riding a bike have become dangerous for the health of inhabitants because of the clouds of pollution. But they do nothing.
Eda:	There are contacts between the different parts of the planet. When a disaster happens in other countries, we're affected, even if we feel distant from it because we only see it on our television screens. We still want to act to fight that, but most of the population doesn't know how to.
Jeanne:	Third, how can we act? Now, all the population is informed; it should want to act to reduce the gravity of consequences.
Eda:	In order to act, first we must change. Not just in our acts, but also in our way of thinking.
Jeanne:	We live in a consumer society. That's the problem, because we always want more, we always want better. We have forgotten how to live simply, with just the necessary. People are blinded by money and they go for development. The society always wants to improve without thinking of nature.
	At first, money used to be a means of exchange, a way to share and allow people to have good relationships, but today, it has become more than that and it's a means of power.
Eda:	Moreover, people are selfish. They always think of themselves first, of their comfort. So they lack love and they need to buy something in order to fill that void. Being aware of the development doesn't mean only having a good relationship with nature, but also good relationships between humans. The rhythm of society is too fast. We don't take the time to take a break, to admire nature. So we degrade it because we don't really know its real beauty.

Jeanne: Fortunately, not everyone is like this and some want to act. But
                   they think their acts are pointless and will not change the world.
                   But they are wrong, because if we work together, little acts will
                   become one same and big act. So we have to work together.
Eda: We have fine examples of little acts to protect our environment.
                   We can do this by planting trees, sorting paper and avoiding
                   plastic, turning off lights, reducing our consumption of water and
                   electricity, using transport like bikes, subway, et cetera. Even
                   young people can do these acts, and we can also find a new way
                   to participate at school by sorting waste, by planting trees in the
                   backyard, by riding a bike to school, or by becoming a member
                   of an association. We must also listen to the youth, because they
                   may be able to teach their elders some things.
Jeanne: So today, everything changes. Current problems are the
                   responsibility of both adults and younger people, because
                   today's youths will be…
Jeanne and Eda: Tomorrow's adults.
Jeanne: And they will in turn teach that to future generations. So for this
                   transmission, first.
Eda: We must be informed.
Jeanne: Be aware.
Eda: Feel concerned…
Jeanne and Eda: And act.

26.5   Students from Istituto Comprensivo "A. Volpi," Cisterna Di Latina, Italy; Liceo Scientifico Statale "U. Dini," Pisa, Italy; Liceo Scientifico Statale "A. Labriola," Naples, Italy; Istituto Comprensivo "R. Viviani," Naples, Italy

Students from a coalition of schools in Italy urged participants to make a difference
by informing and educating others and creating clear plans of action. One student
set the concerns she feels about the state of the environment to music (Fig. 26.4).

Marcello: Our voices, through our eyes. Thank you for hearing us out. What I
                   see through my eyes in my home place. The beauty of my land. This
                   is Naples, my hometown with Mount Vesuvius in the background at
                   the sunset, and the harm we have inflicted on her. A collapsing tree
                   after a rainstorm. A winter flood in Benevento, north of Naples.
                   Tennis ball-sized hail falling. Slaves of the throwaway culture is Pope
                   Francesco's cause in Laudato Si. 2007, annus horriblis, this picture
                   goes round the world. In some areas, problems still exist. Outside my

Fig. 26.4 Students from Istituto Comprensivo "A. Volpi," Cisterna di Latina, Italy; Liceo Scientifico Statale "U. Dini," Pisa, Italy; Liceo Scientifico Statale "A. Labriola," Naples, Italy; Istituto Comprensivo "R. Viviani," Naples, Italy

> window, the "land of fires." Acerra-Nola-Marigliano Triangle. Camorra made for great business with buried waste.
>
> Why does it happen? I tried to get informed, understand the reasons. With my family and friends, we did a Sunday of cleaning up. And at school, I discovered. I work in SUSTAIN project [an EU-supported education project] and I learned to inquire on the life cycle of an everyday object. I focus on my sneakers, and many questions arose in me. Before, what did it come from? Today, made how? After, will it be used again? How? I discovered a world through my sneakers, made in faraway countries.
>
> The long road of my sneakers. A long road through transports that contribute to the air pollution. And I discovered that many sneakers are made by workers as young as I am. I made many discoveries. I understood that effects are connected, but what can I do for them and for my land? How to behave? I understand now that even the smallest action can be important. I am also trying to involve my friends. I will keep on working on it.

Alessandra: Looking through eyes of our far countries.

Leonard: We belong to a connected world.

Alessandra: Philippines and Nigeria. We are so far away, but still so close. We have relatives, friends, grandparents, which we always keep in touch with.

Leonard: We want to give witness to what is happening in our countries.

Alessandra: We are here now, but we enshrine in our eyes and in our hands our countries of origin.

Leonard: The near and the far are within us.
Alessandra: And this keeps us united wherever we are and wherever we will be. At school, we learn and discuss about these problems. Now, we understand that to change here also means to change far, in our countries of origin.
Leonard: Everything is connected.
Alessandra: Trying to act in our simple, small everyday deeds reflects farther and farther away.
Kenneth: It is as if our hands could reach them. We give hands to our eyes. I will be an example of change with my daily action, at school, with my friends.
Alessandra: I will fill my heart with love and not with things that I can only buy.
Kenneth: I will take care of my friends, as my brothers, and of the Earth, as my sister.
Gabriel: I will not waste water, I will turn off all unnecessary lights. I will use the bicycle instead of the scooter.
Alessandra: Altogether, through simple actions, we can contribute to taking care of our connected world.
Anas: Earth is slowly exhausting. One of the tools we use to measure the state in which we are is the ecological footprint. We are literally squandering our house's resources. We have no time. We have to act now. There is a strong inequality between the waste of resources all over the world. We are wasting resources.
                The progressive temperature increase leads to catastrophic changes in climate. We have arrived on a healthy planet. We need the same chance our fathers and mothers had. But there are no rights without obligations. I have to do more. Together, we can make a difference. So we have to inform people, educate children, create sustainable environments, give examples, and discuss and identify clear roads to act now. Thank you.
Francesca: [Singing; tune "What a Wonderful World"].
                I see trees cut down, seagulls in oil.
                I see them fade, what can I do?
                I think to myself, what a sick, dying world.
                I see skies are grey, and clouds of smoke,
                The greenhouse effect, the ozone hole,
                And I think to myself, what a sick, dying world.
                The tears of hungry children, while streets are full of junk.
                The wasting of resources, will murder our mankind.
                There is no more time left, we must act soon.
                If we join now, I hope to.

> See the skies getting blue, flowers will bloom.
> And birds will be flying, kids will stop crying.
> And I'll think to myself, what a wonderful world.
> I'll think to myself, what a wonderful world.
> Thank you.

26.6   Principles and Guidelines for Educators, All Students

As a group, these youth, who originally hail from all over the globe, came together to present a proposed Declaration of Principles and Guidelines for Education to the panelists attending the workshop (Fig. 26.5).

Clark: Thank you, students, that was wonderful. I'm so proud of you all. That was great. Thank you all for listening and for having us here. Thank you for giving us, all these students, a chance to share with you. Thanks for hosting us all. In addition to making the individual presentations that the students made just now from their different schools, we also worked together to compose some principles and some guidelines for educators that we're going to take a few moments now to share with you.

This was a collaborative project. Each individual contingent came up with some ideas, and then we spent some time yesterday going through these ideas and putting together a compilation that we feel reflects the sentiments of these students, from 12 different countries and five continents and seven different schools. So I hope this is helpful as you move forward in your wonderful work that we also really appreciate. Thank you.

Fig. 26.5   In front of the Casina Pio IV, the group of students with the Chancellor of the Pontifical Academies.

Massa: Declaration of Principles. Environmental education is not a privilege, but a right.

Society (politics, economy, and culture) is inseparable from the environment. All species, including humans, are part of nature in a nonlinear web of interdependence. Cooperation and mutual respect are imperative for the survival of all species.

All living things are entitled to equal opportunities and resources to live a healthy and fulfilling life. There is a need for a shift in consciousness, concerning the relationship among societies and environments.

Basnight: Humans live in a finite world. Resources must be used sustainably with future generations in mind.

Interdependence involves giving to and receiving from the environment in which one lives. Therefore, all life has the right to use resources responsibly and wisely, while also contributing to the healthy maintenance of the living system.

Wealthier people disproportionately impact the health of ecosystems. Yet the poor and vulnerable disproportionately suffer the consequences of environmental problems.

Kmyts: We also would like to share with you Guidelines for Education. Ecological literacy—understanding the source of one's food, water, and other materials, as well as the impacts of their procurement—should be considered foundational curriculum, the same as numeracy and literacy.

Each student's unique interests should be cultivated in a loving and caring environment, thus planting the seeds of socially and environmentally compassionate in people.

Schools and families must be examples of sustainability. Teachers, to begin with, should be models for inspiration. Education of educators is a requirement.

Khalil: Develop new approaches of teaching students about sustainability and climate change, based not on the concept of fear and feeling powerless about future situations, but based on love and respect for living beings, and balance between humans and their environment.

Provide children with simple actions that they can practice every day to make the world more sustainable and build habits from these experiences.

To truly understand the world, students should understand the interconnections of society and nature, through an interdisciplinary education that does not create artificial boundaries between subject areas.

Marmion: Students must understand that sustainable development is related to science, as learning to solve problems from a scientific point of view is the first step to understanding the problem.

Children should be given the opportunity to learn through a variety of experiences inside and outside of classrooms. They must see with their own eyes the degradation of nature, but also the wonders of nature to understand its fragility.

Anxiety provides a motive to act, but this must be balanced with hope.

26.7   General Discussion

Chidsey:	Bravo. Thank you. This concludes the students' presentations, and we don't know if you'll have time or questions for them. Do they have time?
Yves Quéré:	(Translated from French) We have just had a marvelous illustration of the meaning of the word "curious." Curiosity, first of all, is the desire to know, and these children have shown in a superb way how to make something certain. That's curiosity. Further, etymologically, curiosity, curious in English, comes from the Latin *cura*, and *cura* means the care we bring to something. We hear it in French, *cure*, take care, take care—the same word as curiosity. Therefore, we have two meanings of the word curiosity: the desire to know and to love what we see. And you have said it magnificently. You are curious in a scientific sense—curiosity— and you are curious in an empathic sense because you like nature and you have demonstrated magnificently this double sense of the word *curieux*, *curious*, *cura* in Latin.
Chidsey:	Thank you. Dr. Arber?
Werner Arber:	I am deeply impressed. I'd like to thank you in the name of the Pontifical Academy of Sciences, and also of the Pontifical Academy of Social Sciences, for your deeply reflected insights into the laws of nature, the big laws of nature, which are anchored in what we appreciate on our planet and further in the whole universe.
	Of course, I'm aware that evolution of the nonliving world, the universe, our Solar System, our planet, is an extremely slow process. It's difficult to see, but we have more and more succeeded in last decades to understand how that works.
	Astrophysics is going to see whether there are other so called exoplanets, where life may or may not exist also. You will be in the course of your life, probably testifying of the results of these investigations. And it will be extremely interesting to see if life on this very far exoplanet, to which we could not go

directly, but to which, back to physics—astrophysics—has found ways to explore. And I hope they will be successful.

Therefore, I think that will tell you that, in particular, our human society should avoid with the use of science and its technological applications to destroy that wonderful world in which we live not only alone, we live in the presence of a multitude of others—actually, no one knows yet how many different species of living beings are on our planet.

In your bodies, we investigate actually how many different micro-organisms, bacteria, are there, one already has some ideas that more bacterial cells are steadily in your body, than your human cells, which of course are a larger size. It is clear that these bacteria are symbiotically working with you. You give them some nutrition and they give you much help for your own life—digestion, keeping away infections, and so on and so forth.

The more we investigate how nature works and how its evolution works, the more we are absolutely amazed to see this wonderful force in nature, in using the laws of nature and producing what we have. We should really, deeply think. We should allow the human society—humans are actually, so far, the only species of living beings which have highly developed intelligence. But also—and the Church has reminded us—we also should take care of the rest, and we have duties not to interact so that the future development also of the human civilization, might be not only for our immediate two, three generations, but for very long distances.

The other day I said we should at least care for keeping this humanity for another few million years, I think—and this is not easy, as you can understand. I have seen in your presentation that you have learned to think on long term. That's very important. And I encourage you to continue your way, as you did. Thank you very much.

Chidsey: Dr. Singer.

Wolf Singer: I want to convey you my admiration. You have summarized, without having been with us yesterday, more or less what we have been saying—all these distinguished professors and scientists. You made the point, and it's very difficult to add anything. It will be difficult for us to continue this conference, I think.

But you have beautifully demonstrated what mankind did to our planet. Mankind also does a lot of very, very nasty things to itself. We have wars everywhere and you will have heard about the disaster in Paris last night [the terrorist attack on Nov 13, 2015].

	I invite you to invest your curiosity and your future studying also in the psychological dimension that makes it that man does so much harm to man, not only to its planet. Thank you.

Jacques Blamont: (Translated from French) You have chosen well your song and your films, and we thank you for that. I want to draw your attention to something that is missing and is a symbol of all that is happening today in our attack of nature. When you eat an egg, when you eat some meat, when you drink a glass of milk, it is the villain who is wounding the animals each year. These animals are treated in an absolutely appalling manner in our industrial farms that are all over the planet and are appearing more and more everywhere. Think carefully about how these animals are treated in such a manner today that it is worse than death. Think, because we are effectively committing a crime in which we all participate, and even yourself, without knowing it.

Margaret Archer: Just one word on the part of the Pontifical Academy of Social Sciences, to thank you enormously for how much you have understood and how ready you are to speak about it.

But there is one word that has not appeared, and semantics is important. Thank you for your little discussion on where "care" came from, but have you noticed that the one word from the French revolution—liberty, equality, but whoever mentions fraternity? Fraternity is at the core of our human relationships, together. Without that fraternity that overcomes so many of the barriers that you have done, that you do not care about ethnicity, you do not care where people come from, except to learn the differences.

But one last word, because it is a word that is lacking in French and it is lacking in Italian. We always have to use approximations. And this is the word "concern." It is just as important to be concerned about our natural relationships and to be fascinated by natural science discoveries. And these come in an irregular manner, but what comes to us every day is the possibility for fraternity. And without this to bond people together, we will have no solution that overcomes international relations based upon competition, competitiveness, ferocity, coercion, domination. And I hope you will think of this as just as important for the sustainability of humanity as all of the other things are important for sustaining the planet. But congratulations to all of you.

Lee Yee Cheong: Mr. Chairman or Chairperson, can I just say that, let us not lecture the young. We want to hear from them, please. We have less than half an hour. Let them talk to us, not everyone asking them to do more of this and more of that. Thank you.

Yves Coppens: Yes, just a word, short word. Well, congratulations first. It was very nice, very tonic, very happy, very joyous. I just want to tell you, I am a paleontologist. I mean that I know life since the beginning. Life is four billion years old. Quite a lot of years. The origin of life is unique, which means that all the beings are from the same family. Which means that when we will leave this room and go outside, the bird which is passing above your head is a cousin. You can say, "Hello, cousin." And the grass on which you will walk on are also cousins. So be careful. Look at the cousin that you are walking on. Well, thank you very much.

Panelist: Well, thank you also from my side and particularly happy how you balanced love for nature and love for people. That came through in all your statements. I agree with colleague Lee, that we from now on stop lecturing you, but you deserved praise. And an old saying is "It's always surprising how much praise the human being can absorb without suffering in its soul."

I have a question to you. Many of you come from countries who are currently facing turmoil. Some of you come from countries where many refugees are currently coming to this country and to northern Europe. You are in a very happy situation. What is your advice to the educational system to help these children of your age and younger? Half of the refugees are children.

Have any of you started action programs in France, Germany, or Italy to help teach these children? Can you speak from your own experience? I know first of all there's a young lady from Syria—maybe you could kick it off—but there are others in the room. We have discussed this here in the academy, but we haven't really come to some good conclusion. So I'm asking you for advice, honesty.

Natali: Okay, so the question was forwarded directly for me. Thank you. We are the young generation, and for me, we have the responsibility more than the other generations because we were educated earlier. So we have to pass this education for other people who don't have this opportunity.

And as I said in the presentation and especially in my part about social inequalities, I was exactly meaning this part—that as well, people, not only refugees in France, Germany, or in Italy, but as well, people in Syria should be educated. This

education should be equal. That will happen by the help of many organizations and the help of the more developed countries. This is part one about people in Syria.

Second part is about refugees who live now in France or Germany or Italy, wherever. In our school, we have a special program that we go and help refugees for education. Personally, I'm working in a kindergarten where I help people from different backgrounds, immigrants, to associate more with the environment around, because I know how hard it is. This is an individual initiative that we all should do and we all should encourage people to do.

Iryna: I'm prepared to respond. Our action is concrete. We help people understand what is sustainability and environment. I'm talking about refugees by first of all translating from their own languages to other languages. It's basically our service and our volunteering work, which is not short-term, which is regular. Every week, we go to the refugees group, especially in our city in Freiburg, and we act. I think that this point is gather also our college community together because we have a problem and we try to solve it together. Thank you.

Marcelo Sorondo: (Translated from Italian) It is a common thing for your entire generation to be concerned about forced labor, which you very well explained. Forced labor, above all concerning children, and other forms of slavery, such as prostitution and organ trafficking. You know that this has been one of the major concerns of the Pontifical Academy, and one of the most immediate goals of the United Nations is to eradicate these forms of human trafficking, forced labor, forced prostitution, and organ trafficking. This is now a moral imperative for all the 193 members of the UN, including Italy and all the other countries here present. Is your generation well aware of this problem? This is my question.

Marcello: (Translated from Italian) Let's say, our generation is unfortunately not always aware of the problem because we tend to overlook what happens on the other side of the world, or even close to us, because, for example, those who are wealthy do not feel morally obliged to do anything. They go to school, they have a normal life. Often, unfortunately—because it is a negative thing—they are not concerned with what surrounds them. We are not talking about parts of the world that are far away, but also places that are closer to us. And so, unfortunately, my answer is no. Unfortunately, if our teachers do not teach us about these things at school, we adolescents often do not worry about these "obligations," these situations.

| | We had two meetings with young people below 30 years of age to spread awareness and try to find the best practices to eradicate these terrible evils of the global society, and the indifference that the Pope often talks about. And so we want to invite you and other young people who would like to join us to become part of this group that we would like to consolidate. |

Marcelo: Grazie.

Pierrre Léna: (Translated from French) I would like to say that you have made an important point for our meeting here by underlining the necessity for hope in the future, and not only to tell us the problems. I would like to ask you a question that will complete what the previous speaker said. Do you think that education must change? In your schools in France, in Germany, in Italy, and at the Ross School, things are already different. You are in good schools, probably interesting schools. Are there things that must profoundly change? And perhaps I will ask the question to this young person Jonas.

Jonas: This is a very hard and complex question to answer.

Pierre Léna: I know it's complex, but we are meeting here to try to answer a little bit this question.

Jonas: First of all, in general, I would say that, the refugee problem right now is a very paradox problem in a way, because on one hand side, it needs local integration. On the other hand side, we need global guidelines how to deal with this. And how those two interact is very hard.

In fact, in 3 weeks I'm going to do a model United Nations on the problem on displacement of Syrian refugees. I'm very interested on what's going to come out of that. In terms of education, I would say that especially in Germany, yes, of course, it has to change in a way. First of all, we need to—the German language is not that common, so we need to educate this language to the children who come. That's the first step necessarily, because people can't be integrated in Germany without speaking German.

Pierre Léna: Yes.

Jonas: And then, the German educational system, from what I've experienced, is kind of directed towards giving or educating people to a specific job or a specific thing to do. And I think that education in general has to be—I don't want to say globalized, but has to be made more broad to be able to adapt this education or the things you've learned to everything or every place you go or want to do.

Lee Yee Cheong: I would like to tell my young friends that I was educated in Malaysia in a Catholic school, although I'm not a Catholic. My years in a Catholic school had actually underpinned my philosophy of life. I would like to ask my young friends what part religions play in your life, in you becoming such caring persons?

Kwazi: Well, I'm Christian, personally, but then, during my times in school, we studied all sorts of religion because you want to have a worldview of all types of religion in the world. And what I found out is that there is no religion that praises bad doings. Like the common goal, the core of all religions is to do good and be good towards other people and treat other people as well as your surroundings well. I also feel that even if you don't follow religion, it should be human nature to do good. I don't know if I'm being a bit optimistic, but I do feel that it should be human nature to do good. And that has really shaped me throughout my life.

And then, also, if I could just phrase back to the previous question. I also feel that as children, we have a responsibility not only to the future but also to our peers. Because although we often talk about bridging the gap between private schools and public schools, but I feel as that, we shouldn't always marginalize people who had a private school education or marginalize people who are more, who had a better life. We should use them as agents of change and don't make them feel guilty. Ask them to use what they've had in their life to make other people's lives better.

Yes, I didn't grow up rich. I did not have a million dollars, but I had a million-dollar education. I got a scholarship into the best schools ever. I had a scholarship to Kingsman College, which is a private school in South Africa, and now I have a scholarship to the Ross School. But throughout my years in school, I used my million-dollar education and imparted that to my peers who didn't have a million-dollar education. I took it upon myself, as a responsibility to myself and my peers, to educate them in the parts which they lacked in public schools. And I feel that that's something that needs to be radiated throughout the world, and throughout all public school children, I mean, private school children, and people who are more better off, that we should use our advantages and impart them on other people. Thanks.

Diego: Going back to the question, is that I think that we should get
                the core classes for example, or the core concepts. Because I
                used to go to a public school in the United States. We would
                mostly only learn about American history. We wouldn't learn
                about what's happening in the rest of the world.

                What I love that Ross School does is that it teaches you about
                interconnections. For example, I'd be learning about the
                American Revolution, but I wouldn't know what that did to
                influence art—for example—music, painting, science. But here
                we learn about, let's say we learn about Greece. We learn about
                what they did to contribute to math, science and then we go in
                a chronological order, which is the consciousness of mind. So
                we start off with Homo sapiens and then we keep on going.
                Then we go to Mesopotamia and go higher and higher up, until
                we're in the modern century.

                But I feel like there should be core classes, for example, about
                the environment, to just get kids to know about what's
                happening not only in their country, but all around the world,
                because we're all connected and we all need to change the way
                we think.

Anas: (Translated from Italian) I endorse what has been said by the
                girl here in front of me, and I speak as a Muslim because I
                think that all religions have the ultimate goal to regulate
                humans' life in order to preserve human life and maintain life
                on Earth in a fair and equal way. Going back to the previous
                question about education to which the girl answered (I am
                sorry I do not remember her name), I would like to add that the
                problem is always the same. From whatever point of view you
                look at it, the problem is always the same. In order to achieve
                sustainability, what's lacking is education. In the poorest
                countries, education is what's missing, because if a country had
                an education system that allowed its people to understand their
                possibilities, there would be no poverty at all. Therefore, the
                root of all problems is always education. You cannot act upon
                what you do not know. And so I believe that the end goal of
                any movement created to improve somebody's life should be
                to provide information first, educate people on how to use the
                tools that we have given them, and finally, teach them how to
                move forward. Thank you.

Shanshan: I agree with what both of them addressed. Religion is really
                important. I've been to a Catholic school before I went to Ross
                School. But my mom also believes in Buddhism. All the

religions, they are all going for the common good. It's all about emotional attachment. Moral obligations all come from the emotional attachment because when you have emotion, you sense, you feel the world.

In our school education, we have hands-on experience to experience the natural world. It's all about diversity, and that's how I got really emotional about everything around us. And also, we are all humans, we are the same species. We are 99 percent genetically the same. So I think we should love each other and also love the nature around us.

Chapter 27
Youth Declaration of Principles and Guidelines for Education

Antonio M. Battro, Pierre Léna, Marcelo Sánchez Sorondo and Joachim von Braun

27.1 Declaration of Principles

- Environmental education is not a privilege, but a right.
- Society (politics, economy, and culture) is inseparable from the environment. All species, including humans, are part of nature in a nonlinear web of inter-dependence. Cooperation and mutual respect are imperative for the survival of all species.
- All living things are entitled to equal opportunities and resources to live a healthy and fulfilling life.
- There is a need for a shift in consciousness concerning the relationship among societies and environments.
- Humans live in a finite world. Resources must be used sustainably with future generations in mind.

The students, invited to the Workshop, had prepared a short Declaration and Guidelines for Education, which are reproduced here.

A.M. Battro
Academia Nacional de Educación, Buenos Aires, Argentina
e-mail: abattro@ross.org

P. Léna (✉)
Observatoire de Paris, Université Paris Diderot, Paris, France
e-mail: pierre.lena@obspm.fr

M.S. Sorondo
The Pontifical Academy of Sciences, Vatican City, Holy See (Vatican City State)
e-mail: marcelosanchez@acdscience.va

J. von Braun
Center for Development Research, University of Bonn, Bonn, Germany
e-mail: jvonbraun@uni-bonn.de

- Interdependence involves giving to and receiving from the environment in which one lives. Therefore, all life has the right to use resources responsibly and wisely, while also contributing to the healthy maintenance of the living system.
- Wealthier people disproportionately impact the health of ecosystems. Yet, the poor and vulnerable disproportionately suffer the consequences of environmental problems.

27.2   Guidelines for Education

- Ecological literacy—understanding the source of one's food, water, and other materials as well as the impacts of their procurement—should be considered foundational curriculum, the same as numeracy and literacy.
- Each student's unique interests should be cultivated in a loving and caring environment, thus planting the seeds of socially and environmentally compassionate people.
- Schools and families must be examples of sustainability. Teachers, to begin with, should be models for inspiration. Education of the educators is a requirement.
- Develop new approaches of teaching students about sustainability and climate change, based not on the concept of fear and feeling powerless about future situations, but based on love and respect for living beings, and balance between humans and their environment.
- Provide children with simple actions that they can practice every day, to make the world more sustainable and build habits from these experiences.
- To truly understand the world, students should understand the interconnections of society and nature through an interdisciplinary education that does not create artificial boundaries between subject areas.
- Students must understand that sustainable development is related to science, as learning to solve problems from a scientific point of view is the first step to understanding the problem.
- Children should be given the opportunity to learn through a variety of experiences inside and outside of classroom. They must see with their own eyes the degradation of nature but also the wonders of nature to understand its fragility.
- Anxiety provides a motive to act, but this must be balanced with hope.

Part V
Values and Perspectives

Chapter 28
Biospheric Consciousness: A Moral and Ethical Imperative for Education

Courtney Sale Ross

Abstract Courtney Sale Ross, Founder of Ross School and Ross Institute, introduces a video titled Ross Learning System: Educating for a Sustainable Future and video transcript follows her remarks. As climate change and sustainability issues emerge as pressing global concerns, Ross School, showcases a complex systems-based sustainability curriculum that encourages both students of all ages and educators themselves to cultivate innovative, integrated solutions to the planet's problems. The video features footage of and interviews with students, educators, and mentors involved with these efforts and provides an overview of the Ross Learning System (RLS) as a transformative model for education.

28.1 Introduction

My name is Courtney Sale Ross. I am the Founder and Chair of Ross School and Ross Institute in New York. Twenty-five years ago, my late husband Steven J. Ross and I wanted to reimagine a precollegiate school that would best serve the current—and future—planetary needs. Our mission as an academic laboratory is to change the way education meets the future; to foster interdisciplinary thinking and innovative leadership; to engage fully in the global community; and to facilitate lifelong learning. Our school has flourished to approximately 500 students, with 25 countries represented in our boarding population.

Allow me a moment to offer special thanks for this gathering. First, to Monsignor Sánchez Sorondo, Chancellor of the Pontifical Academies of Science and Social Sciences, for his friendship and engagement on educational matters. It has been a true privilege for me to attend these workshops over the past years. Furthermore, I would like to thank PAS President Werner Arber for his gracious approval to convene this substantive workshop. To our esteemed organizers and scientific committee, please accept my deepest gratitude for your preparations, in

C.S. Ross (✉)
Ross School and Ross Institute, New York, NY, USA
e-mail: csr@ross.org

particular to Antonio Battro, who introduced me to the Academy. Antonio has served as a Mentor-in-Residence at Ross School and demonstrated leadership with the Mind, Brain, and Education initiatives. And I want to express my appreciation to Pierre Léna for championing this program and for his commitment to science education.

Today, climate change and sustainability have emerged as the most pressing and urgent of our planet's needs. Given that our species has created this looming crisis, it is our moral and ethical imperative to educate teachers and students to cope with the challenges, to reduce the threats, and to create solutions.

It is wonderful to look around this room and see many faces of the scholars and experts who have contributed their ideas, research, and experiences to raise the awareness and consciousness of our faculty. Contributions made by these scholars have created the foundation of the Ross Teacher Academy.

At Ross, we have partnered with experts to create a transformative educational culture. We designed the school from the ground up, constructing our buildings in tandem with our curriculum. Together, the physical campus and academic program, both rich in content, art, and artifacts, are meant to enrich the holistic learning process of both teachers and students. We believe that education is intended to be a "two-school" approach—a teacher's academy within a precollegiate school. With the rapid rate of change and transformations occurring in a highly globalized world, teachers must continually cultivate knowledge across disciplines to fully prepare their students.

Since our founding in 1991, we have been engaged in a curricular design initiative resulting in the Ross Learning System. The curriculum's complex systems structure of nodes and links forms "threads" across time and disciplines, centered around cultural history. The curriculum emerges in the form of the spiral, whose scaffolding permits new threads to be inserted where and when needed. The architecture blends stability and flexibility, allowing important topics such as climate change and sustainability to be adopted with relative ease.

As you will see in the brochure before you, our Sustainability Thread, which is currently taught at Ross School, was created as a collaboration between experts and our teachers. Over the course of three years, the development of the Sustainability Thread has resulted in the entire school creating and ratifying a "Declaration of Principles" for our community.

As we instill empathy and agency in our students, it is important to share what we are learning. The materials created by Ross that directly relate to sustainability will be provided, open source, to all. This will include our app, "Project Circles" (Ross Institute 2016), which is being developed at Ross by faculty, specialists, and students. By using the app, students around the world, alone or in class, can develop community profiles with a systems lens and then identify links and connections between other profiles. It will be a local, as well as global, sustainability assessment tool. As these profiles populate, it will allow users to build understanding of environmental health.

In thinking about the form of my presentation, I wanted to invite you into Ross School to witness elements of our learning experience: our commitment to

innovation, our dedication to research and development, our adherence to core values, and our collaborations with other learning communities.

You will also witness the emotional and psychological reactions of our students, which emphasizes how very important it is for those who take on these initiatives to care for the psychological well-being of our children. As children become more aware, you will hear them express feelings of sadness, anger, and fear. As the scientific knowledge is being unfolded, it is imperative for educators to enable students to cultivate a positive outlook for the crises they will face, and to encourage them to be part of the solution through opportunities to innovate, create, participate, and serve.

At this time, I would like to invite you into our "two schools"—Ross School and Ross Teacher Academy—to see firsthand our work on sustainability education. Thank you, and enjoy.

28.2 Video Presentation

The video Ross Learning System: Educating for a Sustainable Future (Ross Institute 2015a) is available online. A transcript of the video follows (Fig. 28.1).

A. Introduction

Teacher: Look at this system we have here.

Fig. 28.1 Through hands-on learning experiences, Grade 2 students discover how elements of an ecological system, like the life cycle of monarch butterflies, are interconnected and dependent on each other

Students: We studied the migration system of butterflies.
            The system is the butterfly lays an egg.
            They lay their eggs on milkweed.
            Then the egg hatches, a little caterpillar crawls out, and then when
            there's a chrysalis, when the chrysalis opens, it'll be a butterfly.
Teacher: If our problem at the beginning of the year was that people came along
            and pulled out some milkweed, what else is affected? Who else felt like
            their string got really loose just now?
Students: When the monarch butterflies lay their eggs, they lay them on
            milkweed. If there's no more milkweed, the eggs will fall off.
            If there's no milkweed, they have no place to put their eggs.
            And the whole population will stop.
            I'm going to plant some milkweed.
Teacher: So inside here, we have hundreds of seeds.
Students: The monarch butterfly cycle is in a big system, the ecosystem.
            It's sad how our environment is going to be different in a couple of
            years. It's getting worse. It's not getting better.
            Yeah, it's kind of scary because the polar ice caps are starting to melt.
            Not that many are looking at it from the big picture. Certainly, some
            people are benefiting from the destruction of the Earth.
            It is scary what's happening in the world, what's happening to our
            environment. There are 7 billion people just like you who are sharing
            the same space, and everybody has the same rights.
            Third world countries are going to have increasingly less water. We
            need a wide-scale paradigm shift of the way people think.
            My hope and dream is that the world can be better, that there'll be good
            in the world.
Mentor: (Jeremy Rifkin) The teachers in this school, you're trying to do
            something that's never been done before: prepare young people for
            biosphere consciousness. You're trying to create the possibilities of a
            generation who can heal the planet, restore the Earth, save our species.
            The mission begins here in this school.

B. Ross Spiral Curriculum (Fig. 28.2)

Narrator: The Ross Spiral Curriculum centers on the narrative of cultural history,
            which unfolds chronologically through the grades. Each discipline is
            integrated with the cultural history narrative, providing a global,
            21st-century, systems thinking–based curriculum.
Teacher: If we are studying a particular culture, in a historical time period, say,
            the Golden Age of Islam in Baghdad, we are also studying the science
            that was occurring at the House of Wisdom, the mathematics, the
            astronomy, Middle Eastern food, wellness. We're looking at art of the
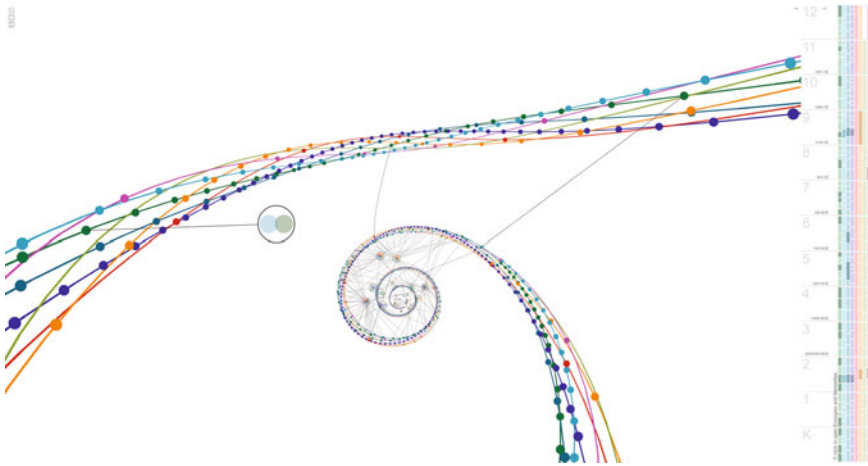   time and architecture, spiritual beliefs.

Fig. 28.2 The Ross Spiral Interactive (Ross Institute 2015c) allows users to explore the Ross Spiral Curriculum and illustrates how learning experiences in various domains and at multiple grade levels are connected with curricular threads that enhance student understanding of complex concepts

Narrator: While gaining the skills and knowledge native to each discipline, Ross students examine the world as a hierarchy of interconnected systems, both natural and cultural.

Teacher: You'll be trying to think rather than in terms of causation, in terms of systems dynamics.

Teacher: The evolution of consciousness serves as a cohesive glue for the curriculum that connects a thematic from grades K through 12. There are many threads that run through the curriculum.

Teacher: Like art and architecture, or philosophy and spiritual beliefs. In a particular time period, these threads connect horizontally, but there's also the vertical story.

C. Sustainability Thread (Fig. 28.3)

Teacher: The Sustainability Thread tries to emphasize how humans have interacted with and been influenced by the environments in which they live.

Students: Because we are studying early humans, we are looking for good shelters.

Fig. 28.3 A schoolwide sustainability teach-in brought Ross students of all grade levels together to learn about protecting our planet

	And where are the highest peaks, where they would either get warm or defend themselves. If there was a little moss, they could've used that as their roof.
Teacher:	So as we go through the thread, we look at how humans have lived in their environments, how they've used the natural resources.
Student:	We're studying the Renaissance and rebirth.
	The Prince was written by Machiavelli. We connected The Prince to our game.
	Every factor that's in the game is like a node, and so they're all interconnected like a system.
Teacher:	Anyone have trade routes? If you want to play money on your trade routes you can put them down right here.
Student:	And there are six city-states you can choose from, and I was Venice.
Teacher:	Here's the event card for this round. It's going to allow your city-state to access additional timber to expand your trading fleet. So you can make a greater profit on those trade routes if you decide to cut down more trees.
Teacher:	I mean you do have trade routes right now, you have two of them right now. You want to expand it? What are you guys gonna do?
Student:	We're going to cut down trees.
Teacher:	You're going to cut down trees?
Student:	We needed timber to make the ships that are needed to actually have a trade route.

Teacher: Write down on the amendment sheet whether "yes" or "no." So you're cutting down trees, all right? What will happen here, from this point on, there is a 50 % chance that you've used all your timber. Also from this point on, there is a 20 % chance of flooding because of deforestation of your area, okay? All right, 20 %.

Student: Thirteen.

Teacher: Because you guys cut down trees, it will lead to flooding when it rains in your area, which means that you lose this round. You are out of this round.

Student: In the short term, if you cut down the timber, you've got economic gain, but in the long term, the ecological damage will create more economic damage because you're going to have to pay for rebuilding buildings after a flood or replanting forests to stop the flooding. In science class, we learned about how the soil affects how water can travel through it or around it or off it.

Teacher: What we're trying to do here is were trying to slow down the water enough that the root systems, the plants, have a chance to capture the moisture they need. But at the same time, we don't want it to pool on the surface where it can just wash away. What would be your guess as far as which material is going to pass the quickest?

Student: Gravel?
The largest rocks.
I think…because…
Yes, the pea stones.

Teacher: So let's give it a shot and see what happens.

Narrator: With their integrated and systems thinking foundation, Ross students can grapple with and interpret the complexity of the world today.

D. Moral and Ethical Challenges (Fig. 28.4)

Pope: We are asked to summon the courage and intelligence to resolve today's many geopolitical and economical crises (C-SPAN 2015).

Student: We just watched the Pope in class.

Teacher: And why did it speak so strongly to your group?

Students: He's kind of explaining that we're abusing our planet to its limits and that we just can't go on like this.
I think what he's trying to say is that the Earth doesn't need us, but we need the Earth.
The values that the Pope talked about were a lot of the Ross Core Values, like courage, integrity, responsibility, respect—pretty much all of them.
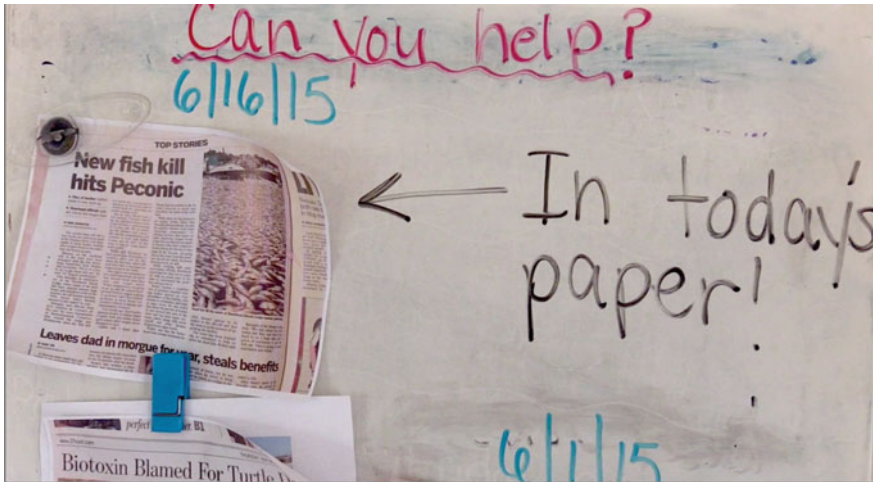You use the Core Values for everything—especially to care for the planet.

Fig. 28.4 Ross Lower School students learned that ecological disasters can happen close to home when they encountered a fish die-off in local waters. The immediacy of the event imparted a sense of urgency regarding sustainability issues to the young learners

Visitor:	(Lama Tenzin) We are all interdependent, do you know that? Taking care of our world, taking care of our animals, taking care of our elements is actually taking care of yourself.
Teacher:	I'm going to spend a little bit of time today talking about the Anthropocene Epoch. And scientists who are advocating a new epoch are saying that humans and human activity are dominant in shaping the planet. When do you think it started?
Student:	The Industrial Revolution.
Teacher:	Industrial Revolution, that is good. Agriculture.
Student:	World War II.
Teacher:	World War II—what happened, how did it end? Nuclear, that's right, nuclear power. But there's also another concept called the Age of Sustainable Development.
Narrator:	By practicing the Ross Core Values in conjunction with their systems thinking-based approach, students respond to the challenges of the world with empathy and a sense of responsibility.
Students:	We were heading up the Peconic River. All of us were like super excited; we didn't know what was going to happen. There were like all these dead fish just lying there. I felt really sad and motivated to do something. It was really sad. It was because there wasn't enough oxygen and there was too much nitrogen.

And when the nitrogen increases, the oxygen decreases.

People are fertilizing their lawns.

And when it rains, it will go down into the water. And then that small action that we did is going to be a lot more than we thought.

It made me feel like I need to do something about it. I couldn't just leave them there and be like, "Oh, no, let someone else do that."

We made a video. We sold popsicles.

We made the popsicles to raise money for Defend H$_2$O.

So we want to save our water and defend it.

I'm just angry at humans, at the world, for what we are doing, but there are definitely ways that we can go about things to fix it. Everyone is constantly taught to think of clear-cut solutions on how to fix things, not for the long run, but the immediate problem. How can I immediately fix it right now? Which isn't how we should be thinking. We should think about the long-term effect.

E. Innovation (Figs. 28.5 and 28.6)

Narrator: Ross students are endowed with essential technical and critical skills and trained to explore and create innovative solutions.

Teacher: So what is the process of DNA barcoding? An organism is sampled, DNA is extracted, and then that sequenced DNA creates a unique barcode for each species. Get the photographs of these species and try to match it. That's awesome, great.

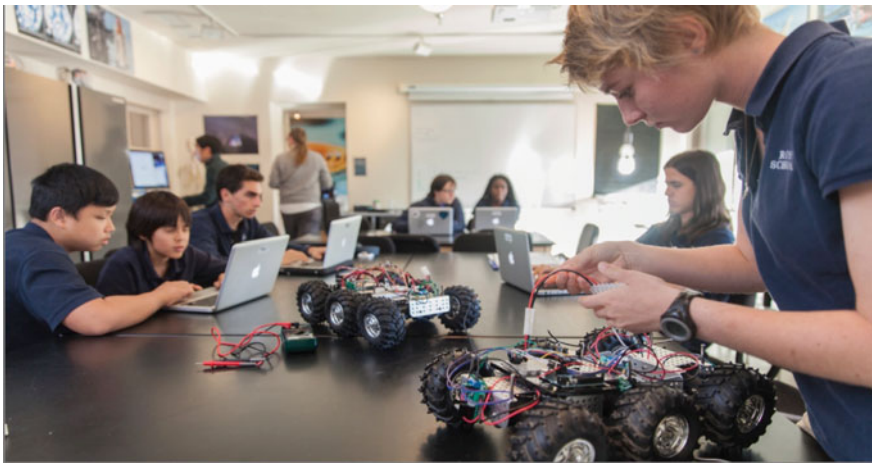The Ross students—they're developing the next generation of solutions.

Fig. 28.5 Students studying at the Innovation Lab @Ross are learning to apply advanced technological solutions to the crises of the day

Fig. 28.6 On a Field Academy trip to Mo'orea, an island in French Polynesia, Ross students assessed the biodiversity of the local coral reefs, photographing and identifying a multitude of marine species native to the area

Student: It's called Autonomous Reef Monitoring Structure. It's basically a standard structure to monitor the biodiversity and the development of the species on one single structure. I have to wait for a few months. When I retrieved the ARMS, I saw a lot of species hiding in there like crabs and fish, so it got me really excited. And then I identify them, take pictures, and document every species.

Student: We're trying to build a wearable power generator that creates one watt of energy.

Teacher: Take the voltmeter and see how much power you're getting off of those batteries right now.

Student: We are going to be learning how to save energy, reuse energy, and we can use this wonderful bike that can charge all the things that are in your household.

Teacher: Basically an exercise bike frame and a converter, and now we can use human power, kinetic energy, to produce a lot more power.

Student: So we were only doing this for two minutes and she got that high.

Teacher: Yeah, she did. She did that much.

Student: Really cool.

Students: With my project, I'm doing a transportation network. I'm trying to let the teenagers understand how much carbon footprint they will produce by train, by bus, by airplane, those kinds of different transportation… and try to save the world.

            I researched, designed, and built a hydrogen fuel cell system.

> I spent the month of August living free from modern amenities, tending a garden, milking goats, and fishing, while keeping a blog of my daily activities through a solar-powered computer.
>
> We exposed fish to elevated CO_2 levels, lowering the pH, and we're seeing a 50 % decrease in survival.

Narrator: Ross's commitment to innovation in education means that the school itself is always evolving.

F. Ross Teacher Academy (Figs. 28.7 and 28.8)

Narrator: Ross faculty epitomize the principles of lifelong learning by continually taking part in professional development courses and expanding their pedagogic approaches.

Teacher: We have these brilliant speakers and we look at the curriculum from all sorts of directions.

Mentor: *Ni hao ma*.

Teachers: *Ni hao ma*.

Mentor: (Dr. Antonio Damasio) It's all about imagination and then about directing that imagination for a certain purpose. That's what creativity is all about.

Teacher: So we have economists and we have neuroscientists and we have anthropologists, and it's just a great mixture and a great way to look at this model.

Teacher: As a teacher, you should always be learning, and you should always be growing.

Fig. 28.7 Each year, scholars and mentors conduct discussion panels as part of Ross Teacher Academy in order to communicate the latest pedagogical practices and theories to the teachers participating in the academy

Fig. 28.8 Ross faculty continue their professional development with a weekly course studying Systems, in support of their understanding of a systemic approach to education contained within the Ross Spiral Curriculum

Founding Mentor: (Dr. Ralph Abraham) Systems thinking: a new way of thinking about world cultural history, current events, and the systems that we live in, using the metaphors of complex dynamical systems theory.

Narrator: Ross School faculty take a 6-month course on chaos theory, complex dynamical systems, and systems modeling developed by Ross School mentor Ralph Abraham, a mathematician and chaos theorist.

Founding Mentor: (Abraham) We are training people for a future, to create a future, to have a future, to avoid collapse. And to do that, we want to provide them with an understanding of the world we live in as a system with its threads, with the interconnection of all things.

Administrator: We offer about 150 h of professional development to teachers a year, and that's planned, programmed professional development that they would take as a whole group, in divisions, in domains. Because it's not just about the student as a learner, it's about the teacher as a learner.

Mentor: (Dr. Kurt Fischer) Learning never stops. That's one of the lessons of neuroscience.
One of the strengths of Ross is that we're a research school where teachers and students and researchers work together to figure out what questions people would like to ask about the effect of the school experience.

Fig. 28.9 The connections between and among grade levels and subject areas are illustrated through the Ross Histomap, shown here in its early stages of development

G. Research and Development (Figs. 28.9 and 28.10)

Visitor:	They have ideas, and you guide individually, more or less.
Teacher:	We're trying to make it so 9th and 10th graders have a little more building blocks. They have great ideas, but sometimes they need to build up more skills to get to where they are.
Founding Mentor:	(Dr. Howard Gardner) The Ross School is a petri dish for expanding our notion of how to teach and how to learn.

Fig. 28.10 At a later stage of Histomap development, the Mandarin team evaluated the best methods of integration of their domain into the curriculum

Teacher: In a laboratory school, there are opportunities to try things, to attempt and experiment, or a theme for a year, and test it.

Narrator: Ross is connected to a global network of mentors who have been training teachers and facilitating the continual development of the Ross Model for 25 years.

Mentor: (Dr. Marcelo Suárez-Orozco) Failure to connect and ease the transition of large, growing numbers of children of color, immigrant-origin children, refugee-origin children to the narrative of the nation, of who are we as a nation, constitutes possibly the most important problem.

Mentor: (Gonzalo Sánchez) This year, in 2014, we have the largest number of refugees since World War II. Fifty-one million people are considered refugees in the world today. But today I'm going to talk about the ones that move because of environmental reasons.

Teacher: Going back to what Dr. Koizumi was saying about empathy, that it is not the subject that we are teaching, but really, we are helping these students grow as a part of a community.

Mentor: (Dr. Hideaki Koizumi) And also the ethics must be very important, to solve the sustainability issues.

Founder: (Courtney Ross) What we are here to do this week is to listen, to learn, to question, and to develop the Sustainability Thread across the entire curriculum.

Teacher: We're trying to find not only where the issues of sustainability actually occur but the rationale behind it. Where does this connect, not only within this grade, but where does it connect before and afterwards?

Narrator: Faculty continue to expand and refine the Ross Spiral Curriculum. Recently, they collaborated with outside scholars on the Sustainability Thread within Ross's integrated Mandarin curriculum.

Teacher: So the goal for the morning session is to look at the Mandarin curriculum that you have developed, and we are going to look at integration, threads, and the histomap.

Teacher: We are using the contemporary context but looking back, linking back, and linking to the future.

Teacher: We look at modern Chinese society. We talk about migrant workers. We start by looking at migration from different times and from different regions of the world, then we zoom in and look at China. The theme of sustainability development comes in—how can we help China and any area that needs that help to grow and develop in a more sustainable way? Our students not only learn the language, they will be proactive when it comes to providing global solutions.

H. Collaboration (Figs. 28.11 and 28.12)

Narrator:	Ross Institute is currently collaborating with schools across the globe.
Teacher:	We are in Havana with the Ross Institute and the Ross School developing our relationship with the Cuban educators in an exchange of ideas and best practices. This is work that will take tremendous collaboration and that we are uniquely situated to participate in.
Teacher:	(Spanish subtitles) The biggest challenges as a teacher in our school are to educate the child for the future. We were invited by Ross School to have an educational exchange with preschool and elementary teachers. We have learned new things that we can take to our country to be able to work with our kids.
Maori Visitor:	My name is Ken Kahuti. I'm the program manager for our secondary students at Te Pu. Perhaps we can collaborate actually on a functional project like a data outpost in New Zealand.
Maori Visitor:	Sustainability of the environment is also quite important to Maori people, and to ensure success for our future, now is the time to do the work.
Maori Visitor:	The reason why we are here is to see what reciprocal learning can happen between Ross and ourselves. In particular, we'd like our kids to get connected with the sustainability efforts, environment, social entrepreneurship, and becoming global citizens, really.

Fig. 28.11 Teachers from other countries, such as these teachers from Cuba, also take part in Ross Teacher Academy, contributing global insights and experiences that are beneficial to all
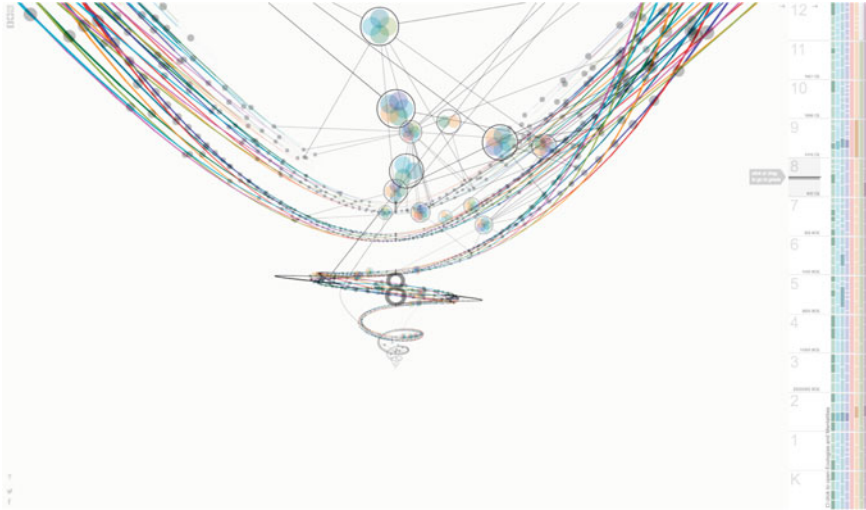
Fig. 28.12 A screenshot from the Ross Spiral Curriculum tool (Ross Institute 2015c) gives an overview of one grade's thematic narrative

Teacher:	We're starting off here at the Ziggurat of Ur, the early Mesopotamia, which is now southern Iraq.
Narrator:	The Ross Model was adapted at Ross Tensta gymnasium in Sweden.
Student:	Because we are in a Ross school, we do a lot of integrated projects. You get to analyze something and think outside the box. I can connect things to each other—you can actually see how the world developed.
Narrator:	Because of the global scope of the Spiral Curriculum, all world cultures can be studied through its structure. It can adapt to any regional context and accommodate diverse, multicultural student bodies.

I. Ross Learning System (Figs. 28.13 and 28.14)

Narrator:	Ross Learning System is a complete digital curricular package providing the tools necessary to adapt the Ross Model. It will be released in 2016.
Administrator:	Ross Learning System is all of the parts that a school would need to really teach the Ross curriculum.
Staff:	We are working on digitizing over 100,000 pages of curricular content, and we have over 6000 image assets as well.
	All the units in the curriculum are linked to professional development modules. There's video content that the teachers
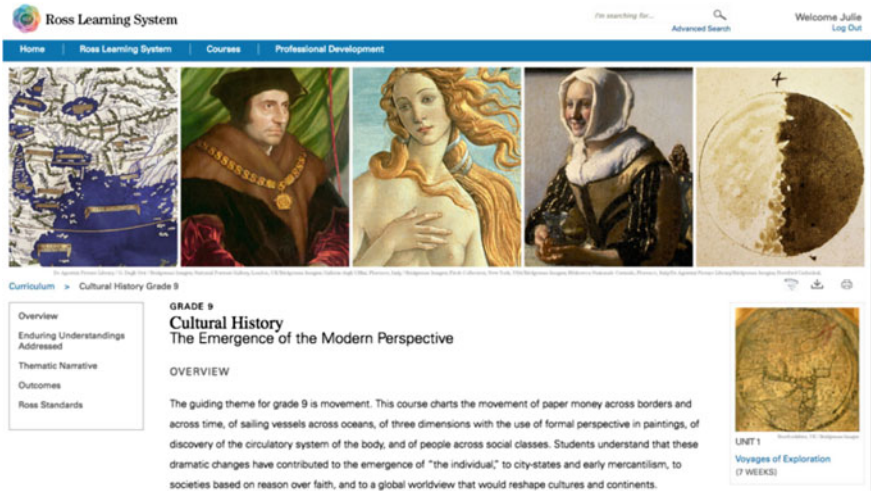
Fig. 28.13 Each grade-level course in the Ross Learning System comprises such curricular elements as the thematic narrative, essential questions and enduring understandings, outcomes, learning experiences, assessments, and integrated projects, as well as instructional material and supporting artwork

Fig. 28.14 Ross's Project Circles interactive website (Ross Institute 2015b) is a tool available for use internationally as a way to connect learners across the globe in the quest to learn more about and promote the importance of sustainability

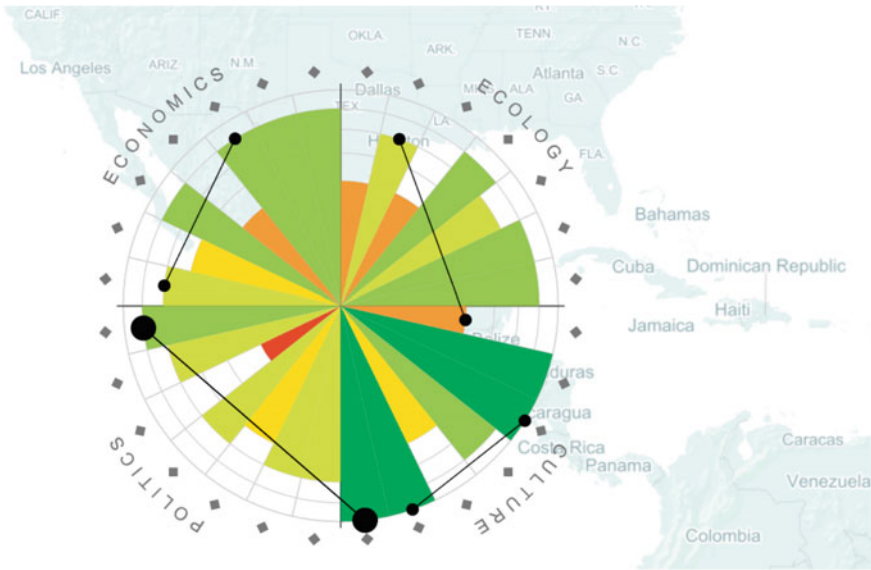|	
	will be able to click in and play. There are annotated walk-throughs or slide shows. There will be curriculum links.
Administrator:	We are making an online resource so that we can more readily share it with others. We can be partnered with other schools more quickly and more, I would say, comprehensively. We're talking about a new planetary culture and consciousness, and it takes a different style of learning, it takes a different style of teaching, and it takes a different awareness about the world to truly be successful in doing that.
Teacher:	As part of this sustainability initiative, one of the projects we were tasked with was to create an interactive tool (Ross Institute 2015b).
Students:	In the top right corner you can type the name of your hometown, so "East Hampton." Ecological sustainability. The first question is, "How sustainable is energy production for the area?"
So the point of the interactive is basically trying to determine the sustainability of the area.
There are four different sections of sustainability that are being rated.
You can see the economics of an area, the political aspects of it, the culture, and the ecology. It's quantitative and qualitative data, so you have to do research to support your answer.
In terms of sustainability, everything is very interconnected. We want to add links between the different domains.
If there is a problem with the economy, you can see how it affects the ecology or the culture. It's just basically showing the balance of things. |
Maori Visitor:	I think it's quite a powerful visual for people to get a quick snapshot of the health or not of an environment. The process behind it is going to allow many people to get into the discussion around climate and its integrated problems and issues. It's the first one of its kind.
Student:	Anyone can use this. All you have to do is make an account, do the research, and rate your own town and see how sustainable it is.
Narrator:	The Ross sustainability curriculum and interactive tools are open source, and serve as a call to action.
All Students:	We firmly declare the Ross Declaration of Principles concerning the sustainability of our global environment.
Mentor:	(Sánchez) What you're doing here at Ross is spectacular, because it's trying to raise those children that will transform the world.

Founding Mentor: (Abraham) We want a higher-level understanding of the world we live in, and that's the purpose of our education.

Student: It's our fault that we made most of these problems happen—poverty, climate change, everything—so we need to find a way to fix it as well, to redeem ourselves.

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Chapter 29
Ethics and Education in Pakistan: Principles, Policies and Practice

Manzoor Hussain Soomro and Saima Huma Tanveer

Abstract Ethics is a code of conduct, that an individual, group or society holds as definitive, in differentiating right and wrong. Pakistan as per its constitution, follows the Islamic principles as guiding path. In Islam, the concept of *taqwa* means the moral ground that underlies human actions and signifies the ethical sense which makes human beings aware of their responsibility to God and the society. The concept of social life of the Prophet of Islam—Muhammad (Peace be upon Him—PBUH); to whom, God in Quran called *Rahmatul-lil-Aalameen* (Blessing for the World), is very much positive and constructive. According to him, the loftiest service is the service to humanity. To serve humanity in an appropriate manner, the better way is to guide him; or in a broader term, educate him. The Quran's first revealed verse began with the word "*Iqra'a*" meaning—"*read*". It is thus surprising that some people in the name of Islam, destroy centers of learning, schools and mosques, and also shoot at girls who go to school. The reason may not be simple but the lack of education and perhaps vested interests, feeling threatened from the "educated" people, who try to find the truth, may be some of the major reasons.

According to a 2014 report, there were 52.91 million school age (5–16 years) children in Pakistan. Among them, only 27.89 million children attend an education institution; whereas, 25.02 million remain out of school. Some of them may be attending Madrasah, offering mainly religious education along with boarding and lodging. It is a considered opinion that substandard or no education, disparities in wealth distribution and injustices in the society, are some of the root causes of unethical social behavior of young people and their mentors. The content of curriculum being taught in Madrasah is perhaps not guiding the tender and immature minds towards positive thinking; instead, highlights the disparities in the society.

There is need for making some fundamental reforms in Madrasah system. Therefore, the role of schools and universities in Pakistan becomes crucial towards

M.H. Soomro (✉) · S.H. Tanveer
Economic Cooperation Organization Science Foundation (ECOSF), 5th Floor, MoST Building, 1- Constitution Avenue, Sector G-5/2, Islamabad 44000, Pakistan
e-mail: manzoorhsoomro@gmail.com

contributing to the promotion of tolerance among the national environment of the country. Lately, the efforts have been made by the Government, whereby, standardization of curricula and training of teachers, is being given more importance. More recently, Higher Education Commission (HEC) of Pakistan announced "Hand-Holding of Schools". Under this Programme the university faculty and students will provide volunteer tutorship to local school students by organizing lectures on specialized topics as well as allow access of students to their laboratories for experimentations.

29.1 Ethics and Education in Pakistan: Principles

Ethics is a code of conduct, that an individual, group or society holds as definitive stand in differentiating right and wrong (Saulat 2014); while, education is considered central to the moral fulfillment of individuals and the well-being of the society in which they live (OECD 2013). Education is vital to the development of a country. It raises human skill levels that are essential for leading the economy to a sustainable future (Rajper 2015).

The Constitution of Islamic Republic of Pakistan states in its preamble:

> Whereas sovereignty over the entire Universe belongs to Almighty Allah alone, and the authority to be exercised by the people of Pakistan within the limits prescribed by Him is Sacred trust. (Uzmi and Nakhoda 2015)

Pakistan as per its constitution follows the Islamic principles as guiding path; wherein, the Muslims shall be enabled to order their lives in the individual and collective spheres in accordance with the teachings and requirements of Islam as set out in the Holy Quran and Sunnah (Uzmi and Nakhoda 2015).

Islam as a comprehensive way of life, encompasses a complete moral system that is an important aspect of its world-view. We live in an age where good and evil are often looked at as relative concepts. Islam's moral system is striking in that, it not only defines morality, but also guides the human race in how to achieve it; at both, an individual as well as a collective level (Saulat 2014). God says in Quran

> Indeed, the most honorable among you in the sight of God is the most pious. (Al-Qur'an, Verse 49:13)

The Islamic moral system stems from its primary creed of belief in One God as the Creator and Sustainer of the Universe, defines universal fundamental rights and standards for humanity by which actions may be deemed moral or immoral. In Islam, the concept of *taqwa* means the moral ground that underlies human actions and signifies the ethical sense which makes human beings aware of their responsibility to God and the society. From an Islamic perspective, the purpose of human life is to worship God, by leading this worldly life in harmony with the Divine Will, and thereby achieve peace in this world, and everlasting success in the life of the

hereafter. Muslims look to the Glorious Qur'an and the Traditions of the Prophet as their moral guides (Khalidy 2008).

The Glorious Qur'an says:

> It is not righteousness that you turn your faces towards east or west; but it is righteousness to believe in Allah and the Last Day, and the Angels, and the Book, and the Messengers; to spend of your substance, out of love for Him, for your kin, for orphans, for the needy, for the wayfarer, for those who ask, and for the ransom of slaves; to be steadfast in prayer, and practice regular charity; to fulfill the contracts which you have made; and to be firm and patient, in pain (or suffering) and adversity, and throughout all periods of panic. Such are the people of truth, the Allah-fearing. (Al-Qur'an, Verse 2:177).

The concept of social life of the Prophet of Islam—Muhammad (Peace be upon Him—PBUH); to whom, God in Quran called, *Rahmatul-lil-Aalameen*-Blessing/Mercy to the Worlds (Al-Qur'an, Verse 21:107), is very much positive and constructive. According to Him, the loftiest service is the service to humanity. He (PBUH) reminded people that high ethics was one of the ways of making belief perfect by saying,

> The most perfect believer in terms of belief is the one who has the highest ethics and who treats his family in the nicest way (Saulat 2014).

Thus the better way to serve humanity in an appropriate manner, is to guide him or in broader term, *educate* him. The Quran's first revealed verse began with the word "*Iqra'a*" meaning—"read"! (Al-Qur'an, Verse 96:1).

Quran reveals:

> Are those who know, equal to those who do not know? (Al-Qur'an, Verse 39:9).

There is another verse in Quran asking the Prophet (PBUH) to pray;

> Lord! increase my knowledge (Al-Qur'an, Verse 20:114).

We find many sayings of the Holy Prophet (PBUH) on this subject, he said; "Acquiring knowledge (education) is obligatory to every Muslim male and female"; "Seek knowledge, from cradle till grave; "Seek knowledge even if you have to go to China" (Questions on Islam 2009). China was perhaps considered a far away from the Muslim base of the time and a difficult journey! Allah Almighty makes the path to paradise easier for him who walks on it for getting knowledge (Shaukat 2012).

Islam inherently and irrefutably gives women, the rights and respect as equal before God and also in this world (Shaukat 2012). Prophet Muhammad (PBUH) always demonstrated a great respect for women and held his wives and daughter in great esteem and his attitude towards women is characterized by politeness, equality, love and respect (Khan 2015).

29.2 Ethics and Education in Pakistan: Policies

29.2.1 State Obligation to Education

Right to Education in Pakistan was not as precisely spelled out as it is now, nor was it binding. Earlier, Article 37 B of the constitution stated:

> The state shall remove illiteracy and provide free and compulsory secondary education within minimal possible time (MET and SHE 2014).

Clearly, the above article (37B) was not sufficient for initiating campaigns or filing petitions for instigating enforcement of Right to Education (MET and SHE 2014).

However, the introduction of Eighteenth Constitutional Amendment in 2010, has brought a number of significant changes in the Constitution of Pakistan 1973 and the inclusion of Article 25-A in the Chapter of Fundamental Rights, changes the circumstances and responsibilities of the State (I-SAPS 2012) making it a justiciable right, thus obligating the state for right to education- *The State shall provide free and compulsory education to all children of the age of 5–16 years in such a manner as may be determined by law* (MET and SHE 2014). Thus after enactment of 18th Amendment, education is now a provincial subject. All legislative and executive powers related to key subject areas of education like policy making, curriculum, planning and standards are the responsibility of provinces (I-SAPS 2012). Nevertheless, realizing the importance of national harmony, particularly in the wake of growing extremism, the Government of Pakistan in 2015, began a process of curricula reforms at federal level (MET and SHE 2014).

The provinces of Punjab, Sindh and ICT (Islamabad Capital Territory), have all passed bills regarding free and compulsory education; while Khyber Pakhtunkhwa (KP) and Balochistan provinces are in process of formulating legislation. However, the Rules of Business have yet to be drafted to ensure implementation of the bills passed. Moreover, the provincial governments must set the stepping stone, upon which, future governments would build to ensure that Pakistan reaches the Sustainable Development Goals (SDGs); or at least comes close to its required targets (MET and SHE 2014). A major shift was seen in the budget of 2014–2015, wherein, all provinces doubled the amount of funds given to their respective education departments; focusing more on infrastructural development, enrolment and retention of students. Yet more needs to be done! (Riazul Haq 2014).

29.3 Education System in Pakistan

The formal education system in Pakistan can be divided into five levels (HEC 2015):

29.3.1 Primary

The standard national system of education is mainly inspired from the British System. Pre-School education is designed for 3–5 years old and usually consists of three stages (Play Group, Nursery and Kindergarten (KG)). After pre-school education, students go through junior school from grade 1 to 5.

29.3.2 Secondary

Middle school follows with grades 6–8. Single-sex education is still preferred in rural areas. Subjects include Urdu, English, Arts, Islamic Studies, Mathematics, Science, Social Studies, and Computer Science where equipment is available.

29.3.3 Higher Secondary/Intermediate/College

Senior school covers grades 9–12 with annual examinations. On completion of grade 10, pupils may qualify for a secondary school certificate. If they wish to, they may proceed further to grade 12, following which they sit a final examination for their higher secondary school certificate. During this time, they opt for one of several streams that include pre-medical, pre-engineering, humanities/social sciences and commerce.

29.3.4 Tertiary Education/University

Entry is via a higher secondary school certificate that provides access to bachelor degrees in various disciplines. A pass requires just 2 years of study, and an honors degree takes 4 years. For the initial period, the curriculum is a mixture of compulsory subjects and specializations. After that, students specialize completely. Thereafter, they may continue with more advanced study i.e., Ph.D.

29.3.5 Vocational Education

Vocational education is controlled by the National Technical Education and Vocational Training Authority (TEVTA). This body strives to re-engineer the process in line with national priorities, while raising tutoring and examination standards too. There are provincial TEVTA institutions as well.

29.4 Parallel Systems of Education in Pakistan

There are three parallel systems of education in Pakistan; public schools, private schools and madrasahs.

According to official estimates there are almost 180,577 public schools, more than 74,693 schools in the private sector, and approximately 12,599 madrasahs. Other studies, such as a 2011 report of the United States Commission on International Religious Freedom on public education and madrasahs, puts madrasah numbers closer to 20,000. According to 2014 reports the public sector accounts for 70 % of enrolment while private sector has 30 % of enrolment. In 2013 it was 74 % and 26 % respectively, and the shift continues (SAFED 2015).

29.4.1 Public Sector Schools

The Public Sector schools are fully funded by either the Federal Government or the Provincial Governments. Lack of resources particularly plague the government run schools, responsible for providing education to the vast majority of Pakistan's school-going children. Some of these schools lack not just school supplies but also basic facilities such as clean drinking water, toilets, boundary walls and electricity. The main language of instruction in public schools is Urdu (the national language) or other local provincial languages (such as Sindhi) (SAFED 2015). Pakistan also has an extensive network of Non-Formal Basic Education (NFBE) institutions with an estimated enrolment of at least 2.5 million students. Establishment of Non-formal Basic Education Schools for out-of-school children was an innovative initiative taken by Pakistan. Presently, more than 13,000 Basic Education Community Schools (BECS) are functioning throughout Pakistan, having a total enrolment of around 0.6 million (MET and SHE 2014).

29.4.2 Private Sector Schools

Private Sector has 30 % of enrolment. Private Sector is playing an important role in imparting education in Pakistan. Private sector enrolment is increasing because of its overall "better quality" of education as compared to public sector (SAFED 2015).

Within Private Schools, there are two categories: The costly private schools with far superior quality of education, mainly in urban areas. They use English as the language of instruction. Given the high fees associated with private education, these schools have traditionally been the main choices for the elite and wealthy sections of the society. While the low cost private schools catering to lower middle class families, have also sprung up and their numbers and enrolment have been growing rapidly, particularly in rural areas due to fast deteriorating quality of education in Government schools (Andrabi et al. 2008).

Pakistan has a number of schools designated as Public-Private Partnership (PPP) schools. These are often categorized as private schools in that their control and management does not lie with government but rather with educational entrepreneurs, NGOs or philanthropists interested in improving the quality of education. Where these PPP schools differ from other private schools, is that their students do not pay fees directly. Instead, the students are provided with vouchers or the fees are paid directly to the schools on behalf of the students, most commonly by an educational foundation provided with recurrent funding through government (Khattak 2015).

29.4.3 Madrasahs

Madrasah is an Arabic world and means any type of educational institution. It has been a source of all types of knowledge for Muslims where education, even in the science subjects, was provided. With the passage of time, the role of the traditional madrasahs has been restricted just to impart religious education (PILDAT 2015). Thus they have become just the seminaries (training schools for clergy). Traditionally, they refer to religious institutions, that may include an equivalent to school, college or university, operated mainly for the purposes of imparting religious education. Madrasahs are the most accessible source of education for many children, especially from poor families in rural areas. Madrasahs offer free education, food and lodging, thus enhancing their appeal to families who otherwise cannot afford to provide any kind of education to their children (Kamal 2014). According to the Societies Registration Act, madrasah refers to a religious institution that may include a Jamia, Dar-ul-Uloom, school, college or university, operated mainly for the purposes of imparting religious education and may even provide boarding and lodging facilities. The following schools of thought exist (PILDAT 2015):

1. Wafaq ul Madaaris al Arabia (Deobandi)
2. Tanzeem ul Madaaris (Barelvi)
3. Wafaq ul Madaaris al Salafia (Ahl-e-Hadith)
4. Wafaq ul Madaaris al Shia (Shia)
5. Rabita ul Madaaris al Islamia (Jamaat-e-Islami).

29.5 Ethics and Education in Pakistan: Practices (Facts)

In Pakistan, the last official Census was conducted in 1998. Afterwards only population projections have been made for various purposes. Latest study shows that in Pakistan there are 52.91 million children of school age (5–16 years) in population of around 200 million (over 25 %). Among them, only 27.89 million

children attend an education institution (public or private); whereas, 25.02 million children remain out of school (OOSC) (Alif Ailaan 2014). Pakistan has the third highest number of out-of-school female students in the world; i.e., 55 % OOSC in Pakistan are girls. While the current female net enrolment rate at primary level is 64 % compared with 72 % for male counterparts. There is vast regional disparity in providing girls with equal opportunities for education. Nationally, 15.9 million boys, between ages of 5–16, are enrolled, compared to just 11.9 million girls. As a result, 13.7 million girls and 11.4 million boys are out of school (Riazul Haq 2014).

According to the report published in Spatial Knowledge and Information Management (SKIM), March 2015, among children of primary-school-going age, almost one in every five is not in school and this proportion increases at higher levels of education. By region, the province of Balochistan is home to the highest proportion of OOSC, followed by the Federally Administered Tribal Areas (FATA). In terms of overall distribution, meanwhile, more than half of the total number of OOSC are in Punjab. The data also reveal vast regional disparities in providing equal opportunities for schooling to girls, with the greatest disparity in the province of Khyber Pakhtunkhwa (KP). For both girls and boys, access to schooling is more difficult in rural areas and the gap widens at higher levels of education. Similarly, children from the poorest families are more likely to be out of school compared to their counterparts belonging to richer families (Rajper 2015).

During the past two decades, there were two major education policy interventions; the National Education Policy of 1998–2010 and the National Education Policy 2009. Although National Education Policy of (NEP) 2009 addressed all important issues of education and envisaged strategic actions and clear targets; yet no mechanism could be instituted to follow up its implementation. As the 18th Amendment to the Constitution in 2010 devolved school education to the provinces, statutory platform for coordination arrangement at institutional level among the provinces for primary and secondary education disappeared, or was weakened. Nonetheless, this important policy document—NEP 2009, still serves as a reference and a source of guidance for planners and education managers at various levels in the country (Bhatti et al. 2011).

However in September 2013, the Government of Pakistan formulated a National Plan of Action—NPA 2013–2016, to accelerate progress towards education related goals and targets identified by MDG/EFA for 2015/2016. The key objective of NPA was to accelerate the progress towards achieving education-related MDGs in the next 3 years. Specifically, the Plan aimed at: enhancing enrolment of out-of-school children in primary education; Increasing retention at primary level and completion of primary education by all enrolled children; Improving quality of primary education (Alam 2014). However the plan could not succeed due to various constraints and Government priorities.

In Pakistan, the weak governance in education sector, is a major constraint. District and provincial education planners and managers lack the required expertise and to some extent commitment and motivation and they need good quality training

to effectively implement education policies and plans in their respective regions. Shortage of school supervisory teams, partly due to financial constraints and partly due to recruitment policies, has resulted in irregular and low quality delivery of service by teachers and support staff across schools. Community participation in school matters is also not effective, thus failing in monitoring educational quality. Likewise, over the past decade, Pakistan has suffered rising insurgency and violent militancy, especially in its northern regions. Educational institutions, especially girls' schools in rural under developed areas have been regularly targeted and destroyed. Also, more recently, crime against young girls has been on the rise. As a result, security concerns have discouraged parents to send their children, particularly girls to school (MET and SHE 2014). Lately, terrorists have attacked mixed schools and even the universities and the incidents have amplified the security concerns.

The curriculum plays a pivotal role in shaping the minds of the pupils and helps them reach their true potential. It forms the basic ideologies and the knowledge base of the masses. Unfortunately, what is actually taught in Pakistani schools is not up to the standards maintained by the developed countries. It still focuses on old styles and methods no longer used by the world. The books need to communicate effectively to cover all the objectives and simultaneously arrange the content in a logical, coherent and stimulating manner. Additionally, in most textbooks there are no self-test problems and activity pages (Rajper 2015). In Pakistan, there is dire need for execution of Science Technology Engineering and Mathematics (STEM) education through Inquiry Based Science Education (IBSE) at primary and secondary levels.

Madrasahs of Pakistan are facing international scrutiny after the event of 9/11 in 2001 in the United States. Since then that event as well as all events of terrorism have been attributed to Islamic militancy around globe. The scholars have developed a dual opinion about Madrasahs. One group understood madrasahs "as jihad factories having less to do with education and more to do with political indoctrination; incubators of Muslim terrorists; origins of conservative violent ideologies, and thus, a security threat to the modern world". The other group of scholars presents madrasah playing peaceful roles in society; like, increasing literacy rate, spreading religious morality and human values, giving space to marginalized class of society, discouraging criminality, and thus, maintaining a social order (Butt 2012).

On the other hand instead of studying math, science and English, students spend large part of their days memorizing religious materials, without understanding (Ahmed 2015). The content of curriculum being taught in madrasahs is not guiding the tender and immature minds towards positive thinking. Inappropriate education and society's condemnation of madrasahs, perhaps encourages the youth towards militancy. Examination of madrasah curriculum incontrovertibly reveals intolerance and speaks volumes about the direction that Pakistan is headed. Students spend large portions of their days memorizing religious materials, chanting war songs, and venerating the state (Kamal 2014).

29.6   Conclusion

Islam promotes knowledge and education but some people in the name of Islam destroy centers of learning and institutions including the establishments of the armed forces, schools and mosques and also shoot at the girls who go to school. The story of Malala Yousafzai and her colleagues and more recently the assassination of Punjab Home Minister Mr. (Late) Shuja Khanzada in Attock in Pakistan and some other incidents in neighbouring Afghanistan involve young people in the terrorist activities; which despite a lot of efforts and expenditures by the Government, is not ending. The reason may not be just one but the lack of education and perhaps vested interests feeling threatened from the "educated" or knowledgeable people who try to find the truth, are major factors. The standard and quality of education in Pakistan is the major issue and many cases of fake certificates and degrees have been appearing in press during the last few years. There are numerous reports indicating low quality of education, absentee teachers and ghost schools. It is a considered opinion that substandard or no education, disparities in wealth distribution and injustices in the society are some of the root causes of unethical social behavior of young people and their mentors. Commenting on the issue, Stern 2004 claimed in a report that global Islamic militancy grows in Pakistani madrasahs, which are functioning without the government supervision; and thus, have become training camps of terrorists (Butt 2012). Since the content of curriculum being taught in madrasahs, is perhaps not guiding the tender and immature minds towards positive thinking; instead, the preaching at madrasahs mainly highlights the disparities in the society, especially against the religious and poor people, thereby instigating them to take revenge (Kamal 2014).

Thus there is dire need for making some fundamental reforms in madrasah system i.e., Madrasahs should not operate without registration and that the misguiding Madrasahs should be banned, curriculum revision has to be properly carried out, and a universal curriculum including pure and social sciences should also be established, which would be acceptable to all the sects in the country (Kamal 2014) and execution of Inquiry Based Science Education (IBSE) at primary and secondary level be ensured to understand the truth of nature. Additionally, 'Peace and tolerance' should be taught as a separate subject just to mould the minds of young children along the lines of acceptability and tolerance, making them aware of the true picture of Islam. Chapters on peace should be related or taught in line with Islamic principals so the masses can accept such a change. More emphasis should be laid on the topics of ethics, tolerance, education and the true meaning of jihad and 'jihad bin nafs' (jihad within oneself) should be strengthened (Malik and Hussain 2015).

Therefore, the role of schools and universities in Pakistan becomes crucial towards contributing to the promotion of tolerance among students, staff, faculty, different ethnic groups, sects, civil society and the national environment of the country (Malik and Hussain 2015). Lately the efforts have been made by the Government since 2015, whereby standardization of curricula and training of teachers is being given more importance. More recently (2016), Higher Education

Commission (HEC) of Pakistan announced "Hand-Holding of Schools" under its Social Integration Programme for Universities. Under this Programme the university faculty and students will provide volunteer tutorship to local school students by organizing lectures and interaction on specialized topics as well as allow access of students to their laboratories for experimentations and also to organize open days for the students (HEC 2016).

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Chapter 30
Education, a Renewable Energy?

Marguerite Léna

Abstract The objective of education is not solely to prepare children for a world capable of sustainable development by making them attentive to renewable energy and fair trade which are its prerequisites. The connection it has to these high stakes is even more fundamental than that: the act of education by its aims and by the unique relationship it establishes between generations, is in itself a sustainable development, a renewable energy and fair trade. I will do it then as the educator and as the philosopher I try to be by relying on the thinking of Paul Ricoeur. His thinking offers a valuable philosophical resource to whomever would seek to reflect upon this task in a globalised world. While our societies, which are in essence impersonal and are marked by technical and computer rationalisation, are mainly interested in the "what" of goals and the "how" of procedures, he never stopped asking the question "who?" Who is acting? Who is responsible? Who, as educators, do we want to form?

Your Academy's work session, that you have so kindly invited me to attend, and for which I express my heartfelt gratitude to Mgr Sánchez Sorondo, is turning resolutely towards our future in two ways as it is looking both towards the youth and towards the future of our planet. These two realities are bound together as shown by the various presentations heard here earlier. Perhaps the objective of education is not solely to prepare children for a world capable of sustainable development by making them attentive to renewable energy and fair trade which are its prerequisites. The connection it has to these high stakes is even more fundamental than that. I would like to suggest with a touch of humour—or audacity—that the act of education by its aims and by the unique relationship it establishes between generations, is in itself a sustainable development, a renewable energy and fair trade.

I cannot do this as a scientist as I am not one; I will do it then as the educator and as the philosopher I try to be by relying on the thinking of Paul Ricœur. He did not

M. Léna (✉)
Apostolic Community of St. Francis Xavier, Rueil-Malmaison, France
e-mail: margueritelena@yahoo.fr

develop a theory of Education, yet his thinking offers a valuable philosophical resource to whomever would seek to reflect upon this task in a globalised world. From Chambon sur Lignon, the centre of the spiritual resistance to Naziism, to the Sorbonne, the seat of European culture then, from the Sorbonne to Chicago, the melting pot of a changing world, he personally experienced this "teacher" relationship where knowledge is communicated through the spoken word and is first certified by the "I" of the speaker. While our societies, which are in essence impersonal and are marked by technical and computer rationalization, are mainly interested in the "what" of goals and the "how" of procedures, he never stopped asking the question "who?" Who is acting? Who is responsible? Who, as educators, do we want to form? I am going to venture to follow in his footsteps.

30.1 Education, Drilling for Renewable Energy

As early as the 1950s, Professor Teilhard de Chardin alerted us: of all energies, human energy is the most precious, and being devoted to making it spring forth is the most urgent task. Each new generation brings with it an unprecedented potential for creative energy as inexhaustible as the gift of life that gave rise to it. Now, this is not about fossil fuels buried in the Earth's past. This is about children and young people standing before the future of the Earth; each of whom has "something to say which is uniquely his, … a vocation that is nothing less than one of God's thoughts" (Daniélou 2011). "Here, in the heart of man/one must dig/… water is here", wrote the poet (Emmanuel 1970). The deeper one digs, the stronger the water. But these new energies can be wasted, squandered, lost. It is Mozart we assassinate each time there is no educating gesture that goes before them to collect their fervour and to channel their course. The risk is not that they be exhausted but that they lay untapped and as though unnoticed by their own depositary.

In opposition to all naturalism as well as to all individualism, Paul Ricoeur underlines that nobody can reach the depths of his own identity without the mediation of other people and the voyage through another culture. Thusly, he assigns to Education its most decisive responsibility, but also allows us to understand how in the world of the manipulable and of the immediately consumable it works against the current. For, on the one hand, we would neither know how to master nor how to use, in a simply functional manner, the unpredictable outpouring of energy that each newcomer to the world brings. "The vocation of a child is to grow away from us" writes Paul Ricoeur, and this is why the profession of educator "stands in a delicate tension between the call of the open and the trap of the enclosed" (Ricoeur 2004). On the other hand, all teaching imposes deadlines, demands and operates under demanding mediations: between the child and the world, between his emotions of the moment and his inner self, between his impulses of the instant and his more genuine desires. "What would we know of love and hate, of moral feelings, and, in general, of all that we call the *self* if these had not been brought to language and articulated by literature?" (Ricoeur 1998)

Moreover, what would we know of the world if it had not been brought to language by science? What would we know, of the soul if it had not made itself perceptible in art and faith? Thus, by the onerous detour of the signs of language, of symbols, and of the texts of diverse cultures, the desire to move towards more difficult and more valuable possessions broadens and deepens, instead of letting itself become saturated and sealed off by temporary possessions.

Such is the lofty mission of the school. The great works of humanity to which it gives voice and access irrespective of the subject, are, in themselves, a field of fossil fuels, since they come from the past but are indefinitely renewable. I see a fine symbol of these fields in the work by Rembrandt: Aristotle with a Bust of Homer. Homer had long since been dead when Aristotle developed his philosophy; likewise Aristotle when Rembrandt painted this painting; likewise Rembrandt when we gaze at it today. But the energy from the beauty and truth enclosed in them continues to spring forth and to have an effect from century to century from masterpiece to masterpiece. Who could exhaust a page from Sophocles or Lao Tzu, a Bach sonata, the intuition of a Galileo or an Einstein? Who could imagine what unpredictable, inexhaustible, new energies will spout up in a young mind when it encounters them? Who could measure the scandal that so many others are denied access to them? Going against the entropy of things, within us is the spirit that can draw from itself more than it contains and that can give to others more than it has received. Of this excess of running waters that maintain self-esteem and the love of life, the educator is simply the water diviner.

30.2 Education a Form of Fair Trade

Therefore, as educators, we have not got a patrimony to jealously protect, but seeds to toss into the wind towards new generations, in this globalized world where every culture is admittedly confronted with the danger of becoming diluted but is above all invited to take the noble risk of engaging in dialogue. "We shall not enter into this great debate of each culture with all or without our memory", again writes Ricoeur" (Ricoeur 2009). The world of technology is a world without memory, as today's inventions make yesterday's obsolete. But the educator must make himself the contemporary of the most ancient of humanity's technical conquests—reading, writing, counting, measuring—so that this distant past may transplant itself on the brand new future of a child. Such is the treaty of alliance that binds the generations: it ties the horizon of the still unformulated expectations of the new generation to the space of the experiences already acquired by its predecessor. I wanted to give this treaty the lovely name of fair trade. It's a weakness - or perhaps a strength—of the French language that it has only one term at its disposal whereas English has two. Indeed English distinguishes between trade and exchange depending on whether goods or words, ideas and feelings are being exchanged in an interpersonal encounter; but Classical French speaks of commerce in both cases as though one cannot exist without the other, the exchange of property without the exchange of

words, the exchange of words without concern for their exact weight… Thus education is actually commerce, since it never stops putting at the disposal of the new generation both the words and the goods that the adult generation is the bearer of. But in what way is it fair?

Aristotle saw in fairness the necessary corrective of legal justice (Aristote 2004). Indeed, the law can only deal with general situations and often stumbles over specific cases. This is where fairness comes in, in the same way that the soft lead ruler the builders of the temple of Lesbos used was capable of following the outline of each stone and therefore infinitely more rigorous and reliable than more rigid rulers. He also stressed that "he who is just will not rigorously cling to his rights but will tend to take less than his share" (Aristote 2004). I see in that the fine metaphor of the educative relationship, as a pact between generations. Our solemn responsibility for the future will first be played out in the field of education, and it has the unique quality of concerning something that does not yet exist: how then can an educator ask humanity for his due based solely on a promise? He has a mission not only to "take less than his share", but even to give more than is asked of him. He has a mission to give freely what is necessary for the future of each child and to make sure to safe guard what is necessary for the future of mankind. This generosity and this vigilance dispute the abstract logic of quid pro quo, and put back in its correct anthropological place of second, the market economy, in favour of a "original cascade of donations" that flow from the adult towards the child, from he who is to he who will be. They quietly carry the history of humanity.

But fairness also comes into play in the concrete of the educative relationship that accompanies the genesis of the child's personality, as the act of teaching demonstrates perfectly. Neither the institutional structures that map out this profession, curricula, rules and regulations, not even the code of ethics, as necessary as they may be would know how to adopt or to exhaust the concrete and unique character of the teaching relationship: This will always be transmitted from person to person, from spirit to spirit in such a way that, as Paul Ricoeur writes "an actual community life is born around the communication of knowledge", a life that has its rules, its spirit and its heart, and man in his entirety is involved. This shared life is, he goes on to say, "entirely under the rule of the utmost task of words" (Ricoeur 1955): the educative relationship is admittedly dissymmetrical, and Ricoeur underlines all the risks of domination, seduction and violence that this dissymmetry can bring about. But it is to be repeatedly overcome by the reciprocity that is, to be fair, established by speech. "What do I do when I teach?" asks Ricoeur, "I speak. I have no other job and no other dignity: I have no other means to change the world and no other influence over men. Words are my work; words are my world" (Ricoeur 1955). The child is not introduced into this as a slave but as an interlocutor, to the point where all genuine teaching, even if is a lecture, recognizes in its addressee the dignity of a thinking being, even if it is the young slave of Meno (Platon 1993). and confers upon him the right to use as a free man the received word. This is how the teacher's authority is the one that embodies most visibly the essence of all genuine authority: being fulfilled by the effacement of itself in the reciprocity that it made possible. "Help me do it by myself" said a child to his

father. If this aim is lacking there is nothing left but conditioning. How can one not evoke anew the silent encounter that Rembrandt was able to establish between the philosopher and the poet? It is hard to tell in this silent dialogue where there is so much tenderness and respect, so much secret complicity and solicitude, who is the master and who is the pupil…

30.3   Education, Sustainable Development

Now we finally come to the theme that has given our session its title: sustainable development. This is a challenge not only *for* education. It is the challenge *of* education, one that it continually poses for our societies who are often mindful of the means but forgetful of the ends, attentive to financial flows but indifferent to the flows of human beings driven out of their lands by destitution or violence. An educator cannot accept this reversal of priorities. For he does not seek to develop resources but to open sources. He does not work for money but for the "price-lessness" of a meaningful human life. He does not act for the present, nor even for the short-term, but for a future that goes farther than him, that stretches far beyond him—the future of another and of others. In our world where personal liberty is more and more often appealed to by collective choices that broaden in space and in time the scope of its responsibilities, the early development and accompaniment of the singular liberty of each child, of each youngster is the only priority that opens onto a "sustainable development". For it is as a free being that man is to himself "a work in progress". But only education allows the closed cycle of needs and of their satisfaction to burst forth into an open world, entrusted to liberty, where "humanity as a totality, the person as a singularity" (Ricoeur 1991) are combined. It has the difficult task of drawing for young eyes man's dignified ends, ends more elevated than man, ends that give a sense of eternity, like beauty and truth, and without which all the modalities of development fall back down into despair.

Paul Ricoeur is, here again, a precious recourse for educators. Indeed, he developed a "phenomenology of Capable man" (Ricoeur 2005), capable of giving a solid anthropological foundation to the challenge that education poses to our world. Capable man is not a specialist in this or that know-how, but one in front of whom opens "the possible" instead of his remaining a prisoner of mere necessity. Nor is he primarily a man capable of evil. This bears a heavy weight in history, but as Ricoeur writes, "evil is not as deeply rooted as goodness" (Ricœur 2002). The possible, goodness: these are two primordial conditions of the educative act. But "Capable man" is most of all he whose being is not defined in terms of its identity, which would freeze him in the immobilism of a destiny, but in terms of the responsibility, affirmation, commitment and faithfulness, that give to his choices their intense duration—their sustainable development. These capacities are not innate. They are at once the material and the manner, the intention and the design of the educative act. And he who, often by feeling his way along, endeavours to fashion his own experience as an educator, will doubtlessly never know which

"sustainable development" of humanity he has thus began. Homer the "man Capable" of writing the tales The Iliad and The Odyssey did not know, could not know what paths of life and of unbroken creation they would trace in the consciousness of men. Well beyond Aristotle, the immobile and blind stone bust of the old Greek bard has not stopped developing in the duration its promises of humanity.

It is time to conclude. I would like to do so by evoking my vocation as a consecrated woman who received a mission to educate young people. I cannot reflect on education without turning to the grace of this consecrated life. It taught me to draw from, without the risk of exhausting it, the source of energy that is always available and who is the Holy Spirit, he whom the biblical book Wisdom refers to by the fine name of Educator (Wisdom 1,5). This life also taught me that it is sufficient to dig a little deeper, with love and respect, into the man created in God's image to sense in him the running waters promised by Christ, and maybe even help to him unseal their source for "deep is the well" (Jn 4, 11). Little by little, I discovered that the "fair trade" established by the educative relationship is nourished by the spirit of service and generosity that the Gospel continually calls for, and it turns with predilection to those who are the most fragile. Finally, I draw from it the certainty that a child's education is not developed for a period of time but prepares the "for ever" of his eternal vocation. In the eyes of a Christian, is the child not the most eloquent of the signs of the Kingdom of Heaven, and already in our midst its anticipation? (translated by Sharon Chehade)

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Chapter 31
Recommendations Issued
from the Participants

**Antonio M. Battro, Pierre Léna, Marcelo Sánchez Sorondo
and Joachim von Braun**

Abstract Fostering sustainablility implies that education develops new ways in terms of justice, learning goals and technologies, educational paradigms, as well as new roles for students, teachers, scientists and scholars, political leaders. To define and implement these changes, Recommendations are proposed and detailed.

The present Recommendations have been extensively discussed during the last Session of the Workshop, submitted to the contributors and invited guests, and finally issued as the result of the Workshop. The Summary focus on the most important points, followed by some more specific Issues for education in the context of Sustainable Development and Climate Change.

They have been submitted to the authors for undersigning.

These Recommendations are available on line in French, Italian and Spanish at http://www.casinapioiv.va/content/accademia/en/events/2015/children.html.

A.M. Battro
Academia Nacional de Educación, Buenos Aires, Argentina
e-mail: abattro@ross.org

P. Léna (✉)
Observatoire de Paris, Université Paris Diderot, Paris, France
e-mail: pierre.lena@obspm.fr

M.S. Sorondo
The Pontifical Academy of Sciences, Vatican City,
Holy See (Vatican City State)
e-mail: marcelosanchez@acdscience.va

J. von Braun
Center for Development Research, University of Bonn, Bonn, Germany
e-mail: jvonbraun@uni-bonn.de

31.1   Summary

Fifty percent of the world's children are currently with insufficient schooling, or out of school, in a world affected by serious sustainability issues. This worrying situation requires urgent, long-term attention. Investing sufficiently in education may seem demanding, but the costs of ignorance are much higher. The future of our globalized society is at stake. Children all over the world need to be included and prepared for the tasks ahead.

Based on scientific evidence of the human impact on climate and environmental crises affecting the inhabitants of our planet—the most vulnerable of whom are those living in extreme poverty, and especially their children—this Workshop aimed to define a set of focused and manageable recommendations for school education, with inclusion as its main goal. Basically, the Workshop was about childhood, children's rights, teacher support, justice and intergenerational responsibility.

The Workshop and its conclusions are built on earlier analysis and statements from the Pontifical Academies (Pontifical Academy of Sciences 2001, 2005, 2013, 2015).

They also reflect the principles set out in the UN Sustainable Development Goals (SDGs), especially SDG#4 on universal education. Significantly, the Workshop was greatly inspired by Pope Francis' Encyclical Laudato Si'. On Care for our Common Home, which calls for "ecological education and spirituality" (Laudato Si' 2015).

In 2015, 125 million youngsters (aged 0–15 years) worldwide are not attending school (UNESCO 2015). The one billion who live in poverty—with inadequate schooling and lack of attention to early childhood results—lag many years behind their peers in more advantaged contexts. The 60 million refugees—their number has doubled in the last 5 years—experience extreme difficulties in childhood education. The children of the growing number of other forced migrants—due to environmental change, for example—are equally a concern. Climate impacts and wars will worsen these migration trends. They require action both in developed and developing countries. Inequalities in education have recently increased in 14 out of 29 developed countries (OECD 2013).

In view of the immense challenges ahead, the main goal is to provide every child with knowledge, competencies, self-confidence, hope in human solutions and resourcefulness. When these children become adults, they will be able to build a global society that respects the human person and the Earth, cultivates empathy and reason, and recognizes the spiritual and holistic dimensions of each individual. Education, with its inherent ethical and moral components, must responsibly meet these challenges with two imperative and urgent mandates of social justice.

31.1.1 Justice in Access to Quality Schooling

Inclusive schooling must be implemented, especially for the marginalized, refugees or forced migrants. This implies international mobilization, global cooperation and government attention to necessary changes.

31.1.2 Learning Goals for All Students

In the global North and South, strong, high-quality academic programs must commit to curricula and teacher training that promote learning about sustainability. These should be climate-aware, emphasizing innovative solutions, increasing appreciation for our common home, and changing behaviors in view of responsible consumption choices. It is imperative that children be encouraged in their inborn love for the inhabitants of our planet and instilled inherent love for our planet itself.

In addition to these fundamental mandates, five essential educational *themes* emerged from the Workshop, whose participants urge education authorities and stakeholders to progressively implement them.

31.1.3 New Educational Paradigm

In all areas of education, a new curricular framework has to be designed to promote education about the prospects of life and human history on Earth and an understanding of global issues. It has to convey both the knowledge and the means to act locally, as well as moral values and the importance of community involvement. Interdisciplinary education and age-appropriate awareness are necessary to teach the complex interactions among natural and social systems. Science and technology education play a critical role in teaching and learning how to observe, think, reason and act sustainably.

31.1.4 Teaching and Learning Technologies

New communication technologies offer outstanding educational opportunities, but can remain ineffective without strong and nurturing interactions between students and teachers. Hence, teacher preparation quality and professional development within this new framework demand considerable care, support, and effort. Additionally, educators must apply scientific findings on biological evolution, neurosciences, and tools (incl. technologies) to better understand a child's developmental process, and to optimize learning experiences.

31.1.5 Youth as Agents of Change

Children and teenagers are not just recipients of knowledge: they must be inspired to act in their local contexts, and design sustainability initiatives in their schools and communities. Youth can encourage change through constructive interaction not only with other young people, but by positively influencing adults. Social media and social networks can be an asset. The education and empowerment of girls is essential to serve as agents of change.

In an unprecedented session, the Academy invited 19 teenagers representing 12 nations to present their views on education for sustainable development. Their presentations and discussions with members of the Academy deeply impressed the audience and contributed to the present Recommendations.

31.1.6 Scientists and Scholars

Close cooperation is required between school systems and scientific communities, given that science and technology are essential in the diagnosis of developmental issues and risk factors, and critical for finding the means to act.

31.1.7 Leadership, Policy, and Funding

Collective engagement and the moral obligations of our common home require global leadership, generosity, funding of innovative projects, and long-term visions that will improve human wellbeing and the environment for present and future generations.

31.2 Sustainability Issues to Be Addressed by Education in New Ways

In complement to the above main Recommendations, a number of important and more detailed points emerge, which deserve to be presented.

1. **A new world.** Deep global changes challenge education systems to think anew their tasks and prepare students to play active and responsible roles. In this context of climate change, education needs to deal with globalization and cross-cultural understanding; migratory imbalances; work profiles; digital revolution; urbanization and neighborhoods; rural change; health, food, water and sanitation; Interdisciplinary education recognizes the need to educate the young

on the complex interactions between natural and social systems, termed "Integral Ecology" in Laudato Si'.

2. **Inclusion and poverty.** "Childhood" needs to be re-defined with an inclusive perspective. Necessary school changes ought to benefit all children: broken families, girls, children of migrants (intra- or inter-national), refugees, victims of trafficking, disabled, ethnically excluded, and individual children that drop out. Education alone will not eradicate poverty, but is a necessary element.

   – Gender equality in education will be most effective for economic and social wellbeing, as well as demographic transition.
   – Education is inseparable from environmental, economic, social and cultural dimensions. UN Sustainable Development Goal #4 (universal education) cannot be separated from others, for instance #10 (reduced inequalities). UNESCO (IISD 2015) estimates that external donors should offer US$39 billion/annum to enable low-income countries to finance the SDG#4.

3. **A better understanding of learning and teaching.** The cognitive abilities of human beings evolved biologically to cope with a simpler 'pre-cultural' world. Humankind now needs to adapt to complex systems and long-term effects. Science provides knowledge and tools which can inspire education: brain and neurosciences; global access to information and new digital tools; and inquiry-based science education. These have the potential to foster self-confidence, creativity, and critical thinking among youth.

   – The potential power of Information and Communication Technology (ICT) in education should be utilized much more in low-income countries, yet requires appropriate guidance, funding and international cooperation.

4. **A new vision on curricula.** Including, but going beyond literacy and numeracy, curricula have to help students understand systems complexity and interconnectedness in the new world, and foster awareness of the challenges that humans will face in the future.

   – Science education should be expanded internationally, especially in low-income countries, and the necessary resources mobilized, as science education is a precondition for today's children to be responsible and effective actors in the future.
   – As literacy positively interacts with brain development, enhanced literacy needs to be given much more attention in order to increase the capacity of future generations to deal with the growing complexities of socio-ecological systems.
   – Education of children should be holistic, including body, mind, spirit, health, sense of happiness and beauty. It aims at knowledge as well as skills.

5. **The key role of teachers.** Teachers themselves need to be brought up to date on sustainability issues. In an integrated world, events in distant and seemingly remote areas can have a global impact. Teachers need to be prepared to implement such concepts in their schools, supported by pre-service and

in-service training and coaching. Their behavior must also be exemplary, since role models are crucial in education.

- To facilitate this role, teachers should be able to network globally, to allow them to exchange experiences and resources, and develop their confidence in young people's capabilities. IT platforms that systematically collect and present sustainability education examples and report experiences should be further pursued and linked.

6. **The central role of children themselves.** Children's rights need protecting. Potential for age-appropriate child development must be taken into account. Acting *with* children goes beyond acting *for* children. Children and youth can be agents of change for sustainable development. Children can also effectively teach their families and communities.

- Education must consider the hugely diverse contexts of people's livelihoods, which are often impaired and marginalized (in slums and in poor villages), while valuing the power of solidarity and the opportunities available in school community and family contexts.
- Local communities are the natural spaces where formal and informal education act jointly and can devise tailored strategies for young people and with young people.

7. **A new role for scientists and scholars.** Science and technology are central in the diagnosis and for the means to act. Close cooperation is required between school systems and science communities, especially in interdisciplinary approaches that are so important for sustainability teaching.

- Experiments on educational innovations for sustainability should be systematically designed, evaluated and combined with concepts for scaling up from small examples. Many interesting examples of innovations were shared during the Workshop (Annex 1).
- Education should be combined with practical initiatives and be accompanied by well-designed research; an example is improved health and sanitation in low-income contexts.
- Research into brain development and brain functions needs to be expanded and its links with education embraced.

8. **Ethics and responsibility.** Over millennia, societies have been characterized by division, competition, and rivalry. Educators must emphasize the contexts in which social and cultural history has developed commonalities, empathic connections and mental habits that are open and flexible, fostering new thinking models that erode a tendency toward fixed beliefs. Changing people's attitudes and behaviors towards nature and towards one other is crucial today. The Encyclical Laudato Si' calls for an ecological conversion through education, recognizing the need for lifestyle, production and consumption changes. Education systems must embrace the spiritual dimensions of every person, the notion of common good and the need to take local actions for the global good.

– The young should be encouraged to respect and befriend others irrespective of their race, culture or religion. In this globalized, interconnected world, they should be made aware early on that lack of peace and prosperity in any remote location will have global implications. This needs to be grounded in an ethical and moral vision.

– Teaching values with firm moral foundations must be part of any education geared towards sustainability, whereas best practices may differ by context. Religious schools should embrace science and sustainability issues, thereby playing an important role. The issues of violence, marginalization and exclusion should be considered as sustainability failures.

In cooperation with the Pontifical Academy of Sciences, the participants will devote their energy to implementing these guidelines by various actions, especially in the context of the Encyclical Letter Laudato Si', the UN SDGs, and the conclusions of the UN COP21 held in Paris.

Approved and signed by:

Jorge Allende, Tobechi Anyadike, Margaret Archer, Antonio M. Battro, Luis Arancibia, Kaushik Basu, Rao R. Bhavani, Jacques Blamont, Joachim von Braun, Yves Coppens, John Holman, Bernard Hugonnier, María Paz Jurado, Hideaki Koizumi, Yee Cheong Lee, Marguerite Léna, Pierre Léna, Jürgen Mittelstrass, Elena Pasquinelli, Yves Quéré, Veerabhadran Ramanathan, Courtney Ross, Jeffrey Sachs, Manzoor H. Soomro, Mons. Marcelo Sánchez Sorondo, Gonzalo Sánchez-Terán, Carola Suárez Orozco, Marcelo Suárez Orozco, Sidney Strauss, Ignacio Suñol, Sally Tomlinson, Cardinal Peter K.A. Turkson, Rafael Vicuña, Daniel A. Wagner, David Wilgenbus, Maryanne Wolf.

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Chapter 32
"Before Using This Device, Please Consult the Manual": The Challenges of Sustaining Language, Education, and Culture

Cardinal Peter K.A. Turkson

Abstract The starting point of this chapter is a question raised by a young school student who was eager to make connections between what was happening in the school he attended and his experiences in the family home. He asked his teacher, since "new things" such as computers and printers arrive with some kind of user's manual, why was it that complicated things, babies for example, arrive without one? Cardinal Turkson approaches this question by identifying the different ways we learn. We learn, he says, in the same ways that we are taught: formally, informally, and incidentally, often in a mix of all three at the same time. If teaching and learning takes place solely in the language of the student's culture and community, then this is a relatively manageable process. Today, in countries that were former colonies, education is frequently delivered in the language of the original colonizers, resulting in the reinforcement of elitism that has no place in the process of education, regardless of its formality or informality. Education in multi-ethnic, multi-cultural, and multi-religious societies must adapt to them. The author concludes with promising experiment: a recent pilot project in Ghana that will examine the impact of two key components of the educational process: (1) the language of its delivery; and (2) the nature of the technology and media used to deliver it.

32.1   Children and Sustainable Development: The Role of a "Manual of Life"

Let me begin, with a story about the need for education.

A village school had received a donation of a computer, a printer, and a video projector. To display the gadgets to the curious class, the teacher had to unpack a lot of printed material from the boxes. Some of the documents were warranties and

C.P.K.A. Turkson (✉)
Pontifical Council for Justice and Peace, Vatican City, Vatican City State
e-mail: p.turkson@justpeace.va

product registration forms. But the most sizeable were manuals of instruction, and users' manuals and guides. The teacher, sensing that the pupils were puzzled over how much printed material came with the new gadgets, decided to proffer an explanation: *"Class, as you can see, every new thing comes with a manual of instruction to show us how to use it, and use it well"*.

The following morning, one of the pupils, Tekyi-Sam, whose mother had just given birth to a baby, put up his hand in class and asked: "Sir, if every 'new thing' comes with a manual, why does a new born baby not come with a manual?"

The class burst out laughing, but Tekyi-Sam had asked a very important question: a question that actually explained why he himself was in school.

32.2 Education: The Art of Developing and Handing Over "Manuals of Life"

Indeed, human beings come into the world without "manuals", because they expect to receive their "manuals", their guides for living life successfully, from the world into which they come, namely, their parents, families, homes, schools, institutions, communities, societies, and the State. And the process of handing over such "manuals of life" to new members of human societies is Education. In this sense, education is said to be as old as humanity and the most cherished and potent tool for passing on a community's sense of identity, its values, its norms, its beliefs and worship, its technologies and methods for developing the personalities of its members and for transforming its world—in sum, its culture—from generation to generation. Accordingly, it is not uncommon to refer to culture as a community's handbook for training its members in the values of citizenship and successful living.

The purpose, then, of education is to provide members of society with "manuals of life"; and its scope is to make their lives succeed: the full development of their human personalities and skills to ensure the flourishing of their society and world. The chief concerns of education, therefore, are the individual's personal life and success in that life, for the sake of the individual, and for the survival, good, and wellbeing of society, however these may be conceived.

Education—the handing over of "manuals of life"—may be done non-formally in homes, at gatherings of the community, at shrines (in the various forms of initiation ceremonies), in churches, in mosques, and in palaces of chiefs, in the form of adult education, skills training, sanitation etc. It may also be done formally in institutions: schools, polytechnics, universities etc. Finally, education may be carried out informally (or incidentally) in homes and in public through example, imitation, and the general process of socialization. Although each differs according to the extent to which they are institutionalized, these three forms of providing education are not at all mutually exclusive. In fact, they complement each other constantly. Learning by imitation and from examples (characteristics of informal education) frequently takes place in schools and in institutions of formal education.

Similarly, the informal educational process of socialization tends to pursue its objectives through the formation of clubs, associations, and confraternities.

The materials intended for one of the forms of education can be used effectively by the other two. Similarly, universities also make use of all three forms of education in their various programmes and courses.

32.3 The Context and Function of Education

The character and content of what I have termed "manuals of life" are produced by the communities they reflect—by the socio-cultural, socio-economic, historical, geographical, and political situations of communities. Thus understood, education is contextual. In its particular context, it functions mainly to equip a community with the wherewithal for ensuring its sustenance and its successful survival within its physical, cultural, and global environment. This can be seen in the case of Ghana, my country. I shall briefly consider two specific Ghanaian contexts which gravely impact and affect the handing over of "manuals of life" for the survival and successful living of the people of this nation and for their place in the world. These are: the challenges of a globalizing world, and the effect of the Country's colonial past.

32.3.1 Globalization and the Globalized Contexts of Education: Pluralistic (Multi-ethnic, Multi-cultural, and Multi-religious) Contexts of Education

In traditional and predominantly mono-ethnic, mono-cultural, and mono-religious societies, the context of education is rather homogenous and relatively simple. As the context changes, however, for example to globalized and pluralistic (multi-cultural and multi-religious, etc.), education also becomes more complex. It continues to understand itself as providing manuals of life, but now within a context that is culturally, religiously, and socially pluralistic. Accordingly, in addition to the goals stated above, this education must also function as an effective tool for integration: the re-definition and reception of new norms, values, etc. This is a very crucial function!

For globalization has not quite brought about the homogenization of culture that some have anticipated (Hannerz 1991, pp. 107–128). It has neither standardized our world (Tomlinson 1997, pp. 117–162), nor simply made individuals and ethnic groups parts of what, in 1964, Marshall McLuhan coined a "global village." (McLuhan 1964) With globalization, the migration of citizens from one country to another has resulted in substantial demographic, ethnic, and socio-cultural changes

in many countries. Globalization continues to accelerate the flow of capital, people, goods, and images and ideas across the world. Innovations in technology—particularly transportation and communication—have made it easier and quicker for people and things to get around. Globalization has compressed both space *and* time, and has made national boundaries porous. Seekers of natural wealth and investors pour into developing countries from the East and from the North; and many people living in developing countries prefer to migrate to the developed countries to pursue more opportunities and to improve their lives.

Most significantly, while the migrants are in the developed countries, they do not sever ties with their homelands. They are able to forge and to maintain social relations that ignore distance. They link together their home and the host society as they develop cultures of the periphery within their host countries and communities (Inda and Rosaldo 2002). In other words, many countries in the West have turned into meeting places of a broadening array of peoples and cultures, making the West sites of extraordinary cultural heterogeneity and home to diverse cultures.

For the sake of completeness, it is worth observing that the experience of cultural heterogeneity, as a result of globalization, is not limited to the West. It is also increasingly becoming the experience of hitherto traditionally homogenous societies of Africa and Asia. New values and norms, new socio-cultural habits and behaviours, new religious faiths and thinking, etc., propagated by the world's improved means of communication, have not spared societies and nation-states, even those with all manner of legislated barriers against such influences. Nations may want to filter the content of internet communications in order to protect their system of governance. They may legislate religion, endorsing some as state religions and proscribing all others. They may initiate national programmes of cultural revivalism to safeguard their identities. Nevertheless, the inter-cultural and the inter-religious challenges and demands of globalization cannot be wished or regulated away. They will continue to knock on the doors of nations and religions, demanding to be recognized and reckoned with, as globalization invites the world to transform itself from being an aggregation of disparate and unrelated entities (nations and peoples) into nothing less than a communion: a world community of related members, bound together by a sense of common origin and common character as human beings and a common destiny or calling to make the world the common home of all.

This sketched presentation asserts that multiculturalism and diversity are realities of our world today. Decision-makers in those nation-states where this condition is prevalent are grappling assiduously with the challenges of accommodating racial, ethnic, cultural, and religious diversity within their societies while still maintaining their national identities. Similarly, those migrants who constitute ethnic, cultural and religious minorities constantly face the challenges of integration in a society to which they feel they can never fully belong. Indeed, in the past year the world's media have captured troubling images that once seen can never be forgotten: thousands of migrants fleeing the violence in their homelands, risking their lives in overcrowded and flimsy boats as they seek refuge on the other side of the Mediterranean. Thousands have drowned on this perilous journey. For those who

do survive the journey, once there, they face the uncertainty of the cautious refugee determination process. Should they be allowed to stay, they begin another difficult journey as they experience the enormous challenges of learning to live in another culture and language.

In several instances where policy makers have opted to encourage the development of harmonious relations between diverse ethnic and religious groups, while they safeguard the identity of their communities and nations, their preferred tool for achieving this is education. So, how then does one do such education in multi-ethnic, multi-cultural, and multi-religious situations?

32.4   Multi-cultural and Multi-religious Education

Certainly, multi-ethnic, multi-cultural, and multi-religious education can neither be differentialist nor assimilationist. When one imposes a practice of differentialist education in a multi-cultural and a multi-religious situation, the dominant group of a society uses its power, status and privileges to devise a policy which minimizes contact with ethnic minorities and restricts their participation in the mainstream life of the society. For example, thinking of the policy of apartheid in South Africa and elsewhere, taken to an extreme, differentialist education would hope to curb any ethnic conflicts in society (Gamson 1995). On the other hand, when one pursues assimilationist education, one seeks to fully incorporate ethnic, cultural, and religious minorities into the mainstream society in the hope that they will abandon their distinctive linguistic, cultural, and social characteristics and take on those of the dominant group. The curricula in the schools reflect the culture of the dominant group in the nation-state in the belief that education based on these models will generate conformity and social cohesion. But, none of these has ever worked. Why? Because formal education is not the only means of education available to cultural and religious minorities in society. Informal education (that takes place in homes, churches or mosques etc.) sometimes consolidates and keeps alive those distinguishing ethnic and religious traits which formal education seeks to melt away.

Education of any type in a multi-ethnic, multi-cultural, and multi-religious society will have to understand itself as "education in the context of the whole inhabited earth" and "in the context of the universal family of humankind" (Turkson 2010). As the context of education changes, it must necessarily extend its function into redefining value-systems, norms, community aspirations, visions and goals etc., in its changed globalized, cosmopolitan, inter-cultural, and inter-religious setting. It must become an inter-cultural, an inter-religious and pluralistic education since this type of inter-cultural and inter-religious education will invariably have to be tolerant of multiculturalism and accommodate diversity and respect for every person. After all, that which gives substance, shape, and form to diversity is the fact that our differences belong to the plan of God, who wills that each receives what he/she needs from others and that those endowed with particular talents (regionally specific, cultural, or religious, for example) share the benefits with those who need

them. A talent in one person can meet a need in another, indeed, in many others. Differences, then, should not lead to division. Rather, they charge the human person to look at the other person as another self (Second Vatican Council 1965, p. 27).

Our common bonds of humanity demand that we strive to live in harmony and promote what is good for one another. Created in the image of God, all human beings, irrespective of where they come from and the cultures and the faiths to which they belong, have the same nature and the same origin, and have been redeemed by Christ (Gaudium et Spes 1965).

As a result, all human beings must enjoy equal dignity and respect—their culture, race, and religion included. Through the search for harmonious relationships between individuals and peoples, and in a culture where openness to the transcendent, the promotion of the human person, and respect for the world of nature are shared by all, it is God's divine plan that is being recognized and carried out.

Accordingly, when the context of education changes to become multi-cultural, multi-religious, pluralistic, and global, then education sheds its particular cultural and religious contextual mould. In this broadened context, it requires recourse to basic anthropology (the sense of the human person: its common character and destiny, and its basic desire for human flourishing). This core understanding of shared humanity provides the ultimate context for education, impelling it to become both a communal exercise and an event. Education becomes *learning for solidarity* in recognition of the brotherhood of humankind and the globalized community we have become; and it becomes an expression of our capacity to look beyond cultural and religious boundaries. It is, according to the Ecumenical and Formation Team of the World Council of Churches, "education for unity in a reconciled diversity which is mutually enriching" (WCC 1999, pp. 7–8).

Such multi-cultural and multi-religious education stresses the need to accept, appreciate, and understand other cultures as well as one's own. It promotes any learner's sense of uniqueness of his/her own culture as something positive and affirmative. In addition, it also encourages and enables all students to accept and appreciate the uniqueness of the cultures of others and that of their own with love. In sum, multi-cultural and multi-religious "manuals of life" should help students view themselves both as individuals and as members of groups.

32.5   Colonialism, the Past, and the Doing of Education

Now, I briefly turn to the challenge of providing basic education in a foreign language. In a recent television documentary produced by a German network about education in Kenya, noticing students struggling with a language they did not speak outside their classroom, the commentator observed: "Here are children struggling to learn in a language they may never fully master".

Universities and educators have drawn attention to the sensitive and complex issue of the medium of education. Specifically, what language does one use as the medium and vehicle of basic education?

This question of language is often posed in Ghana and in other countries in Africa. Indeed, this is an experience shared by many formerly colonized countries in the world. Thus, for example, Ghana achieved independence in 1957 shortly after India (1947). Although both were colonized by the English, the two countries have followed strikingly diverging paths of development and growth.[1] The disparity between the two is huge. Why then is India where it is, and why is Ghana where it is? A similar observation can be made about the so-called Asian Tiger countries (including Hong Kong, Singapore, South Korea, and Taiwan) which have witnessed dramatic shifts in their economic fortunes.

One of the explanations given for the disparity in post-independence growth and development between Asian and African countries is the language that is chosen as the medium of education and vehicle for thinking. Indeed, as the proponents of this position assert, each of the Asian Tiger countries has maintained its own language, which it uses in formal education, at least in basic education. With this policy, these countries have chosen a native cultural tool, their own language, as the medium of education, making the process of education no longer a foreign, former colonial enterprise. Foreign languages are taught and learned there, but later when the need arises.

Now, apart from the Tanzanian experiment with the adoption and full use of Kiswahili, shared somewhat by Kenya, all sub-Saharan countries impose the confusing arrangement of studying in a foreign and colonial language (English, French, or Portuguese) while living in a native language. Given the different outcomes of such African countries comparted with their Asian post-colonial counterparts, one may ask: "Does education in one's own language make a difference?" What is the real value (or detriment) to children of the increasing practice of having children speak a foreign language, however badly spoken and taught by parents and teachers, to the utter deprivation and exclusion of their native languages?

A very modest project in the Archdiocese of Cape Coast, Ghana, called the Cardinal's Foundation for Distance Learning or CAFDIL, seeks to explore this phenomenon.[2] This is a pilot project which will, in a small way, help to bridge a "digital divide" whereby some communities have an abundance of technological support and internet access whiles other communities do not. After a couple of years of implementation the project will be evaluated in order to determine how

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[1]Of course, there is another language challenge here beginning with the world "colonize" itself. This single word is used to cover a swath of very different histories. Apart from the imposition of language to consider, colonizers pursued different colonial practices and policies in the different places they chose to settle. Some of their "colonies" were seen primarily as a source of resources, while others as a source of labour.

[2]As the CAFDIL website explains, this initiative proposes the use of technology as means of providing "equal access to education for children, teens, and adults living in rural and deprived communities in Ghana in order to develop a country with no obvious or permanent educational disadvantage because of poverty, distance from educational facilities or underdevelopment." The goal of the project is to "help bring out the best in people living in rural communities for their development, economic growth, and participation in national life" (CAFDIL 2015).

well students learn and study in their local and foreign languages, supported by appropriate technology.

Back to Tekyi-Sam and his interest in users manuals and when they are or are not provided. Open any of these manuals you may have carefully filed away. Inspect it and typically, right at the beginning of the document, you will find a disclaimer of sorts. It warns the reader to follow very closely any instructions the manual contains:

> Retain this manual for future reference. Adhere to all warnings printed here and follow the operating instructions included in this manual.

It invariably tells the reader that the document is also impermanent.

> This manual is subject to change without notice.

Typically, the company that publishes the documents also assumes "no responsibility for any errors or inaccuracies that may be contained in this manual."

Communities are not manufacturers of usable "new things" that need a user's manual. Besides, regardless of their history or circumstances, communities have no recourse to any such disclaimers. The "manual of life" they communicate, generation by generation, is not a written document at all, but the reassurance that you

> may tell the next generation
>
> that this is God,
>
> our God for ever and ever.
>
> He will be our guide for ever.[3]

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[3]Psalm 48: 13–14.

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Annex 1. Grass-Root Initiatives and Projects Reported at the Workshop

1. *Ammachi Labs and AmritaRite*, community education in India
   https://www.amrita.edu/center/amrita-rite
2. *Assumpta Science Centers,* in Nigeria and Africa
   http://www.ascowerri.org
3. *Fe y Alegria*, a network of inclusive schools in Latin America and beyond
   http://www.fealegria.org
4. *ISTIC*, South-South cooperation in science and technology education
   http://www.istic-unesco.org
5. *La main à la pâte*, Inquiry based science education, France, Europe, Africa, Asia, Latin America
   http://www.fondation-lamap.org
6. *National Science Learning Centers*, In service teacher training, United Kingdom
   https://www.sciencelearningcentres.org.uk/net/cpd
7. *One Laptop per Child*, Uruguay and Latin America
   http://wiki.laptop.org/go/OLPC_Uruguay
8. *Relab*, Teaching biology with inquiry, Latin America
   http://www.amc.edu.mx/amcen/index.php/international-issues/the-la-tin-american-biology-network-relab
9. *Ross School and Ross Academy*, cross-cultural education, United-States and Sweden
   https://www.ross.org
10. *Scholas Occurentes*, a network of community schools in Latin America and Africa
    http://www.scholasoccurrentes.org
11. *Starshine Academy schools*, Innovative and participative school, United States
    http://www.starshineacademy.org
12. *TEH (Transformer l'enseignement en Haïti),* Teacher in-service qualification, Haiti with France
    http://teh.fondation-lamap.org

Annex 2. List and Affiliations of Contributors (Authors and Co-authors (*))

Contributors

Jorge Allende
Faculty of Medicine, University of Chile, Chile
<jallende@uchile.cl>

Luis Arancibia Tapia
Federación Internacional de Fe y Alegría, Colombia
<fi.coordinador@feyalegria.org>

Werner Arber
President, Pontifical Academy of Sciences and Biozentrum Department of Microbiology, University of Basel, Switzerland
<W.Arber@unibas.ch>

Margaret Archer
President, Pontifical Academy of Social Sciences and Department of Sociology, University of Warwick, UK
<Margaret.Archer@warwick.ac.uk>

Kaushik Basu
University of Cornell, World Bank, USA
<kbasu@worldbank.org>

Antonio M. Battro
Pontifical Academy of Sciences and National Academy of Education, Argentina
<abattro@ross.org>

Rao R. Bhavani
Amrita University, India
<bhavanee@gmail.com>

Jacques Blamont
University of Paris VI, France
<jacques.blamont@cnes.fr>

Joachim von Braun
Pontifical Academy of Sciences and Center for Developmental Research ZEF,
University of Bonn, Germany
<jvonbraun@uni-bonn.de>

Cynthia Breazeal*
Media Lab, Massachusetts Institute of Technology, USA
<cynthiab@media.mit.edu>

Yves Coppens
Pontifical Academy of Sciences and Collège de France, France
<yves.coppens@college-de-france.fr>

Tinsley Galyean*
Media Lab, Massachusetts Institute of Technology, USA
<tgalyean@curiouslearning.org>

Stephanie Gottwald*
Center for Reading and Language Research, Tufts University, USA
<steph.gottwald@tufts.edu>

Harie Han*
Environment Politics Dept., University of California, Santa Barbara, USA

John Holman
Chemistry Department, University of York, UK
<john.holman@york.ac.uk>

Bernard Hugonnier
Institut Catholique, Collège des Bernardins, France
hugonnierb@gmail.com

María Paz Jurado
Scholas Occurrentes, Argentina
<maria.jurado@scholasoccurrentes.org>

Hideaki Koizumi
Advanced Research Laboratory, Hitachi Ltd., Japan
<hideaki.koizumi.kd@hitachi.com>

Morgane Leprince*
Fondation La main à la pâte, Paris, France
<morgane.leprince@fondation-lamap.org>

Cheong Lee Yee
International Science Technology and Innovation
Centre for South-South Cooperation ISTIC, Malaysia
<dlyeec@gmail.com>

Marguerite Léna
Apostolic Community of St. Francis Xavier, France
<margueritelena@yahoo.fr>

Pierre Léna
Pontifical Academy of Sciences and Fondation La main à la pâte, France
<pierre.lena@obspm.fr>

Laura Aswati Maciuika*
Amrita University, India

Lu Mai
China Development Research Foundation, CDRF, China
<mai.lu@cdrf.org.cn>

Teenie Matlock*
Cognitive and Information Sciences, University of California, Merced, USA

Radhika Menon*
Center for Research in Advanced Technologies for Education CREATE, Amrita University, India

Robin Morris*
Strategic Initiatives and Innovation, College of Arts and Sciences, Georgia State University, USA
<robinmorris@gsu.edu>

Karunya Mulki*
School of Business, Amrita University, India

Prema Nedungadi
Center for Research in Advanced Technologies for Education, CREATE, Amrita University, India
<ammasprema@gmail.com>

Elena Pasquinelli
Fondation La main à la pâte, France
<elena.pasquinelli@fondation-lamap.org>

Raghu Raman*
School of Engineering, Amrita University, India

Veerhabhadran Ramanathan
Pontifical Academy of Sciences and Scripps Institution of Oceanography, University of California, San Diego, USA
<vramanathan@ucsd.edu>

Courtney Sale Ross
Founder, Ross Institute, USA
<cross@rossteam.org>

Jeffrey Sachs
Earth Institute, Columbia University, USA
<sachs@ei.columbia.edu>

Marcelo Sánchez Sorondo
Chancellor, Pontifical Academy of Sciences and Pontifical Academy of Social
Sciences, Vatican City
<vati332@acdscience.va>

Gonzalo Sánchez-Terán
Center for International Humanitarian Cooperation, CIHC, Spain
<gsanchezteran@yahoo.es>

Srividya Sheshadri*
Amrita University, India

Wolf Singer
Pontifical Academy of Sciences and Max Planck Institute for Brain Research,
Frankfurt, Germany
<wolf.singer@brain.mpg.de>

Manzoor H. Soomro
ECO Agency of Economic Cooperation Organization, Pakistan
<manzoorhsoomro@gmail.com>

Sidney Strauss
Centre for Academic Studies, Or Yehuda, Israel
<sidneystrauss@yahoo.com>

Carola Suárez-Orozco
Graduate School of Education and Information Studies, University of
California, Los Angeles, USA
<csorozco@ucla.edu>

Marcelo Suárez Orozco
Graduate School of Education and Information Studies, University of California, Los Angeles, USA
<mms-o@gseis.ucla.edu>

Ignacio Suñol Esquirol
Federación Internacional de Fe y Alegría, Colombia
<fi.coordinador@feyalegria.org>

Anyadike Tobechi
Assumpta Science Center Owerri ASCO, Nigeria
<tiaen@yahoo.com>

Sally Tomlinson
Department of Education, University of Oxford, UK
s@stomlinson.net

Peter Kodwo Appiah Turkson
Cardinal, President, Pontifical Council for Justice and Peace
segreteriapresidente@justpeace.va

Dan Wagner
Department of Education, University of Pennsylvania, USA
<wagner@literacy.upenn.edu>

David Wilgenbus
Foundation La main à la pâte, France
<david.wilgenbus@fondationlamap.org>

Maryanne Wolf
Center for Reading and Language Research, Tufts University, USA
<Maryanne.Wolf@tufts.edu>

(*Co-authors)

Annex 3. Attendance of the Workshop (Speakers and Observers)

Participants and Speakers

Allende, Jorge (Chile)
Arber, Werner (Switzerland)
Archer, Margaret (UK)
Arancibia, Luis (Colombia)
Bhavani, Rao R. (India)
Basu, Kaushik (USA)
Blamont, Jacques (France)
Coppens, Yves (France)
Hillis, Daniel W. (USA)
Holman, John (UK)
Hugonnier, Bernard (France)
Koizumi, Hideaki (Japan)
Lee, Yee Cheong (Malaysia)
Léna, Marguerite (France)
Léna, Pierre (France)
Lu, Mai (China)
Palmeyro, Enrique (Argentina)
Pasquinelli, Elena (France)
Prema, Nedungadi (Amrita University, India)
Ramanathan, Veerhabhadran (USA)
Ross, Courtney (USA)
Sachs, Jeffrey (USA)
Samroo, Manzoor (Pakistan)
Sánchez-Sorondo, Marcelo (Vatican)
Sánchez Terán, Gonzalo (Spain)
Singer, Wolf (PAS, Germany)
Strauss, Sydney (Israel)
Suñol, Ignacio (Colombia)
Tobechi, Anyadike (Nigeria)
Tomlinson, Sally (UK)
Turkson, Peter K.A. (Ghana)

Von Braun, Joachim (Germany)
Wagner, Daniel (USA)
Wilgenbus, David (France)
Wolf, Maryanne (USA)
Zani, Angelo (Vatican)

Pontifical Academicians

Arber, Werner
Archer, Margaret
Battro, Antonio M.
Coppens, Yves
Léna, Pierre
Mittelstrass, Jürgen
Quéré, Yves
Ramanathan, Veerhabhadran
Singer, Wolf
Sánchez Sorondo, Marcelo
Vicuña, Rafael
von Braun, Joachim

Invited Observers

Azar, Gabriela (Argentina)
Basnage, Mark (USA)
El Shahat, Sameh (China)
Foglia, José (Uruguay)
Humphrey, Chevy (USA)
Keller, Matt (USA)
Lambert, Dominique (Belgium)
Macchi, Odile (France)
Maillard, Sébastien (France)
McCarty, Steve (USA)
McCarty, Trish (USA)
Moawad, Karen (India)
Pascucci, Anna (Italie)
Pedregal, Christopher (USA)
Pennington, Hilary (USA)
Shank, Michael (USA)
Sinclair, Cameron (USA)

Suárez-Orozco, Carola (USA)
Suárez-Orozco, Marcelo (USA)
Vecchio, Giancarlo (Italy)

The Voice of Children and Teenagers (PART IV)

Participants

Educator Facilitators

Jennifer L. Chidsey and Carrie Clark (Ross Institute, USA)

Educator Participants

Béatrice Bachmann and Caroline Nicole (College Lycée Charles-Péguy, France)
Prof. Kieran P. McNulty (University of Minnesota, USA, and REACHE Program, Kenya)
Dr. Anna Pascucci (Italy)
Prof. Emanuele Piccioni (Liceo Scientifico Annesso Convitto Nazionale, Assisi, Italy)
Natasha Tourabi (United World College, Freiburg, Germany)

Students

4 students (age 16), United World College Robert Bosch, Freiburg, Germany: Natali, Iryna, Jay, Jonas
4 students (age 12 to 14), Istituto Comprensivo "A. Volpi," Cisterna di Latina, Italy: Kenneth, Leonard, Alessandra, Gabriel
1 student (age 17), Liceo Scientifico Statale "A. Labriola," Naples, Italy: Francesca
1 student (age 17), Liceo Scientifico Statale "U. Dini," Pisa, Italy: Anas
1 student (age 13), Istituto Comprensivo "R. Viviani," Naples, Italy:Marcello
2 students (age 15), Lycee Charles-Peguy, Bobigny, France: Eda, Jeanne
6 students (age 12 to 18), Ross School, East Hampton, NY, USA: Kwazi, Shanshan, Malik, Isabelle, Diego, Andrew

Annex 4. Group Photograph (Participants)