Leveraging Neuroscience as a Tool to Advance Architecture Pedagogy

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Abstract: The brain alone is a complex organ in which all sensory, intellectual, emotional, and intuitive perceptions take place. Today, one of the research challenges in teaching-learning science is the answer to the question of how much the application of findings from neuroscience studies on learning can be effective in improving the quality of education. Where are the overlaps between the language of neuroscience and the science of teaching-learning? While previous teachings have emphasized the importance of schemas or mental formats as a new learning infrastructure, cognitive neuroscience looks at how knowledge, insight, and experience are processed in the brain and how neural connections in the brain provide new learning. The information encoded in the hippocampus can form schemas reliably in institutionalized neocortical networks. How can these mechanisms be used to improve education, especially architecture education? The current insights from the basic and applied research of cognitive neuroscience, cognitive psychology, and teaching-learning science research promise a change in educating architects. This article introduces the commonalities of neuroscience, cognitive studies, and architectural education.

Keywords: Cognitive neuroscience, Architecture education, Schema, Teaching, Learning

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Introduction

Improving education is one of the most important strategic priorities of many countries. Because the brain is a major organ involved in learning, generating and developing knowledge about brain function can improve educational programs. Cognitive neuroscience is proliferating, and based on its findings, the scientific approach to classroom instruction can move away from the current path (Torabi Nami et al.,2020; Tibke, 2019). On the other hand, many reasons have been raised to explain the relationship between cognitive neuroscience and education and learning (Torabi Nami et al.,2020).To understand how teachers change the brain, we need to begin with a reasonably new understanding of learning biology. The brain is an experience-dependent experience throughout our lives. The cerebrum, the most significant portion of our brain, finds humans to adapt to the world around us, which is described by the scientific term neuroplasticity (Burns, 2019).

The multimedia revolution has also dramatically affected a wide range of human learning (Lazar et al., 2020; Mayes, 2018). The structured growth of the new generation's mind largely depends on exploiting new technologies (Small et al., 2009). Using advanced technologies, such as brain imaging, information about brain functions has multiplied in recent years (van Niekerk,2017; Sousa,2001). The brain is a complex organ where all sensory, intellectual, emotional, and intuitive perceptions occur. Neuroscience has used electrophysiological tools and brain imaging techniques to understand how knowledge, insight, and experience are processed in the mind-brain and the neural pathways involved (Goswami, 2006).

Researchers' findings have brought new insights into memory, attention, alertness, thinking, excitement, motivation, and learning (Wolfe, 2010; Varma, 2008). Neuroscience has had a significant impact on areas such as psychology. It has paved the way for developing disciplines such as cognitive neuroscience, evolutionary cognitive psychology, social cognition, and social neuroscience. Furthermore, the application of neuroscience in educational sciences is more widespread than in other fields (Jang et al., 2021) but has yet to be in architecture education. As the architectural design studio culture is based on old-century traditions, it should be rethought based on an inclusive learning environment to diversify the profession (Pilat, 2022).

Today's students cannot be treated as older generations and have their own needs and demands. The brain of people change over time, and people become altered through their life and historical experiences. The cybernetic era has changed the human brain drastically. The presence of different social media, as well as the multimedia revolution, have had a high impact on the way people learn. Taking a look at Marist's mindset 2026 as a cultural touchstone proves why today's learners are unique ("The 2022 Marist Mindset List for the Class of 2026").

A new field of study called educational neuroscience combines cognitive neuroscience methods and exceptionally functional imaging of the brain with educational sciences and tries to study teaching and learning issues scientifically (Varma et al., 2008; Dougherty et al., 2018), (Pinho et al., 2020; Rodgers et al., 2020). The subjects include the interaction of neuroscience and educational sciences, Mind, Brain, Education (MBE) and learning about the role of schema, individuals' memory, and learning system, and applying Evidence-Based Education (EBE) and Brain Compatible Educational Methods that are covered in the current research. Healthcare has been using evidence-based design (EBD) for years. People for designing places for to feel better upon visiting them. Even though a school building is not a place most people seek to heal, there are ways to make an educational space feel healing. They use research-based design benefits, health, and satisfaction (Moser, 2014 #11).

Incontrovertible biological evidence about the mental and physical affect of the can be tracked. Complex data can be delivered and measured down to cortisol levels to show how different built environments engender biochemical changes in our bodies and can harm human health, both mentally and physically. This means we can no longer teach future architects that the abstract part is design's unique central organizing feature; we need to put people, biology, and human functions at the center of the thinking. There are no more limitations, and the explosion of scientific and tech innovation has produced biometric tools for uncovering people's thoughts, feelings, and emotional responses to build conditions. Architectural educators can no longer ignore this evidence.

Today architects face a unique opportunity to reshape the environment according to biological nature and use evidence-based design to build what people want to be in and experience. With new biometric tools, post-occupancy evaluations are facilitated by asking people where they feel at their best, and this should be referred to and taught in architectural schools (Kim, 2020).

The relationship between neuroscience studies, teaching-learning science, and architecture education

To understand the process of information processing in the brain and its neural exchanges, it is necessary to have the requisite theoretical information about brain structures related to learning and memory. The role of cellular and network mechanisms that are somehow involved in memory has been clearly stated in some studies (van Kesteren et al., 2010; Huber et al., 2014; Gilboa et al., 2017). For example, the events and semantic memory structures include the medial temporal lobe, the temporal cortex, and the frontal cortex (Dolmans, 2005). The medial temporal lobe, which surrounds the hippocampus, plays a vital role in memory storage. The hippocampus is also involved in coding and retrieving memory (Miyashita, 2004; Osada et al., 2008). Of course, the ultimate repository of explicit memory appears to be the neocortex (Miyashita, 2004; Osada et al., 2008). However, the temporal and spatial interaction between environmental stimuli and the superior cortex of the brain, which forms the basis of event memory, depends on the function of the neural circuits in the temporal lobe (Miyashita, 2004; Osada et al., 2008). These areas are activated in two processes when recalling and in connection with retrieving the contents of memory. One is the active recovery current that flows from the frontal cortex downwards, and the other is the retrograde flow from the medial temporal lobe for automatic recovery of the current flow from the frontal lobe. The presence of these pathways, especially the medial temporal flow, has been shown in monkeys (Miyashita, 2004; Osada et al., 2008; Wang et al., 2010).

One of the fascinating challenges in learning studies in neuroscience is to show the interactions and hierarchies of areas of the cerebral cortex and to analyze these connections using functional Magnetic Resonance Imaging (fMRI). Functional magnetic resonance imaging, one of the valuable practical tools in the study of cognitive neuroscience, can also have many applications in research related to human learning. There are various methods of fMRI imaging in neuroscience and cognitive studies (Morris, 2006; Morris et al., 2003). The strategy of a functional magnetic resonance imaging study is to create an action in the brain and to observe and examine the brain's response to that action. Brain activity depends on the blood oxygen level in the target area, called Blood Oxygen Level Detection (BOLD). The basis of BOLD is the reaction in the magnetic field and the creation of an analytical image sensitive to changes in the oxygen level of hemoglobin. Areas of the brain with high oxygen concentrations produce more signals than areas with less oxygen. The practical application of this process is a kind of indirect measurement of neuronal activity at the moment when a person performs a specific cognitive task. BOLD sensitivity is directly dependent on the strength of the magnetic field. Imaging is repeated every one to three seconds, and the brightness of that area of the brain after statistical analysis indicates the amount of neural activity (Miyashita, 2004). Other technologies, such as Positron Emission Tomography (PET), are also used in neuroimaging studies. Weakly radioactive glucose is used so that areas of the brain that absorb more blood due to cognitive activity caused by the radiation of radioactive material in the image are specified. Before choosing the appropriate neuroimaging method for a particular cognitive function, one must determine the proper fit between that function and the intended imaging method (Miyashita, 2004; Gilboa, 2017). In cognitive assignments, a set of stimuli is presented, and at the same time, the outcome of the BOLD response is examined. This response represents a steady state of the individual hemodynamic response functions against the set of stimuli presented. In the current study, there is a great deal of interest in examining theories about the relationship between previous teachings and new learning and the role of the neocortical hippocampus (Miyashita, 2004; Osada et al., 2008). These studies examine the role of neural circuits and synaptic processes in the hippocampus and neocortex in memory formation, which the main principles are:

1. The role of schemas in consolidating neocortical memory.
2. How to update memory as a critical factor in consolidating memory in the hippocampus.

Despite some architectural innovations, its core pedagogical theory remains firmly rooted in the past, ignoring significant biological insights about the human condition and our functioning. Cultural and social factors shape, process, and transform our cognitive schemas and processes. During the learning process, schemas are formed to structure the individual's mental models of the subject matter. Learning can be influenced by previous learning and supplementary learning that has emerged from cognitive psychology. Professors who understand these theories can choose the most suitable teaching-learning methods. Mental models or schemas represent a specific part of a cognitive system. Changes in one part affect others in a cause-and-effect relationship.
It reinforces learning when learning conditions are appropriate for the sensory input associated with the learned subject. This means there is a logical connection between sensory stimulation and the subject matter because the sensory stimulus and the subject matter relate to previous experiences. Therefore, creating a schema facilitates learning. For example, the use of non-verbal skills by speakers of speeches creates a kind of multisensory interaction. Perceptual representations are formed when body postures stimulate the listener's pre-motor cortex. The homogeneity of auditory-conceptual perceptions results in better understanding, representation, and learning.

Learning studies emphasize the crucial role of multiple sensory aspects in information processing. These findings confirm each other, whether electrophysiological (Event-Related Potential (ERP)) or functional magnetic resonance imaging (Shams et al., 2008; Tatz et al., 2021). Seitz and Shams have proposed three possible neural processes in support of the theory of multisensory or multimedia learning, which includes, creating change and synergy in one-dimensional sensory structures, change of multisensory structures that interact indirectly with each other, and modification and facilitation of encoding in multi-sensory structures by other multi-sensory structures (Shams et al., 2008).

The appropriateness of learning conditions to the type of sensory input related to the subject being learned reinforces learning, meaning that because the sensory stimulus and the subject matter are relevant to the individual's previous experiences, there is a logical relationship. Hence, it is tangible that creating a schema will facilitate learning. For example, when giving a speech, using non-verbal skills by the speakers creates a kind of multisensory interaction. Enhancing speech content with body postures causes the formation of perceptual representations in the pre-motor cortex of the listeners. This homogeneity links auditory-conceptual perceptions and body movements (e.g., proportionate hand movements), resulting in more and better understanding, representation, and learning. It should be noted that some actions that have a work aspect (such as running) are also represented in parts of the motor cortex, while actions that are not (such as knowing) create activity in the pre-motor cortex.

Accordingly, researchers have long focused on the function of the brain in the learning process as an integrated structure. If appropriately used, E-learning, multimedia learning, educational skills, existing software used in the design of educational content, and many current topics in teaching and learning will have increasing effects on improving education. Examining the interaction of different brain regions in information processing, learning consolidation, and memory retrieval can be done in detail in future neuroscience and cognitive research. In their core thinking, architectural design educators might hold the false notion that the mind is a "blank slate." In reality, humans are hardwired to respond to specific patterns in particular ways when they enter the world; it is time for architects and educators to take note of this reality as well (Sussman et al., 2014).

Therefore, by inviting brain researchers to natural learning environments, the interaction between neuroscientists, educators, and professors providing architecture education can be strengthened. It should be noted. However, those non-specialist understandings of neuroscience findings will lead to distortions of educational neuroscience (Gobet, 2005; Gobet et al., 2001).

The interdisciplinary field of neuroscience and education includes the interconnected findings of three types of studies: scientific, mediating, and practical. Each is derived from three types of primary evidence (biological, experimental, and social). Today, advanced technologies such as functional magnetic resonance imaging, event-dependent capacity (ERP), Magneto Encephalo Graphy (MEG), and positron emission tomography are practical tools in neuroscience studies. They have found a prominent place. The necessary evidence can be collected and analyzed to achieve the goals of cognitive neuroscience research in related fields such as teaching and learning. Of course, there is no one-to-one relationship between these three types of study and the three types of evidence on which they are based. With the increase in human capabilities, the need to process information in the environment has also increased. In this process and the transformation from natural experiences to scientific experiences, architects need to set criteria for designing the environment. People are affected by various environmental elements every day. Their feelings, perceptions, and desires are affected by the environment. Neuroscience in architects' access to those criteria can be very useful. The brain, as one of the most complex organs in the human body, which is responsible for processing all information received from environmental stimuli through the five senses as well as intellectual, emotional, and intuitive perceptions, is the basis of new research conducted in recent years by brain scientists and some architects as well as environmental psychologists are doing (Sternberg, 2006). Advanced equipment has made it possible for learners to understand more accurately the effects of the environment on the nervous system, the active areas of the brain against environmental stimuli, and the extent to which each affects the brain, perceptions, and emotions. Relying on that information while defining the appropriate architectural criteria, an environment in harmony with human beings' physiological and neural structure is created. The Academy of Neuroscience for Architecture of the American Association of Architects is one of the research centers in this regard (Sternberg, 2006). Significantly as the use of technology and computers is changing our brains, it is essential to become more familiar with how these technologies alter our brains. Teachers, as brain changers, can promote deep learning by building on the student's prior knowledge, and that knowledge base provides the foundation for deeper understanding and transference (Hattie et al., 2017).

In this regard, neuroscience can be helpful for an architecture career in two ways. First helps educate future architects according to their capacities and based on new computer technologies which have evolved the learning and the capabilities of today's learners. Second, it helps future architects find the mentality that they should design according to the affects, needs, and desires of today's human mind.

Mind, Brain, Education (MBE): Joint Chapter of Neuroscience and Educational Sciences

Applying neuroscience research in educational settings is not straightforward (Bruer, 1999). In any case, in the study of scientific texts, we encounter two significant gaps between the two fields (Tokuhama-Espinosa, 2015). The first gap arises from the abstract concepts of neuroscience and the educational sciences and the epistemological differences between their explanatory and scientific theories. The second gap stems from the differences between the basic sciences on the one hand and the applied sciences on the other (Della Sala, 2009). These differences are in the field of the underlying neuroscience philosophy, theory, research method, and data type (Tokuhama-Espinosa, 2015) and in educational practice in terms of cost, time, and issues of this kind (Tokuhama-Espinosa, 2015). Despite all these obstacles, today, some prominent researchers in neuroscience and educational sciences strongly believe that it is possible to bridge these gaps and that the link between these two branches of science is mutually beneficial (Goswami, 2006; Tokuhama-Espinosa, 2015; Della Sala, 2009; Ansari, 2011; Della Sala, 2012). Effective practice has been proposed to link different dimensions of neuroscience and educational sciences. Because these gaps involve scientific and practical aspects, establishing this link requires a complex and multi-step approach. Ansari and Coch believe collective effort and wisdom are needed to clearly define the goals and benefits of linking educational sciences and cognitive neuroscience (Ansari, 2011). In this regard, a new branch of applied sciences has been formed in Mind, Brain, and Education (MBE), which considers using brain knowledge in teaching and learning sciences necessary and undeniable (Ansari, 2011). Science in Mind, Brain, and Education (MBE) is, by definition, transdisciplinary. The Science of Learning (MBE) integrates neuroscience, psychology, and education to identify research-informed practices to help students achieve the ultimate goal of the discipline. With this approach, a new perspective is applied to research and training consistent with education's very nature, namely understanding and managing educational processes (Steenbeek, 2015 #9). This new field is expected to provide accurate information on the potential consequences of the interaction between neuroscience and academic science (Della Sala, 2012). Ansari and Coch suggest that teachers should learn the basics of neuroscience and that neuroscientists should be trained in the basics and theories of teaching methods (Ansari, 2011).

It is essential to point out two issues here to understand the potentially beneficial effects of this interaction. The extent to which educational principles, mechanisms, and theories can be improved and complemented by the findings of cognitive neuroscience and the category of neuroscience principles that may be applied in academic research, leading to attractive and used interdisciplinary research experiences. The results of knowledge sharing and effort in the two fields of education and neuroscience will include a better understanding of learning, using theoretical knowledge in education, and interdisciplinary research projects (Ching, 2020; Sigman, 2014). In teaching architecture active processing of experiences and brain interaction with the environment, and the growth of neural networks can be a reasonable basis for designing brain-compatible training in architectural studios, which can take place by applying multiple technics, which are listed as follow:

- Using multimedia training to stimulate multiple senses:

Such as Smart Boards, Miro boards, 3D Printers, iPad, VR glasses, Touchable Holograms, Metaverse, etc.

- Creating a learning environment free of stress but with a degree of difficulty and a pleasant challenge: Even though students might experience exhaustion and stress, especially during deadlines and charette, the vibe of the studio and the bonds between students can create a flexible environment that makes any student feel at ease.
- Motivate learning in the learner and facilitate it by being enthusiastic and by Strengthening students' self-confidence

Enthusiasm and passion are contagious. The educator's positive energy motivates students, as a positive attitude is necessary for a thriving learning atmosphere. Praise builds students' self-confidence, competence, and self-esteem. Recent neuroscience research has shown that receiving sincere praise activates the same areas in our brain that are activated when we receive money or romantic attention – the ventral striatum and the ventral medial prefrontal cortex. It is also said to release dopamine, which is associated with motivation, focus, and positivity. In other words, it activates the reward circuit in our brain.

The content of the course should seem exciting and relevant to the students and provide authentic, real-world tasks through engagement with community members. Educators sharing their love and passion for the profession can also motivate the students (Pilat, 2022). Including all learners to improve based on their brain capabilities: Varying teaching technics and diversifying the design studio environment by incorporating all potential learners with various talents according to their respective skill sets and disability, are means of including all learners based on their capabilities. In explaining brain-compatible educational methods, it is essential to consider the effects of nutrition and sleep (work hours of undergraduate, graduate, and doctoral architecture students), individual differences, emotion in learning, motivation, and a positive attitude in the learner.

Many scientific principles of education can be well generalized in architecture education. Architecture education includes its various dimensions, including the characteristics of the subject matter, the training environment before the practical work and during the suitable course, the sense of responsibility, and the relationship with peers and professors (Matcha et al., 2019; Slavin, 2020; Tett at al., 2021). Findings of teaching-learning science can also help improve architecture education. These findings include the importance of individuals' prior learning in new learning, the effects of multimedia education, metacognition-based knowledge, and self-regulatory skills (Zhou, 2018; Wade et al., 2018).
Bruer emphasizes the following factors in this regard:

- Constructivist patterns of learning and teaching
- Active participation and involvement of learners in the learning process
- Semantic processing instead of parrot-like retention
- Create a learning environment that is minimally threatening and highly challenging (Bruer, 1999).

Students' engagement triggers neurochemical changes in the brain (Merzenich, 2013). As learning shapes, dendrites grow, and an increasingly vast network builds up. When two dendrites grow close together, chemical or electrical messages can be sent from one neuron to another. Over time—and numerous synapses—the pathways related to the topic are made more robust, allowing the student to connect and act upon learned ideas (Envision, 2015).

Students can be held back if they experience emotions such as fear, frustration, embarrassment, melancholy, and stress. Emotions control learning, according to scientists. In the limbic system, located in the lower part of the brain, incoming stimuli are interpreted emotionally. The limbic system interprets stimulus by opening or closing access to cortical function in higher parts of the brain. Many students mistakenly believe they have poor memories when their emotions have undermined them. In order to learn quickly and effectively, a different set of chemicals flow into the synapses when learners feel confident. The level of intelligence is not fixed. A neuron can grow more synapses and strengthen its connections, no matter how many synapses it has. The "growth" mindset of students who embrace this fact leads to a motivating sense of empowerment. As part of a learning process, in "growth" mode, students are more likely to work hard to develop their abilities (Sisk, 2018).

It is essential to strengthen such an interaction between neuroscience and architectural education, which has raised hopes in architecture education and related research (Douglas et al., 2019; Dossi et al., 2020; Metternich et al., 2020). Following from a psychological point of view, the role of previous teachings will be discussed, then from the spectrum of cognitive neuroscience, and finally, the use of these concepts in architecture education and research will be reviewed. This article tries to provide a good perspective of the interaction and synergy of architecture education and cognitive neuroscience by emphasizing its practical aspects by presenting a list of recommendations.

Cognitive Psychology Perspective on Previous Teachings and its relation to New Learning

One of the requirements for receiving and coding information and acquiring new knowledge in the mind-brain is the existence of previous knowledge related to that subject, which is referred to as mental design or schema (John, 2018). The term schema is often used instead of general knowledge, which leads to processing information in a particular field. Each student, while linking the separate structures of a concept together and linking them together, like a fabric, will be able to produce a schema and understand its content. Schema facilitates the process of encoding, storing, and retrieving information related to a domain (John, 2018). According to research, complex information is coded in the form of four main steps: concept selection and reconstruction, abstract thinking, interpretation, and conclusion (Gao et al., 2021; Kuhns et al., 2020). Reconstructing the concept is crucial in recovering stored information and reducing that amount of information as much as possible. In recent years, social and cultural perspectives on learning have changed the concept of schema. Cultural and social indicators influence our cognitive schemas and processes that play a decisive role in shaping, processing, and transforming schemas. The formation of schemas is an integral part of the student's learning process in which the individual's mental models of the subject are structured. Learning makes sense this way (Dunlosky et al., 2019; Obersteiner et al., 2019).

There is evidence to support meaningful learning, which refers to the employment of student-centered, active learning pedagogy, including:

A. In the learning process, meaningful understanding by the learner is a decisive indicator.
B. B. Learning meaningful concepts and learning how to do a task or acquire a skill are two separate processes.
C. Some of what we have learned is limited to a specific area, while others are transferred to other areas (Michael, 2006).

The relationship of previous learning with new learning that has emerged from cognitive psychology can influence the learning process. Professors with a deep understanding of theories associated with cognitive psychology and neuroscience which applies to education can choose the best teaching-learning method and observe the effect of those methods in assessing their students (Dunlosky et al.,2019; Obersteiner et al., 2019; Di Vesta, 2017). The above concepts can improve students' learning, professional performance, and efficiency, leading to recommendations that change the way architecture courses are offered (Di Vesta, 2017; Lachman, 2015).

A mental model or schema is a kind of cognitive representation of a part of a system. The cause-and-effect relationship shows how a change in one part affects another (Lachman et al.,2015; Mayer, 2004; Dolmans et al., 2005). According to Mayer's theory, there are three essential steps in the process of meaningful change: understanding that what we encounter is different from what we have ever encountered and that current mental models cannot justify it. Build a new schema that represents these changes meaningfully and use a new model that anticipates dealing with new conditions (Lachman et al., 2015; Mayer, 2004). These principles stem from the insights that cognitive psychology research has given us. Today, the emphasis of this branch of psychology is not merely on purely laboratory forms but on practical and realistic tests (Dunlosky et al., 2019; Di Vesta, 2017). Most of the researchers that support the practice of schema in architectural design education generally focus on the interaction between the student and instructor, such as producing concept-solving problems and integrating design strategies. One step to go further in these approaches is to include the cognitive actions of the design process, including the designer's cultural and psychological components, and to analyze the relationship between design activity and the designer's cultural schema in a design studio (Önal, 2017 #10).

Therefore, teachers should know what students learn and how they learn it in practice (Dolmans et al., 2005; Horvath et al., 2016). The above is a representation of evidence-based education, which is emphasized today by the European Commission's Education Commission (Dolmans et al., 2005; Horvath et al., 2016). Evidence-Based Education (EBE) seeks to bridge the gap between real-world learning on the one hand and education-related studies and research on the other (Ramani, 2006).

To achieve these goals, it is recommended that the methodology and policies of education should be studied and carefully reviewed by professors, teachers, and trainers. A new assessment method should be designed to improve the relationship between educational goals and learning lessons. Additionally, providing access to evidence at various levels for researchers in the field of education and neuroscience. In this way, the evidence obtained will help further research, policy development, and performance in the field of education (Ramani, 2006; Al-Eraky, 2015, p. 1018).

Fortunately, many of these recommendations have been used to provide architecture education and related research. The result can be evidence-based architecture education that is gaining traction today and can improve the quality of architecture education worldwide. Cognitive neuroscience research offers a multi-step approach to bridging the gap between architecture education and neuroscience. In teaching architecture, two types of learning are essential, in which the importance of students' previous teachings is evident. Multimedia or multisensory learning and the acquisition of specific skills (Paas et al., 2004; Schneider et al., 2010; GAO et al.,2009; Maia et al., 2020).

Meaningful learning is achieved when a person selects a specific section from a mass of information, organizes it logically and meaningfully, temporarily stores it in their short-term and active memory, and then combines this information with previous teachings will leave them in the long-term memory. In multimedia education, the information presented in multimedia increases the learner's problem-solving ability; the person finds the ability to compare different information and draws a better picture of the problem in mind (Lasry et al., 2007). In this regard, Aulls and Lasry have proposed a theoretical model based on multiple mental representations called n-coding (Lasry et al., 2007). The structure of multiple coding indicates how information is processed independently in various aspects, such as verbal, visual, tactile, mathematical and logical, and social. The proponents of this model believe that using multiple encryption structures leads to better and more effective problem-solving and conceptual knowledge.

In addition, research from this model shows that to achieve a more appropriate educational learning environment, more dimensions of conceptual input should be considered. Given that the space for multidimensional learning, e-learning, and multimedia education is currently provided in the architecture education system, the critical point is to optimize how to benefit from these dimensions, quality, quantity, sequence, and timing (Kapenieks, 2013; Ali et al, 2021). In such an environment, students' previous encounters with teaching should be considered in their encounters with subsequent teachings. Teaching based on multiple sensory methods will lead to the conceptualization of facts in students' minds and, consequently, effective learning in them (Paas et al, 2004; Schneider et al, 2010).

An example of multimedia that can be used in studios is Metaverse which creates spaces where the real and the virtual world become one. Users can interact with one another in the form of avatars utilizing virtual reality technologies in the metaverse. This online virtual environment combines augmented reality, virtual reality, 3D holographic avatars, video, and other digital communication. In addition, the metaverse enables us to explore fully immersive 3D environments while extending our ability to see, hear, and touch. Since locations influence our emotions and an excellent environmental design produces emotion and purpose, the Metaverse is an inclusive and commonplace universe. As a result, in addition to teaching about architectural history, construction methods, and materials, architectural education will also need to use digital media and 3D technologies. ("Designing the Metaverse: What Is Metaverse Architecture?").

Students can present their work in the metaverse, a network of 3D virtual worlds focused on social connection. Students can explore how "new tools enable designers to tell richer design narratives through annotated site models, interactive design options, exploded-axons that become three dimensional exploded models, section-cuts that become experiential, and fully experiencing the designs at 1-to-1 scale" in these 3D worlds. (Foster, 2022)

Conclusion

The following conclusions and suggestions can be presented from what has been briefly discussed in this article. Given the promising results of interdisciplinary research in cognitive neuroscience and educational sciences and the potential fields of applied and practical research in architecture education, the possibility of positive reinforcement and synergy between architecture education and neuroscience findings exists.

Cognitive psychology is essential in creating a conceptual connection between neuroscience findings and architectural education. Teachers must be aware of what students are learning and how they learn. This principle is the basis of evidence-based education that strengthens the connection between learning and strategies for its improvement through basic and applied studies. Since the formation of schemas plays a pivotal role in the active learning of students, studying this topic can be a research priority. Recent studies in neuropsychology emphasize multimedia education. Examining such homogeneity determines whether the combination of inputs of different sensory aspects can be institutionalized in the form of a schema.

To understand the brain processing and neural circuits involved in learning, it is necessary to be aware of theories related to learning and memory from the perspective of neuroscience, educational sciences, cognitive psychology, and philosophy. To enter the field of neuroscience studies and teaching-learning science, and especially architecture education, it is necessary to form interdisciplinary working groups that include at least specialists in neuroscience, architecture, educational sciences, and cognitive psychology. The basis of all this research should be evidence-based learning.

Opportunities for conducting attractive research in architecture education should be explored and introduced. Topics such as the role of previous teachings in understanding new content and learning multisensory or multimedia aspects of architecture can be prioritized.

It is recommended to provide codified training courses based on an interdisciplinary approach to supplement the knowledge of specialists, professors, and trainers. Mind, brain, education, learning, and language are topics that not all professors in the field of architectural education are aware of in its various aspects. Familiarity with these concepts is the background for moving toward applied research in architecture education and its neurological infrastructure. Instead of just trying to continue what already exists as evidence-based learning sciences, one can think of defining a new branch of research, including the mind, brain, and education, so that it can be considered a new science of learning.

Neuroscience can be used as a tool for facilitating teaching in the architectural faculties in order to prepare professionals in the area better. Understanding the brain and how it works is helpful for educators to become high-impact effective teachers. Educators may seize the opportunity to explore neuroscience's incredible depth of knowledge to improve their daily interactions with students. Finding out some of the ways the process of learning takes place in the brain helps to teach architecture to the students more indirectly and reliably than the didactically and through disciplinary autonomy that has been dominant in the studios for ages. his methodology helps to understand individuals' ways of learning and to diversify the profession, not only for those who are talented and born as architects but also for those seeking opportunities according to their passion and dedication. In design pedagogies, neuroscience can be used as a tool to create equity, inclusion, and consideration for all.

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