

THE PROBLEMS AND PROMISES OF SCIENCE EDUCATION IN CHILE

JORGE E. ALLENDE

Chile is in a process of developing its science and technology capacity. Having worked as an active scientist for 40 years in my country and having lived through very difficult times, I am optimistic that now we are making some significant progress.

I will show you a few facts why I am optimistic.

Transparency 1 shows the number of scientific publications indexed by the ISI originating in Chile through the last decade. Presently there are more than 2000 publications per year. Per capita this is the highest number of publications for any Latin American country.

The number of publications is important, but the quality and impact is more important. The following transparency (2) shows the number of citations per publications and the ranking of the different countries with this criterion. We see that Chile occupies the 23rd position – the highest for any developing country and ahead of some European countries with long traditions of research such as Greece and Poland.

In transparency (3) I have included some new Programs for support of science in Chile which have been generated by the government and which

Transparency 1. ISI PUBLICATIONS FROM CHILE

	1990	1991	1992	1993	1994	1995	1996	1997	1998
SCI SEARCH	1.220	1.197	1.306	1.404	1.412	1.629	1.739	1.770	1.843
% World Total	0.178%	0.170%	0.181%	0.184%	0.177%	0.190%	0.193%	0.189%	0.195%

Transparency 2. THE 30 CLASSIFIED NATIONS BY CITATIONS
PER PUBLICATION (1992-1996)

Country	Citations by Publication	Number of publications	Total citations
1 Switzerland	5,66	55.213	312.564
2 United States	5,03	1.239.188	66.234.187
3 Netherlands	4,45	80.016	356.025
4 Sweden	4,38	61.072	267.685
5 Denmark	4,38	30.719	134.616
6 United Kingdom	4,19	330.677	1.259.427
7 Belgium	3,94	38.095	150.206
8 Finland	3,93	26.998	106.151
9 Canada	3,83	167.326	641.114
10 Germany	3,78	258.956	979.823
11 France	3,66	197.816	723.156
12 Austria	3,54	24.388	86.275
13 Israel	3,45	39.977	137.980
14 Italy	3,42	116.534	398.285
15 Norway	3,30	19.814	65.305
16 Australia	3,23	85.215	275.599
17 Japan	3,18	280.855	892.029
18 New Zealand	2,94	17.015	59.007
19 Ireland	2,78	9.233	25.630
20 Spain	2,72	73.224	199.443
21 Hungary	2,55	14.768	37.724
22 Portugal	2,40	7.135	17.097
23 Chile	2,31	6.666	15.366
24 Greece	2,02	15.216	30.666
25 Poland	2,00	32.728	65.610
26 Argentina	1,98	12.266	24.334
27 South Africa	1,94	17.418	33.737
28 Hong Kong	1,92	19.379	40.106
29 Mexico	1,91	13.043	24.962
30 Brazil	1,89	25.578	48.406

Source: ISI - Science National Indicators

Transparency 3. NEW PROGRAMS FOR SUPPORT OF SCIENCE AND TECHNOLOGY IN CHILE

<p>FONDAP PROJECTS CONICYT <i>1999, 2001</i></p>	<p>7 projects in Astronomy, Oceanography, Physics and new materials, Applied Mathematics, Cell Biology, Signal Transduction and Ecology 1 million USD/year for 10 years</p>
<p>MILLENIUM INSTITUTES WORLD BANK – MINISTRY of PLANING <i>1999, 2001</i></p>	<p>3 in Biophysics, Biotechnology and Genomics 700.000 USD/year for 5 years 10 Nuclei 300.000 USD/year for 3 years</p>
<p>INTERAMERICAN BANK – MINISTRY of ECONOMICS <i>2000-2005</i></p>	<p>100 million USD for Technology Development in Informatics, Biotechnology, Agriculture (5 million for Genomics)</p>
<p>WORLD BANK – MINISTRY of EDUCATION <i>1999-2002</i></p>	<p>250 USD million for higher education From this, approx. 50 USD million are dedicated to support Doctoral training and expensive research equipment</p>

are improving the situation for funding for science and technology research in our country.

President Lagos is truly interested in scientific research and understands the relevance of science for cultural and socioeconomic development. We must recognize that despite the present financial crisis which has hit our country very hard, he is trying to honor his promise to double investment in R&D from 0.6% of the internal product to 1.2% during his 6 year term.

This may sound very rosy to you, but despite our optimism, we recognize that we still have very big problems. The biggest of them is that our society in general is not aware of the importance of endogenous science for their own development and for the progress of Chile as a nation. For most people in Chile, Science is something magical, complex and expensive that is done in the United States, Japan and Europe and that results in new gadgets or medicines that eventually appear in the stores, supermarkets or pharmacies in Santiago. The general public does not realize that scientific research and knowledge generation is something that can and should be done in their own countries and that their future and especially the future of their children depends on this.

Unless the perception is definitely changed and a general consensus among our national and regional (Latin American) societies is achieved, our present rosy picture will be fragile and ephemeral and will be changed depending on whether we are lucky on the political lottery and draw a more or less enlightened President or Minister.

It is obvious that the most sure and efficient way of changing the situation and achieving a society that understands and values science is through science education of our children.

But our argument must not be the selfish one of improving science education because that way we will get more money for science, for our labs and for our students. We should emphasize that science education must be improved because the knowledge, the attitudes and the values of science are essential for our children to live a fuller, freer, more democratic existence in the 21st Century.

Unfortunately the level of science education in Chile is very low. This statement is objectively ascertained by international tests as well as by national measurements. Rafael Vicuña presents in his contribution the results of the TIMS international test in which Chile is very close to the bottom of the list. The same very negative results can be seen in the SIMCE, a national exam that also tests natural sciences. (Transparency 4).

The most disturbing factor of these test results is the great disparity between public education, attended by the poor and the lower middle class (70-75% of the people) as compared to the private education of the privileged part of society. This is disturbing because it indicates clearly that we are not providing an equal opportunity to the children of the poor, on the contrary, we are giving them a handicap in the competition to enter the University or to prepare themselves for their life work.

Transparency 4. RESULTS OF SIMCE NATIONAL EXAM
IN NATURAL SCIENCES

4^o Year of Primary Education – % correct answers

Year	Municipal Public	Private State Supported	Private Paid
1992	56.1	62.5	76.3
1994	64.3	67.4	78.0
1996	65.7	69.0	81.4

Average of 24.000 students in a National sample

8^o Year of Primary Education – % correct answers

Year	Municipal Public	Private State Supported	Private Paid
1991	47.81	52.32	67.11
1993	50.87	55.03	68.33
1995	55.68	60.15	75.14
1997	59.26	63.05	75.42

The last two years around 150.000 students were tested

The key factor to explain this low level resides in the training and support received by those rather heroic individuals that teach science at the primary and secondary education.

The market economy and the low salaries and poor social recognition that teachers receive in our countries have made teaching in pre-university

Transparency 5. SECONDARY SCHOOL SCIENCE TEACHERS
GRADUATING IN CHILE – 1999

Mathematics.....	78	[only 7 graduated from a research University]
Mathematics and Physics.....	4	
Physics	11	
Chemistry	37	
Chemistry and Biology	4	
Biology.....	44	
Total	178	

In the national entrance exams, the students accepted to train as science teachers were in the lowest 30% of those accepted to institutions of higher education.

education very unappealing. Despite incentives and fellowships recently provided for those that enroll in teaching careers in Education Faculties and Teacher Universities, the numbers of those graduating in science teaching are terribly low. (Transparency 5).

In addition to the low numbers, their performance in the national university entrance exam shows that the students applying to be the future science teachers have some of the lowest qualifications of any profession.

To compound matters, only a very small percentage of teachers graduate from the few research universities that we have in the country. Therefore, science teachers graduate without ever being exposed to the real active science and without having contact with working scientists.

Obviously this rather dismal picture has to be changed drastically if we are to improve science education.

We have to raise the salaries and prestige of teachers and have to get the research universities involved in teacher training. Those are national policies that imply major financial and political decisions.

Another area in which scientists and scientific institutions can and should directly participate is the area of working with science teachers and

with the education institutions to update their knowledge of science progress and to provide them with materials and tools that can be used to transmit to the children the fascination and the adventure of science.

As will be stressed in a special session of this meeting, we, the scientists individually and collectively have a responsibility to work to improve the science education that is provided to our children and youth.

This responsibility arises from our contract with society, with our duty to inform society what we are doing and why our work is important for our countries and the world. We have to serve as antennae for our people to tell them what is happening in the world of knowledge and how new scientific discoveries impact them. We also have a responsibility to prepare the children and the young to grasp the opportunities of the Age of Knowledge.

I am pleased to report that in Chile the scientific community has become aware of this responsibility and has started to do something about it. (Transparency 6).

The Chilean Academy of Sciences and the scientific societies gathered around the National ICSU Committee have played a key role in organizing the National Association of Science Teachers, which now has close to 1000 members throughout the country. This association founded in 1994 as a result of an interacademy meeting held in Santiago in 1993 organizes a yearly Congress and stimulates many activities. Its headquarters are precisely in the premises of the Chilean Academy of Sciences and since its foundation it has been a joint effort in which scientists collaborate with science teachers in those areas in which they require support.

The Chilean Academy as a result of the meeting of the Interacademy Panel held in Tokyo last year, also decided to increase its concern with science education. We are organizing a meeting in January 2002 to which 15 other academies, from other Latin American country and from many other countries will participate.

The focus of this meeting is the design and use of simple experimental materials in the classroom to allow children to use their hands and do experiments and learn on their own important scientific principles. We have obtained support from the Andes Foundation and the Minister of Education to organize this meeting. More important than this, is the fact that both a group of scientists and the Ministry of Education are excited to start this kind of Program in our country.

Another very positive aspect is that the Ministry of Education is very much aware of the need to raise the level and equity of education in all areas but very specifically in the sciences.

Transparency 6. INVOLVEMENT OF SCIENTISTS IN SCIENCE EDUCATION ACTIVITIES

- 1) *Chilean Academy of Science and National ICSU Committee*
 - Foundation of the National Association of Science Teachers in 1994.
 - Organization of an International Meeting of Academies to discuss the use of experimental materials in inquiry based learning of science Santiago, January 9-11, 2002

- 2) *Ministry of Education*
 - Educational Reform together with a group of active scientists have defined a set of Fundamental Objectives and Minimum Obligatory Contents for Primary and Secondary Education
 - Detailed programs for each discipline for each year of basic and secondary schools
 - Massive training courses for teachers
These programs provide examples of content and activities for teachers and “Benchmarks” for student attainment.

- 3) *The National Research Council (CONICYT) - EXPLORA Program*
 - has the objective of making science accessible to society and stimulating science education.
 - National Science Week (every year)
1000 scientists in 1000 class rooms
 - Science interactive museum

- 4) *Research Universities*
The Instituto de Ciencias Biomédicas, Faculty of Medicine, University of Chile
 - Teacher training courses in biology
 - Practical course on molecular biology
 - Adoption of schools in poor neighborhoods
 - Training of bright students to enable them to enter University careers

To achieve this, a very large and ambitious Educational Reform Program has been launched by the Ministry of Education a few years ago and in the framework of a large increment in the investment in education.

In the area of sciences, the Educational Reform as designed by the Ministry of Education has worked with a group of very active scientists to define a set of Fundamental Objectives and Minimum Obligatory Contents of Secondary Education. The publication of a book with these essential definitions has been a very important step which require an active debate,

which in the case of Chile, was concluded with the decision to maintain the rather conservative idea of the large scientific disciplines, not the more revolutionary idea of integral learning of all sciences.

The group of scientists and educators in the Ministry has gone on further to provide Programs of content and activities for the teachers as examples of what they should be doing with their students to achieve the minimal standards. These Programs are books for each subject and each year of basic and secondary education and serve as teacher's guide and also as a guide for the authors of text books which are selected in an open competition. These Program books are extremely helpful to point at "benchmarks" of knowledge that the students should attain in these subjects.

I think this is a very positive example of how government policies can be implemented with the very active and decisive help of active scientists who are generous enough to give their time for this crucial task.

Another very important activity that is being carried out by our government with the help of the scientists is the Explora Program of the National Research Council (CONICYT). During the past 3 or 4 years this Program has greatly increased its activities of motivating children and science teachers to undertake projects and initiatives in science education. EXPLORA organizes a yearly science week that take place in our Spring. In that week there are many activities but the most important is called "1000 scientists in 1000 classrooms" in which that number of scientists visit and give lectures to primary and secondary school children about science, its fascination and its impact. Although this is a large part of the Chilean scientific community, there is no problem getting the scientists to agree to give these lectures because they find it a very rewarding experience.

A new interactive science museum build in Santiago is also a very positive aspect in this area.

A further example of what is being done by scientists in the area of education deals with University units.

I have stated that one of the most serious problems with teacher's training is that this is carried out in Education Faculties or even in "Teacher's Colleges" or Universities. These Faculties or Universities do not have groups doing scientific research. It can be concluded that science teachers are trying to convey to their students about the marvelous achievements of science without ever visiting a laboratory or talking to active scientists. This situation is made more serious by the celerity of scientific progress. It is very difficult for the scientists themselves to keep up with the advancement of the ideas and techniques in their specific field, obviously it has to be

impossible for teachers to maintain abreast of a very wide discipline of knowledge about which news are coming out every day in the internet and in the news programs.

We can and should do something to remedy both situations. Scientific institutes and university departments that are research oriented should take part in organizing training courses for updating teachers.

In our Institute of Biomedical Sciences, Faculty of Medicine, University of Chile, we are actively working with biology teachers in the public schools of Santiago running courses on morphology, physiology, genetics and molecular biology.

In this last subject we have developed a practical one week course in which we have trained more than one hundred high school teachers. It is great to see the excitement of these teachers when they can clone genes and transform bacteria and isolate DNA.

We have the project of developing a mobile DNA laboratory that can visit schools and let the students carry out experiments of genetic engineering.

One of the most worthwhile programs undertaken by the Faculty of Medicine deals with the adoption of 3 high schools of one of the poorest neighborhood in Santiago, called La Pintana. This means that the teachers of those schools get the chance of a number of special training programs to help them raise the level of their teaching. In addition, 8 of the top students from that neighborhood are receiving special individual tutoring in the Faculty of Medicine with the objective to get them to do very well in the national entrance exam so that some of them can enter medical school or some other university careers. That was something unheard of in that neighborhood of La Pintana, its youth thought they had no future and were destined to increase the number of jobless or problem citizens. The fact that some of their own will be given a chance to escape this fate has had a tremendous impact in the morale of the whole school system of this poor municipality. It is something we should expand.

We are pleased because in the past few years, our scientific community has really started to understand its responsibility and has worked with enthusiasm on science education. However, it is a huge, massive task and there is a great deal to be done.

In this respect, I think that it is very important in this international meeting that we go further than the stimulating exercise of learning from each other what we are presently doing. In my opinion there is a need for generating international collaborative projects in this area in which we can

synergize and complement each other and make full use of the resources and infrastructure available in various countries.

There has been a lot of discussions about the good and bad things of globalization. Well, whether we like it or not, science is a globalized area that was born that way, there is no folklore in science, international science is the only true science. We should make use of this in science education through international efforts.

Transparency 7. PROPOSALS

Academies and scientific institutions should generate one or many projects to carry out joint international activities dealing with pre-university science education.

- 1) International courses to train and update science teachers
- 2) A set of “benchmarks” of minimal required objectives for the attainment of children at an international level
- 3) Sets of experiments and materials that could be available to science teachers of any country
- 4) International science teacher prizes

These activities should be included in an international project.

For instance (transparency 7), we could organize international courses for updating science teachers. We could generate and agree on an international set of benchmarks for our children’s science attainments. We could design sets of experiments and materials that could be available at minimum cost in all countries. We could institute international science teacher prizes for outstanding achievement. I am sure that you will have many other ideas, but it is certain that if academies with the prestige of the Pontifical Academy, together with TWAS and some of the National Academies, get behind such a project, we will be able to find funds to support this very worthwhile effort.