Journal for the Education of Gifted Young Scientists, 7(2), 341-352, June 2019
e-ISSN: 2149- 360X
http://jegys.org

Review Article

Connecting Neuroscience and Education: Insight from Neuroscience Findings for Better Instructional Learning

Muhammad Syawal AMRAN[1], Saemah RAHMAN[1], Shahlan SURAT[1] & Abu Yazid Abu BAKAR[1]

Received: 2 May 2019 **Accepted:** 13 June 2019

Abstract

Educational Neuroscience (EN) also known as Mind and Brain Education is a multifaceted interdisciplinary effort to bridging the gap between neuroscience and educational research. There is growing interest in the contributions of neuroscience to educational practice because applying neuroscientific research to classroom is a new and exciting endeavour to promote better learning. This article will discuss critically the emerging of education and neuroscience field and how its take place in education setting. Besides that, we illustrated the frameworks of educational neuroscience that bridge between two diverse perspectives of learning that related each other. We also reflect challenges and practices among the teachers and researchers in education and how neuroscientific approaches can complement educational practices. This article also will further show that, ideally, research efforts in neuroscience and education should be reciprocal. We suggest that a better understanding of neuroscience may offer significant advantages for educators. In this context, we have considered insight in neuroscience of education research specifically emotions and its links to cognitive processing. Therefore scientist and educators need to collaborate to build a strong research foundation of neuroscience and education that underpin emotions in learning. We believed this article will provide meaningful inputs for teachers and researchers to improve learning instruction and enhance student's performance.

Keywords

education, instruction, neuroscience, Malaysia

To cite this article:

Amran, M.S., Rahman, S., Surat, S., & Bakar, A.Y.A. (2019). Connecting Neuroscience and Education: Insight from Neuroscience Finding for Better Instructional Learning. *Journal for the Education of Gifted Young Scientists, 7*(2), 341-352. DOI: http://dx.doi.org/10.17478/jegys.559933

[1]Faculty of Education, Universiti Kebangsaan Malaysia. E-mail: syawal@ukm.edu.my, saemah@ukm.edu.my, drshahlan@ukm.edu.my, yazid3338@ukm.edu.my

Introduction

The emergence of Educational Neuroscience field has been trend especially in the educational research for that period of time (Janet et. al, 2015; Jones, 2014; Thomas, et al., 2018). Education is about enhancing learning and teaching and neuroscience is about understanding the biological brain as well as mental processes involved in learning. In 19th century had been the climax period of research related to brain until it was known as '*decade of the Brain'*. The development of imaging technology such as *Magnetic Resonance Imaging* (MRI), *Electroencephalogram* (EEG) and functional *Magnetic Resonance Imaging (*fMRI) has driven all the scientists particularly in neuroscience to interpret the structure and function of brain in micro (De Smedt, 2018; Dick, et al., 2014). This growth has drove all kinds of new invention about brain development such as brain region, neurons and hormone, rather associated biological brain functions with physiological and psychological particular emotions as well as cognitive processing. Result from the research has contributed to the improvement of all fields including education. This has attracted all the researchers in psychology and neuroscience fields to investigate and associate the finding from the neuroscience research to be applied in educational context (Howard-Jones, 2014a, McCandliss, 2010; Goswani, 2004). This has gave implication in influencing the landscape of research and practice in education because it has gave room for the finding of neuroscience research to be applied in the context of teaching and learning.

This growth has encouraged the emergence of various terms that associated with the neuroscience research findings to be transformed in the context of teaching and learning comprehensively such as brain based learning (Caine & Nummela, 1999; Caine et al., 2005), cognitive neuropsychology (Ansari & Coch, 2006), neuroeducation (Ansari, DeSmedt, & Grabner, 2012; Battro, Fischer & Lena, 2008), and educational neuroscience (Immardino, 2007; Mareshal et al., 2014; Zanida, 2015). The use of this term explain that the disclosure has close up the findings in research of teaching neuroscience in the classroom could help to improve instructional strategies, emotion and social development, cognitive processing skills, learning strategies, and behaviour towards learning. Neuroscientists believe that not only teachers can educate students to learn yet educate their brain to comprehend and process their learning (Kozumi, 2004; Tommerdahl, 2010).

In addition, there are many endeavours in bringing the gaps between neuroscientist, psychologist, and educators through academic discourse such as seminars, conference, and workshop. Effort can contribute to the opportunity for all the experts to interact and discuss the findings of neuroscientific research in the academic context and the direction of research in this field. During the early 2000, there were three national conferences that were organised in New York, Granada, Spain, and Japan. All the conferences discussed and debated the agenda in existing

Mind Institution, Brain and Education Centre, Havard, as well as centre of Educational Neuroscience, UK. The main purpose of the establishment of this institution is to be a centre of research and development of knowledge about psychologist, neuroscience as well as education. Furthermore, the learning approach that associated neuroscience findings got the encouragement output and attracted the attention of all the researchers in education as well as educators (Goswami, 2004; Zadina, 2015).

Since previous ten decades, there were many research database which integrated neuroscientific research in education like *Mind Brain and Education Journal*, *Trend Neuroscience as well as Education Journal* and many more. This has proven true as this research of neuroscience in education has got the serious attention from the researchers and educators. Report from UNESCO in 2013 related with the third series research policy reported that around 2012, averagely more than twenty scientific articles were published every day from the research findings of neuroscience in education (Zadina, 2015; Howard-Jones, 2016). This proved that the published research has proposed the Neuroscience field in education as a field that got the attention in this era. Report justified that more aspects that have not been explored and less given attention and remark in improving teaching and learning in classroom. Thus, continuous effort should be done in order to close the neuroscience gap in education particularly in teacher's teaching and learning. This writing will discuss in further frameworks of educational neuroscience, issues and challenges as well as insight form neuroscientific research findings particular brain, emotions and memory in learning.

Educational Neuroscience Framework

The emerging of interdisciplinary research studies related to neuroscience, psychology and Education has been referred to by different names, such as brain based learning (Caine & Nummela, 1997; Nummela-Caine & Caine, 1998), cognitive neupsychology (Ansari, & Coch, 2006; Antherton, 2002, 2005, Berninger & Corina, 1998; Byrners & Fox, 1998), neuroeducation (Ansari, DeSmedt, & Grabner, 2012; Battro, Fischer & Lena, 2008; Howard-Jones & Fenonton, 2011), educational neuroscience (Immardino, 2008, Mareshal et al, 2014; Zanida, 2015). However, in this article the term Educational Neuroscience is used because education is about enhancing learning and neuroscience is about understanding the biological brain as well as mental processes involved in learning. Educational Neuroscience also the combination of knowledge between finding of neuroscience research with the educational research theories and practices scientifically in improving teaching and learning of students. It also illustrated understanding of biological role and student's brain that can be associated with the teaching pedagogy (Howard-Jones, 2010; Thomas et al., 2018).

According to the report by Royal Society Brain Waves Module (2011) the common ground suggest a future in which educational practice can be transformed by science, just as medical practice was transformed by science about century ago. Moreover, educational neuroscience is an emerging effort to integrate neuroscience methods particularly functional neuroimaging with behavioural methods (Dick, et al. 2014; Howard-Jones, 2010), bridging gap between educational learning theories (Zanida, 2015; Tommerdahl, 2010) to address issues of learning instruction and enhancing psychological development and academic performances. Tokuhama (2014) has been illustrated the Neuroscience Model and education detailed in order to understand/comprehend/perceive clearly how the result and applied the findings into the classroom context. Therefore Venn diagram which referred to three main circles involves neuroscience, psychology and pedagogy that represent education has been showed in the result. In that Venn diagram below, the psychology component that overlapped with pedagogy circle is representing for education psychological field. This field could give implication in understanding and knowing the cognitive, social and emotional development that can contribute to the process of teaching and learning.

Meanwhile, the third neuroscience circle that associated with psychology and pedagogical produced educational neuroscience. This is because the emergence of interdisciplinary can be integrated in research that involves biological, psychological and educational perspectives, with the express intention of improving educational practices. All the three discussed circles in the end will produced a holistic neuroeducation branch as illustrated in Figure 1.

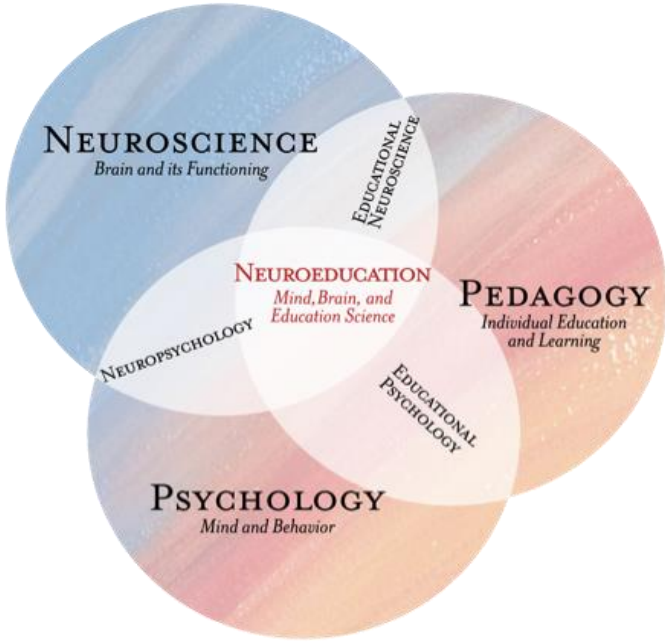

Figure 1.

The Emergence of Neuroeducation

Source: Interpretation of Tokuhama-Espinosa's Transdisciplinary Field by Nakagawa, (2008), redrawn by Bramwell 2010

Issues and Challenges in Educational Practice

The rapid development for education world in 21st century has produced different kinds of new fields incline with education for this century. Scientific research findings for two decades ago was done to improve the quality of education system. Researchers in educational psychology field and neuroscience cognitive have produced and integrated many models and theories that are able to contribute to the teaching and learning process. They agreed that research for this period need all networks from different/multi knowledge that covers the social, cognitive, biological and behaviour aspects that are able to contribute to the upgrading, advancing educational practice directly or indirectly (Bowers, 2016; Jodi Tommerdahl, 2010). Result from the interaction between experts from the educational psychology and cognitive neuroscience has created new field known as Neuroscience and Education. They believe that the understanding of brain and mind is the key to help teachers and learners in improving learning process. However, the process of this understanding need great cooperation and teamwork between the researcher and practitioner especilally in education field. However, there are few issues raise especially in terms of context of practice (Ansari, et al., 2011; Mareschal et al., 2014).

Previous Neuroscience Research looking more towards the functionable of brain and roles of neuron inside the brain hence results of findings in the research were viewed differently according to the science social context (Tokuhama-Espinosa, 2010; Fischer et al., 2009). This is because neuroscience research viewed more findings results as a clinical data compared to the data in science social field. The arising issue is how the findings can be translated to the social science field especially in education field. Furthermore, less interaction between the experts in neuroscience and cognitive neuroscience has limited the barrier and network of that knowledge (De Smedt, 2018). Although there are many conferences and seminars have been organised for encouraging and close up the knowledge gap between neuroscience research with education field. For example, forum *Organisation for Economic Co-operation and Development 2007*, *Forum Oxford's Cognitive Neuroscience and Education* and many more. However, neuroscience field and education still poorly understood especially among the practitioners. (Zadina, 2015; Howard-Jones 2010). In other meaning, the practitioner has not mastered clearly the neuroscience application to be applied in teaching and learning.

In addition, less further research especially in teaching and learning which involve normal student compared special needs students such as dyslexia, autism, attention-deficit problems, giftedness, and many more (Abu Yazid, 2016; McCandliss, 2010; Ansari et al., 2011). Although the surveys give lots attention to the special needs students however the surveys are viewed as clinical data that need to be translated in teaching and learning context. In educational context, this problem has restricted teachers to undertand the development of normal students afterwards can construct the instructional strategy taht can contribute to the process of teaching and learning.

Besides, neuroscientists and psychologists need to get all the inputs from the teachers to identify real issues face by students and teachers in teaching and learning process. To make sure all the results from the neuroscience surveys are relevant in educational context, information from teachers and psychologists is very crucial to make sure surveys that have been done could cope the learning issues in the classroom. This collaboration can make any survey is more holistic and relevence to be applied in the classroom.

In educational context, teacher is the only close individual with the students because teacher is not only teaching students to learn but also educate student's brain to understand and processing the learning. (Kozumi, 2004). However, most of the teachers not fully understand the students's cognitive and giving more attention to the teaching syllabus. Goswani (2006) cited that student brain development and mind are different according to their age level and student biological development. This is because, less courses and professional training that are related to the cognitive development and neurosciences unable them to understand further ways to improve their brain through teaching and learning (Howard-Jones, 2010; Bruer, 2003).

These training and courses have limited teacher's knowledge to understand the related neuroscience terms especially that involve with biological brain. This implication cause aspect involve with biological development less given attention in the classroom. Teachers need to have basic knowledge about brain development in order to deliver suitable teaching with student's brain development (Gazzaniga, 2004). Thus, neuroscientists and psychologists need to have interaction with teachers through training and courses which can help to develop suitable learning instructional with students' development.

In conclusion, it can be understood that there are many issues and obstacles in this new field. However, with networking and cooperation between the neuroscientist, researchers and educationalist as well as practitioners are able to create the theoretical framework and model that can contribute to the teaching and learning. In the same line, the findings in neuroscience research can help teachers to understand the function of students' brain as well as improve their teaching and learning process in the classroom.

Insight from Neuroscientific Findings: Brain, Emotions and Memory

Human emotion plays a significant role in influencing individual life growth. Emotion is one of result of the burst of outdoor stimulation that catalyst with subjective feeling, physiological response and behavior (Tyng, et al., 2017; Damasio, 2013). Advance technology during this period has helped all the neuroscience researchers to understand clearly about role of emotion using neuroimaging technique that function to detect and acknowledge the emotion state that will contribute to the comprehension in cognitive field, affective neuroscience and educational psychology that will optimum memorization which influence result of learning (Carew et. al. 2010; Immordino-Yang, 2015).

There are few views to understand situation and emotional transition: (1) Subjective approach that can evaluate feeling and previous experiences going through (Jack, 2015); (2) Understanding through behavior, facial expression (Russell, 2003) shown and voice expression portray as well body gestures (gestural) (Dael, 2012). In the educational context, both approaches mostly used to measure student's emotion in understanding emotion role in teaching and learning process (Penkrun et. al. 2006; Damasio, 2013). This is because there are many previous research works explained that emotion influence student cognitive processing. In other neuroscience contexts, (3) objective approach through physiological response cover all the activities of Central Neuron System (CNS) electrical and hemodynamic as additional response to the response of Autonomic Neuron System (ANS) such as heart rate, body temperature and blood flow rate have been used to understand emotion and its function towards human brain (Noa, Qijing & Zhijian, 2016; Jack, 2015). There are many neuroscience research that assigned role of

emotion in influencing part of students' brain which are their amygdala and prefrontal cortex. These parts of brain can influence students' cognitive in the classroom (Lyons & Beilock, 2012; Vogel et al., 2016; Levenson, 2011). Prefrontal cortex is brain part that processing information for higher order reasoning while amygdala will record the emotion or situation in life. (Immardino, 2015). From the research found, researchers will discuss in detail the findings in neuroscience research that can be applied in learning context.

In the classroom context, pressure and tension towards emotion will give effect to the physiological and biological brain. There are two main parts involve which are *Autonomic Nervous System* (ANS) and *'hypothalamus – pituitary – adrenal'* that wil stimulate biochemical to react towards phisological and biological brain of human. *Autonomic Nervous System* (ANS) plays role to secrete *Catecholamines* hormone. Catecholmines hormone that has been secreted from the part of brain which is Locus Coeruleus and Adrenal Medulla that act as '*Flight or Fight'* in determine any responses happening with around the environment (Immardino, 2015).In the other word, these responses will give effect to students' behaviour in learning such as play truant; disturb the class session and many more. Stimulation of the hormone will give effect to their concentration, working memory and long-term memory. (Susanne Vogel, et al., 2016).Thus, it can be understood that negative deep emotion will produce *catecholamines* hormone that disturb the biological and physiological of human.

Moreover, learning environment that cause stress can stimulate amygdala to capture students' emotions such as fear and worry in the classroom. Attention that given by amygdale toward negative emotion can disturb focus of students while they are learning in Mathematical Subject. Stress in the classroom influenced *'hypothalamus – pituitary – adrenal* that secrete Corticotropin hormone (ACTH). Breedlove, Watson and Rosezweig (2010) and Sapolsky, (1990) cited that hipotalamus stimulate anterior pituitary on part of the brain to secrete Corticotropin hormone (ACTH). These secreted hormone produced cortisol to be released in blood vessel. The concentration of the cortisol takes time between 20 to 30 minutes to influence the neurons that can reduce the process of plasticity inside the brain to form cell and interconnect it with other cells. Beside that, this hormone also can slow down the dendrite production to receive and send stimulation to the other body cells. Moreover, this also can give effect to the formation of myelin channel (*myelination*) which is the conductor to protect the flow of neurons as well as affect memory. This can retard the activation of neurons development especially in both parts; prefrontal cortex and amygdala inside the brain for actively function.

In the behavioural context, when students are not interested paying their attention to understand and focus toward teachers' teaching, it will affect to the prefrontal cortex particularly when its involve reasoning, decision making aspect

and many more in mathematic. Susanne Vogel, et al., (2016) supported those emotional pressure unable students to process learning information that will be transmitted or delivered but recorded negative emotion while learning mathematic. As the result, negative emotion recorded from the students in the classroom will left negative experiences for them to learn mathematic. In other hand, those experiences influenced perception, emotion, interest and motivation of students to learn (Lyons & Beilock, 2012; Noa, Qijing & Zhijian, 2016). This problem will affect students' achievement academically. Moreover, anxiety also affects their concentration because of their fear and nervousness, sweating and many more. This has gave them negative experiences to learn as well as influence their perception, memory performance and academic achievement. Above all, the neuroscientific research has given clear picture on the significant of emotion in influencing cognitive process among students.

Conclusion

Research in educational psychology is related to the process of improving the teaching and learning of student while research involving neuroscience is to understand the function of part of the brain and how its function to process information. Research result in neuroscience field has gave great implication to the education field as it capable to contribute to the modification for the teaching approaches used by the teachers and improve student's achievement for this century. Howard-Jones (2007) justified that student's achievement is not only can be determined from the environment factor but also by biological factor as it plays a significant role in understanding abilities of student. In other words, the understanding of biological factor enable the practitioners especially teacher to understand learning problem specifically faced among student. Moreover, the finding in neuroscience research has helped teacher to understand structure and function of students' brain thus prepare the suitable materials for their level of brain growth. Thus, the consciousness of the neuroscience and education is one of the efforts to upgrade the delivery system in education as well as improve students' achievement. Although the disciplinary knowledge between neuroscience and education quite complex however, comprehensive efforts should be done because result of this knowledge network able to give great impact in improving more teaching and learning practices in a classroom especially for coping with students' emotion and cognitive. These inputs are able to help teachers to understand student's growth and create fascinating, motivating and fun learning environment. This fun learning environment will boost up students' emotion to learn and change their negative perceptions of teacher's teaching style hence stimulate their performance memory. This writing expected to offer benefits especially for teachers

in improving a suitable instructional learning with emotions, biological, and student's cognitive development.

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