The Fun Imperative During Learning: A Neuroscientific Perspective

Angele Pulis
Institute for Education

Abstract
The search for the optimal learning environment is a journey that draws on various domains of study; neuroscience opens a window into the functioning of the brain and so provides crucial information for educators. The purpose of this desk research is twofold: firstly, to offer knowledge on the biology of the learning process that demonstrates the importance of fun during learning and secondly, to explore the practical implications of this knowledge. The review of literature offers an understanding of brain plasticity during learning, the functions of the different parts of the brain and the biochemical changes which connect learning and fun. This research is intended for practitioners, and so it attempts to bridge the gap between theory and practice. Finally, the paper proposes the idea of using a Fun Barometer to help educators gauge the climate of a learning context.

Keywords
Neuroscience, Education, Brain, Fun and Learning, Fun Barometer, Funactor

Introduction
The brain has fascinated mankind since ancient times. Aristotle (384–322 BC) studied the size of brains in different species and compared it to the size of the body, concluding that the ratio was the highest in species that were more cognitively developed, such as humans (Ward, 2015). Advances in techniques that enable scientists to study how the brain functions have brought with them an increased interest in learning more about how neuroscience can inform

Contact: Angele Pulis, angela.pulis@ilearn.edu.mt

classroom practice (Ansari et al., 2011; Guy & Byrne, 2013; Jaeggi & Shah, 2018; Varma et al., 2008) and how it might influence educational policy (Farah, 2018).

The relevance of neuroscience to classroom practice is not a foregone conclusion. There are sceptics who question whether neuroscience is directly useful to teaching (Bruer, 2006); other researchers are questioning whether neuroscience is "hype or hope"? (Martínez Pérez & Salvador Bertone, 2019, p. 6). Nevertheless, research that combines the neuroscience of learning with pedagogy is gaining widespread momentum and popularity (Howard-Jones, 2011; Kelly, 2011; Willis, 2010), and researchers such as Patten (2011) believe that "the birth of educational neuroscience is long overdue" (p. 86).

Sousa (2010a, p. 2) comments: "Sure, the brain remains an enormously complex wonder that still guards many secrets. But we are slowly pulling back the veil and gaining insights that have implications for teaching and learning." This desk-based research attempts to throw some light on the neuroscience of learning, particularly on the neuroscience of the effect of fun on the learning process. The research seeks to provide knowledge of utilitarian value to practitioners so that students can be offered better learning environments and opportunities.

The researcher's interest in the topic

The science of things around us has evoked my curiosity since my primary school years. I grew up to become a teacher of Chemistry, Biology and Integrated Science. Although I no longer teach these subjects, I do not consider myself an ex-teacher. To my mind and my heart, once a teacher, always a teacher. I consider myself both a teacher of science and a learner interested in science. In my dual role as a lecturer and a learner, knowledge which provides an insight into unravelling the workings of the brain holds a strong attraction to me. It intersects with different aspects of my life: the self-interest in my own personal learning process, my work as a practitioner whose primary aim is to bring about learning in others, and my role as a researcher hoping to contribute to the body of knowledge on the application of neuroscience in the classroom.

My experience as a classroom teacher had demonstrated to me that when students are enjoying themselves, learning occurs faster and more easily; however, it was only when I was not an intimate participant in the teaching and learning setting that this lesson was driven home to me in an emphatic manner. When I was a primary Head of School, during my class observation visits I could witness, more objectively, how students react to activities that they perceive as fun. The very mention of a forthcoming task that is enjoyable for students would change the learning climate; students would suddenly sit up and take notice of what the teacher is saying. Their faces would suddenly radiate eagerness and happiness. Often students would make verbal and non-verbal gestures to affirm their readiness for the task. I could observe the positive effect that activities which, from the students' perspective are considered fun, had on the learning process and the resultant learning outcomes. I began to question the dynamics between fun and learning. In coupling my interest in the neuroscience of learning with a focus on the fun dimension during learning, the research topic was conceived: a neuroscientific perspective on the fun imperative during learning.

Statement of problem

The primary aim of teaching is to facilitate learning. Ideally, teaching and learning exist in a mutually satisfying cause-and-effect relationship. The current bodies of knowledge on teaching and learning, as two separate processes, are not balanced. The teaching component is extensively researched and it ranges from the educator's intrapersonal and interpersonal skills to pedagogical knowledge, specific subject content, skills on how to create and use resources, philosophical underpinnings of approaches, classroom management, and understanding and applying different forms of assessment. The body of knowledge on teaching is continuously being updated and expanded. On the other hand, the learning process which is purportedly occurring in the learner appears to be somewhat of a mystery. How does learning occur? What happens in the brain during the learning process? How does the introduction of the element of fun in the learning process affect the actual learning which is occurring? How can the power of fun be harnessed to invigorate learning?

An insight into the science of learning, and the effect of fun on learning, might offer a vantage point enabling a better explanation of what is happening at the receiving end of teaching. In turn, this could provide valuable information on how to accomplish good teaching.

The purpose of this research

The purpose of this research is to provide educators with usable knowledge on the neuroscience of learning and on the role of the fun component in the learning process, which is relevant and helpful in the classroom scenario. In addition, it offers a practical tool that might be used to help quantify and augment the fun dimension during a learning episode.

"Neuroscientists and educators must work together to produce the Holy Grail: new ways of understanding development that have practical implications for the design of learning environments" (Immordino-Yang, 2011, p. 101). The purpose of this desk-based research may be viewed as a step in that direction.

The structure of this research

This desk-based research focuses primarily on educational neuroscience: the branch of neuroscience that is concerned with the science of learning. Firstly, an overview of what neuroscience entails is presented. This is succeeded by a description of the main structure and function of the brain and an explanation of the main processes which occur during learning. Next, the salient implications of the knowledge extracted from a review of literature on neuroscience are articulated in five main lessons. The rest of this desk-based research addresses the notion of fun and learning; it presents neuroscientific justifications for the fun imperative during learning, and finally, it introduces the Fun Barometer: a simple tool to measure the level of fun during lessons.

Demystifying the neuroscience of learning

What is Neuroscience?

A broad definition of neuroscience describes it as the study of the nervous system (Augustine et al., 2018a). Other definitions articulate it as the study of the development and function of the human brain (Craver, 2007). The definition presented by the National Research Council et al. (2000) encompasses both the wide spectrum within this area of knowledge, and the specific focus on the brain: "Neuroscientists study the anatomy, physiology, chemistry, and molecular biology of the nervous system, with particular interest in how brain activity relates to behaviour and learning" (p. 115). Within such a broad area of study, there are different specialisations. Cognitive neuroscience, from which educational neuroscience is derived, focuses more on the learning process, and on how "the human brain creates the human mind" (Gazzaniga et al., 2009, p. 1247); in other words the study of "how physical matter (the brain) can produce mental experiences" (Ward, 2015, p. 13).

How do Neuroscientists Obtain Information About the Brain?

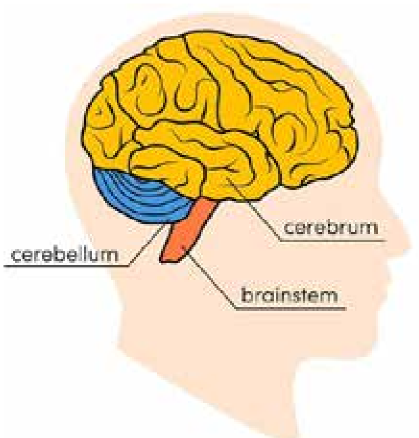
There are three main ways how neuroscientists study the brain: by locating and quantifying the blood flow, by observing the electrical activity in the brain, and by studying physical changes in the anatomy of the brain (Immordino-Yang & Fischer, 2009; Posner, 2010).

The Brain: Basic Structure and Function

The brain can be described as the "organ of learning" (Ansari et al., 2011, p. 36). An understanding of the basic structure and function of the brain could prove useful for further comprehension of how learning occurs in the brain.

Figure 1

The basic structure of the brain



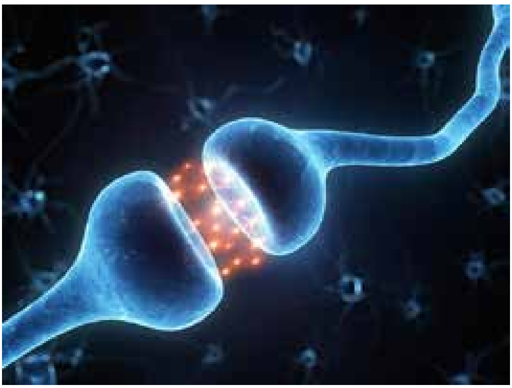
Note: The three main parts of the brain. From Johns Hopkins Medicine, n.d. (https://www.hopkinsmedicine.org/health/conditions-and-diseases/anatomy-of-the-brain)

The front of the brain is the cerebrum and its outer area is called the cerebral cortex; it is made up of the grey matter (Roberts, 2014). The cerebrum forms the largest section of the brain, and it facilitates and coordinates different functions: thinking, emotions, learning, movement, and it also regulates body temperature. At the back of the brain there is the cerebellum, which controls balance and voluntary movement, and is probably connected with social behaviour, emotions and intellectual skills (Drake et al., 2015). The brain stem forms the connection with the spinal cord; at its bottom there is the medulla, which controls basic bodily functions such as blood circulation and breathing, together with reflex actions such as swallowing and sneezing (Snell, 2012).

The basic building blocks of the brain are the nerve cells, also called neurons; neurons receive and transmit information from, and to, our sensory organs, our muscles, and different parts of the brain (Morris & Fillenz, 2003). Information passes along neurons by means of chemical transmitters, called neurotransmitters, and by electrical impulses. The transmission of signals along neurons occurs very fast; in fact, it occurs within milliseconds (Augustine et al., 2018b).

Figure 2

The synapse



Note. The synapse: where one neuron connects with another neuron. Electrical signals or neurotransmitters facilitate the transmission of signals at the synapse. From Biology Notes for A Level, (2016, June 7). (http://biology4alevel.blogspot.com/2016/06/122-synapses.html)

Neurons communicate with one another, although there is no physical connection. Electrical signals or neurotransmitters facilitate the transmission of signals at the synapse. The point where information passes from one neuron to the next is called the synapse (Wolfe, 2010). Most of the synapses in the brain are formed after birth (National Research Council et al., 2000); synapses design the "wiring diagram of the brain" (National Research Council et al., 2000, p. 116).

Brain Plasticity

The brain is composed of trillions of neurons (National Research Council et al., 2000). The brain is changeable because neurons in the brain can change the way they send signals and the way they communicate with each other (de Jong et al., 2009). As explained above, these neurons connect with each other at an intersection called a synapse. The ability of the neurons, and hence of the brain, to change is referred to as brain plasticity and it is directly related to the process of learning in the brain. Apart from changes in the neurons, Long and Corfas (2014) refer to the possibility of new neurons forming during learning. Owens & Tanner (2017, p. 3) explain that "learning appears to occur primarily because of changes in the strength and number of the connections between existing neurons, a process called brain plasticity".

To recapitulate, learning involves changes in the neurons, which effectively cause changes in the brain; the ability of the brain to change is referred to as brain plasticity.

The Complexity of the Brain

An awareness of the complexity of the brain might help in understanding what educational neuroscience is trying to understand. The brain is a multiplex organ; "the brain is a dynamic, plastic, experience-dependent, social, and affective organ" (Immordino-Yang & Fischer, 2009, p. 6).

The following study provides an insight into the intricate functioning and complexity of the brain. Villarreal & Steinmetz (2005) studied the eyeblink conditioning, which is considered to be a classical example of how learning occurs, and which has been heavily researched for over 30 years. The response (the eyeblink) to external stimuli (for example, an air puff) is a form of learnt behaviour (Villarreal & Steinmetz, 2005). The researchers drew on dozens of previous studies which focused on the role of the cerebellar cortex with the aim of trying to understand how the eyeblink conditioning occurs. They were surprised to discover that the neural circuit involved was extremely complicated, involving far more sites of plasticity and connections than they had previously envisaged. Previous descriptions of which parts of the brain were being triggered, and how, fell short of providing a comprehensive explanation.

The glimpse into the level of complexity which the eyeblink conditioning entailed led Villarreal & Steinmetz (2005) to conclude that understanding how learning occurs is far more complicated than they had ever anticipated. In addition, they concluded that neuroscience on its own will never provide all the answers; behavioural analysis must also be integrated with neuroscientific analysis in an attempt to comprehend how learning occurs.

To comprehend how the brain is organised, Gazzaniga et al. (2009) reviewed earlier research and used the findings to compare the brain to complex systems. They proposed a "comprehensive theory of brain function" (p. 1249). The main tenets of this theory are that firstly, a single, main controller of the brain does not exist; secondly, the brain is organised into modules that do not function in sequence; instead, they function in parallel. These modules are made up of groups of neurons and they self-assemble; Gazzaniga et al. (2009) proposed an "interconnected modular architecture of the brain" (p. 1247) to explain brain organisation and operation. This model could provide new perspectives on how the brain develops and functions.

Five lessons for the classroom

A restricted review of literature has distilled five lessons which might be useful for classroom practice.

1. **The brain can change, it is malleable.** The brain has a capacity to grow, even in a direction against the trajectory which might have been previously set according to the learner's genetic inheritance, socioeconomic background, or past experiences. It appears that the brain has the ability to recalibrate and reset the direction of its own development (Rimm-Kaufman & Jodl, 2020). According to Rimm-Kaufman & Jodl (2020), this paints a hopeful scenario: despite the limiting factors that a learner might have inherited or any debilitating external factors, there still exists the possibility that these might be offset by the direction of growth of the brain. This finding should be interpreted within a comprehensive

understanding of the brain that takes into account that nature, nurture and the brain's malleability all play independent and interdependent roles in affecting the brain, particularly the effect of how learning occurs in the brain.

2. **Emotions and social interactions affect learning**. Learning occurs in a social and emotional context. The way that learners are feeling will affect their receptiveness to the learning experience. It appears that emotions and learning are intertwined. Teruel (2013, p. 1) claims that "any process of conscious learning and memory is always emotionally coloured", and furthermore concludes that "there is no reason without emotion". Drawing on the evidence provided by cognitive neuroscience, Martínez Pérez & Salvador Bertone (2019, p. 8) explain the mechanics of this interrelationshipbetween emotions and learning: "emotional processing during learning has allowed for maintained, selective attention to take part in the circuit of working memory and in the access to new modules of executive functioning that guarantee the efficacy and durability of learning."

   Apart from emotions, social interactions also influence the learning process (Immordino-Yang & Faeth, 2010). A study by Nelson et al. (2007) found that the cognitive development of Romanian orphans was impeded because of the lack of social interaction they were experiencing. The study was conducted with 136 children who were younger than 31 months of age. The results showed that living in an institution had a negative effect on the intellectual development of the children. On the contrary, foster care had a beneficial effect on the intellectual growth of previously institutionalised orphans. In addition, the results indicated that the earlier children were removed from living in an institution, the more pronounced was the positive effect on their intellectual development.

   The importance of social interactions for successful language acquisition was demonstrated by research conducted with young infants. Experiments with nine-month-old infants showed that when exposed to an inanimate resource transmitting a foreign language, such as an audio recording, learning did not take place (Kuhl, 2011). When the same infants were exposed to humans interacting with them whilst transmitting the new language, learning did take place. It appears that apart from the "statistical learning" (Kuhl, 2011, p. 1) which occurs during learning acquisition where the brain is registering the frequency of the sounds forming the language, the social component is crucial for infants to be able to "crack the speech code" (Kuhl, 2011, p. 2).

3. **There are stages in brain development when the brain is particularly receptive.** Two such stages that have been identified are early childhood and adolescence. The brain development during early childhood is more receptive to the acquisition of languages. Drawing on research carried out by herself and by other scientists, Kuhl (2011) suggests that infants as young as eight months start learning a language phonetically and at nine months can start learning a new language. Another sensitive period during brain development is adolescence. During adolescence, brain development can counteract the ill effects of trauma; it appears that at this stage the brain can build resilience (Rimm-Kaufman & Jodl, 2020).

4. **Different parts of the brain are interconnected during the learning process.** Different physical parts of the brain are concentrated on specific domains of learning and mastery of skills; however, the actual learning process is an integrated and intricate one, which involves the simultaneous contribution of different areas of the brain. As Rimm-Kaufman & Jodl (2020) explain, during learning, new connections are formed between different parts of the brain. Earlier schools of thought emphasised the role of the right and left parts of the brain during learning, which were referred to as the creative and affective domain, and the logical and mathematical domain, respectively. This viewpoint is now considered as being too simplistic and detached from what appears to be happening in the brain during learning (Rimm-Kaufman & Jodl, 2020).

5. **Motivation and attention increase learning.** Motivation and attention both increase the release of dopamine and acetylcholine; these are organic chemicals that increase synaptic activity in the brain (Owens & Tanner, 2017). When synaptic activity increases, learning is more likely to occur. Attention is a prerequisite for learning since it selects which stimuli will be presented to the brain. "Attention, through its role in determining what enters memory, guides learning" (Lindsay, 2020, p. 16). Lindsay further explains that there is an interplay between attention and learning. Attention influences what can be learnt by determining the sensory input; at the same time, what has been previously learnt and stored as memory in the brain will, in the future, affect what the brain preferentially chooses to give attention to.

The neuroscience of learning and fun

"Emotion has a pop-out effect that increases attention" (Tyng et al., 2017, p. 16); furthermore, Tyng et al. (2017) explain that emotions can increase not only the encoding of memories but the retention of memories. Like all other emotions, the emotions generated during fun can increase attention and hence stimulate learning; however, fun provides an added impetus to the learning process. The neurotransmitter acetylcholine is released when there is an element of surprise (Owens & Tanner, 2017), and enjoyable sensations during the learning process release dopamine (Willis, 2007). These sensations are associated with fun. As explained earlier, neurotransmitters facilitate communication between neurons at a synapse. In addition, acetylcholine increases synaptic plasticity (Picciotto et al., 2012) and this is associated with the facilitation of learning. Dopamine increases motivation and learning (Berke, 2018) and it is directly involved in the "stamping-in of memory" (Wise, 2004, p. 1).

To reiterate, apart from providing a climate that promotes attention and promoting emotions which are conducive to learning, the sensation of fun stimulates the release of the neurotransmitters acetylcholine and dopamine, which in turn accelerate learning.

Introducing fun

According to the Cambridge Dictionary, fun is defined as "enjoyment or pleasure or entertainment". Fun is a subjective construct. As the maxim reminds us, one man's meat is another man's poison, and likewise, the concept of fun is a personal one. On the other hand, from an anecdotal perspective, there are activities or factors that are commonly attributed to fun in the classroom. Novelty, excitement, and movement may contribute to creating a fun environment. Some of the attributes associated with fun are also connected to the learning process. According to Kidd & Hayden (2015, p. 449), curiosity drives learning, and they define it as "information-seeking behaviour". Curiosity could be aroused through novelty.

Surpassing curiosity is the stage of wonder, which according to L'Ecuyer (2014, p. 2) goes beyond mere curiosity and spurs "the desire to know the unknown". According to L'Ecuyer, when there is no wonder, learning is not possible, only training may be achieved; learning can only occur if there is wonder.

The interdependence between learning and emotions was explained and explored earlier. According to Willis (2007) who was both a neurologist and a classroom teacher, brain imaging demonstrates that a "positive emotional environment" (p. 5) facilitates more effective learning. Fun can be used to create a positive emotional environment; fun tends to bring out the better side of students. Excitement is another emotion that can contribute to attaining a positive emotional environment. Martínez Pérez & Salvador Bertone (2019) argue that since research has shown that emotions play an important role during learning, the planning of educational experiences should aim at providing "optimal levels of emotional excitation" (p. 6). As classroom experience demonstrates, there is an interplay between fun and excitement; when students are excited, they are having fun and when they are having fun, they become excited. Movement can also be employed to enhance learning, and it appears that movement has beneficial effects not only on emotions but also on the brain and on the learning process itself. Drawing on research carried out earlier, Sousa (2010b) asserts that movement augments learning by increasing brain mass, and by positively affecting moods and cognitive functions.

A final justification for introducing fun in the classroom is the fact that fun also affects the other half of the teaching and learning duo: the teacher. The positive climate generated when learning and fun are combined contributes to positive interactions, and these positive interactions include interactions with the teacher. Emotions are contagious (Wild et al., 2001). If students are having fun, chances are that the teacher is too. The positive responses and emotions generated by the students are likely to trigger positive reactions from the teacher. If learning is fun, then probably, the teaching is fun. Biochemical and neural changes are also occurring in the brain of the teacher having fun. What sparks curiosity and generates joy in students is likely to bring about similar reactions in the teacher; hence, the teacher is also more likely to be more receptive to learning. One can infer that a fun environment creates a climate where teachers can learn how to become better teachers.

The Fun Barometer

To be able to gauge the level of fun of a learning episode, a Fun Barometer may be used. This Fun Barometer (Figure 3) attempts to quantify what students qualify as fun. In the proposed Fun Barometer a number of factors that bring about fun, or rather funactors, a term coined by myself, are listed. These funactors have been derived from literature and from experience.

Funactors can be tailor-made for each particular class or learning episode. These funactors may depend on the age of the students, the subject being taught, the particular content matter being delivered, the time of the year, the class dynamics, and various other external or internal variables.

Figure 3

Fun Barometer

	Anticipated				Actual			
Funactor: a factor that stimulates fun	0	1	2	3	0	1	2	3
Causes excitement								
Arouses curiosity								
Causes wonder								
Involves playfulness								
Makes use of resources that students enjoy								
Encourages creative expression								
Incorporates something new								
Involves humour								
Encourages positive interpersonal interactions								
Involves movement								
Other funactors:								
Overall fun rating								

Source: Author

During lesson planning, the Fun Barometer might be used to help the teacher purposely design activities or adopt strategies that foster fun in the classroom. After the lesson, when the teacher is compiling the record of work or carrying out a self-reflective exercise on the teaching episode, a post-assessment of the effectiveness of the funactors could be conducted. During the planning stages, the teacher can only anticipate what the students will judge as being fun. The post-assessment could help inform the design of future funactors. The Fun Barometer was designed as a flexible tool to assist the teacher, so it is not meant to be prescriptive, but it should rather be adapted to suit the needs of the teacher and the students. The Fun Barometer should be used at the teacher's discretion.

Conclusion

This desk-based research has brought forward justifications for integrating fun with learning. The review of literature has shown that the learning process in the brain occurs because of brain plasticity, which is brought about by the changes occurring at the neural level. Several studies have demonstrated that emotions play an integral part in the learning process, and emotions related to fun bring about heightened attention and the release of neurotransmitters. Both changes trigger and enhance learning.

The ultimate goal of exploring the fun imperative in learning is to inform classroom practice, thus enabling better learning climates. According to Willis (2007, p. 1): "Brain research tells us that when the fun stops, learning often stops too." Taking a leaf out of Willis's book, let us increase the fun, so that learning increases too.

Notes on contributor

Angele Pulis is a full-time lecturer at the Institute for Education. Her research domains include educational leadership, quality assurance of schools, pupil voice, and mixed methods research. She holds a PhD from the University of Leicester, a Master in Philosophy from the University of Wales, a Postgraduate Diploma in Educational Administration and Management, and a B.Ed. (Hons) from the University of Malta. Her career in schools has included various roles. She was Head of a primary school and an Assistant Head in both a sixth form and a secondary school. She has taught Integrated Science and Chemistry in various secondary schools and has also taught Biology up to sixth form level.

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