*Journal of School Administration*

*Vol 11, No 3, Autumn 2023*

*ISSN: 2538 - 4724*

University of Kurdistan

# Design And Validation of Brain Compatible E-Learning Environment Model of School Student

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ARTICLE INFO

Article history:

**Received:** 08/04/2023

**Accepted:** 09/10/2023

Available online: Autumn 2023

**Keyword:** Educational Design, Electronic Learning Environment, Educational Neuroscience, Educational Model.

**Abstract**

The aim of the current research was to design and validate an electronic learning environment model based on educational neuroscience (knowledge of the mind, brain and education). The method of this mixed research was an exploratory design. First, various sources were examined and the components of the cognitive educational model were determined using the content analysis method. Then, using the Delphi method and the opinions of the judges, the components were finally approved. The statistical population in the content analysis section consisted of experts in the field of educational neuroscience, written and electronic documents and resources from domestic and foreign databases, and in the Delphi section, experts in the field of educational technology and distance learning. To search for and find all the articles related to e-learning based on neuroscience, a systematic review method was used to identify, review, evaluate and analyze the articles. This systematic review was carried out using the prism method.The selection of samples in both sections was purposeful and in the content analysis section there were 22 specialists and experts for interviews and in the Delphi section there were 15 specialists from different universities and institutions in Iran, the Netherlands and AmericThe analysis of the data obtained from the qualitative interview was also done using the inductive content analysis method and in the Delphi section using descriptive and inferential statistical methods. According to the content analysis, six categories of attention, Generation and communication, Emotion, Spacing learning, Individual-environmental factors and social factors were obtained. Also, 17 sub-components were extracted for the main classes. After analyzing the content and extracting the codes, the components and sub-components were presented in the form of a template. The results of internal validation based on experts' opinion have shown that the provided educational model has high internal validity and has the necessary effectiveness for teaching fifth grade students.

Rajabiyan Dehzireh, M., Maghami, H., Talkhabi, M., Zarei Zawarki, I., & Younesy, J. (2023). Design And Validation of Brain Compatible E-Learning Environment Model of School Student, *Journal of School Administration*, 11(3), 1-31.

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## Introduction

With the spread of technology and the introduction of e-learning into the world of education, the process of designing educational environments has become one of the most important issues in this field, emphasizing how they influence the learning process of students. The principles of educational neuroscience is a science that examines the learning process and its effect on the individual's brain structure. Therefore, the issue of designing an e-learning environment with an emphasis on the principles of educational neuroscience has become one of the most important issues in the field of e-learning. This issue is one of the vital and key issues in realizing the quality of education in the 21st century, considering the breadth of the learning process, the complexity of educational environments, and the correct understanding of students' needs. The problem is that not all e-learning platforms offer effective learning programs that can lead to a successful learning experience. Such platforms may have problems such as insufficient user interaction, lack of rich content, poorly structured or even completely unstructured learning content. Consequently, student dropout is a constant challenge in online education. There is a need for more structured and robust platforms that can make learning as integrated and interactive as possible. The goal is to provide a thoughtful online learning platform according to the principles and good practices of educational neuroscience. The field of educational neuroscience provides useful approaches and tools for online education. These approaches enable the teacher to increase students' creativity and learning. In addition, they give learners the opportunity to experience an educational environment that can support critical thinking, improve perception, enhance memory and attention.

Under these conditions, today traditional methods no longer meet the huge demand for education, and e-learning literacy has been proposed instead of conventional literacy as a solution for the transition to an information society (Yagoubi et al., 2008, cited by Tavakoli Ibndansari and Halajian , 2021).

Neuroscience in education aims to bridge the gap between knowledge of how the brain works and how to use this knowledge in classroom experiences (Pressley, 2017). Learning is a way to increase the ability to transfer information and knowledge to students (Lapada et al., 2020). Brain-based learning is a holistic approach to education based on current neuroscience research on how the brain naturally learns. Brain-based learning is a type of learning model that enables students to learn naturally by facilitating brain function (Vidyana et al., 2017).

Neuroscience is an interdisciplinary field that focuses on the study of the anatomy, physiology and function of the nervous system, as well as its effects on human development, health and behavior (Antonopoulou, et al, 2023).

Since brain-adaptive learning theory is a learner-centered process that utilizes the whole brain, brain-adaptive learning principles provide a theoretical framework for effective learning, the teaching process, and the best conditions in which learning occurs in the brain. to do Brain-adaptive learning makes the connection between what is known about the brain and how to teach (Jensen, 2005). Kein and Kein have stated the theoretical foundations of adaptive learning in twelve principles, under the title of brain-adaptive learning principles, which include a summary of the existing knowledge about learning and have focused on expressing its implications and educational applications (Kane and Kane, 1991). Based on their experiences and research, they believe that effective and desirable learning requires considering three fundamental elements: 1. Relaxed awareness: creating an optimal emotional atmosphere for learning, 2. Harmonized immersion in complex experiences: creating opportunities for challenges. Suitable motivation for learning. 3. Active processing of experiences: using effective methods to consolidate learning (Noori, 2009; Talkhabi et al., 2010). The theory of brain-centered or brain-based learning aims to validate and recognize its role in the teaching and learning process by confirming and emphasizing the place of the brain in people's learning (Mari, 2020). In this approach, relying on the neurological and biological foundations of human behavior, the nature and functions of the nervous system, the cerebral cortex and its diverse features and functions, it is emphasized that the learning environment in its broadest sense is organized in a way that causes the emergence and The appearance of people's brain capacities. This theory of learning is based on the structure and function of the brain, as long as the brain follows its normal processes, learning occurs (Kane and Kane, 1991). Some specialists and experts in the field of brain-based learning, acknowledging the characteristics of brain-based learning and teaching, especially emphasize the use and type of integrated curriculum in this approach. In this regard, Jensen believes that the human brain learns better when multidimensional data activates brain pathways. Therefore, learning in the brain takes place in a multi-dimensional way, and therefore integrated training and programs can create better learning opportunities for students (Jensen, 2008). These programs should be designed in such a way that they include all cognitive, emotional and psycho-motor learning goals at the same time. This theory is based on our current understanding of the structure and function of the human brain at different stages of development. Students are the main subject of the learning process. They engage in various activities to achieve the best result (Kratikanikinchtiz, 2018). To date, educational neuroscience, which integrates education with psychology and neuroscience, has been applied to manage learning in the classroom (Serikon, 2023). In recent decades, theoretical interest in the connection between mind, brain, and education has increased (Wilcox et al., 2021; Golla et al., 2022). As a result, a new field of research was developed, which is referred to as educational neuroscience, neurolearning, or neuroeducation (Oden and Gowan, 2022). This new field applies brain research findings to classroom teaching and learning in general and to the education of diverse K-12 teachers and students in particular (Ansari et al., 2011; Brown & Daly, 2016; Thomas et al. colleagues, 2019). Neuroscience is a rapidly evolving multidisciplinary field (Durantes-González & Balsa-Yapes, 2020). It explains how a specific part of the brain shapes knowledge, behavior, thought processes, and learning (Willis, 2008; Amran et al., 2019).Educational neuroscience is an interdisciplinary field in which researchers from the fields of neuroscience, cognitive science, psychology, and education, in collaboration with teachers, try to identify methods and techniques for better learning. The goal is to use objective evidence about how the brain works and develops so that learners: a) participate more in the educational process, b) create new knowledge, and c) store new knowledge so that it is permanent and accessible. This effort led to the field of educational neuroscience, where with the help of psychology, neuroscience, cognitive science, computer science, and sociology, efforts are being made to transform education in general (Dukakis et al., 2022). Meaningful learning is the main goal of the brain-based approach to education. Brain-friendly education includes a motivational and positive method to maximize teaching and learning (Raghavandran and Begum, 2019).

Information and communication technology tools are a gateway to facilitate learning. Many educators argue that as any education is based on brain activities, where is the necessity of brain-based education? Brain-based learning is a way to understand how the brain naturally works best and how we can enhance learning to the desired level. Information and communication technology tools emphasize meaningful learning instead of piecemeal learning (Raghavandran and Begum, 2019). The new world of technologies gives researchers the possibility to gain access to the human brain through imaging and new equipment for neuroscience studies and to gain deeper and more accurate knowledge of what exists in the world of the mind and brain. let us The integration of digital tools in the educational process has had a significant impact on the approaches of professors and students to learning (Morse et al., 2021). Instructors must know how to maximize student learning in an e-learning environment by considering brain-based techniques and principles. The principles and techniques of brain-based education can be implemented by integrating information and communication technology tools into the e-learning environment. When designing educational materials in the e-learning environment to increase the quality of learning, pay attention to the basic principles of brain function, such as creating optimal learning conditions, assigning tasks to activate different parts of the brain, repeatedly presenting ideas and concepts in the brain in different ways. Reconstructing electronic tasks is very important to motivate students by stimulating the release of dopamine because their achievements are recognized and they access the next stage of the task and try to avoid stress in order to avoid blocking the flow of information in the amygdala of the brain (Papas, 2016). Creating short content in an e-learning environment is believed to meet the needs of the wandering brain. However, along with the advantages of e-learning, there are certain concerns related to this method.

Brain-based learning techniques used by instructors in e-learning environments may improve asynchronous learning by implementing designed principles and measuring its impact before, during, and after each lesson (Akirek and Afakan, 2013). Examples of brain-based learning techniques include stimulating students through engaging activities and cooperative learning groups, providing a safe environment for sharing thoughts and ideas, reducing anxiety and threat, providing flexibility, making resources available, and providing timely feedback. . Although most early childhood educators have attempted to implement brain-based instructional design in their classrooms, many have been misinformed about the relationship between neuroscience and educational concepts, which affects teachers' ability to implement the principles of brain-based learning. The brain has had a negative impact and shows that teachers are not able to implement the principles of brain-based learning in the classroom environment (Odro-Bediako, 2020). Experts believe that education becomes more efficient and effective when it is based on the brain's natural learning method (Hendayani and Corbema, 2017; Odoro-Bediako, 2020). Miskatics et al. (2023) conducted a research titled online professional development in educational neuroscience in higher education based on design thinking. The overall evaluation showed a significant level of satisfaction regarding the quality of the course. Freilandau et al. (2023) conducted a research entitled "The implementation of digital neuroscience in the education of teachers with special needs: examining the results of multifaceted student-teacher learning related to teaching children with neurodevelopmental disorders." Findings revealed a process involving four learning outcomes: understanding brain-based mechanisms, increased empathy, expanded understanding of teachers' professional role, and designing instructional adaptations. The analysis also pointed to various ways in which the digital platform facilitated these learning outcomes. Mohammad and Defaleh (2023) conducted a research titled the interaction between brain-based learning strategies and infographic patterns and its effect on the development of information concepts among undergraduate Saudi cyber security students. The quantitative analysis of the findings of this study shows the interaction between the variables of brain-based learning strategies (spaced repetition and distributed practice - mental models) and infographic patterns (static/moving) in e-learning environments on test scores. The findings also showed that repeating information at increasing intervals using infographics is effective for learning concepts in an organized manner and improving short-term memory. Huang et al. (2020) conducted a study entitled The New Science of Learning: Harnessing the Power and Potential of the Brain to Inform Digital Learning. Integrating teaching methods and measuring brain activity has the potential to make learning more engaging and productive. Direct recording of electrical activity in the brain provides important information about the complex dynamics of cognitive processes and mental states that occur during learning, which can ultimately empower learners. Rostgar and Aghajari (2022) conducted a research titled the role of brain-based learning on sixth grade math deepening in a course based on e-learning. The results showed that statistically, the average deepening score and learning speed are different among people. That is, the use of brain-based learning has increased the depth and speed of learning. Racminis (2021) and Retan and Markar (2020) state that technologies may help integrate the principles of brain-based education because technology may support a comfortable learning environment for students and motivate them to have different sources of knowledge. slow The findings of this study confirm that online education with brain-based learning includes a motivational and positive method to maximize meaningful teaching and learning (Kane and Kane, 1994; Raghavandran and Begum, 2019). Schwartz (2015) and Uzzi and Jonah (2017) also found that a brain-based teaching approach increased student achievement and motivation. Researchers have shown that five-year-old children understand and perform more difficult tasks faster and better in face-to-face education compared to interactive touch screen education (Kestyrka-Alchern et al., 2019). At the same time, the results of another study showed a decrease in attention span in children after screen exposure, as well as a negative correlation between screen exposure and theta, beta, and gamma wave patterns in EEG analysis (Harrell, 2019). When designing an electronic learning environment model based on the principles of educational neuroscience, the principles of communication with the brain and neuroplasticity are used. These principles help to design an educational environment according to students' cognitive functions. For example, following a multi-sensory educational approach, properly designing web pages, interacting with content and producing attractive and convincing content, connecting different activities during learning and using appropriate rewards and effective stimuli are among the most important approaches to designing an electronic learning environment.

The design of the model of the electronic learning environment based on the principles of educational neuroscience not only deals with the better understanding of the learning process but also with the design of content, interaction and communication of learning activities in the educational environment using student principles. Also, the design of the electronic learning environment model based on the principles of educational neuroscience should pay attention to the needs of the students, the ability to adapt to their environmental and cultural conditions, in order to improve the cognitive functions, concentration and memory of the students. In general, in the mentioned studies, brain-compatible learning affects the progress of mathematics, reading, learning English, as well as the amount of recall, attitude, understanding of concepts, differences in learning styles, motivation levels, and teachers' understanding of the principles of brain-compatible learning. The case of contextualization and intervention has been studied. In these studies, a comprehensive design that takes into account all the components such as the learning environment, teacher training processes, and the application of brain-compatible learning principles in the education process has not been consistently observed, and only each of the mentioned studies They have paid attention to a limited number of components in a short period of time. This gap can lead to the need to formulate a coherent and comprehensive educational model compatible with the brain in the fifth grade of primary school - which is considered the basis of other grades and there is a lack of research in this grade - which the present study will partially answer. On the other hand, few studies have been done on brain-based training in e-learning environment. Therefore, this study aims to fill the gaps of previous studies by combining brain-based learning with online learning. Obviously, adding the principles proposed in the theory of brain-based learning in the e-learning environment provides the possibility of designing richer and more attractive activities. Those who have theorized and researched in this field believe that until now the emphasis in the educational system has been on the compatibility of the brain with the educational environment, while this should not be the case and the compatibility of the educational environment with the brain should be emphasized. In other words, curricula and educational environments should be designed based on how the brain works. In educational research, environment and context are very important; But in neuroscience and brain research, these aspects are less important. Due to the spread of Corona virus and the spread of virtual education, there has been no research regarding the use of brain-friendly learning in the e-learning environment. Therefore, the research questions are, what components and elements does the design model of the electronic learning environment based on brain-compatible learning include? How is the validity of the electronic learning environment design model based on brain compatible learning?

**Methodology**

Considering that the use of one research method (quantitative or qualitative) alone was not sufficient to achieve the objectives of this research, a mixed research design was used. When using research designs in which only one method (quantitative or qualitative) is used, it is not possible to comprehensively answer questions related to situations of uncertainty in education systems, but by using mixed research methods, it is hoped that a better understanding and recognition of situations of uncertainty can be achieved (Bazargan, 2013). Among the types of mixed research design (triangulation, nesting, explanatory and exploratory), the exploratory design was used. The aim of the two-stage exploratory plan is that the results of the first (qualitative) method can help the research grow and expand or play an informative role for the second (quantitative) method (Delavar and Koshki, 2014). In other words, a research model or framework is obtained using a qualitative method and then validated using a quantitative method. In the qualitative research section, the inductive methods of qualitative content analysis and Delphi were used. In this study, the first phase of the research was qualitative. Firstly, a qualitative content analysis was carried out with an inductive conception of the theoretical foundations of the e-learning environment based on educational neuroscience and then, based on its results, an initial model was drawn up. In order to modify the model based on educational neuroscience, the opinions of experts in the fields of educational neuroscience, cognitive science, cognitive psychology and knowledge of the mind, brain and education were sought, and the necessary modifications were applied in accordance with their opinions. Once the components of the model had been determined, the Delphi method was used in the next phase. To confirm the final educational model of neuroscience in the e-learning environment, this model was given to experts in educational technology and e-learning, who expressed their opinion on each component on a five-level Likert scale, from very important (1) to not very important (5).

First, various sources were examined and the components of the cognitive educational model were identified using the content analysis method. Then, using the Delphi method and the opinions of the judges, the components were finally approved. In this section, the main question is to what extent the obtained contents and components are consistent with the basics of the desired model, and the experts' opinion examines the researcher's bias. After examining the various sources and design patterns provided, the components of the educational model are determined using the content analysis method, and then the components are finally approved using the Delphi method and the judges' opinions.The research community in the content analysis department were experts in the fields of educational neuroscience, knowledge of the mind, brain and education, cognitive science and cognitive psychology, e-learning and educational technology, and in the Delphi department, the subject experts were academic staff members in the field of educational technology and e-learning. They were. In the qualitative part, the purposeful sampling method was used. In purposive sampling, the sample is not selected for convenience, but the researcher's judgments based on his previous information are the basis of sample selection (Delawer, 2016). The purposeful sampling continues until the new data does not contain new information related to the research topic and the data reaches theoretical saturation. In purposeful sampling, the researcher's intention is to select cases that have a lot of information according to the purpose of the research (Delavar, 2016). For interviews with people in a targeted way, people were selected from among specialists and experts in the fields of educational neuroscience, knowledge of the mind, brain and education, cognitive neuroscience, cognitive science, and cognitive psychology. To collect the data, the qualitative section after the initial investigations to collect all action documents and also to weave the articles related to the separation of Farsi and English, specific important and key terms and titles and then in the databases of systematic search and search Google Scholar was also used to complete the work. Articles between 2008 and 2023 were selected. During the study of the sources, key and important sentences and phrases were selected and included in the qualitative content analysis cycle. In order to identify the internal researches, a search was made in Normex, Mag Iran, Iran Doc, Jihad Datshgahi and Alamnet databases, and a manual search was also made in Google to complete the work. In order to identify English articles in Scopus, ProQuest, Eric, Web Science, Wiley and Science Direct databases, a systematic search was conducted in November 1400. A manual search was also done in Google Scholar to complete the work. After reviewing the system and clarifying the theoretical foundations; Using the content analysis method, the components of the model were extracted from the theoretical foundations, documents and interviews

Document selection criteria: In order to accurately select the articles, the limit of the year of publication between 2008 and 2023 was applied. In addition, no other restrictions were applied in the search phase, such as the type of research, the publications, the geographical location of the research and the language of the participants. In addition, all peer-reviewed scientific

with experts in the field of educational neuroscience, knowledge of the mind, brain and education, cognitive science, cognitive psychology, and then the educational model along with its components Through the Delphi method, it was provided to experts in the field of educational technology, electronic learning, and distance education.

journals, conferences, doctoral dissertations and theses were included in the results, but book chapters, newspaper articles, general journals, reports and editorials were excluded from the search process. In addition, articles that did not fall within the field of education were excluded from the selection process.

**Table 1- Specialists who participated in the interview process for content analysis, Delphi and validation:**

| *group* | *Specialization* | *Location* | *Number of people* |
|---|---|---|---|
| Faculty member | Cognitive Sciences | Allameh Tabatabai University | *1* |
| Faculty member | Educational technology | Allameh Tabatabai University | *2* |
| P.H. D | Educational neuroscience and educational technology | Educational neuroscience and educational technology | *1* |
| Faculty member | Cognitive neuroscience and medicine | University of Tehran | *1* |
| Faculty member | Educational technology and educational neuroscience | Birjand University | *1* |
| Faculty member | Educational technology | Bojnord University | *1* |
| Postdoctoral | psychology of human behavior | Mashhad Ferdowsi University | *1* |
| Faculty member | Neuroscience | Qom University of Medical Sciences | *1* |
| P.H. D | Cognitive Sciences | Shahid Beheshti University | *1* |
| Faculty member | Educational technology | University of Florida, USA | *1* |

| | | | |
|---|---|---|---|
| Faculty member | Educational technology | Alabama, USA and Wageningen, Holland | 1 |
| Faculty member | Educational technology | farhangian University | 1 |
| Faculty member | Educational neuroscience | farhangian University | 1 |
| Faculty member | Educational neuroscience | Malayer University | 1 |
| Faculty member | Educational technology | Bo Ali Sina Hamedan | 1 |
| Faculty member | Educational technology | Arak University | 1 |
| Faculty member | Educational technology | Shiraz university | 1 |
| Faculty member | Educational technology | Chamran martyr of Ahwaz University | 1 |
| **total** | | | 22 |

The data collection tool in the Delphi section was a questionnaire. According to the research questions and model elements, a questionnaire with 757 questions on a Likert scale was compiled and completed by the specified statistical sample. The content validity of this questionnaire was confirmed by two educational technology experts, one e-learning expert, two educational neuroscience experts, and its reliability was calculated with Cronbach's alpha coefficient of 70. In the qualitative part, data analysis process was done during data collection. The data coding process was carried out during data collection until it was determined what data should be collected in the next step. This is usually done by specifying open coding categories and using a constant comparative approach to saturate the categories by comparing data to events and events to categories. After open coding, axial coding was done. The final process of coding deals with selective coding or in other words with theory development. This step involves relating the categories in the coding paradigm. Doing it has improved the coding paradigm so that it is presented in the form of a model or a theory about the studied process (Homan, 2013). In order to analyze qualitative data, inductive qualitative content analysis was used. After selecting the items for analysis, first the semantic parts were read based on the thematic analysis unit, then a label or code was considered for each of them. Next, similar codes were placed in a subcategory. By constantly going back and forth between data and code, they changed during the work. In the continuation of the work process, the main categories of the research were calculated by combining similar subcategories with each other. In the continuation of this method, after sorting the codes and specifying the sub-categories and categories and compiling the main categories, the researcher finally compiled the pattern based on the data obtained from the qualitative content analysis.To analyze the data in the quantitative part of descriptive statistics (including the calculation of indicators of central tendency and dispersion, such as the mean, standard deviation and descriptive graphs related to statistics) and to analyze the data obtained and test the hypotheses, observing the assumptions, the one-sample t-test was used. SPSS software was used to analyze the data.

## Findings

### Findings of the qualitative section

To answer the first research question, the texts of books and research resources and the interviews were carefully studied and analyzed and initially coded. The unit of content analysis in this research is the theme. In this way, a paragraph or sentence or part of it is used and assigned a numerical or text code. After open coding, axial coding was carried out. In this step, similar codes are classified semantically.After classification, 17 sub-components and 6 main components were identified. The extraction of the components and sub-components was checked by four experts and their initial validity was confirmed. The final identified components of the standard are 6 items. Table 3 shows the components and sub-components.

**Table 2 – Examples of semantic units and related coding**

| *Component* | *Subcomponent* | *coding* | *key sentences of the text or interview (semantic unit)* | *Row* |
|---|---|---|---|---|
| *Attention* | Attention networks | Distinct neural circuits in basic functions related to attention | Three different and important attentional networks for learning were identified: attentional, orienting, and executive attention. | 1 |
| | Attention span | amount of attention | Learning depends heavily on a person's motivational and emotional states, including the amount of attention and their previous knowledge and skills. Educational neuroscience seeks to increase students' ability, motivation and attention. Neuroscience provides a significant amount of data related to cognitive processes (learning and memory, attention, motivation, etc.) that can be useful in the field of education. | 2 |
| | Functions of attention | Selective or focused attention | Human learning requires concentrated attention. At any given moment, the brain is immersed in a field of emotions, perceptions and stimuli, and is constantly choosing what to pay attention to and what not to. Since the brain can't pay attention to all stimuli, it presumably ignores information that doesn't make sense in terms of the existing neural networks. | 3 |

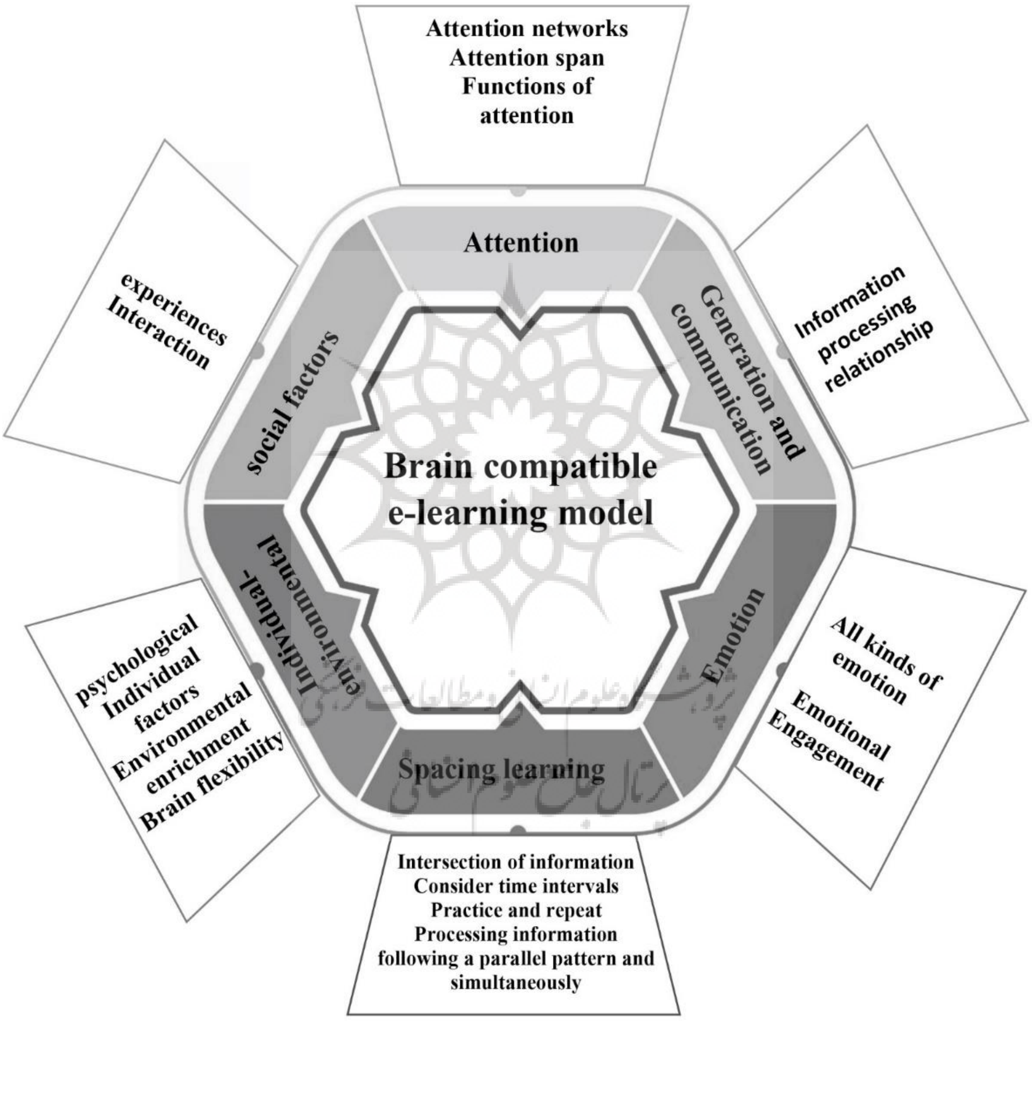
| | | | |
|---|---|---|---|
| | Distributed attention | The brain is designed in such a way that it is not able to pay continuous attention, but its attention follows upper and lower processing. Attention is distributed in different areas related to the brain. | 4 |
| | Sustained attention | Focused attention can be maintained in a consistent manner over time. | 5 |
| | Periodic attention | Attention can shift from one variable to another. | 6 |
| | Shared attention | Concentrated attention shared with other individuals on a specific stimulus | 7 |

**Table 3 – Categories and subcategories of the brain compatible e-learning environment model**

| Component | Subcomponent |
|---|---|
| **Attention** | Attention networks |
| | Attention span |
| | Functions of attention |
| **Generation and communication** | Information processing |
| | Relationship |
| **Emotion** | All kinds of emotion |
| | Emotional Engagement |
| **Spacing Learning** | Intersection of information |
| | Consider time intervals |
| | Practice and repeat |
| | Processing information following a parallel pattern and simultaneously |
| **Individual-environmental factors** | Psychological |
| | Individual factors |
| | Environmental enrichment |
| | Brain flexibility |
| **social factors** | Experiences |
| | Interaction |

Once the components and sub-components have been extracted, the relationship between them is presented in the form of a qualitative content analysis model. The way they are placed and arranged is based on the order of importance of each of these elements in relation to other elements. This relationship is shown in the conceptual model in Figure 1.

**Figure 1. Model of brain compatible e-learning environment**



| | |
|---|---|
| **Attention** | Designing curricula and teaching according to students' growth levels, taking advantage of the capabilities of multiple senses in curriculum and educational design, using multiple and diverse forms and methods of teaching and assessment, creating expectations, using novelty and more change during learning experiences, using interactive educational methods and using technologies aligned with cognitive abilities, using multimedia and preparing electronic content according to the principles of multimedia, using fixed colors and fonts, communicating and coordinating graphic format. Use according to the student's stages of growth, taking into account the principle of cleanliness, |
| **Generation communication** | Use continuous assessment and provide constructive feedback, confront students with real (authentic) tasks and situations, use questions, create links between past and present topics with an emphasis on understanding course information, encourage collaboration in the form of discussion forums, chat rooms and... |
| **Emotion** | Engaging and stimulating the desired emotions of learners, creating a positive emotional environment and opportunities for people to get positive feedback and a deep connection with others, diversity in learning resources and tools and enriching the learning environment, using humor and playfulness in the learning process, placing rewards in the learning process, creating stimulating arguments when designing activities and... |
| **Spacing learning** | Integrated organization of content and learning experiences based on common themes (concepts, projects, problems, central questions, parables, metaphors and similes, stories), using more time intervals in learning rather than repeating with a large amount of content. Dispersed, using examples: emphasis on memorizing information, offering training in short units and small modules, repeating concepts in the form of different media, offering exercises and tasks, taking into account rest time between training and creating regular breaks in learning, etc. |
| **Individual Environmental factors** | Paying attention to environmental factors (light, color, oxygen, music, nutrition and sleep), preparing a sufficient and appropriate nutrition plan, dealing with factors that cause sleep deprivation, creating a learning atmosphere free of stress and serious threats and with a balanced challenge (relaxed mental alert mode, designing a physically supportive learning environment). |
| **Social factors** | Designing a physically supportive learning environment, facilitating and encouraging participation and social interaction using different teaching methods and in the form of interactive exercises, using communicative and collaborative elements effectively, supporting and reinforcing cooperative learning, emphasizing group tasks, using one of the learning skills through observation |

**Figure 2. Trend pattern**

**Table 8- Categories and implementation strategies for each category in the e-learning environment (final Delphi phase)**

| *Component* | *Indicator* | *Average* | *standard deviation* |
|---|---|---|---|
| Attention | Involving the whole physiology of the body in learning and teaching | 4.47 | *0.640* |
| | Arousing attention, concentration and learning from the surrounding context | 4.53 | *0.516* |
| | Designing learning opportunities and experiences that facilitate meaningful learning | 4.67 | *0.488* |
| | Asking questions between providing feedback | 4.40 | *0.507* |
| | Providing conditions that facilitate exploration and stimulate continuous learning | 4.27 | *0.799* |

| | | | |
|---|---|---|---|
| | Taking advantage of multiple methods of presenting knowledge | 4.53 | *0.640* |
| | Designing curricula and teaching in accordance with the growth levels of learners | 4.47 | *0.834* |
| | Attention to curriculum elements including goals, content, teaching-learning methods and evaluation | 4.47 | *0.640* |
| | Multisensory learning: involving multiple senses, using the capabilities of multiple senses in curriculum design | 4.60 | *0.737* |
| | Adapting teaching and assessment to changes in the attention rhythm of learners, using multiple and diverse forms and methods of teaching and assessment | 4.27 | *1.033* |
| | More focus on learner motivation and creating high motivation and arousal, creating expectation | 4.33 | *0.727* |
| | Use more novelty and variation during learning experiences | 4.07 | *0.704* |
| | The use of interactive educational methods and the use of technologies aligned with cognitive capabilities | 4.67 | *0.488* |
| | Using multimedia and preparing electronic content according to multimedia principles | 4.87 | *0.352* |
| | Use of fixed color and font, connection and coordination of the graphic format used with the student's growth stages | 4.07 | *1.100* |
| | Attention to the principle of cleaning | 4.20 | *0.862* |
| | Place the visual appeal, choose the right design for course management elements | 3.93 | *0.594* |
| | Education planning considering the limitations of the learners' attention span | 4 | *1.254* |
| | Taking advantage of the power of emotions in attracting attention | 4.07 | *0.799* |
| | Physical movement as an effective strategy to strengthen learning | 3.73 | *0.961* |
| Generation and communication | Utilize practice and repetition with feedback | 4.53 | *0.516* |
| | Using continuous assessment and providing constructive feedback | 4.67 | *0.617* |
| | Confronting learners with real (authentic) tasks and situations. | 4.67 | *0.488* |
| | Use the question | 4 | *0.756* |
| | Creating a connection between past and present topics with an emphasis on making sense of course information | 4.47 | *0.516* |
| | Suitability of content with people's past experiences | 4.47 | *0.743* |
| | Considering time for reflection and reflection: providing opportunities for the development of metacognitive thinking and self-reflection | 4.53 | *0.640* |
| | Encouraging cooperation in the form of discussion boards, chat rooms, etc. | 4.40 | *0.632* |

| | | | |
|---|---|---|---|
| Emotion | Design activities with a level of difficulty to engage learners in learning | 4.47 | *0.640* |
| | Using strategies for effective use of memory systems | 4.33 | *0.816* |
| | Engaging and arousing the desired emotions of the learners | 4.33 | *0.724* |
| | Support the outreach effort and provide guidance | 4.20 | *1.014* |
| | Creating and learning without stress and intense threat and with a balanced challenge (relaxed mental state of alertness) | 4.20 | *1.082* |
| | Respecting the individual differences of learners and paying attention to the characteristics of learners | 4.47 | *0.640* |
| | Creating a positive emotional environment and opportunities for people to gain positive feedback and deeply connect with others | 4.47 | *0.640* |
| | Diversity in learning resources and tools and enriching the learning environment: can create a new challenge in "up-to-date and new information". | 4.47 | *0.640* |
| | Using humor and humor in the learning process | 4 | *0.926* |
| | Putting rewards in the learning process | 4.07 | *0.961* |
| | Self-evaluation, peer evaluation and feedback from the course instructor | 4.67 | *0.488* |
| | Creating exciting arguments in activity design | 4.20 | *0.775* |
| Spacing learning | Integrated organization of content and learning experiences based on common themes (concepts, projects, problems, central questions, parables, metaphors and similes, stories) | 4.33 | *0.724* |
| | Using more time intervals in learning instead of repetition with a large volume of scattered content | 4.20 | *0.862* |
| | Use of example: emphasis on memorization of information | 4.40 | *0.737* |
| | Providing training in short units and small modules | 4.47 | *0.834* |
| | Repetition of concepts in the form of different media, providing exercises and assignments | 4.13 | *1.125* |
| | Considering our break time between teaching and creating regular breaks in learning | 4.20 | *0.676* |
| | Planning to hold additional courses after a certain time | 3.60 | *1.242* |
| | Using tests and emphasizing process measurement instead of products | 4.13 | *1.125* |
| | Avoiding burdening the content of curriculum and education | 4.13 | *0.640* |
| | Emphasis on the spiral pattern instead of the linear pattern in the sequence of curriculum materials | 4 | *0.926* |
| Individual-environmental factors | Paying attention to environmental factors (light, color, oxygen, music, nutrition and sleep), preparing a sufficient and appropriate nutrition | 4.40 | *0.828* |

| | | | |
|---|---|---|---|
| | plan, dealing with factors that cause sleep deprivation. | | |
| | Creating a learning atmosphere free from stress and intense threat and with a balanced challenge (relaxed mental state of alertness | 4.27 | *0.704* |
| | Designing a physically favorable learning environment | 4 | *0.845* |
| | Facilitating and encouraging participation and social interaction by using different teaching methods and in the form of interactive exercises, efficient use of communicative and collaborative elements. | 4.60 | *0.507* |
| Social | Supporting and strengthening collaborative learning | 4.33 | *0.617* |
| | Emphasis on group tasks: forming a cooperative activity that increases learning and improves the cognitive capacity of the learner. | 4.40 | *0.737* |
| | Taking advantage of learning abilities through observation | 4.13 | *0.834* |

The results of the third phase of the Delphi show that all the components were approved by the sample members. The overall mean of the components in this phase was 4.31 and the total standard deviation was 0.752. At this stage, no factor was added or removed based on the opinion of the experts and all the components were confirmed, with the judges' agreement criterion at this stage calculated using Kendall's coordination coefficient.

**Table 9- The results of the judges' agreement using Kendall's agreement test**

| ***Indicator*** | ***Number of components*** | ***Kendall coefficient*** | ***Chi-square coefficient*** | ***Degrees of freedom*** | ***The significance level*** |
|---|---|---|---|---|---|
| Design model of electronic learning environment based on educational neuroscience | 57 | 0.871 | 184.200 | 56 | *0.001* |

Based on the opinion of 15 judges, Kendall's coordination coefficient for the components of the e-learning environment design model based on educational neuroscience was obtained in the third round with 0.87, which is significant at the level of 0.001, so the opinion poll was stopped in this round. According to the results of the content analysis and the Delphi method of 57 components of the e-learning environment design model based on educational neuroscience, the model designed has a high internal validity based on the coefficient of agreement between the experts.

**Conclusion**

The aim of this research was to design and validate a brain-compatible e-learning environment. First, by reviewing relevant sources and interviewing experts using the inductive content analysis method, the components of the specific model and the conceptual model were designed. Then, to validate the model, a questionnaire was designed and completed by experts. The results obtained from the internal validation of this research showed that the model presented is effective for fifth graders. According to the content analysis, seven components were obtained: attention, communication, enthusiasm, distance learning, environmental factors and social factors. In addition, 17 sub-components were extracted for the main classes. After analyzing the content and extracting the codes, the components and sub-components were presented in the form of two conceptual and process models.

The first research question: What are the main elements of the brain-compatible e-learning environment model? The results of the first research question led to the development of a prescription model with six components. The components include attention, communication, enthusiasm, distance learning, environmental factors and social factors. For the pedagogical design of any system, it is necessary to identify its constituent elements and the relationships between them. Due to its different nature, the design of a brain-compatible e-learning environment has several elements, which, in this research, were used to extract and identify these elements through content analysis and Delphi methods.

**As a first step, the discussion on the components of the model is made by separating each component:**

**First component: Attention.** In order to learn, the ability to concentrate intensely on the learning material is essential. According to neuroscience, when students concentrate on a subject without distractions, the hippocampus, which is responsible for transferring information from short-term memory to long-term memory, begins to activate and release the neurotransmitter dopamine. If the information presented is sufficiently interesting and important, the hippocampus prepares the memory/information for long-term storage. Keeping students' attention during a training session using techniques such as marking important topics and presenting new information for 20 minutes can help students' ability to pay attention without distraction. It is important to break up the training into shorter segments and allow students to discuss the information and practice retrieval. Attempting to learn new information for longer than 20 minutes will lead to an increase in cognitive load, a decrease in motivation and, ultimately, a decrease in attention.For the hippocampus to be sufficiently activated for learning to take place, the student must pay full attention to what they are learning. Dividing attention between two tasks significantly reduces the quality of attention and the potential stability of any learning, because the hippocampus is not activated during divided attention (Kensinger et al., 2003). Concentrating on multiple streams of information, including trying to multitask in a learning environment, also results in a reduction in neuronal firing and, consequently, a significant reduction in learning (Arnsten, 2003/1998). Teachers who use teaching strategies that are new, engaging and personally relevant are more likely to capture and retain students' attention (Sosa, 2017). In general, the brain can only focus on one task at a time and learning deficits occur when students switch between several tasks (Sosa, 2017). In neuroscience, attention refers to the brain processes that allow a person to stay focused on one aspect to the exclusion of other aspects (Kanoff, 2020). Brain-friendly teaching strategies offer teachers the opportunity to help students maintain attention and remain engaged in the learning experience (Jensen & McCunchy, 2020).

**The second component: communication**. Communication, in this context, is the ability of students to make connections with new ideas. In most contexts, meaningful learning is better than fragmented learning. Meaningful learning engages students emotionally, socially and cognitively. Meaningful learning leads to success. It enhances students' emotional and cognitive development. Meaningful learning helps develop curiosity and leads to students' self-fulfillment. The knowledge acquired through meaningful learning is relevant to new learning situations. This type of learning accompanies students throughout their lives. Meaningful learning is active, constructive and lifelong learning. This allows students to participate fully in the learning process. Meaningful learning teaches students important cognitive skills that are based on brain-based learning. Cognitive skills are also developed through brain-based learning, so students can evaluate, analyze, memorize and compare for themselves.Brain-based learning is therefore used as a tool for creating meaning, which is the most effective way for students to participate in the learning process (Aron and Singaravolu, 2018). The principles of brain-based learning suggest that effective learning only occurs through practicing real-life experiences. Learning becomes more expressive when the brain supports the processes of searching for meaning and patterns. It therefore allows students to internalize and personalize learning experiences. It is therefore essential that students are encouraged to actively participate in the teaching and learning process and that teaching materials are selected based on their learning preferences. Brain-based learning (BBL) was developed based on the structure and function of the human brain, with an emphasis on meaningful learning (Akyurek and Afakan, 2013; Noreen et al., 2017). This type of learning encourages students to be active and to feel more comfortable, confident and motivated in class (Haqiqi, 2013; Saleh and Subramaniam, 2018). The presence of prior knowledge has been consistently shown to enhance the learning of new relevant information in educational research, psychology (Rejean & Pettiguero, 1992; Piaget, 1926) and cognitive neuroscience. It has been proposed that prior knowledge structures facilitate many stages of memory processing - such as encoding, consolidation and retrieval - and reduce memory interference (Preston &

Eichenbaum, 2013). Information that is consistent with prior knowledge is generally better remembered. Other strategies involved in brain-based learning include contextualizing learning, making links between concepts, using trial and error, providing targeted feedback, revising work, giving students choice and encouraging questions, other ways of increasing learning and learning (Haqiqi, 2013; Ozden and Goltkin, 2008).Strong evidence of student growth can be found when students are taught using brain-based strategies, as opposed to traditional methods. Providing students with opportunities to interact with the material improves their ability to retain information and leads to higher academic achievement (Macarina & Ningsieh, 2017). Through the use of diagnostic, formative and summative assessment tools and the use of frequent, non-threatening assessments with feedback on the understanding of an idea or concept, the teacher can identify prior knowledge and (possibly informal) prerequisites. Monitor your students' knowledge and progress. Assessment plays an essential role in memory consolidation and can be a good way of storing important and new information in the student's memory during the educational process. The use of polls during lessons, using true/false questions and the ability to create multiple-choice tests or short-answer sentences during lessons or to assess students after lessons, provides opportunities for students to reinforce their memory.

**The third component: emotion:** emotions have a significant impact on people's memory and learning. It was also shown that excitement has an effect on attention, learning focus, perception, reasoning, problem solving and decision making (Hakiplas et al., 2022). Emotion recognition is now performed through a wide range of sensory mechanisms, mainly involving non-physiological and physiological signals. Facial expressions (Solemani et al., 2016), speech (Lee et al., 2023), text (Bharti et al., 2022), and body gestures (Sun et al., 2018) are classical non-physiological signals that record. Given the various interactions between the amygdala and the hippocampus of the brain, it appears that the amygdala may be involved in the processes in which one's emotional nature is triggered, stored, and encoded by relevant memories resulting from emotions.This suggests that the amygdala can be activated and function to encode data from specific emotional stimuli in response to external stimuli. This data can be related to positive and negative emotional states. Based on psychology and neuroscience studies, human emotions can affect and alter the memory system, which is directly influenced by the hippocampus. As a result, the interaction of the two aforementioned systems allows emotions to have direct or indirect effects on memory and learning (Baron et al., 2015). Emotions are one of the important regulators of learning and memory formation. From the point of view of neuroscience, emotion and feelings can be considered as specific neurological and physiological changes in a living organism in response to environmental stimuli (Fosati, 2012). Zoll (2006) also emphasizes the fact that emotion is the basis of learning.Therefore, it is very important to take emotions into account when defining curricula and planning lessons and, furthermore, emotions are very important as a component of education (Hosutani and Imai Matsumura, 2011). Several research studies have shown that the teacher's emotional state also has a major impact on the teaching and learning process (Yin et al., 2017; Scott and Sutton, 2009; Yuto et al., 2015). Both the awareness of the teacher's specific emotions and the way in which these emotions are processed and expressed affect the quality of teaching and even the students' learning experience (Srinivasan, 2015; King and Chen, 2019). Studies have shown that positive emotions, such as pride, hope and happiness, seem to play an important role in motivation for learning (Pekron et al., 2002). Subsequently, this affects students' academic performance and even their learning behavior (Goetz et al., 2008).Studies by Frederickson and Brannigan (2005) and Villavincio and Bernardo (2013) reflect the positive impact that these emotions can have on self-regulation and cognitive flexibility, which are critical precursors to various skills, such as problem-solving. Students' perception, attention, learning, memory, reasoning and problem-solving and all cognitive processes are affected by emotions (Ting et al., 2017). Emotions can also contribute to how effectively a student encodes or retrieves information (Ting et al., 2017). Emotions can improve or hinder student learning and retrieval (Ting et al., 2017).

**The fourth component: distance learning.** The spacing of information over time leads to faster and better retrieval of new information (Litman and Davachi, 2008). Repeating information briefly and with space between improves students' ability to remember it. The brain needs time, repetition and reinforcement to understand, apply and remember what it has learned. Distance learning is endurance training for the brain. It is widely accepted that spaced learning (repeated learning sessions separated by time intervals) has a distinct advantage over mass learning (learning done in a single session (Benjamin and Tullis 2010; Kapler et al., 2015; Delaney et al. colleagues, 2018).Education professionals have long been investigating ways to increase learning retention in order to maximize learning outcomes. One of the main findings of researchers in this field is the spacing effect. German psychologist and memory researcher Hermann Ebbinghaus was the first to demonstrate the distance effect. According to him, learning retention can be maximized by repeating instructions at regular intervals. Educators call it the spacing effect because instructions are given to students at regular intervals. In distance learning, the course material is divided into smaller modules. Learners receive the modules at a specific time. The number of repetitions and the interval between repetitions are determined by the learning designers based on various factors, such as complexity, inclusion profile, level of mastery required, etc. Learning is only retained when it is transferred to long-term memory. However, unlike computer memory, human memory is not permanent. So, as human beings, we tend to forget things that we don't remember for a long time. This is known as the forgetting curve. The forgetting curve is nothing more than the amount of things we forget over time when our brain doesn't repeat the same activity. Spaced learning takes this forgetting curve into account and repeats the learning module before learners completely forget the learning. As learners repeat the learning over and over again, the brain becomes more efficient and effective at memorizing the learning. In layman's terms, we call this "practice makes perfect".

**The fifth component: environmental factors.** Upon entering the classroom, the student's brain begins to process the physical environment (Jensen and McCunchy, 2020). The brain prefers new stimuli, and factors such as color, accessories and decorations contribute to the message that the classroom environment sends to the student's brain (Jensen & McCunchy, 2020). Sight, hearing and touch are essential components of the physical classroom environment that affect attention, problem solving and memory in the classroom (Jensen & McCunchy, 2020). For students to succeed, the teacher must be willing to create an environment conducive to learning. Learning is more likely to take place in physical environments free from threats or intimidation (Sosa, 2017). As educators become more aware of neuroscience, interest is growing in how a person's environment affects brain growth and development (Sosa, 2017). Barrett (2013) carried out an empirical study in the UK that investigated the impact of the physical environment on pupils' learning. The results show that, all other factors relating to pupils' abilities being equal, pupils in the best physical environments have the equivalent of an extra year's growth in reading, writing and mathematics compared to those in the worst environments.

**The sixth component: social factors.** Distance learning environments offer many opportunities for a variety of activities that can increase student participation. In particular, the teacher can use tools such as private chat, group chat and the interactive whiteboard to actively engage students and build knowledge. For example, a teacher can give students a question or problem to investigate/explore/review/think about for a few minutes and ask them to send him or her a message via private chat. In this way, a) all students participate in the activity because the teacher has asked for an answer. b) If a student sends a wrong answer, the teacher can ask them to try again via private chat. c) The students themselves do not participate in the group, but only listen to the teacher's information. d) All students have to send an answer and cannot agree with a previous answer, because students do not have access to each other's answers.

In an online classroom, collaboration between students is important for two reasons: a) it allows them to share their ideas and, ultimately, successfully study the problem presented to them and b) it helps them learn to understand and recognize students' performance. Collaboration between students helps each of them individually recognize that others also have learning difficulties. In this way, students will be able to think critically about their learning and consider that learning is a process in which students face similar or identical problems/obstacles that they are asked to solve. They overcome them. At the same time, students have the opportunity to make connections between ideas and express their opinions. In other words, instead of memorizing knowledge, students have the opportunity to explore ideas and collaborate in solving problems.Discoveries in the field of neuroscience have proven that when people cooperate with each other, the medial orbitofrontal cortex and the frontoparietal network are activated and, consequently, the development of executive functions is promoted (Disti et al., 2004). Cooperation therefore plays an important role in learning, goal achievement and brain development. Distance learning provides the context for such collaborations, because it allows students to communicate using learning tools, make team decisions and present the results of knowledge and information to the whole class.

The results of this research are comparable to the AGES e-learning environment model (Dauchi et al., 2010). The AGES model (Davachi et al., 2010) and the RAD learning concept (Willis, 2008) examine how neuroscience influences the learning environment. The AGES model, which stands for Attention, Generation, Emotion and Spacing, describes how individuals deal with learning situations and shape themselves and their social environment (Davachi et al., 2010; Davis et al., 2014). Adults need to understand how children think, react and absorb information.RAD Learning by Willis explains that the success of a child's learning process depends very much on the functioning of the brain: (1) the filter of the network activation system (RAS), (2) the filter of the amygdala and (3) the hormone dopamine when the child receives it through the receiver. The senses (seeing, hearing, feeling, smelling and touching) receive information from the outside, the information passes through the RAS filter in the lower part of the brain, which is attracted to color, to novelty. The unique and rare event here would be a selection process to determine whether the information received is interesting enough to be sent by the RAS to the next part of the brain.Information that is considered interesting enough is sent to the second filter, the amygdala. If the amygdala is in a safe state and the child has positive emotions, the information is sent to the reflective brain to absorb new knowledge and store it in memory. On the other hand, if the child has negative emotions such as fear, depression and insecurity, the information is transferred to the reactive, non-thinking brain. The production of the hormone dopamine is also necessary to maintain the child's mood during the learning process. This hormone is produced when children have a pleasant experience, so it is very important to maintain a happy atmosphere in the classroom. Racminis (2021) and Retan and Markar (2020) state that technologies may help integrate the principles of brain-based education because technology may support a comfortable learning environment for students and motivate them to have different sources of knowledge. slow The findings of this study confirm that online education with brain-based learning includes a motivational and positive method to maximize meaningful teaching and learning (Kane and Kane, 1994; Raghavandran and Begum, 2019). Schwartz (2015) and Uzzi and Jonah (2017) also found that a brain-based teaching approach increased student achievement and motivation. Researchers have shown that five-year-old children understand and perform more difficult tasks faster and better in face-to-face education compared to interactive touch screen education (Kestyrka-Alchern et al., 2019).

**The second research question: Does the brain-compatible e-learning environment model have internal validity according to the experts?**

Based on the opinion of 15 referees, Kendall's coordination coefficient for the components of the e-learning environment design model based on educational neuroscience was obtained in the third round with 0.87, which is significant at the level of 0.001, so the opinion poll was stopped in this round. According to the results of the content analysis and the Delphi method of 57 components of the e-learning environment design model based on educational neuroscience, the designed model has a high internal validity based on the coefficient of agreement between the experts.

This model provides a framework for the education system so that it can take advantage of the new capacities and facilities resulting from the new technologies in a targeted and planned way, while maintaining the existing capacities of the common, ordinary system. It is suggested that, in order to use this model, teachers receive the necessary and sufficient training on brain-compatible teaching methods and on the possibility of using educational strategies in schools. Development and training courses to increase the relevant and necessary skills of teachers and students in order to familiarize themselves with the use of brain-compatible e-learning environments, design and implement mechanisms to use the facilities of e-learning systems to increase attention, interaction and improve the quality of the content presented and communicate effectively with each other, producing and presenting educational content based on the principles of educational neuroscience and technological standards, and updating previously produced content in a timely manner. It is suggested that other e-learning environments be used to carry out the research: Modelo, Simulacro and other environments where educational neuroscience can be implemented.Various cognitive technologies, such as artificial intelligence, robots, automatic natural language processing and machine learning, can be used in the e-learning environment to teach and learn students. It is suggested to create a model in this field for students with special educational needs. It is also possible to provide a model for the use of cognitive technologies in the integrated learning method. It is suggested to provide a model for measuring students in the brain-compatible e-learning environment, or to provide a model for increasing students' motivation and participation in the brain-compatible e-learning environment. This research had limitations in the field of lack of resources in the field of educational neuroscience or the connection of neuroscience with educational sciences and the knowledge of the mind, brain and education, as well as the difficulty of accessing some experts in educational neuroscience to conduct interviews.

**Ethical considerations**

During the implementation of this research and the preparation of the article, all national laws and principles of professional ethics related to the subject of research, including the rights of statistical community, organizations and institutions, as well as authors and writers have been observed. Adherence to the principles of research ethics in the present study was observed and consent forms were consciously completed by all statistical community

**Sponsorship**

The present study was funded by the authors of the article.

**Conflict of interest**

According to the authors of the present article, there was no conflict of interest . This article has not been previously published in any journal, whether domestic or foreign, and has been sent to the Journal of School Administration Quarterly for review and publication only

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