Chapter 20. Science for Education network: The Brazilian proposal

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The new concept of Science for Education is proposed in this chapter, based on the 2D suggestion by Donald Stokes about the Pasteur's quadrant as the golden standard for best efficacy of scientific research. In addition, we introduce and describe the effort to constitute a network of Brazilian leading scientists who perform research translatable to education. A description of the way this network was formed, as well as its proposals and activities are offered. It is expected that the adoption of translational research inspired by education will add virtuously to other policy measures designed to push Brazil and other countries to a more developed educational level.

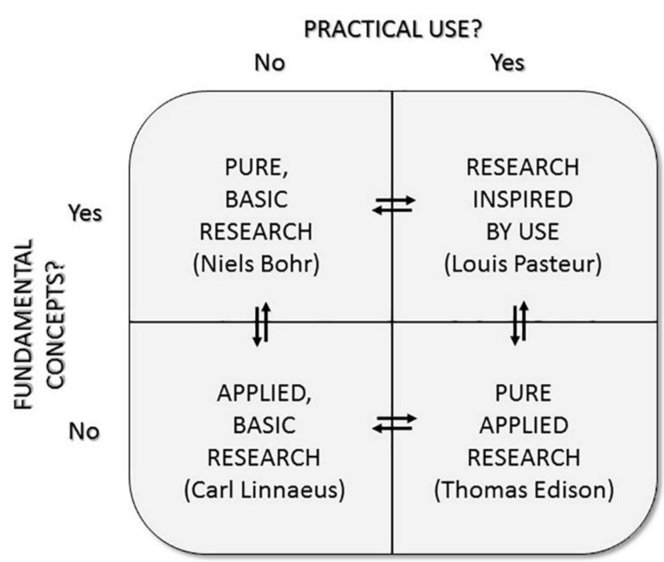
Conceptual baselines: The present

Translational science needs to target education

One of the most important advances in the world, at the transition between the 20th and 21st centuries, has been the consolidation of the concept created by Donald Stokes (Stokes, 1997[1]) on translational research inspired by use, implemented with great success in health and engineering in practically all countries of middle and high GDP. This concept, understood as a bidimensional quadrant connected both to basic, fundamental research and to innovation and development of technologies with a social insertion (Figure 20.1), stimulates the financial agents of scientific research (public and private), as well as scientists themselves, to orient their scientific efforts towards research lines framed by potential applications of social interest.

In the biomedical sciences, for instance, translational research ("from bench to bedside") acquired a consistent set of players – from scientists in universities and research institutions, on one side, to the hospitals and clinics on the other side. Making the bridge between both sides there are small startup and spin-off companies, big pharmaceutical companies that make part of the health industrial complex and governmental systems that formulate public policies in this area.

Figure 20.1. The Pasteur's quadrant



Note: Bidimensional model of scientific research based on quadrants coined after representative, historical names of outstanding scientists who performed research responding to the questions displayed at the axes. Modified from Stokes (1997).

This structure has capillarised in many countries, and orients, for instance, the initiatives of the National Institutes of Health, in the United States, as well as the work of the Oswaldo Cruz Foundation, in Brazil. In general, world population health has advanced during the last decades worldwide, despite inequalities and internal difficulties of each country (WHO, 2015[2]). This evolution can be verified by the general health indicators, such as child mortality, life expectancy and the growing therapeutic possibilities developed for cancer, degenerative diseases and many infectious diseases. A similar rationale may be extended to the exact sciences (mathematics and physics, for instance) and their technological applications.

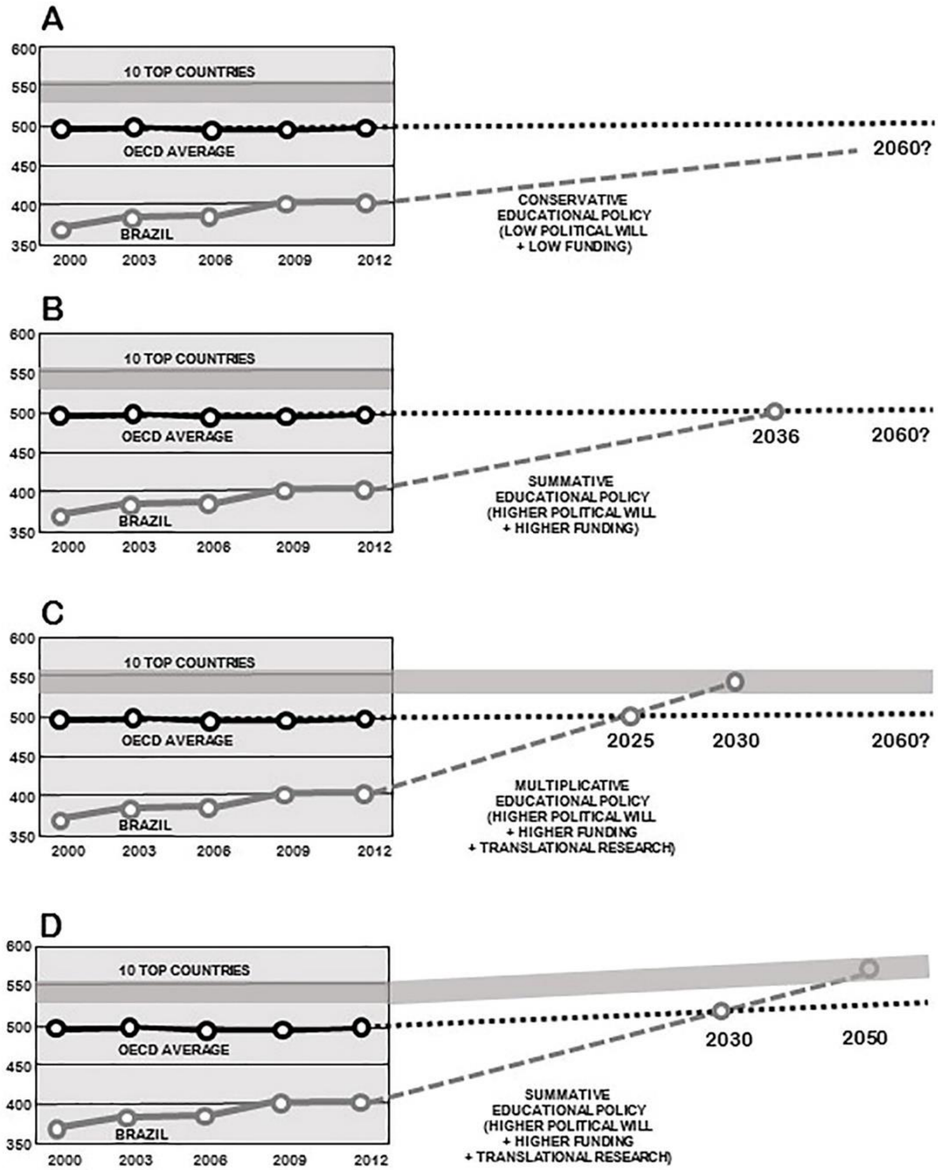
The same, however, has not occurred in education. There is still no clear perception by social agents, even in developed countries, that scientific research is already able to understand how students learn, how teachers communicate with students, which are the possible mechanisms that accelerate learning and teaching, and how this would impact on the economy and social progress of all nations. It is not perceived, as well, neither that technological innovations can be validated with populational studies to rationalise in great scale education at the classroom, nor which socio-emotional competences future citizens should have in order to become inserted in companies more and more automatised and informatised; and many other possibilities. The players who exist in health and engineering have not been connected in education ("from bench to the classroom"), and the humble attempts to link science in universities and research institutions with the schools have not succeeded as much as necessary to multiply initiatives by the public and private economic sectors, as has been the case in health. As a consequence, educational policies are either intuitive or ideological but seldom based on scientific evidence, both for the proposal of new interventions in the school system and for the evaluation of those effectively implemented.

The quality of basic education in Brazil is far below international average

Perhaps because of this omission gap, at least partially, progress of the Brazilian educational indicators has been so modest (OECD, 2013[3]), albeit positive, with maintenance of the gap relative to countries with a more aggressive stance in this particular issue, such as Finland, Poland, Singapore, South Korea and others (Figure 20.2A). In the case of health, public policies not only invest on material improvements (sanitation, hospital attendance, nutritional balance, for instance), but also in science and innovation capable of creating new options, original and competitive in the international scenario (such as new therapies for degenerative diseases and new vaccines for infectious diseases). Differently, in the case of education, investment is exclusively focused on material improvements (more schools, better salaries for teachers), which are necessary, but insufficient to accelerate the growth of Brazilian indicators at rates faster and more competitive, that would allow the country at least to reach the educational development rates of central countries in less time (Figure 20.2B-D).

Perception of this shortcoming is just starting, in Brazil as much as among the international scientific community (Meltzoff et al., 2009[4]; Sigman et al., 2014[5]) albeit just in a few countries that have created incipient initiatives in the form of Science of Learning Centers – among them the United States (NSF, n.d.[6]), Australia (SLRC, n.d.[7]) and China (Asia Society, n.d.[8]). Very recently, in February 2016, the Japanese National Science Council organised a meeting of 12 Academies of Sciences of different countries, including the Brazilian Academy of Sciences, in which one of the approved documents mentions explicitly the need to invest in this aspect of science (Statement, 2016[9]). The document was forwarded as a proposal to the G-8 meeting of international leaders that took place in May 2016 in Japan.

Figure 20.2. PISA: The Brazilian performance and the future



Note: Different prospective scenarios for Brazilian Education. Ordinates depict the PISA average indexes for reading, mathematics and sciences. In A, a conservative scenario with low investment both on educational policies and on funding (conservative educational policies). B shows a more positive scenario in which political will for new educational policies add to increased funding (summative educational policies). C depicts an even more positive scenario, on which translational Science for Education increases even more the Brazilian growth derivative (multiplicative educational policies). Finally, D takes into account the possibility that Science for Education becomes adopted more widely and implemented by most top developed countries, increasing their growth accordingly.

The potential contribution of the different scientific disciplines to education, nonetheless, is becoming undisputable. Gradually, more and more, Neuroscience manages to unravel brain connectivity and the dynamics of functional interaction between the brain, behaviour and the environment (Mišić and Sporns, 2016[10]), as well as the pathways of nervous system development and plasticity (Tovar-Moll and Lent, 2016[11]) that make the brain capable of moulding, adapting and modulating its development in response to external stimuli. Mathematics develops algorithms and models capable of describing and reproducing cognitive processing, a knowledge that transfers to computer science with an aim at creating machines that change their performance by learning from the inputs (Ghahramani, 2015[12]). Moreover, molecular and cell biology advance in understanding the interactions between molecules and cells of different organic systems, during learning and social interchange (Kandel, 2012[13]; Liu et al., 2014[14]). And developmental biology allows understanding embryogenesis and child development and their disorders (Homberg et al., 2016[15]), both their genetic and epigenetic determinants, as well as other environmental influences. This multidisciplinary development has created processes and tools that accelerate learning (especially in the area of educational applications and software of extensive social diffusion), with a high potential of use in great scale. Besides, it has stimulated the work of the Social and Economic Sciences, in the effort to unravel macro- and microeconomic determinants that may underpin public policies (Doyle et al., 2009[16]).

A new scenario ahead: The future

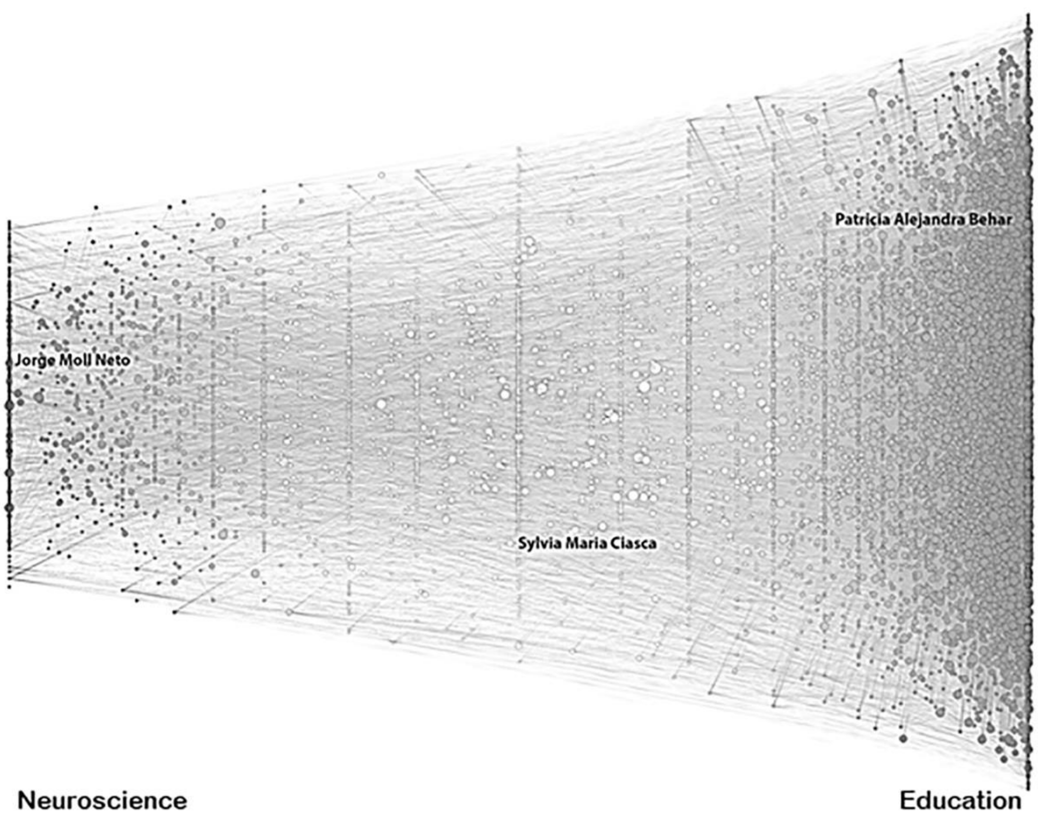
The aforementioned scenario has opened to Brazil a window of opportunity, aiming to create alternatives with this profile, with new laboratories conceived to perform research translatable to education. To give concreteness to this possibility, the proposal here offered for discussion is that new initiatives of funding by public and private agencies adopt Science for Education as a structuring axis. This term is preferred instead of Science of Learning, in order to be maximally inclusive for a broad range of disciplines and to take into consideration not only the mechanisms of learning, but also the environmental contours that facilitate learning and improve education as a social initiative. Education in the social context is a bi-univocal, interactive process, involving someone who acquires skills and/or information, and someone else (or institution) who manages to convey them to the former.

Based on these concepts, a small group of researchers founded at the end of 2014 the Brazilian Network of Science for Education (Rede CpE[1]). Due to the lack of tradition in translational research for education, mentioned above, there was no structured information available on who did – or could do – such kind of work in Brazilian universities and research institutions (Lane, 2010[17]). A survey was planned to identify research groups and researchers with this profile in the whole country, and a data mining tool was used with this purpose (Mena-Chalco and Cesar-Jr, 2009[18]). It was possible to search the Bank of PhD Theses and MSc Dissertations of the Brazilian Ministry of Education, and also the Lattes CV Platform of the Ministry of Science, Technology, Innovation and Communication, using keywords and filters to identify those scientists by their research lines, their connection to graduate programmes and their degree of seniority and productivity.

The first step was the production of keywords identifying areas of interest in Science for Education. We opted initially for 337 keywords connecting neuroscience with education, and these were first used to data mine the Bank of Theses and Dissertations, yielding 607 389 documents. Then, in order to prioritise the established research groups (qualified critical mass of senior researchers), we applied a filter to eliminate supervisors with less than five completed theses or dissertations, arriving at a figure of 7 301 researchers. Using this list, we searched the Lattes CV Platform, filtering homonymous and inactive profiles, and calculating the academic age of these researchers (time interval between the first and the most recent published paper). The resulting number was 4 165 senior researchers. This showed us that Brazil counts currently with at least a critical mass of over 4 000 senior researchers with a potential to inspire their research by educational issues.

The following step was to use algorithms to identify the degree of collaboration between these researchers, since we were interested in identifying those more articulated with their colleagues to perform multidisciplinary studies. The software Gephi was used to visualise the network structure, and to identify nodes and connectors. The resulting number totalised 1 397 names of researchers whose collaboration map, as well as their CV, can be scrutinised directly by the developed software (Figure 20.3). We then focused again on the above keywords in order to achieve an easier approach of the critical mass available. In this context, from a list of 200 research groups led by senior, experienced and productive researchers, we started inviting them to make part of the Brazilian Network of Science for Education.

Figure 20.3. Graph depicting network of Brazilian researchers



Note: A graph depicting the network relations between Brazilian researchers whose work fulfil the proposed keywords. The proof of concept of this study was performed opposing "pure" Neuroscience researchers (at left) with "pure" education investigators (at right). Intermediate dots illustrate the distribution of all others whose work associate neuroscience with education. Some names are given as examples. The same analysis, of course, can be done with different keywords to include other approaches. Modified from Botaro et al. (2016).

A research network in benefit of education

By September 2016, almost 80 groups have accepted to make part of the network. These groups work on different disciplines, namely (in alphabetical order): biochemistry, biology, computer science, economics, epidemiology, genetics, information technology, linguistics, neuropsychiatry, neuroscience, pedagogy, psychology and speech therapy. Some examples of research topics investigated by CpE members are: synaptic plasticity and sleep (Blanco et al., 2015[19]); number transcoding and phonemic awareness (Lopes-Silva et al., 2016[20]); computational modelling of synaptic plasticity (Antunes, Roque and Simoes-de-Souza, 2016[21]); reading comprehension in dyslexics (Kida, Ávila and Capellini, 2016[22]); brain representation of bilingualism (Buchweitz et al., 2012[23]); relation between school performance and future wages (Curi and Menezes-Filho, 2014[24]); machine learning (Garcia, Carvalho and Lorena, 2016[25]); biochemistry of memory (Furini et al., 2015[26]).

Besides the censitary data mining described above, different initiatives were done in the last two years, including national and international meetings (especially the International Symposium on Science for Education in July 2015, a satellite event of the IX IBRO World Congress of Neuroscience, held in Rio de Janeiro, Brazil). In addition, work documents are being prepared by groups of members about topics as literacy, learning disorders, socio-emotional competences and physiological factors that influence learning. (Lent, Buchweitz and Borges Mota, 2017[27])

The mission of the CpE network can be summarised in four main objectives: 1) to perform and foster scientific research in any discipline having a potential to impact educational policies and practices; 2) to establish a bridge between scientists and society at large, especially the educational actors (policymakers, educators, teachers), through a strong presence in communication and diffusion by the media, mainly among the young people; 3) to maintain links and partnerships with universities and research institutions, on the one hand, and the public and private sectors, on the other hand, with an aim to facilitate knowledge production translatable to educational products and processes; and 4) to form human resources of high level (scientists and educators) through university graduate programmes.

The CpE network proposes that objective 1 be implemented by a facility formed by four laboratories, forming a **National Center of Science for Education**, of multiuser characteristics: 1) laboratory of neuroimaging, using MRI and fNIRS technology; 2) laboratory of functional multi-recording, using electroencephalography, eye tracking and different physiological recording; 3) laboratory of mathematical models and digital technologies; and 4) laboratory of animal models. Steps and forms to constitute these laboratories, as well as the necessary budget, their scientific and technical personnel and organisational profiles are being negotiated with private and public sources.

Objective 2 is being fulfilled through a strong effort of science communication through media (material or virtual) created to diffuse the themes of Science for Education among the public in general[2], especially children and youngsters. It would be substantial, as well, in this context, to make the theme a pole of national and international attraction, through the organisation of events (symposia, seminars, workshops) designed to discuss the pertinent topics. In this respect, the CpE network has organised national and international meetings, some more restricted to scientists, other designed to bridge the gap between scientists and educators. In particular, special mention is deserved by the International Symposium of Science for Education, a satellite of IBRO World Congress of Neuroscience, held in July 2015 in Rio de Janeiro. Other important initiatives are work papers on important themes, which are currently being written collectively by CpE members, to be launched by the end of 2016.

Objective 3 will be attained by opening the above-mentioned laboratories to universities or technology developers in order to create and test products and processes of educational interest, that could be utilised in large scale both in schools and within families. The laboratories, in this case, would function as facilities for use both by university actors (basic science) and those linked to the productive sector (startups, spinoffs, big companies).

And finally, objective 4 will have to be gradually tackled, first through the involvement of established graduate programmes, then through the creation of latu sensu programmes and professional and academic graduate programmes (strictu sensu). An intensive programme to attract postdoctoral students will also represent a shorter and more efficient way of forming qualified human resources (scientists and educators).

Conclusion

Science for Education is meant as a translational approach to connect basic science in different disciplines, to educational objectives with strong and fast social repercussion. It has been seldom recognised in the global scenario, what offers a powerful window of opportunity to the countries that take the lead in this movement. It will be fundamental for Brazilian society to foster this new field of national actions in science and technology, and thus accelerate the pace to overcome the severe burden of illiteracy, low level of educational standards among the youth, and as a consequence the low social position of the people and the poor competitive power of Brazilian economy in the international scenario.

Notes

[1] CpE is the acronym of Ciência para Educação, the Portuguese equivalent of Science for Education. http://cienciaparaeducacao.org/eng.

[2] A site at the internet contains technical as well as general information on topics of Science for Education: http://cienciaparaeducacao.org.

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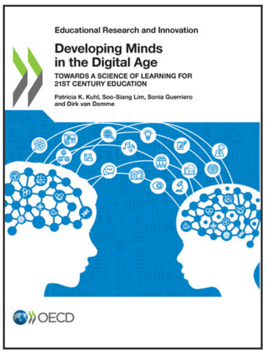

Developing Minds in the Digital Age

Towards a Science of Learning for 21st Century Education

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