# Editorial

# Building Bridges – Education and Neuroscience – Speaking a Common Language for the Benefit of Learning

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## Introduction

The Symposium 2022 of the Institute for Education focused on "The Neuroscience of Learning". It is a known fact that the brain and learning have an intimate link and when learning happens, the brain undergoes a change which can be chemical and structural. The papers presented here provide a remarkable insight into the area of neuroscience and create a connection with learning or the disposition of the individual to learn. The affective domain is placed at the forefront of the studies, highlighting the effect it has on the development of the child and the outcomes of the educational journey. Though brain research and its relation to learning is still in its early stages, it is imperative that we continue to delve into this field to investigate the processes that can be adopted to create a positive educational journey. It is through the collaboration between neuroscientists and educators that the pathway towards the development of a person's full potential can be achieved. However, language can be a major barrier, considering the jargon used when communicating methodologies, analyses, and findings. Thus, bridging the language can be considered the initial factor that may result in translating the scientific findings of neuroscientists into personalised strategies used in the classroom and in the community to overcome learning hindrances and exploit the brain's potential.

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## From Education...

Educators continuously adopt strategies to enhance the learning potential of every student. The uniqueness of each student lies in their genetic profile, experiences, culture, perspectives and competencies. Thus, both nature and nurture have a role to play in influencing learning. Understanding in what way each affects the individual and influences learning can indicate the strategies and techniques that would be most beneficial and effective to achieve the intended goal.

Bartlett (1932) explained how subjects distorted stories they had been told and images that they had seen and included their own perspective to create "schemas". Richardson & Richardson (1998) explain this process of remembering as "a reconstructive process – an interaction between experience and some more abstract metacognitive representation of the world experienced" (p. 89). For Johnson-Laird (1983), when individuals form different perspectives of the same thing, they would be creating mental models which amalgamate the objective with the subjective. In practical terms, when a teacher explains a concept to a group of students, each student forms mental models that are exclusive to that person, since the explanation gets rooted and construed with the previous experiences and knowledge of that person. Therefore, the assumption that, since the explanation was the same for everyone, all students will be recalling and understanding the concept in the same manner is totally wrong. How could a teacher know what was understood? This can only happen if the teacher collects evidence, allowing the students to dialogue about the concept while listening for any misconceptions. This would give the teacher the opportunity to redirect after understanding why the misconception has been formed.

Consequently, such models evolve or deconstruct to create new ones or become a hybrid with other mental models, depending on the experience and new knowledge encountered. The constructivism paradigm goes back to Jean Piaget (as cited in Hanfsting et al., 2019, p. 514), who linked meaning-making, or mental model construction, to the relation between what is known and experienced. Hanfsting et al. (2019) explain that individuals adapt to the environment by assimilating (applying known knowledge) and then accommodating (when new knowledge needs to be learnt first and then applied to the situation). This can be perceived as a building that is always a work in progress, and which sometimes grows bigger, other times deconstructs, and

some other times changes form. Whereas Piaget (as cited in Jarvis, 2011, p. 20) places more emphasis on cognitive constructivism, which is self-dependent, Vygotsky (1978) and Bruner (1966) stress the importance of other individuals in creating new meaning through scaffolding.

So, do students absorb information during explanation time? Are they expected to listen and learn? The constructivist learning theory resists this notion, stating that knowledge is constructed from experiences and self-reflection (Garmston & Wellman, 1994). In a typical classroom this would be when the teacher creates the opportunity and makes resources available for the students to become curious, explore, ask, investigate, research, speak about, and demonstrate the learning that is happening. When the evidence produced indicates a misconception, the feedback given by the teacher or by a peer is supposed to have the function of resolving and adjusting the learning to a correct version. However, this does not always happen. It is interesting to note that when students are asked for the reasoning behind the evidence they produced, their explanation is almost always logical even when wrong. Such misconceptions cannot be unlearnt unless proven wrong (Grima, 2008). When the teacher listens and understands the logic behind the misconception, they can ask questions that could assist in reflecting and modifying the internalised concept. New cognitive structures form and thus, learning that makes sense and that replaces the misconception happens and is not forgotten. Ausubel and Fitzgerald (1961) refer to this as meaningful learning and retention.

Thus, the process of learning is not the same for everyone, and even when the teaching is the same for a group of persons, what is understood, experienced and internalised is unique for each person. Moreover, the fact that each person has a different starting point from where new learning is accessed makes the resulting outcome different for each individual and therefore, "finding out what students have actually learned would appear to be not just desirable, but essential for effective instruction" (Wiliam, 2018, p. 42). Therefore, continuous learning requires continuous assessment that would constantly indicate whether learning is happening and whether misconceptions are being formed. Consequently, this also entails identifying what is hindering the understanding of the concept by listening to the interpretation of meaning which could reveal the reason behind that understanding. This evidence discloses the learning taking place, and when the individual is given the opportunity to explain the mental models that have been constructed, the teacher can determine what

parts need to be adjusted and in what way, because the dialogue about the mental models reveals the reasoning behind that learning.

And again, while reflecting on this process and on what induces learning, how it happens and what happens to the child during the process, one has to include the brain into the equation. The brain is the organ that processes all learning. But how does this happen and what influences what is learnt and what is not? What enhances the process and what can hinder the brain from learning? Is pedagogy influencing the brain processes in any way? What is the link between education and neuroscience, and how can this be optimised so that all the different children can develop their potential to the full?

## ...to Neuroscience

In accordance with Attard & Schembri Frendo (2022), there seems to be a missing link between educators and neuroscientists in that they tackle these areas from two different perspectives, and it would be beneficial if the gap could be bridged. Educators use pedagogical strategies and techniques to enhance the learning process, and neuroscientists study the brain as the biological structure that executes the processes involved when it is stimulated. The brain is the organ that enables the cognitive, the affective and the motor domains to develop and function. To support the maturity of these domains we ought to get together, build bridges and speak a common language.

In the past few years, great advancements have been made in the studies of the different parts of the brain and how these are affected when exposed to stimulation. Brain imaging has shown that different parts of the brain are activated depending on the stimulation. Zatorre et al. (2012) state that the brain undergoes structural changes in the grey and white matter when learning happens, and while the brain "is the source of behaviour, ... in turn it is modified by the behaviours it produces" (p. 528). For instance, Ansari (2008) states that parts of the brain show stimulation during reading. However, persons who experience difficulties in reading such as developmental dyslexia show an "atypical" stimulation of the brain. Nonetheless, structured reading remediation programmes are capable of normalising this atypical stimulation.

Thus, it is obvious that learning is a consequence of the correct brain stimulation that causes it to grow (neurogenesis), or change (neuroplasticity). Zatorre et al. (2012) explain that anatomical imaging of the brain reveals how

different groups of people develop differences in parts of their brains that result in differences in skills, knowledge or expertise. Experience-dependent plasticity results in a larger hippocampus. Conversely, musicians have a thicker auditory cortex, and differences in their motor regions and in the organisation of the white matter of the brain. Clive Wearing, an accomplished musician, contracted a virus causing him retrograde and anterograde amnesia, i.e., no new memories could be formed and no new learning could happen, and yet his musical capabilities were still intact due to the muscle memory that he had developed when he used to practise, which indicates an experience-dependent neuroplasticity. If this were to be translated into educators' jargon, one could state that a variety of different experiences and practices will enable the different parts of the brain to change and grow. Linked to the constructivist approach that was referred to earlier, one can understand how learning happens in relation to what happens structurally to the brain when knowledge is amalgamated with experience and practice.

Furthermore, it is interesting to note that for learning to occur, children are required to experience an amount of stress (eustress), which causes their arousal and attention to increase (Whiting et al., 2021). The issue, however, revolves around the amount of stress that causes this benefit. In my experience as a teacher, the beneficial amount of stress was referred to as being the challenge that induces the child to move towards the zone of proximal development and out of the comfort zone while being excited to investigate new grounds and progress. However, the stressor that arouses one child may generate a negative response in another child, who could experience high levels of cortisol, the primary stress hormone produced by the hypothalamus-pituitary-adrenal axis, and the result could be a hindrance to learning and a reduction in the executive functions – inhibition, working memory and cognitive flexibility. The prefrontal cortex of the brain contributes to these functions. Koncz et al. (2022) define these functions as being those that regulate our behaviour and act according to the objectives we have rather than as an automatic response to a stimulus. Thus, we are capable of storing information in the short-term memory until it is consolidated in the long-term memory section of the brain, we refrain from acting inappropriately, and we have the ability to modify our behaviour according to the environment we are in. Koncz et al. (2022) emphasise that childhood chronic stress must be avoided as it may result in abnormal brain development and low cognitive function. However, exposure to stress, especially environmental, should not be completely eliminated since it induces the child to

react to the situation and adapt accordingly. Thus, one should try to find the personalised, optimal stress level that would enable cognitive performance.

The boundary between what is perceived as a challenge and what is felt to be a threat is quite blurred due to its dependency on the person as a complex being. It is interesting to note the findings of Flinn et al. (2016) since they show that criticism causes a great amount of stress and impairs performance. Being observed can also cause an amount of stress at first but when the subjects get used to it, the level of performance increases on par with the control group and with the group that received words of encouragement. It was concluded that encouragement does not tangibly improve performance, but criticism actually impairs it as it is felt to be threatening and, thus, producing the highest amount of cortisol. Aligning this to the learning experience, when the educator gives feedback, words need to be chosen wisely and not take the form of criticism in any way. When the learner feels comfortable in the situation, cortisol levels fall, cognition is strengthened, and learning can take place, enabling the brain to grow or adapt.

Neuroplasticity and cognition (executive functions) have been demonstrated to benefit from physical exercise (Hötting et al., 2016). The study also revealed that high intensity exercise enhances memory since the volume of the hippocampus increases. "Not only chronic effects of exercise interventions lasting for months up to years have been reported, but also a single bout of exercise has been shown to increase performance on a large variety of cognitive tasks" (Hötting et al., 2016, p. 1).

The meta-analysis of current research in this area carried out by Attard & Schembri Frendo (2022) recognises that cognition and brain development are also affected by emotions in that the working memory is linked to situations that stimulate emotions, particularly positive emotions, and activate the amygdala. Experiences, challenges and interaction with the world result in a change in the structure of the brain that has the capability not only of growing or changing but also of pruning. Pruning means that the weak synaptic connections are removed so that the brain can adapt to the new environment, which in educators' terms is learning. These changes would be mostly occurring in the frontal lobe of the brain. The brains of preschool students grow rapidly, as Paredes et al.

(2016) claim, to prepare the individual for more intricate "human cognition". As for adolescents, they "often have difficulties understanding subtleties of social and emotional interactions" (Anderson, 2015, p. 194) because the cerebellum, which is responsible for managing complex social situations, is the last part of the brain to mature. Pulis (2022) focuses on fun as an emotion that sustains memory and retention and "stimulates the release of the neurotransmitters acetylcholine and dopamine, which in turn accelerate learning" (p.77). In her paper, Bezzina (2022) discusses the role of empathy in academic achievement. She concludes that "through positive schooling, where there is ample practice of empathy by educators and ample space for students to be empathic, there is more safety, more flourishing, more engrossment, more brain expansion and more holistic achievement" (Bezzina, 2022, p. 53–54).

Schweizer et al. (2011) studied brain-training/working-memory training programmes and their ability to improve cognitive functions and concluded that only brain-training with emotional material managed to instil control over the affective information on an emotional Stroop task. This demonstrates that

> transferable gains across to affective contexts require training with material congruent to those contexts. These findings constitute preliminary evidence that intensive cognitively demanding brain-training can improve not only our abstract problem-solving capacity, but also ameliorate cognitive control processes (e.g. decision-making) in our daily emotive environments. (Schweizer et al., 2011, p. 1)

The aim of this symposium is to attempt to start a journey that brings together two domains – education and neuroscience. This is just the beginning since several more studies have to be carried out, but the language has to be common and comprehensible to the experts in both fields. Rushton (2011) provides an immensely clear narrative of what happens in the body in neuroscientific terms during an accidental interaction between two kindergarten students. The language used is clear and understandable and, in fact, he uses this narrative to show teachers the importance of listening and observing the process adopted by the children when reacting to particular unexpected situations. Darmanin (2022) agrees that all educators need to become acquainted with the findings of neuroscience. This will provide an insight into how the brain of each child works and the processes it undergoes when learning is happening. Child-centred education should start from here and it is for this reason that pedagogy has to

be linked to neuroscience if the findings are to be communicated in a language that can be translated into pedagogical strategies.

## Notes on contributor

**Joanne Grima** has been the Chief Executive Officer of the Institute for Education since founding it in 2015. She leads an ambitious and energetic team that develops qualifications and continuing professional development for educators while providing a platform for research. She holds a Bachelor Degree in Education from the University of Malta and taught Chemistry in the secondary sector for ten years. In 2009 she moved to Higher Education to teach Environmental Science. She has read for a Postgraduate Diploma in Education, Administration and Management and for a Master's degree in Education (Science). Joanne was an Education Officer – Assessment for Learning and developed a teacher-training programme to implement this pedagogy. This was then transformed into a Postgraduate Certificate in Assessment for Learning Strategies, which is currently being offered to teachers. She also developed the Core Curriculum Programme for learners that require alternative learning and assessment programmes. She also served as Assistant Director – Assessment within the Curriculum Department.

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