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Practical points for brain-friendly medical and health sciences teaching

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Abstract:

BACKGROUND: Special learning outcomes are considered for medical and health sciences education which can be acquired by some interactive learning systems in the human brain. Given the importance of this issue, based on literature, we attempted at mentioning certain practical points for medical and health sciences educators to employ in preclinical and clinical teaching.

MATERIALS AND METHODS: We searched databases of PubMed, Proquest, Scopus, ERIC, and ISI Web of Science for relevant literature from January 2010 to January 2019.

RESULTS: From a total of 1029 records, 30 articles along with 35 papers from snowballing and hand searching were included in this study. The following 12 main items were encompassed: teaching students the basic neuroscience of learning and set individual learning goals, "just right challenge" heeding the balance between supervision and autonomy, brain-friendly coaching, repetition with spaced learning, visualization as a powerful learning tool, multimodal teaching, cognitive learning and mental model, cognitive-emotional learning, active and social learning, creativity and art, sleep, medical faculty's participation regarding the courses of "neuro-education studies," and "neuro-myths" were suggested for brain-friendly medical and health sciences teaching.

CONCLUSIONS: We considered 12 practical points for brain-aware medical and health sciences teaching according to the recent literature on the basis of the association between education, cognitive science, neuroscience, and psychology. Interdisciplinary research and practice regarding this issue can improve teaching–learning quality, students' well-being, and ultimately patient outcomes.

Keywords:

Cognitive science, education, learning, medical, teaching

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Introduction

New learning science is a fledgling interdisciplinary field on the basis of the synergic association among education, cognitive science, neuroscience, and psychology in an attempt to ameliorate the hypothetical and actionable understanding of learning and education;[1,2] this field further provides educators with insights as to what occurs in the brain in the natural course of learning.[1,3-6] This newly emerging field is called "Neuro-education Studies"[1] which can inspire education and teaching methods.[3,7-9]

Learning involves "knowledge," "skills," and "attitudes," all of which are physically shown through neural networks. Moreover, because learning will be available for future utilization, it has to completely alter the brain function and not just utilize it.[4,5,10] Faculties are designers of experience which, through either formal or informal learning, eventually, alter the level of synapses and neural circuits in the brain,[4,11,12] hence the fact that pedagogy and andragogy are the philosophy and theory behind the changes in the brain.[12,13]

During a convoluted learning process, data originate from outside stimulant and are channeled to the thalamus for further process. Data are further directed to suitable cortical structures (occipital and temporal lobes) and subcortical areas (the amygdala). In the case of an emergency stimulus, the

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amygdala rapidly recruits other vital brain areas. For more evaluation, the data are later dispatched to the hippocampus, where they are maintained for a while. Over time, the hippocampus organizes, distributes, and connects the information to other parts of the cortex in order for the long-term memory to be stored. The initial process, though intense and complicated, occurs very fast; the subsequent process, on the other hand, employs from hours, or days, to weeks to be finished.[14]

In the brain, there are at least eight interacting systems for learning, namely (a) a system for the memorization of special occasions, generating autobiographical or episodic memory. Such a system is the hippocampus, and the surrounding structures able to alter its associations quite swiftly in order to record snapshots; (b) the brain learns the correlation between perceptual data and motor reactions, spotting complicated space-related and time-related patterns via this ability, also named "concepts," occurring in the cortex, in which seconds, minutes, or hours are required to change the connections; (c) certain connections are not conscious, entailing the emotion (limbic) structures located the way in the brain, correlations between stimulus and response are more often named as "classical conditioning." Such associations can take over seconds or minutes to form; (d) in posterior cortex, the brain understands how to manage content-related structures, later in a way that activated in appropriate contexts. Controlling by the prefrontal cortex is done by interacting with limbic systems for emotion planning; (e) a reward-related the structure exists to specify what must be done in order to obtain the desired goal – this function results in good things happening and precludes bad experiences, a process which takes, seconds or minutes to complete; (f) a procedure-centered learning exists, associated with activities regularly and often unconsciously performed, such as surgical skills. Through practice, it takes days, months, or even years to master such automatically acquired skills. The involved systems are the looping outer-to-inner circuits which, via the basal ganglia, connect the cortex to the thalamus and the cerebellum and back again; (g) the brain makes use of its broad connections to perceive and understand individuals and learn skills by merely looking at them, a mechanism named "modeling;" (h) the brain utilizes its broad connections and language to build novel concepts and goals and enable us to learn through instruction.[15]

As regards among major clinical competencies (as learning outcomes) in medical and health sciences education are "communication and history-taking skills," "professional attitudes" and "awareness of the ethical basis of health care," "physical examination," "procedural and clinical laboratory skills," "diagnostic and therapeutic skills," "resuscitation skills," "critical thinking," "reasoning and problem-solving skills," "team working," "organization and management skills," and also "information technology skills,"[16] which can be acquired during basic sciences, preclinical, and clinical courses. In this article, we try to mention the implications of brain-aware learning science for the optimization of teaching–learning in medical and health sciences education according to literature reviews.

Materials and Methods

We searched the databases of PubMed, Proquest, Scopus, ERIC, and ISI Web of Science for relevant literature in January 2019. The main search strategy was: Title: (neur * OR cognit * OR brain * OR "new learning science*" OR "new science * of learning" OR "science* of learning" OR "learning science*") AND Title: ("medical educat*" OR "health sciences educat*" OR "health professions educat*" OR "health care professions educat*" OR "education in health sciences" OR "education in Health Professions" OR "education in medicine" OR "education in health care professions"), and it was adapted according to different databases. The inclusion criteria were: (a) new articles from January 2010 to January 2019, (b) document type of article, (c) English language, and (d) studies published. The exclusion criteria were: (a) studies irrelevant to brain-aware teaching–learning and (b) studies irrelevant to educational contexts. One author scanned all the titles and then abstracts to identify potentially relevant articles. Then, full-text versions of these articles were obtained and reviewed. A subsequent searching of reference lists of all full-text studies (snowballing) and a hand searching were also performed. As the aim of this study was to produce practical points for brain-friendly medical and health sciences teaching, the studies that best addressed the aim of this review were included from cross-referencing and hand searching [Figure 1].

Results

A total of 1029 articles were identified by preliminary database searching, and 87 duplicate references were removed. A total of 924 articles were reviewed according to the titles and abstracts. Thirty-five articles were added by hand searching and cross referencing, and finally 65 articles were used in this study according to direct relevancy to medical and health sciences teaching–learning in preclinical and clinical settings. We categorized the effective topics to 12 main practical points which were extracted including teaching students the basic neuroscience of learning and setting individual learning goals, "just right challenge" heeding the balance between supervision and autonomy, brain-friendly coaching, repetition with spaced learning, visualization

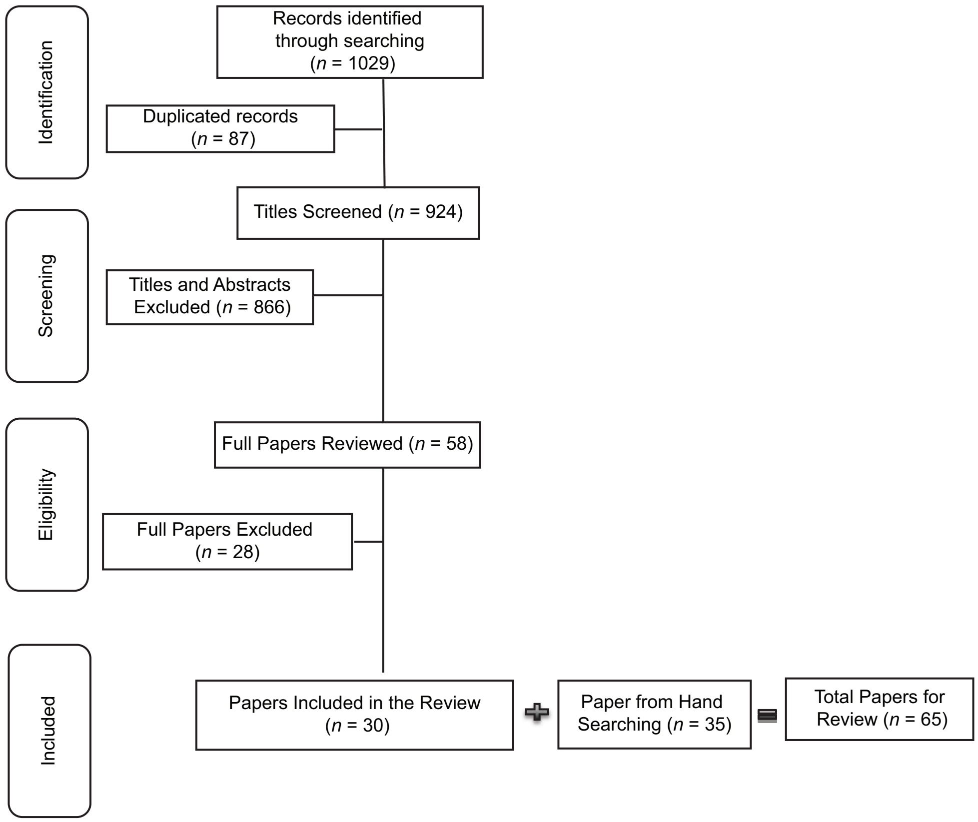

Figure 1: Flowchart for including papers in the review

or mental rehearsal as a powerful learning tool, multimodal teaching, cognitive learning and mental model, cognitive-emotional learning, active and social learning, creativity and art, sleep, and medical faculty's participation regarding "neuro-education studies" and "neuro-myths."

Teaching students the basic neuroscience of learning and setting individual learning goals

Literature indicates that teaching "neuroscience of learning" augments students' self-understanding, self-efficacy, motivation, and metacognition, all of which can render them more self-directedness.[17-19] By knowing how the brain learns, students can better set individual learning goals of their own. Students with learning goals are likely to hold intelligence to be flexible and personal growth to be possible; such students provide a more positive response to feedback and are less likely to skip challenging tasks. Faculties can also frame regular low-stake evaluations instead of infrequent high-stake evaluation as chances to enhance relative learning goals according to the weak points besides confirming capabilities by learners.[17,20] Getting advice from trained experts in educational psychology is also conducive to students, reflecting on their own learning, practicing novel plans, and implementing changes according to the best evidence and suitable for their own needs.[17]

"Just right challenge" heeding the balance between supervision and autonomy

Just right challenge (desirable difficulty level) means that experiences associated with learning hard enough to create cognitive challenge, yet not so hard as to have the students disengage from the material. Learning and retention are improved if learners are required to make an endeavor while learning and remembering information, which, though decelerates the learning in the first stage, entails a long-term retention. Spoon-feeding such as provision of detailed handouts to be memorized by students works in opposition to the principle of desirable difficulty level. Correctly answering questions in which the material has to be integrated across myriad sources of information encourages learners to try harder, thereby rendering learning more unforgettable.[17,20] However, it is a challenging task to encourage autonomy and active learning in an environment steeped in the close supervision of learners and providing a good balance is noticeable.

"Experiential learning" is yet another mechanism from which learners can highly benefit; via this system, they become able to consider new problems and make use of already-fathomed concepts. In the whole clinical conditions, students are to be reinforced to try hard via demanding scenarios and relating the already-understood ideas with the present scenario. When the data are easily accessible to a student, it is often less maintained compared to that discovered and pondered on ones' own.[12] Jensen also defined "learning by trial and error" as "error learning." He holds direct teaching to be the optimal approach to instructing some courses; however, he argues that brain neural connections are more effective provided the students to experiment various alternatives prior to providing a correct response.[14] Hence, the term "desirable difficulties" points out that, the harder the study process is, the longer the learning is going last. Such a study process has to be incorporated in the education system, and learners must be convinced as to their value while not being cognitively loaded.[20]

Brain-friendly coaching

The literature considers "coaching" as a major role of a medical faculty. Successful professors have had coach(s) who push them to more difficult conditions via encouragement and feedback. Coaching is comprised of three areas, namely role-modeling, motivation, and feedback. Because students are different in terms of skill, the initial stage is contemplating individualized goals for students and encouraging them to meet each expectation conducive to their achievement of expertise. From a practical viewpoint, medical faculties have to create explicit expectations, setting them from day one. A novice student in a clinic, as an example, is expected to achieve a complete history and physical examination and deliver a pellucid evaluation of the patient's issues by a month's end. Having the same significance are expectations, as concerns professional behaviors, such as social interaction, critical self-reflection, and life-long learning skills. Creating expectations paves the way for a highly crucial façade of coaching: feedback. Students are often weak at their self-evaluation at first, when external feedback is not significant. In the case of errors, receiving feedback which is constructive in a proper manner and condition may act as a potent learning experience for learners.[21] Asking students to ponder on their work prior to feedback stirs up the soil in their brain, making room for the feedback seeds to settle and grow.[22] Further, the efficacy of feedback is related to when, how, and where it is given which is out of this article`s objective.[21] Encouragement of learners to enhance self-reflection over their performance and expert ones have to be continuously done by convincing them to think about their knowledge and skills and how they can make up for their lack of knowledge and skills. Faculties are to model such behaviors and ask questions to induce deep thought. After a student indicates that his/her patient has a specific disorder, reflective questions, such as "what is required for understanding more on how to take care of such patient in a better way?" are to be considered. Learners should be encouraged to identify the uncertainty that might exist in the conclusion of a clinical encounter or a teaching session, which is a key teaching point. It is recommended that the teaching session ends 5 min early, a time utilized by students to ponder on the learned material or the problems yet to be answered. Through the provision of time and permission to think actively, faculties create a calm environment for students to share their ideas, create associations, and specify the gaps. Such interactive methods called "think–pair–share," in which students work in pairs to answer a question, followed by sharing their ideas with a bigger group, should be employed to make group thinking and sharing easier. These strategies can also be employed by larger didactic sessions to allow for the solidification of learning.[12]

Moreover, the clinical instructor has the opportunity to be a role model to his/her learners and teach professional ethics and professionalism, performing procedures and conducting physical examinations without lecturing in a purely theoretical mode.[23-25]

Repetition with spaced learning

Repetition augments exposure and strengthens the connections, which is related to learning in the brain. The synapses are active and continuously adapt in response to long-term potentiation (LTP) and long-term depression (LTD). Accordingly, via a model of information presentation to the learners, the chances of students retaining the information, accessing or activating the information, and learning skills in a quicker and more accurate way are increased. The brain requires time for data storage in "long-term memory." Too much information with no settling time negatively impacts learning.[14,26,27] "Distributed learning" or "spaced learning" refers to reviewing the just-learned material within a day of the first exposure. When the material is fathomed, the interval among reading sessions should increase up to months so as to reliably remember the information for longer periods of time. "Massed practice," or "cramming," which refers to spending a lot of time reading a subject or exercising a skill during one session, might seem efficient on the first glance; however, the longer the participants study in one session, the less effectual that time gets.[5,10,28]

For instance, Lauria mentioned that attention and concentration seem to peak between 10 and 15 min in a presentation; after which, they steadily decrease. Although the perfect presentation time remains unclear, research indicates that it is certainly <60 min, perhaps somewhere between 20 and 30 min. If this is not possible, listeners can be given 3- to 5-min breaks. To solve these problems, instructors can assign supportive information before the class. The in-class time is then used for problem-solving, discussion, a connection of ideas, or other demanding and engaging interaction, called "flipped classroom."[29,30]

Moreover, it is believed that becoming an expert depends on the entire experience and practice time, along with encouragement and a supportive setting. Ericsson and Pool (2016) made use of the term "deliberate practice" to discuss the years (typically) of study or practice concentrated on weak points and controlled by an instructor who is expert on providing feedback and facilitating improvement.[5,10,31] For deliberate practices, students require intrinsic motivation created by supportive instructors.[5,10,21] Ericsson's "4/10" rule summarizes this concept by saying that to be a professional, the practice or work has to be repeated 4 h daily for 10 years, which is an approximate 10,000 h.[11] Elaboration is also encouraged when a student has variety, to the possible extent, how, where, and when he/she practices, so that information can be gradually associated with a large gamut of contextual cues involving multiple senses.[5,10]

Visualization as a powerful learning tool

A powerful way to optimize learning is creating pictures or images because "images cue memories."[5] Research related to mental rehearsal microsurgery skills revealed that it may result in fewer complications from errors and better operative outcomes.[32] Visualizing involves both the early and higher-order visual thalamus–cortical pathways of the human brain[33] and develops and refines internal demonstrations of solid and convoluted objects and their relative spatial position. The neuronal networks assembling the information and constructing memories do not concern the source (either created from within) of the inducing inputs so long as the necessary cellular and circuit signaling processes are available. Activities generated internally from visualization are capable of conducting the procedure of learning. Among major constituents of processes are introspection and self-reflection conducive to the strength of practiced activities or thinking. Networks of "mirror neurons" in the brain possibly conduce to such procedures. Visualization processes further gain access to neural circuits that are engaged in sensory, motor, executive, and decision-making pathways in the brain. Dependent on the degree of learners' experience is their ability to utilize visualization approaches in a successful way and so as to improve learning. A relatively new learner's level of knowledge and expertise in a certain field might be a restricting element, and strategies such as visualization are more effectual in the final chapters of education, as an instance, after having observed and taken part in the processes.[34]

Multimodal teaching

Sensory processing is employed to detect, encode, and analyze external data and develop inside indications of information to fathom and consolidate information. The learning process is more likely enhanced via multiple teaching approaches tackling similar information through different sensory processes, potentially carrying more neural hardware for data processing and storage.[34] The more the methods are employed, the more likely they become effective as they engage more senses, resulting in better information encoding in short-term memory.[5] As an environmental datum is entered to auditory and visual working memory separately, the collective capacity of working memory increases to send more data for a further cognitive process; for example, by using multimedia.[35] Teaching utilizing multimedia such as videos, games, mobile applications, animations, and simulations can enhance learning and result in diagnostic accuracy and early diagnosis if it is according to how the cognitive systems work with providing appropriate interactions, involvement, participation, and challenges to the learners.[36-40] An interactive video requiring the viewers to detect typical errors and provide answers to questions presented during the video can enhance learning. Presenting information using PowerPoint or Prezi can also result in information transference if used correctly. Spatial contiguity (the placement of an image and related texts in physical space) and temporal contiguity (the presentation of verbal and nonverbal materials simultaneously rather than sequentially) are among important items for a good technical design.[29,41] Gaming and simulations allow learners to explore different actions and their consequences and to learn through a variety of experiences provided by "restarting" multiple times. Gaming can allow training for effective coordination and distributed cognition among team members, coping with time pressure, distractions, and unexpected events. However, if the gaming is not cognitively effective in embedding the training within it, the fun and entertainment can minimize the learning rather than enhancing it.[38,42]

Cognitive learning and mental model

"Mental model" or schemata refers to the general knowledge of a person about a special domain.[18] Mental models allow for more effective reasoning, problem-solving, and creating.[5,43] For both an amateur on the way to his/her expertise and a professional extending his/her expertise, learning is comprised of three essential stages involving various brain parts, all of which require active engagement, called by encoding, storage, and retrieval.[34,44] First, encoding refers to forming a cognitive illustration (memory trace) of an outside conception in short-term memory. The neo-cortex is for the initiation of the learning process, and the prefrontal cortex ensures sufficient attention to task, called "focused-mode thinking" or "effortful attention." Short-term memories are received and processed by the hippocampus. The important point here is that, the more the undistracted cognitive strength allocated to concentrating on a novel and demanding challenges, the more accurately and completely the data are represented in short-term memory.

Memory consolidation (storage) is the second step referring to the transfer of information from short-term memory to long-term memory. Important correlations between the hippocampus and neo-cortex are coordinated by the entorhinal cortex, which processes memory traces in a precise manner, storing the chosen ones in the long-term memory. Hence, the hippocampus, entorhinal cortex, and neo-cortex are engaged in these two steps.

Contrary to the focused-mode thinking of encoding, "diffuse-mode thinking" is associated with consolidation; this mode happens without our conscious effort (90% of what is learned) and engages myriad brain regions, usually containing various areas of the neo-cortex.[10,14] It reveals the role of the informal and hidden curriculum in learning, called "peripheral perception."[45] To create associations and meaning in this step, Jensen mentioned that previous knowledge of the content should be related to new knowledge. Feeding students with previous knowledge and instances is a crucial element as far as coherence is concerned.[14,46] Elaboration is another strategy to optimize data storage, which induces a symbol or visual picture when a topic is explained again by the learner`s own words again. This ilk of elaboration extends the mental prompts for further transfer of data and recall. Higher-order thinking of students can be ameliorated via "why" and "what if" questions. Further conducting to elaboration is teaching students in a clinical setting.[10] Diverse contextual prompts correlated with learned data means that the brain is doing a better job of understanding and accessing the information via additional different applications.[5]

Retrieval is the third and final stage, which refers to the change, use, and movement of long-term memories to short-term memories and back again. Retrieval is obtaining data saved in the long-term memory (neo-cortex) and taking the information back to short-term memory (hippocampus). Every time the brain gains access to the fathomed information, a change occurs in the memory, and for the better, because it connects with a novel series of prompts reflecting the newest setting. Testing effect (test-enhanced learning) is a learning strategy, where tests are repetitively given during learning, which facilitates retrieval from long-term memory; this strategy modifies information based on the new knowledge and improves learning by the reconstruction of schemas.[4,18,47,48] Research shows that students remember about 50% more data when a test is conducted by the learners themselves.[2] Retrieval provides a student with feedback after grappling with the data. Pretests warm up the brain for learning through exposing the gaps in knowledge and understanding. When understood, the brain subconsciously starts to search for the required information, a condition called "foraging brain."[4,18] Pretests are either clinical cases with essay questions or more discrete multiple-choice questions. These pretest questions are revisited over the course of the session, where the answers are discussed in the final part of the presentation to make sure that learners understand the concepts. To increase the eagerness of students and practice retrieval, such strategy is used in bigger didactic conditions, such as noon lecture scenario.[2] Retrieval further augments the chunk size related to the learned information, ameliorating its transferability to novel conditions.[5]

As far as cognitive load theory (CLT) is concerned, on the other hand, the human brain is only able to simultaneously process-specific extents of data. We constantly receive information through senses, holding it temporarily in the working memory. Due to the fact that the capacity of working memory is limited, data processing and storage is done in long-term memory for further use. Information in the long-term memory is categorized into schemas of increasing complexity, allowing for schema retrieval to be employed as a single construct in the active memory. The CLT further classifies learning into "intrinsic load," "extraneous load," and "germane load." The first reflects the convolutedness of the information itself, while the second is the endeavor needed to analyze novel data because of the manner it is shown. Germane load encompasses the mental activities associated with schema construction and automation.[49-51]

The intrinsic load can be managed by learning tasks ranging from facile to dificile, working environments varying from low- to high-fidelity, pre-training principle which provides information on the features of important concepts, and segmenting principle reducing the lessons into learner-controlled segments.[52-58]

Among the principles for reducing extraneous processing, mention can be made of coherence principle which discards extraneous material, signaling principle underlining essential material, and contiguity principle which puts the printed words close to the corresponding graphics, as mentioned in a multimedia presentation. In the work environment, the extraneous load is high because of the convolutedness associated with audiovisual stimuli in a hospital ward or clinic. Faculties should reduce such interferences (i.e., silencing unnecessary alarms, discouraging disruptions to rounds) and highlight the importance of recognizing the impact of these distractions on the thought processes of the learners. We can reduce extraneous loads through the use of goal-free tasks, which provide students with a general (nonspecific) objective;

an instance for such goals is asking students to mention as many illnesses as possible related to the observed symptoms. Worked example refers to replacing routine tasks with worked examples, which provides a complete answer that students are to study closely; for example, students can be allowed to criticize a treatment plan done by faculty, rather than asking them to independently generate such a plan. Task completion also means providing a chain for a learning task; for instance, can be letting medical student closely observe a procedure and only perform part of it, rather than the whole parts independently. Split attention principle refers to substituting different data sources, distributed in space or time with an integrated data source. The redundancy principle refers to tackling various extra noneffective data related to the topic.[43,49,54,56,59]

To optimize germane load, variability can be used, and it refers to the illustration of tasks or problems by the use of multiple examples. Contextual interference also refers to alternate tasks or problems to prevent students from concentrating on only one aspect of the task and practicing it in different contexts close to real ones. In self-explanation, learners are asked to think out loud, act as a teacher in a clinical setting, and hold that teaching as a potent learning tool. Among other suggested approaches, mention can be made of visualization, asking clarifying questions, compare and contrasts of contents and skills, situational awareness training, teaching at the moment, and explanation of faculties related to own schemas.[2,52-54]

In addition, it is important to pay attention to timing in cognitive performance. According to the research, the brain has many different rhythms or patterns on a daily basis. Ultradian rhythm, one of these cycles, is around 90–110 min long. There exist around 12–16 of these cycles happening in a day. High and low periods constitute one cycle. These cycles are affected by external elements such as exercise, caffeine, or novelty; however, they are relatively constant throughout the day and play a major part in fathoming the mental ability of the brain.[14]

Cognitive-emotional learning

Jensen considers emotions to be major regulators of learning and memory.[14] A good teaching strategy is letting the students to have sufficient time and space for interpreting the teaching contents and having sufficient time for expressing their feelings.[60] Positive emotion strategy is the basic strategy of brain-based medical teaching, which represents a kind of idea to lead teachers to change their behavior. It permeates all different teaching strategies. For instance, the feeling of fear or excitement in a certain condition increases the likelihood of recalling it with more details and developing a deeper connection. Research has shown that negative emotions such as anxiety decrease mental activity due to the repression of glucocorticoid hormones influencing cognition. Negative incidences are remembered in a more facile manner and influence a larger part of the brain circuits. Concerning positive emotions, the neurotransmitter dopamine, considered to enhance cognitive function, is associated with our view of positive experience. Positive experience, even memorable smells, increases dopamine generation.[14,61]

Body language while teaching can also improve recall by engaging the audience, grabbing attention, controlling challenging learners, and conveying passion for a topic. Psychologists have studied the use of body language in discussions to reduce psychological stress and improve performance. A well-recognized study indicated the significance of nonverbal communication, leading to "7/38/55" rule, where 7% of communication originates from spoken words, while 38% comes from the tone of voice and 55% from our body language. Medical educators looking to optimize their teaching effectiveness can benefit from body language.[59]

Active and social learning

It is believed that the more we engage with something – such as listening, talking, reading, writing, or reviewing – the more powerful the associations in our brain will be, and the chances of the new learning becoming a more permanent memory will be higher.[5,62] Educators with constructivist viewpoint use active discovery and suitable activities which challenge the learner's point of view and discloses misconceptions, so that they can actively assimilate and restructure information without error.[63] In medical education, one of the strategies which can generate active learning chances is "student as a teacher." Such opportunities tend to spark reward and motivational pathways of the brain because of having social interactions, taking individual responsibility to obtain information, and having feedbacks from others.[34,46] Another strategy is having interactive classes, which induces that the data are encoded in short-term memory optimally, when the participants consider the main data several times in a session.[5]

Creativity and art

Art has unique qualities conducing to the creation of new ways to involve medical learners, especially when medical faculties take particular engagements ensuring a calm and productive learning condition. Therefore, learners become able to make novel meanings when they are actively participating in educational programs with the objective of generating new meanings which entail better medical practices, especially if learners consider the way these meanings can be made into plausible future plans.[64] Storytelling throughout a presentation can increase attention and retention. The multisensory information contained in a story strengthens the schema generated by the brain.[29] Movies stir several elements in the hidden program, engaging the viewers in the active process of learning. In particular, a movie including medical practices increases learners' curiosity and attention through its realistic medical scenarios, thereby reinforcing the original learning process. Cinema further aids students to select the right path after the exposure to constructive and destructive role models. It has the potential to balance between topic teaching and self-learning and between teaching clinical reasoning and professionalism. A teacher can bring the reality of drama into focus and can act both as critics and guides. Nevertheless, it should be noted that students can study the setting of a medical scenario and the relationship among characters according to their individual likes and idiosyncrasies, in order to have a more profound stance at the event.[65]

Sleep

Sleep is crucial to memory consolidation which might be a main objective behind sleeping in the first place. Data can be consolidated with a short sleep or other cognitive "breaks," yet sleeping at night is the best, hence the necessity to have a good night's sleep with all sleep phases because sleep phases are related to various kinds of learning. For instance, rapid eye movement sleep concerns pattern recognition and inventive solutions to questions. Sleep further warms up the brain by clearing space in short-term memory. In order to master a skill, the brain requires time to process the practiced skill, to which it refers at various moments separated via sleep periods.[5] It is observed in animal brain as neuronal activity patterns recapitulating the incidences during sleep. Much can be done by educators to encourage rest/sleep among learners; however, there exist possible occasions for the incorporation of consolidation times for busy schedules. Moreover, it is necessary to have proper intervals between challenging sessions, where detailed quantitative reasoning skills are needed. Such downtime provides a break from the formal process of teaching.[34] Sleep deprivation can result in increased reaction times in overnight call residents, which shows sensorimotor and cognitive slowing. Furthermore, as circadian rhythm disruption occurs during the overnight call, it may lead to increased workplace accidents. Sleep deprivation can cause memory, alertness, concentration, and fine motor skill impairments and interfere with problem-solving and learning abilities.[66]

Medical faculty's participation regarding the courses of "neuro-education studies" and "neuro-myths"

Neuro-education studies are potentially conducive to evidence-based policy and practice in education.[1] The objective is to apply the biological knowledge of learning and memory to the medical education in order to effectually guide learners to percept, understand, retain, retrieve, and apply the basic and applied sciences and also having effective clinical reasoning skills. To obtain this, it is required that we identify and assign levels of significance to the biological constituents of learning which are strongly understood, for which there exist actual chances of integration in the medical education process. Hence, such an approach necessitates that medical schools be aware of that and also some misconceptions related to this approach.[34]

Certain misconceptions in brain-based learning entail "neuro-myths" such as 10% brain use, visual–auditory–kinesthetic learning styles, left- and right-brain thinking, Brain Gym© method, and crucial periods, none of which is corroborated by the latest scientific evidence.[1] Neuro-myths originate from a crude association between neuroscience and education, stemming from the various epistemic natures of the two sciences. Neuroscience is a basic science, whose findings can be employed in the practice of teaching within the framework of a translational science; hence, the necessity of raising the awareness of faculties in this area is important.[15,18,52,67,68] Even though certain health sciences educators are conservative regarding the use of neurobiological findings related to education,[1] faculty development can better help faculties become aware of and apply learning basics to the design and practice of teaching.[17]

Discussion

According to the documents, brain-aware learning principles are those fostering profound and long-lasting learning which are the objective of all future health professions.[14,17,69] We considered 12 practical points for brain-aware medical and health sciences teaching according to the recent literature on the basis of the association between education, cognitive science, neuroscience, and psychology.

It seems that distributed learning, retrieval practice, information interleaving and cumulative review (beginning each study session with a concise review of previously learned material and cumulatively reviewing the material throughout the course and curriculum), elaboration and contextualized learning (providing a relevant and meaningful context for learning), self-regulation (planning and observing the learning process), metacognition (personally attending to and self-evaluating the learning process), desirable hardness levels (structuring materials to promote effortful learning), deep questions and explanation effect (the significance of asking questions and providing explanations to make complex ideas easier), cognitive flexibility (enhancing learning through the use of problems and cases varying in content and complexity), and test effect (effect of cumulative/comprehensive testing on long-term retention and effect of routine and cumulative evaluation with feedback on retention) can enhance learning.[10,17,70-72] It is discussed that activities involving longer time exposures tend to be effectual; for instance, the brain is required to retrieve the data several times, entailing iterative cycles of encoding, consolidation, and retrieval, with sufficient sleep intervals to support consolidation (following the first exposure) and reconsolidation (following each subsequent exposure). Moreover, activities concentrated on important results and motivated are more bound to be efficacious because activities can better engage participants, entailing data solidly encoded and more likely to be later processed (consolidated) owing to their significance for the participants. Interactive teaching activities necessitate that learners think about their knowledge and beliefs and get feedback on what they can do. This type is consistently correlated with retrieval strategy, able to show occasions for amelioration in major educational outcomes. Another way to focus learners' attention on major results is to have them realize the relative weak points through retrieval practice. Making students aware of their lack of mastery helps them to prioritize for more study or practice.[5,10,70]

And, finally, learning improvement in health professions schools has to be achieved via curriculum reform endeavors, pedagogical changes, and educating the medical faculty and the students.[17,69]

Literature also mentioned that interdisciplinary research and practice regarding this issue can improve teaching–learning quality, student's well-being, and ultimately patient outcomes.[7]

Conclusions

Teaching students the basic neuroscience of learning and setting individual learning goals, "Just right challenge" heeding the balance between supervision and autonomy, brain-friendly coaching, repetition with spaced learning, visualization as a powerful learning tool, multimodal teaching, cognitive learning and mental model, cognitive-emotional learning, active and social learning, creativity and art, sleep, medical faculty's participation regarding the courses of "neuro-education studies" and "neuro-myths" is considered the practical point for brain-friendly medical and health sciences teaching.

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Conflicts of interest

There are no conflicts of interest.

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