# Democratizing neuroscience for education

*Today neuroscience can offer important insights gained through decades of brain research. Teachers, students, and adults in general are intrigued to learn more about the brain and related research that impacts their day-to-day learning and life.*

Author/s:

**Vivian Reigosa Crespo**
*Senior Researcher and Deputy Director General, Cuban Center for Neuroscience, Havana University, Cuba*

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Executive summary

- A direct approach to neuroscience and education that incorporates the neurobiology of learning is the most pragmatic, as it can inform teaching and learning practices in classroom settings.
- There are very few teacher training programmes that use the neurobiology of learning, but there are several initiatives (e.g., BrainU and OptimA) attempting to change that.
- Aspects of neuroscience enhance the metacognitive knowledge of students, which is an important component for successful learning outcomes.
- To ensure effective neuroscience results for teachers and learners, policy makers and practitioners need to consider barriers to translation, the teaching profession, and the learners themselves.

Is neuroscience informative for educational practice?

Today, neuroscience can offer important insights gained through decades of brain research. Teachers, students, and adults in general are intrigued to learn more about the brain and related research that impacts their day-to-day learning and life. However, the role of neuroscience findings in guiding educational practice has been intensely discussed over the past 20 years and, consequently, some detractors and enthusiasts have emerged. Some authors argue this is a “bridge too far” because of the great distance between neuroscience and education in terms of goals, methods, language, and conceptual background[1]. They also state that extrapolating from the neuroscience laboratory to the classroom would bring more problems than benefits; for example, it is really hard to imagine how knowledge about the detailed ionic basic of the synapsis (connections) between neurons can inform educational practices. Instead, they advocate for connecting neuroscience and education indirectly through the intermediate discipline of psychology. Some researchers, including the author, argue this approach reveals a serious misunderstanding: The neuroscience that is

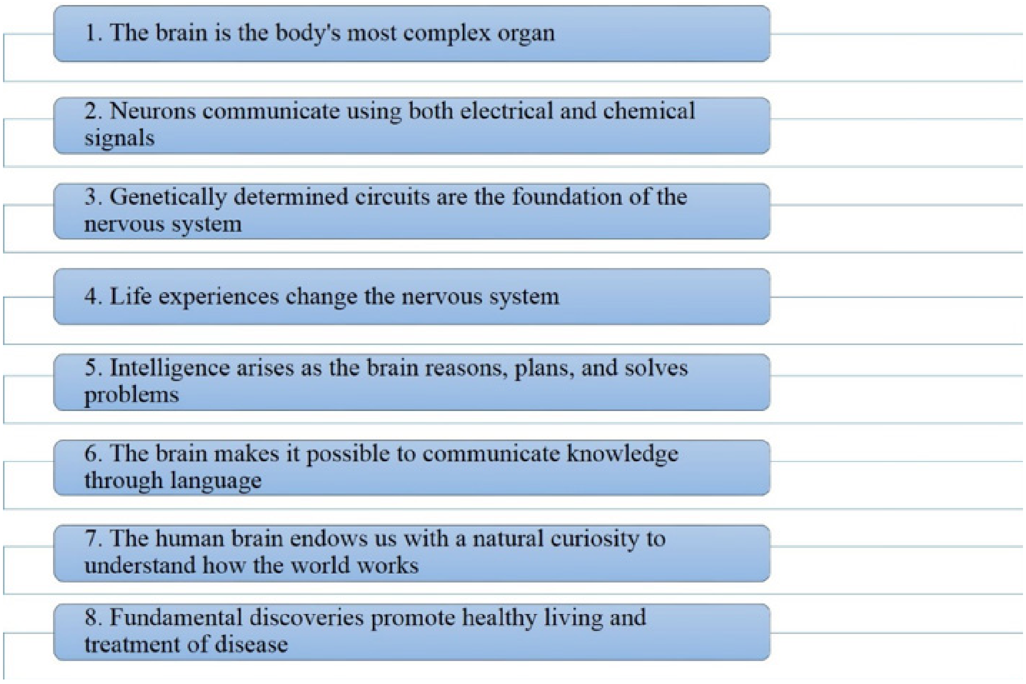


Figure 1. Neuroscience core concepts for education

relevant to education is “cognitive neuroscience,” which has psychology as an essential part. While psychology constructs theoretical models to explain and predict learning behaviour, cognitive neuroscience constrains these models by demanding they concur with evidence of tangible changes in brain function[2].

Others have proposed a direct route to actively teach teachers the main concepts about the neurobiology of learning. This is because, potentially, this route can transform teacher preparation and professional development, and ultimately can improve how students think about their own learning[3]. Accordingly, far from just being abstract background material, core concepts of neuroscience represent practical knowledge that can inform teacher practice in classroom settings, as well as motivate students to learn. These concepts were issued by the Society for Neuroscience in 2008[4], and they were comparable to those underlying the U.S. National Science Education Standards (NSES) (see Figure 1).

### Neuroscience for teachers

Teachers are among the best cognitive enhancers in the world, changing students' brains on a daily basis to acquire literacy, numeracy, reasoning, and many other skills[5]. However, although the need for teachers to understand how students learn may seem self-evident, there are actually few reported examples of teacher training that include the neurobiology of learning. Most such examples take the form of large symposia composed of a series of lectures on neuroscience topics. This approach disseminates general scientific knowledge but fails to answer individual teachers' questions, including how to model specific strategies that teachers can use in the classroom to apply this new knowledge.

Fortunately, some initiatives are currently running focused on fulfilling teachers' demands for accurate, up-to-date knowledge about the neurobiology of learning. One of them is **BrainU**, an approach for teaching neuroscience core concepts[4] to secondary education teachers. Several reports showed promising results[3,6,7]. Firstly, a change is observed in teachers' classroom practices due to teachers' improved knowledge of, and confidence in, basic neuroscientific knowledge and research. Secondly, an effect of transforming their pedagogy is seen in how they view student learning, and therefore how they teach their students. Thirdly, teachers shared their newfound knowledge of neuroscience with their students, increasing their understanding of metacognition and their role in learning.

### Why is BrainU successful?

- BrainU focused on an experiential approach to learning about the nervous system. Teachers learn through observation, experimentation, hands-on activity, and discussions designed to be used in their classrooms.
- Lectures account for less than 20% of the workshop time.
- Teachers learn neuroscience in the manner they are expected to teach it to their students.
- Teachers engage in investigations designed for classroom use and they become sufficiently familiar with experimental processes that the inertial barrier to introducing experimentation into the classroom is lowered.
- Experimentation and hands-on activities are integrated into the course.
- Open-ended classroom-based investigations provide real experience in doing science.

**OptimA** is another initiative that was designed for the educational neuroscience lab (EN-Lab) in the Cuban Centre for Neuroscience. This is also a direct way to actively teach to teachers, but focusing on the biological basis and characteristics of neurocognitive development in kindergartners and primary school-age children (see author's brief, "Neurocognición y aprendizaje. Retos para la educación inclusive," for an overview of the critical concepts of this approach).

### The main features of OptimA are:

- Focused on a pragmatic approach to learn about the relationship between brain/genes, cognition, and learning
- A well-balanced combination of talks, practices, and seminars providing opportunities for teachers to discuss "real problems" of day-to-day educational practice
- Capacitation of teachers on research-based tools for screening and profiling the neurocognitive status of their learners using information and communications technology (ICT) facilities
- Capacitation of teachers on guidelines for accommodating the classroom settings to attend to individual differences in

the trajectories of the neurocognitive development of their students

- Discuss and plan the implementation of school-based programmes for enhancing the neurocognitive development of learners

There are currently several teacher training programmes that use OptimA in Latin American countries with the support of the education ministries, specifically, in Ecuador, Cuba, and El Salvador. The latter was promoted by the Universidad Paracentral de El Salvador and supported by OEI. The early results are promising. Figure 1 shows the outcome of anonymous satisfaction surveys applied to 287 Ecuadorian teachers from Santa Elena and Guayaquil provinces after participating in the OptimA courses.

Scale: Nothing 0 – Little 1 – More or Less 2 – Much 3 – Very Much 4

| | |
|---|---|
| The matters were previously known by me | 2 |
| The facilitators explained clearly | 2,9 |
| We discussed about real problems that occur in the classroom | 2,7 |
| The training was useful for my educational practice | 3,2 |
| The training had an effect of transforming my pedagogy – how I view student learning, and therefore how I teach students | 2,9 |

Figure 1. The results of teachers' surveys after OptimA courses. The numbers correspond to the mean rating for each proposition. Source: Final report of "Estudio piloto de programa para la protección al neurodesarrollo en la edad escolar en las ciudades de Guayaquil y Santa Elena de la República del Ecuador," Quito (2015).

### Neuroscience for learners

A critical goal of the world's educational systems is to produce long-lasting learners. In this sense, teaching students how the brain changes during learning becomes critical. Today we know that understanding how memory traces are constructed from one's own repeated and relevant experiences enhances students' metacognitive knowledge—which is an important component for successful learning outcomes[8]. Students understanding that they are implicated in changing their own brains encourages them to apply themselves in school and positively change their own educational trajectory. Accepting the idea that their brains are plastic and that learning produces new synapses that turn on genes can provide students with the hope that their efforts can lead to success[9]. Also, this idea may build their resilience for later educational encounters with courses that emphasise knowledge acquisition[10].

The BrainU initiative mentioned previously provides teachers with neuroscience core concepts and demonstrates that teacher content knowledge gains could be effectively translated to gains in student knowledge related to how the brain works and how to maintain brain health. It may also increase students' interest in science and confidence in their scientific ability[6].

Concordantly, several Scientists-in-the-Classroom (SiC) programmes have boosted positive attitudes toward science. A recent report[11] revealed that this initiative produced enjoyment of science amongst students. The neuroscience content introduced to students was well-received and remembered. The lower-level content messages ("the cool stuff") were more easily taught than the higher-level ones ("What does this mean for my own learning?"). Ideas about doing poorly also diminished in a subset of students. Impacts were greatest when presenters were experienced and well-trained and in schools with more student diversity or higher poverty levels.

### Challenges for policy and practice

The world is now facing important educational challenges. According to test grades, innovation and creative thinking are not being taught, practiced, or nurtured in children's lives, and something must be done to prepare our children for the 21st-century future. In this sense, what can we do? Democratizing the relevant neuroscience findings about how the brain learns through the active teaching of neuroscience to teachers and learners may provide one critical element toward a solution. However, this endeavour will only be successful if educators and neuroscientists are working together.

To successfully meet this target, policy makers, and practitioners must take into account several important issues:

- *Barriers to translation*. There is a lack of an integrated knowledge base that limits the effectiveness of disseminating findings from the laboratory into the classroom. A common platform and a common language become necessary for identifying and addressing misunderstandings as they arise and developing concepts and messages that are both scientifically valid and educationally informative[2]. A critical component of this endeavour is that tangible financial resources must materialize for progress to be made, from the local level up to the governments. Notice that, as a worldwide practice, the government education budget spent on research is significantly smaller compared, for example, with the government health budget spent on research.

- *The teaching profession.* The majority of in-service teachers have no neuroscience in their backgrounds, and preservice teachers do not receive information about the neurobiology of learning. Removing the *barriers to translation* is a necessary condition to effectively teach teachers about the brain and learning. In line with this, a thoughtful way to train teachers is to create courses in partnership between teacher educators and neuroscientists[12]. On the other hand, introducing neuroscience into initial teacher education requires faculty cooperation across department and college lines[7]. In this sense, effective mechanisms should be established to diminish administrative barriers relating to the development of tuition-sharing arrangements, calculating faculty time assignments, coordinating the participation of the faculties that have different sets of pressures and priorities, etc. At the level of individual faculty, communication and cooperation among people with expertise in each area should be required. For example, concepts such as synapsis, neural plasticity, sensitive periods, and memory recovery must be explained by neuroscientists to educators; and concepts such as curriculum, assessment, and learning trajectories must be explained by educators to neuroscientists. A final challenge for introducing neuroscience content into initial teacher education is that university-level teacher educators need to be convinced that doing so will result in better-prepared classroom teachers. Finally, policy makers need to take in mind that introducing neuroscience concepts as a background for initial teacher education is likely to demand consideration of new entry requirements and new qualifications for future teachers.

- *The learners themselves.* Direct contact between neuroscientists and learners through SiC programs can build basic neuroscience literacy, increase interest in scientific endeavours, and provide learners with a more positive understanding of their own potential. All this could eventually lead to an overall increase in public neuroscience literacy[11]. In view of these benefits, similar initiatives could be encouraged and supported from the local level up to governments. They could also be included in the Next Generation Science Standards of the different countries.

## Key messages

1. Teaching neuroscience to teachers is relevant to improving teaching practice and, consequently, student learning.

2. Teaching neuroscience to learners can make a positive contribution to students' attitudes toward science and learning.

3. "Bridging" the gap between neuroscience and education requires the elimination of *barriers of translation*. This is a two-way venture in which neuroscientists can benefit from exploring their concepts in the classrooms, and educators can benefit by gaining new insights into educational practice.

4. Educational policies must be in line with these challenges. Financial resources and decisions must materialize for progress in collaboration and also for reforming the role of teachers and the curricula of teacher education institutions. All these efforts will contribute to making tangible the Education-2030 targets agreed by the world's governments.

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