



Educating for Sustainable Development & Climate Change: a Challenge for Science Academies

Pierre Léna

Université Paris-Diderot & Fondation *La main à la pâte*, France

Introduction

The future of the Earth's climate, hence of humans beings, is becoming today a central issue in science, in economics, in politics, and even in ethics. Mitigating the global warming, adapting to its worse consequences, designing new ways of living, consuming, producing food and energy are subjects of considerable research, analysis, policies and actions. Climatology was born of 'hard' sciences, such as physics, chemistry, Earth sciences, biology, oceanography, geology, astronomy, indeed mathematics and computer science: it has developed as an interdisciplinary field mixing all these disciplines. More recently, the potential impact of climate changes on human societies and on the fate of individuals has required the involvement of social sciences, extending the interdisciplinarity. Finally, the magnitude of the risks encountered by present humanity and future generations, as well as the necessity to invent a new relation between humans and nature, introduced anthropology and ethics. Entering the *Anthropocene*, to use the term coined by Paul Crutzen, is a great mutation in the course of history.

My contribution aims at stressing the importance of education to prepare and accompany this mutation. The 1946 call by Albert Einstein, initially on the risk of a nuclear war, may well apply today: *A new type of thinking is essential if mankind is to survive and move to higher levels.*[1] Education is the way societies have built to transmit the knowledge of the past, but also to prepare the young generation for the challenges of the future. Adults of tomorrow are today in schools, and they are the ones who will live in the whole 21st century, bearing its evils but possibly being agents of change.

The concern has recently emerged for education as a way to cope with climate change. We analyze here this emergence, what this concern may mean, and how *new types of thinking* could be implemented worldwide in primary and secondary schools, as well as in higher education, to better prepare youth for its future.

1. A recent surge of concern

It is well known that the influence of atmospheric carbon dioxide on Earth's temperature, hence climate, dates back (publications from 1896 to 1903) to the Swedish scientist Svante Arrhenius (1857-1927). After refinements in models and in the physics of the problem, the American Jule Gregory Charney (1917-1981) chaired a Committee of the National Research Council (USA), which in 1979 established a relation between the rate of CO₂ increase and induced temperature rise: although refined, the 1979 prediction remains essentially valid. Eight years later, the Vostok ice drilling in Antarctica produced evidence of the role of insolation changes and established the positive feedback of greenhouse gases on climate. The Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) *to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation*. Successive IPCC reports and Conferences of the Parties (COP) increased public and political visibility of climate matters, while the diagnosis remained stable, reaching a constantly increased accuracy (e.g. deciphering the role of clouds and aerosols). A combination of powerful numerical modeling and data collection led to an improved and much more precise attribution of the observed global effects (sea level rise, ocean acidification, arctic ice melting) to global warming, due to greenhouse gases (mostly CO₂, CH₄ and N₂O, H₂O having a different equilibrium regime) and their dominant anthropogenic increase. The projections in the future and causal analysis were expressed in terms of likelihood, translated into more precise degrees of confidence.

In May 2014, when the 5th IPCC Report[2] was finalized, the two Pontifical Academies (Sciences and Social Sciences) organized a Workshop on *Sustainable Humanity, Sustainable Nature, Our Responsibility* where most of planetary the issues were addressed, from physics to social sciences.[3] Nevertheless, the high quality of the work and discussions stopped short of addressing the challenges which climate change, adaptation and mitigation pose to education, despite the obvious conviction of the participants that it was an important and urgent matter. A series of important events were soon to underline this point.

Firstly, just a year later, Pope Francis published his Encyclical Letter *Laudato Si'*, which devotes a full chapter to 'Ecological education and spirituality', pointing to the educational challenge: *Many things have to change course, but it is we human beings above all who need to change. We lack an awareness of our common origin, of our mutual belonging, and of a future to be shared with everyone. This basic awareness would enable the development of new convictions, attitudes and forms of life. A great cultural, spiritual and educational challenge stands before us, and it will demand that we set out on the long path of renewal* (6, 202).[4]

Then, in September 2015, the United Nations published the *Sustainable Development Goals*, including education (SDG #4).[5] This synthesis of goals was more specifically accompanied by an inspiring and extensive UNESCO Global Education Monitoring Report (2016), *Education for people and planet: Creating sustainable development for all*. [6]

On December 12 the same year, the 195 national delegations at the Conference of the Parties (COP 21) in Paris signed the *Paris Agreement*, which entered into force after the requested number of ratifications on November 4, 2016. This Agreement addresses education in a specific manner in its Article 12, which reads: '*Parties shall cooperate in taking measures, as appropriate, to enhance climate change education, training, public awareness, public participation and public access to information, recognizing the importance of these steps with respect to enhancing actions under this Agreement*' [7]. The point was already present in the United Nations Framework Convention on Climate Change (UNFCCC, 1992), requesting '*The development and implementation of education and training programmes ... in particular for developing countries*' (Art. 6.b.ii). [8] Although the legally compelling aspects of the Paris Agreement remain unclear, its Article 12 is fundamental, since for the signing countries it relates the quantitative goals of the Agreement to a specific action in education.

As climate science is at the heart of the whole process, the scientific community could not stay absent from this new scene of educational challenges. In order to complement its 2014 session and in phase with the COP21, the Pontifical Academy of Sciences organized a specific Workshop in November 2015 on *Children and Sustainable Development: a Challenge for Education*, [9] which began to address the educational challenges for coping with climate change and to gather a series of local actors, from India to California, from Nigeria to France, ready to move into these. At the COP22 in Marrakech (Morocco), several Side Events gave visibility to the matter, including one organized by the Hassan II Academy in Rabat, [10] and several others during the COP itself (IPCC, UNESCO...). In France, the Académie des sciences, jointly with the Agence française de développement, organized a Workshop (Nov. 2016) on *Développement durable, changement climatique et éducation*, [11] which was concluded by Laurent Fabius, the chief negotiator of the COP21. His passionate plea was to condition the long-term success of the COP21 to a considerable effort in education: *It is necessary that, by a diversity of methods, using the oldest techniques as well as the most recent ones, one reaches a point where the young generation would really understand the phenomenon* [of climate change]. [12] And he concluded with a quote by Nelson Mandela: *Education is the most powerful weapon which you can use to change the world, and it is a peaceful weapon*.

This short overview of the last few decades clearly shows a surge of concern. There is decisive progress in the consciousness of the role of education for the future of humanity as a whole, in face of the very real threats of climate change. How then should one proceed? At this point, it appears clearly that climate education, although not explicitly present in the IPCC terms of reference and mandate for action, is requiring some specific analysis, global organisation and actions, in parallel with local initiatives which begin to appear. These will be discussed below.

2. Educating to climate: from understanding to action

The cumulative effect of greenhouse gases in time implies that every delay, measured in years rather than decades, in acting on their production (attenuation/mitigation) makes the next step more difficult, whether it is related to environmental impacts (sea level, ice melting, extreme events...) or societal ones (water availability, food security, climatic refugees...). On the other hand, the timescale for changes in education is usually long, measured in decades rather than in years. This obvious contradiction will not be easily resolved, but this is not a reason for refusing to confront it.

Education will have to make understood and acceptable behavioural changes regarding jobs, energy and water usages, agriculture, transportation, carbon taxes, hence regarding almost all relations which humans have among themselves and with their host planet, fragile and finite. Moreover, the recent notion of climatic justice calls for new solidarities beyond the nation, the region, even the continent, since projections indicate that the ones who will suffer most, if too little is done, are the poorest, often very remote from the ones who contribute most to the climate degradation. On the very positive side, the building-up of decarbonized societies offers opportunities to imagination and entrepreneurship – as did in the past the industrial revolution, the advent of electricity, telephone, nuclear power, medical or pharmaceutical ventures and today digital revolution. All these

enterprises were and are calling for science and technical expertise, as well as management, and required an adapted and renewed education.

In the past, some changes at very large scales resulted, when education took the issue seriously. Hygiene offers such an interesting example. In France, between 1850 and 1950, life expectancy at birth increased by 50%, jumping from 40 to 60 years. This was before the discovery and generalisation of antibiotics, and resulted, especially after the discoveries of Louis Pasteur, from long-term actions in elementary schools (primary education became compulsory in France in 1881) as well as within the general public: these actions made perceived and understood the basic scientific contents of hygiene, and the potentially spectacular results of behavioural changes, once people got informed. Indeed one should not forget the ‘hygiene-sceptics’, who denied the work of the Hungarian physician Ignace Semmelweis in 1847 in his obstetrician service in Vienna, hence condemning him to a sad death in a psychiatric hospital:[13] ‘climate sceptics’ are today their equivalent, and education has to convincingly carry the word of science in face of them.

Making climate change understood represents a long way to go, seeming a nearly impossible task. One billion students on Earth receive a mediocre education, and nearly 200 millions do not receive any. In the last five years, 60 millions people increased the number of refugees worldwide, half of them being under the age of 15.[14] At the current rate of schooling, only 14% of children will access secondary education worldwide in 2030. An UNESCO inquiry, analysing the school curricula in 78 countries, showed that only 58% use the term *ecology*, and less than half of them refer to *environmental* topics.⁶ A majority of adults ignore the causes of climate change, barely understanding the greenhouse effect,[15] even if they are fearful of the future. The observed impact of opinions that deny the anthropogenic origin of the current climate change is a testimony to the ignorance of many people and of their lack of trust in knowledge and scientific reasoning. Even in developed countries such France, teachers in primary and even specialized teachers in secondary schools react more with opinions than with rational analysis.

Youth are somewhat divided when facing climate issues. On one hand, it is easy to witness enthusiasm and generosity in many NGOs (as presented during a recent conference at Erice in Sicily),[16] together with a remarkable presence of young people organisations in the UN-FCCC process and at its Conference of Parties. Emotional reactions, although generous, may not represent a strong enough background for carrying a life-long informed judgement. On the other hand, a recent in-depth analysis of the engagement of young people shows a low level of understanding and responsible conduct.[17] We conclude that a huge and sustained effort is needed to ensure that the younger generations acquire the tools for understanding and for action, forging a *critical and capable mind* to understand and to judge, and a *hopeful heart* – using here the terms proposed by Ramanathan *et al.*[18] – which will be able to build a positive future with solidarity as a beacon. Since it is almost impossible to predict what will be debated and decided in twenty years, the only solution is to empower those who will then be adults with tools that will keep them away from a *priori* thinking, ideologies or irrationality.

3. Specificities of climate education

Let me outline here some of the requisites that a sound climate education should fulfill. We shall focus on secondary education, not forgetting nevertheless the importance of primary school, where some elements could already be conveyed. Higher education would require a dedicated and different analysis.

Climate is undoubtedly an interdisciplinary subject, as it considers the Earth and its inhabitants as a global, complex and highly interdependent system, which cannot be reduced to a specialized, although needed, study. Scientific facts, models and predictions are at the heart of this systemic view, but they are not sufficient: this is well reflected in the IPCC organization into three groups (I for the science, II for the adaptation, III for the attenuation), the latter two involving social and human sciences, as well as climate science and technology. Middle and high schools are not well prepared to deal with such interdisciplinarity: their organisation in separate disciplines, the training and expertise of their teachers, and as mentioned above the present curricula do not naturally facilitate the introduction of climate by taking a systemic approach.

Consequently, practitioners of traditional disciplines, such as physics, chemistry, Earth sciences, life sciences, mathematics, social science and economics, etc., must collaborate in an interdisciplinary manner to address these issues across the curriculum, even at the elementary level. In addition, there is a need to understand how these complex interactions between natural and societal systems (e.g. risk management) connect local actions to global consequences.

Teaching complexity departs from the classical, mostly analytical scheme used to build up knowledge in schools.[19] Yet, in recent times, science has become conscious of the limits of the pure analytical method. The Earth climate system is a beautiful example of this new capability. It requires at least some understanding by the policy makers –leading to the IPCC *Summaries for Policy Makers* – as well as from the average citizen, who in a democratic regime has to exert informed choices – hence the need for education. As expressed by

the French sociologist Edgar Morin, *The inability to recognize, address and think the complexity is the result of our educational system* [...], hence a blindness of intelligence which has invaded all the sectors, technical, political and social ones.[20]

Teachers have to be introduced to scientific notions, some rather difficult, which are not usually taught in the science courses they receive and escape immediate evidence. Climate studies and conclusions involves multi-factorial causes of phenomena, a great span of space and time scales, randomness, instabilities and phase transitions, non-linearities and feedbacks (positive and negative), a sense of orders of magnitudes, differences between stocks and fluxes, probabilities and projections into the future, etc. Even if these will not be taught in detail in middle school, or even high school, they should be sufficiently approached to retain a scientific content, rather than being reduced to a vague opinion.

Scientific facts and evidences have to be transmitted as knowledge in schools, and accepted as the contribution to the truth built by science. On the other hand, actions on climate change, whether attenuation or adaptation, are based on political, economic and personal choices which result indeed from rational analysis, but also from values (justice, solidarity at distance and intergenerational) which themselves reflect ethical choices. Beyond communicating scientific facts and reasoning, education there opens the eyes of the students, develops their consciousness, ability to hope, freedom of judgment and choices to act.

Climate science education can build up on the pilot projects, which started two decades ago under the name of *inquiry-based pedagogy*. Inquiry-based pedagogy was initiated by renowned scientists (Georges Charpak, Leon Lederman, Bruce Alberts, Wei Yu, Guillermo Fernandez de la Garza, Jorge Allende, and many others). It has developed in nearly a hundred countries in the form of pilot projects of various amplitude, and has an important development in France, under the name of *La main à la pâte*. [21] Its roadmap is to provide support to teachers (primary, secondary and possibly high school) to help them teach science in an attractive way, involving active student participation in observation, experimentation, hypothesis making, argumentation, and reasoning. The scientific community is closely associated to the support and professional development of teachers, the production of relevant resources for the classroom, and the creation of national and international networks. The considerable development of these actions in the world has contributed to fuel wonder, curiosity, imagination, rationality and understanding of the processes on which science is built for over ten million schoolchildren. This development offers a sound basis for the emergence of climate change education. Nevertheless, additional elements will have to be included: economical and social issues; and ethical values.

4. A proposal to implement Climate Change Education worldwide

On December 12, 2017 a political *One Planet Summit* was called in Paris, exactly two years after the COP21. Focusing on financial issues, this Summit did not deal with education. Nevertheless, the InterAcademy Partnership for science (IAP) issued on this occasion a Statement approved by a majority of the 113 science Academies grouped under IAP. This detailed Statement, titled *Climate Change and Education*, [22] was prepared by a large group of experts, designated by these Academies. Some of its headlines messages are quoted as follows, and provide guidelines for future actions:

- a. *Climate change education must consider the need to provide teachers, in developed as well as in developing countries, with up-to-date facts, new and innovative training processes, new resources for the classroom, and new tools to empower their students as 'agents of change'.*
- b. *Inquiry-based science education (IBSE), developed over the last two decades, has demonstrated an effective way to teach science at primary and secondary school levels and also to inspire higher education worldwide. It provides a firm basis to develop urgently a specific, interdisciplinary climate change education programme.*
- c. *Climate change and associated events will disproportionately impact the poorest three billion of the global population, whose schooling is far from adequate. Climate justice calls for supporting their schools and their teachers with specific initiatives.*
- d. *International collaboration, through the involvement of the science community, will greatly enhance the mobilization of educational systems. As the Intergovernmental Panel on Climate Change (IPCC) is producing periodic 'Assessment Reports', accompanied by 'Summaries for Policy Makers', the scientific community should use the material from the IPCC reports to produce 'Resources & Tools for Teachers'.*

In the course of preparing this Statement, several remarkable projects, aiming at climate change education and teachers preparation, were quoted. Let mention here the efforts in Australian schools, [23], [24] in India, at Carleton College [25] in the United States, or in France with *La main à la pâte* [26] or *Le Train du Climat*,

[27] while many experts from developing countries pointed out the urgent need of actions in education. There clearly exists a background on which to build the program outlined in *item d* of the Statement.

This *item d* calls for 'Resources and Tools for teachers' to be published in phase with the IPCC Reports and deserves particular attention. It is currently leading to an initiative, in continuity with the above-mentioned efforts (Section 1). This initiative emerges within the Fondation *La main à la pâte* in France, with the support of the Académie des sciences, the InterAcademy Partnership and the IPCC Group I, which is devoted to climate science. This initiative, named *Office of Climate Education*, owes special credit to Dr. Valérie Masson-Delmotte, climatologist and co-Chair of Group I, who fostered most of the initial ideas. During the years 2018-2022, the Office and its Network will publish resources for teachers worldwide, along with the planned reports of IPCC: Global Warming of 1.5°C (2018), Ocean and Cryosphere in a Changing Climate (2019), Climate Change and Land (2019), Sixth Assessment Report (2022).[28]

It is not the purpose of my contribution to present in detail the *Office*, being established in Paris, and its associated *Global Network for Climate Education*. [29] Both are emerging in the frame of a French-German scientific and operational partnership (with the Siemens Stiftung); both would connect with the various networks which remarkably contributed to the Pontifical Academy of Sciences Workshop on *Children and Sustainable Development*, held in 2016.

We can enumerate here a list of attainable goals for students in almost any school in the world, if teachers are properly accompanied:

- Acquire basic scientific knowledge on climate science;
- Understand climate change in all its dimensions, both scientific and societal, at local and global levels;
- Develop their reasoning and critical thinking abilities;
- Develop their creativity, by discovering the prospects of innovation that can be explored by the struggle (mitigation and adaptation) necessitated by climate change, both in their daily lives and their future career choices;
- Perceive the profound changes in behaviour required, such as sobriety (especially in developed countries), promoting ethics and solidarity;
- Take concrete action at the scale of their school, family and community, to cope with climate change (mitigation and/or adaptation).

Conclusion

We have mentioned the contradiction in time scales between urgently required climate control and the slow pace of education changes. In his Encyclical Letter, Pope Francis says: *Although the contemplation of this reality in itself has already shown the need for a change of direction and other courses of action, now we shall try to outline the major paths of dialogue which can help us escape the spiral of self-destruction which currently engulfs us* (163). In this contribution, we have proposed to create a new and organised dialogue between the scientific community and the educators, especially the teachers, in developed as well as developing countries, in order for them to jointly contribute to an escape from self-destruction and to develop for the youth a positive vision of the future, where science would play its universal and creative role.

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References & Notes

[1] Quotation from 'Atomic education urged by Einstein', *New York Times*, May 25, 1946, p. 13. The text refers to a telegram, published the previous day by the Emergency Committee of Atomic Scientists, chaired by Albert Einstein. Other sentences with similar meaning are often 'quoted', but their sources remain untraceable (https://en.wikiquote.org/wiki/Albert_Einstein).

[2] <https://ipcc.ch/report/ar5/>

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