

Access this article online
Quick Response Code:

Website: www.jehp.net
DOI: 10.4103/jehp.jehp_644_21

The double-edged sword of emotions in medical education: A scoping review

Nahid Toufan¹, Athar Omid¹, Fariba Haghani¹

Abstract:

Emotions are universal in academic and clinical settings. A student is likely to hope for success, maybe be worried about failure, or may feel comfortable after an exam. These feelings undoubtedly affect his/her motivation, effort, academic performance, and progress. This study aimed to investigate the role of emotion in the learning and performance of medical students and its mechanism. This study was a scoping review conducted in 2022 to examine the role of emotions in medical education. The three databases PubMed, ERIC, and Science Direct and the search engine Google Scholar were searched using the following keywords: "emotion," "medical student," "teaching," "learning," and "medical education." English articles published from 2010 to 2022 were reviewed, and finally, 34 articles that met the inclusion criteria were reviewed. Review of the selected articles showed that there was a significant relationship between the cognitive system and emotions in the brain. The conceptual framework of the relationship between cognition and emotion can be explained in the form of dimensional and discrete views of emotions and based on cognitive load theory. Emotions affect cognition with the four mechanisms of memory, cognitive resources, cognitive strategies, and motivation and can be effective in learning self-regulation, clinical reasoning, and academic achievement of medical students. Emotions in medical education is a double-edged sword. In other words, it is highly recommended to divide emotions into activating and inactivating, instead of dividing them into positive and negative ones. In this context, medical educators can use the positive aspects of nearly all emotions to improve the quality of their teaching.

Keywords:

Education, emotion, learning, medical, students, teaching

Introduction

An important challenge for medical professors is understanding the personal factors that lead to effective learning in medicine and other health sciences students. Emotion is among the key personal factors that enormously impact medical students' achievements.^[1,2] In other words, education involves our intellect and feelings.^[3,4] Although students definitely have positive personal emotions, negative emotions seem to be more frequent.^[2] Feelings like hope, worry, and relief undoubtedly affect the motivation and effort they make to succeed and even the study strategies

they adopt.^[3] Previous studies have emphasized that emotions influence the process of teaching and learning. It has an important effect on human cognitive processes, including comprehension, attention, learning, memory, reasoning, and problem-solving.^[4]

Although some studies have demonstrated the relationship between emotions and learning processes, the present literature is not conclusive regarding biological, conceptual frameworks and the mechanism of this relationship and its operational uses in medical education. The purpose of the present study was to fill these gaps to optimize teaching and learning processes. The present article would be especially useful for teachers as their attention toward

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Toufan N, Omid A, Haghani F. The double-edged sword of emotions in medical education: A scoping review. *J Edu Health Promot* 2023;12:52.

¹Department of Medical Education Research, Isfahan University of Medical Sciences, Isfahan, Iran

Address for correspondence:

Dr. Fariba Haghani, Department of Medical Education Research, Isfahan University of Medical Sciences, Isfahan, Iran.

E-mail: fariba.haghani@gmail.com

Received: 07-05-2021

Accepted: 02-07-2022

Published: 28-02-2023

the emotional dimension of learning can significantly boost students' learning.^[5]

Materials and Methods

A scoping review was conducted to collect information on the relationship between emotions and learning in medical education. Three major databases, namely, Science Direct, PubMed, and ERIC, and the search engine of Google Scholar were searched for articles published from January 2010 to January 2022. The PICO-based search strategy (Population, Intervention, Comparison, Outcome) was: ("emotion" OR "emotions" OR "fill*") AND ("medical student" OR "medical educat*" OR "health sciences educat*") OR "(residence OR resident) AND ("teaching" OR "learning" OR "academic performance"). The inclusion criteria were: (a) articles published from January 2010 to January 2022, (b) document type of article, (c) English language articles, and (d) studies published. In addition to the time frame, the other exclusion criteria were articles related to learning in general, those not dealing with learning in medical education, books, non-English language articles, and editorial publications.

A total of 5396 articles were found in the initial search. After removing duplicates and considering the language of publication of the articles and other exclusion criteria, the summary of 212 articles whose title was appropriate to the purpose of the study was studied. Out of 212 abstracts read, 53 were evaluated as appropriate, and the full text was read. Finally, 34 articles were included in the study [Figure 1].

Results

Definition of emotion from different views

Considering its relationship with other psychological constructs, emotion is quite a subset of the more general term called affect. Emotion is divided into two categories: affective traits and affective states. In this general classification, mood and emotions are considered two distinct emotional states; the distinction between moods and emotions is mainly based on resistance and duration. Moods tend to be longer and may not be about a certain incidence, such as depression. At the same time, feelings are shorter, more intense, and occur in response to a particular event or activity, such as having anxiety about a future exam.^[6-8] What is considered in the current article is the role of emotion in learning.

Defining emotions is not easy. There are different definitions of emotions as witnessed in the literature on medical education concerning different approaches. Among these, two approaches of neurophysiology and cognition are of more interest.

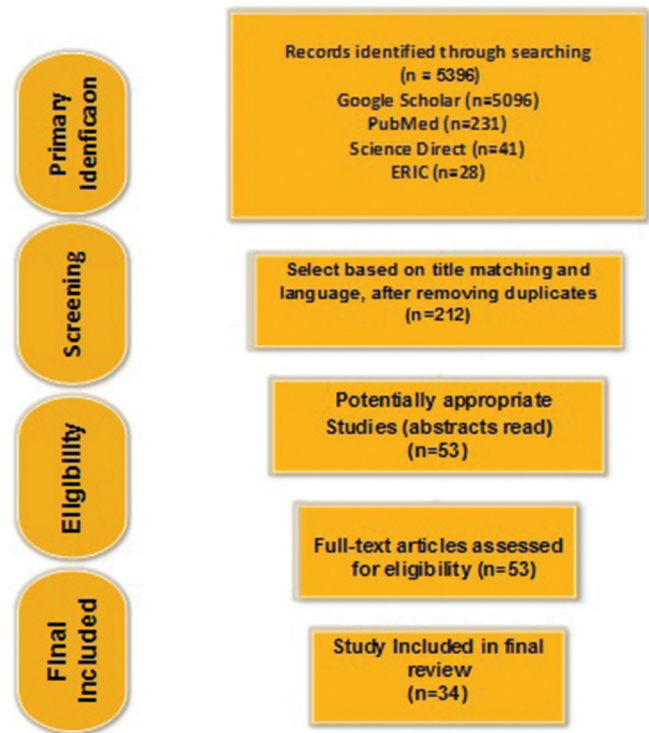


Figure 1: Articles were included in the study

The neurophysiological approach defines emotions based on psychological and physiological manifestations.^[9,10] In this approach, emotions cause neurophysiological changes that alert the organism against favorable or unfavorable conditions around it. Activation of the physiological axis of the hypothalamus–pituitary and adrenal glands, which secrete the hormone cortisol, is the reason for this approach. This signal triggers somatic responses like changes in heart rate and blood pressure, which are often severe and short-lived.^[6,8]

From a cognitive point of view, emotions are an integral part of human cognitive function. Likewise, cognitive function is also proven to create emotions. According to this approach, emotions are only a reflexive reaction to various situations that may result from a person's interpretation of the situation in which they are placed. According to this view, a person's mental experience determines the degree of importance of events and situations, and the response to the event is based on the overall value. At the same time, in the neurophysiological approach, emotional reactions occur without mental experience.^[1]

In general, it can be argued that emotions are dynamic, permanent, and dependent on their contextual situations, and responding to them is based on the cultural and social contexts.^[10] According to these two approaches, emotions have five components: (a) mental component, such as the feeling of pleasure, (b) physiological component, such as

somatic changes, (c) cognitive components, like position assessment based on the previous experiences and related perceptual effects such as labeling processes, (d) motivational component, such as the desire to perform a particular behavior appropriate to the situation created, and (e) behavioral component, like specific performance occurs in an emotional situation that is often, but not always, purposeful, adaptable, and expressive.^[11-13]

One of the types of emotions that is given special attention within teaching and learning is the emotion of progress. Pekrun^[6] defines feelings of progress as “feelings directly tied to activities or outcomes,” for example, the joy of being involved with an interesting patient or the boredom felt during a boring speech. On the other hand, feelings of success are associated with the results of success in activities, such as the pleasure of doing well in an exam or feeling proud after achieving a high rank from a clinical trainer following a successful clinical performance.^[13] Emotions of progress are closely related to cognitive, motivational, behavioral, and physiological processes and are described as positive emotions, such as the joy of learning, hope for success, and pride, and negative emotions, such as anger. Feelings are constantly associated with learning and affect information processing. They are influenced by educational situations experienced by students in classrooms and clinical settings. Although the learning processes and academic emotions are interrelated, it is shown that what students feel is not just about academic feelings.^[14] The misbehavior and disrespect of some patients and entering a new phase may cause different feelings, such as interest, determination, or curiosity. Research on medical culture reveals that bullying and abusing students is common. A survey of undergraduate medical students in New Zealand and the USA found that humiliation, along with verbal harassment, was the most common form of abuse,^[15] a behavior that could affect learning.

An overview of the biological relationship between emotion and cognition

The past decades have brought about dramatic explosions in our understanding of the biological basis of learning. Neuroscientists have more accurately defined the different signals and pathways within and between nerve cells involved in learning. They have retrieved human brain strategies for acquiring and storing information using functional brain imaging. Although these achievements have provided many insights and opportunities to understand the biological basis of learning and memory in healthy and diseased brains, the use of this knowledge in education has been limited. Learning to move information from transient to more stable memory is for future use. Learning leads to functional and structural changes in cells and

communication networks between neurons (synapses) throughout the central nervous system. In learning, the efficiency of chemical transmission at synapses between neurons in areas of the brain associated with the formation of new memories undergoes changes, which alters the strength of subsequent signals produced, which is the potential for action in postsynaptic neurons.^[16]

Recent advances in neuroscience have challenged the notion that emotions and cognitive functions are processed separately in the brain.^[17] Recently, structures that are part of the “emotional” limbic system, for example, the hippocampus, have been shown to play an active role in cognitive processes, including memory, as the structures responsible for cognitive functions, for example, cortex, play active roles in processing emotional data. However, the input from emotional systems to cognitive systems is stronger than that from cognitive systems to emotional systems, which indicates the priority of processing emotional issues over cognitive processing. People with brain damage in the areas involved with emotion lose learning and decision-making capabilities despite having intact parts of attention, memory, and reasoning. Therefore, humans cannot function without emotions.^[1,12]

Damasio showed that when emotions are completely out of the realm of reason, the reason is more flawed, compared with when emotions play bad tricks on our decisions; thus, it seems that emotions coordinate one’s thoughts and actions and produce a set of physiological, behavioral, inspirational responses that help the individuals cope with the conditions faced. They trigger behavior and bring about the motivation that enables the person to deal with the situation.^[1] For instance, stress-related molecular signals amplify synapses in brain circuits that affect memory and learning. However, high levels of stress can have opposite effects.^[16] Compared with ordinary memories, events related to anxiety factors that are stored in memory through the amygdala pathway are at the risk of being lost.^[18] In addition, contrary to entertainment which may improve memory, tedious education can stimulate superficial learning. In one study, 10 young adults were shown six pleasant, neutral, or unpleasant pictures with six irrelevant words. Word recall was significantly higher after seeing images that induced a pleasant mood (35.7%), compared with seeing images that were neutral (23.9%) or induced a negative mood (23.6%). Simultaneous brain activity was assessed using functional Magnetic Resonance Imaging (fMRI) scanning. Active areas included the parahippocampal gyroscope when viewing pleasant images, while the amygdala and fear-related areas were active when viewing unpleasant images, with weaker word recall. In another study, 66 young people were shown 10 min of entertaining comedy, a relaxing or

scary documentary. Next, they were shown a series of words to determine if each word was the same word they had previously been given while watching the film. Scores were the highest after comedy and the worst after horror clips.^[19]

Conceptual framework and hypotheses

Scientists have different views on emotions, including the dimensional versus discrete views. The assumption in dimensional models of emotions is that all positive emotions have the same effect on cognition, distinct from the effect of negative emotions. Contrary to this view, the discrete approach to emotions is based on the assumption that positive or negative emotions do not have the same effect on cognition in all situations, and their effect depends on the individual's previous experiences. Also, in some theories, the dimensions and background of the emotions are not considered, but the cognitive burden created is deemed important.

In the following perspective, five theories are discussed considering the three dimensions of emotion (level of stimulation, value, and dependence on the goal):

In the Arousal level model, the level of emotional stimulation determines its effect on cognition. All provocative emotions reduce attention to side issues and the cause of emotion. In contrast to emotions that are not provocative, regardless of their positive or negative value, they are accompanied by a decrease in cognition. In addition, anger and rage can be irritating, regardless of the value they may hold. Stimulation refers to physiological activation or inactivation.^[1,20]

In the Valence value model, the value of any emotion that refers to its inherent pleasure or unpleasantness is reported as positive or negative. Positive emotions are the focus of cognitive activity.^[1,20]

As for the Goal relevance model, goal-related emotions stimulate cognition; especially, pre-goal emotions are more effective than post-goal ones.

Also, the Circumplex model considers two capacities, namely, positive or negative, and two degrees of arousal, that is, strong or weak, for emotions. The combination of the stimulus and the value of a feeling is considered effective in the amount of cognition. Accordingly, all emotions with a stimulus and a positive value load similarly affect cognition.^[1,11]

Finally, in the Control-value theory model, Pekrun uses three dimensions of emotion, namely, emotion capacity (pleasant vs. unpleasant), degree of activation (activation vs. deactivation), and emotion focus (activity vs. outcome), which provide a

three-dimensional classification of feelings of success. For example, fatigue in a dull speech is a negative, inactive, and activity-related emotion, while pride in achieving a correct diagnosis in a challenging case is a positive, activating, and outcome-related emotion.^[6,20,21]

According to the dimensional approach to emotions, repeated exposure to a certain activity or outcome eliminates the need for conscious cognitive evaluation. For instance, when a teacher says, "Who is ready for the competition?," many students become anxious when they evaluate the word "competition," without the need for conscious cognitive effort.^[13]

In the Discrete Models of Emotions, the effect of emotions on cognition is not always fixed. These emotions trigger specific physiological behaviors and responses and allow individuals to deal with emotion-provoking events.^[11]

Finally, cognitive load theory assumes that active memory can hold a limited number of elements (typically seven to nine) for a limited time (up to 20 s). It can originate from the environment or recover a person's long-term memory. Active memory load is under the influence of information complexity (intrinsic load), the way the task is presented (extraneous load), and the creation of a schema for new learning elements (germane load). Emotions can be effective by creating an additional burden on the intrinsic load, while artificially removing the feeling from the intrinsic load can lead to oversimplification. Excitement makes the students repeatedly think about learning in a learning session, which itself affects the German load, or in other words, learning. Paradoxically, reviewing the emotions associated with learning reviews the learning session's content and consolidates learning.^[22,23]

Mechanisms of impact of emotion on cognition

Emotions affect learning through different mechanisms. Schunk *et al.*'s (2008) classification of the mechanism of emotions' effect on learning seems useful in this regard. Moreover, emotions can affect students' success through two main cognitive and motivational pathways and four mechanisms. The cognitive path discusses three mechanisms of memory, cognitive, and metacognitive learning strategies and the optimal use of cognitive resources. Motivation comes in the second path and as the fourth mechanism.^[6,13,24,25]

Memory

The first way emotions are believed to affect learning and performance is through the processes of storing and retrieving information, or the so-called mood-dependent memory. Mood-dependent memory refers to emotional states learned simultaneously with information encrypted in long-term memory.^[6]

Attention and perception are the first stages of information processing and, as a “filter,” allow only a part of the vast realm of information around us to be processed.^[9] Negative emotions and learning materials attract students’ attention and process new information. As a result, this information is not “recorded.”^[26] On the other hand, they cause the person to ignore (parts of) what is learned because of negative attitudes toward it. They are automatically activated in memory, and they tend to avoid it.^[9] They also tend to limit people’s attention to detail.

For this reason, they facilitate more accurate decisions. On the other hand, positive emotions improve our attention to work^[25] and cause people to focus on the generalities of the learning event. This extensive processing style may enable learners to discover the connection between learning events, thus increasing the likelihood of transferring knowledge and skills to new situations.^[1,7,27]

However, both positive and negative emotions can be detrimental to learning and divert students’ attention to something unrelated to learning. In addition, the interpretation of events is often influenced by individuals’ current emotional states. For example, anxiety, even if mild, is associated with an increased interpretation of ambiguous stimuli (facial expressions, social situations, or homophones heard as “color” vs. “death”) as a threat factor. Finally, emotions can act as information. People innovatively trust their emotions to judge the world around them.^[1]

Encryption is how newly recorded information is combined with what has been previously stored. This process directly affects the ability to retrieve information in the future. Learning relies on encrypting new information, and performance depends on retrieving it from memory.^[20] Mood matching and dependence theories show that emotionally charged information is more accurately coded and better remembered.^[19]

Although negative emotions, such as fear, reduce the ability to process information, low anxiety levels lead to greater curiosity and engagement with learning activities.^[9,12] Compared to ordinary memories, events related to emotional and stressful factors are recorded in memory through the amygdala pathway, resulting in stronger encryption and retention of information.^[1,18]

The ability to retrieve information is an important part of learning. One potential explanation for the increased memory of emotional events is that the person experiencing an emotional response is more likely to mentally practice the event or “think” more about it. More unintentional retrieval of emotional events and

experiences is likely to enhance the learning of emotional experiences. Also, negative events are spontaneously remembered more than positive events. For instance, one study found that although both negative and positive events are subject to involuntary retrieval, retrieval of negative involuntary memories related to life events is more common.^[27] On the other hand, paramedics disrupt the recall of previously learned information during an emotional event, such as drug dose calculation formulas.^[1]

Cognitive resources

The second cognitive pathway through which emotions affect learning is their impact on cognitive resources. Cognitive Load Theory assumes that working memory can accommodate a limited number of elements. Emotional information is usually given priority in mind.^[8] Positive and negative emotions consume active memory by focusing on the subject of emotions, and by occupying the working memory space, they leave less cognitive resources to process learning activities. An example is the explanation of the cognitive burden of experimental work on test anxiety and its negative impact on learning.^[6,13,26] Even emotions that are considered mild on the Positive and Negative Affect Schedule scale prevent undergraduate psychology students from learning about physiological concepts.^[26] Interestingly, positive emotions do not appear to consume cognitive resources in the destructive way negative emotions do. This different and asymmetric effect between positive and negative emotions is not well understood and needs further exploration.^[13]

Cognitive strategies

The third cognitive pathway, which links emotions to learning, is different in using cognitive and metacognitive thinking strategies. Recent studies have shown that students who experience negative moods use less in-depth processing strategies because deep content processing requires more interaction and a positive approach to academic assignments. In contrast, positive emotions are thought to lead to greater interaction and deeper processing strategies.^[6,25] Positive emotions related to learning enable the individual to stimulate high-level cognitive processing (such as problem-solving, inversion, organization, development, and critical thinking), facilitate the use of regular learning strategies (strategic thinking, planning, and supervision), and motivate students to do hard work and strive to overcome tough academic challenges that can increase student success. Pekrun believes that some negative emotions, such as shame, anger, and anxiety, reinforce the use of simple learning strategies such as simple practice and repetition and create the need for external motivations.^[14] On the other hand, positive emotions facilitate the use of metacognitive and flexible learning strategies with individual goals, which, in turn, improve

creativity, facilitate exploratory behavior and openness to information, increase potential solutions that may come to mind, reduce trust in outdated and potentially inadequate problem-solving strategies or reduce the likelihood of premature closure errors, and increase student success. Therefore, metacognitive learning strategies can mediate the effect of emotions on academic performance. For example, enjoyment of learning is associated with better academic outcomes.^[16,20,25,27] Deep learning is associated with better performance on work and exams, higher self-esteem, greater course satisfaction, and better clinical experience.^[19] Learners who experience positive emotions are more likely to engage with their learning environment. Positive emotions increase verbal mastery and decision-making; however, they are associated with decreased endurance and increased distraction.^[7] According to the studies, flexible thinking is especially desirable for recognizing and transmitting similarities between different tasks with similar features or the same infrastructure. Therefore, such cognitive flexibility can have important implications for medicine. By cultivating positive emotional states, educators help improve students' learning and transfer knowledge to clinical skills and knowledge.^[7,27]

In general, the specific impact of any positive or negative emotion is probably much more complex than these general assumptions.^[25] For example, in one study, participants expressed shame as a negative emotion through greater readiness to participate in the round, and that any attempt to eliminate cognitive biases improved their learning. At the same time, they emphasized that while the long-term effects of embarrassment can be positive, the emotional distress reduces their overall value as learning events.^[28]

Motivation

The fourth and final path is the connection between emotions and learning and performance through their effects on the internal and external motivational processes. Self-conscious emotions probably have a significant and largely undiscovered effect on learner's motivation. The amount of motivation refers to whether it is high or low, and the quality of the motivation refers to the source, that is, whether it is internal or external. Emotions can affect a student's academic achievement by influencing intrinsic motivation (interest in learning) and external motivation (achieving positive results or avoiding negative outcomes). Some researchers believe that positive emotions can increase intrinsic and extrinsic motivation.

Conversely, negative emotions act as a factor in reducing intrinsic motivation, but can reinforce external motivation to prevent failure.^[14] In analyzing five contemporary theories of motivation, Artino and

Cook identified four frequently recurring themes in learning motivation: belief in ability, perceived value of the learning task, the importance and relevance of the learning task to future tasks, and direct involvement of mental processes not visible (e.g., cognition). A person's beliefs about competence may be directly affected by self-conscious emotions, and they affect motivation. The perceived value of the learning task begs the fundamental question, "What happens (good or bad) if I do this?," similar to a learner who is proud of himself or receives approval for it.^[29] From this perspective, positive emotions, such as job-related pleasure, lead to greater interest and intrinsic motivation, that is, more motivation to participate in work *per se*, as a means to an end. Negative emotions, such as boredom at work, reduce a person's innate motivation. For instance, in one study, participants described a decrease in learning motivation due to feeling ashamed. They believed that the feeling of shame caused by answering questions incorrectly causes panic and the reflective choice of "shutting down" in the round, extending to other student activities in the learning environment.^[28] Shame can degrade students' self-regulatory power, motivation, memory, cognitive resources, sense of belonging, and subsequent academic achievement.^[14,30] In general, negative activating emotions can be effective in increasing external motivation. For example, the fear of punishment for not doing the required activity can create more external motivation, thus forcing the person to act at the coach's request. Although most psychologists believe that external motivation is less important than intrinsic motivation in the long run, it may, nevertheless, motivate individuals to do learning tasks.^[6,13]

Important Consequences of Emotions in Medical Education

Clinical reasoning

Emotions play a reciprocal role in clinical reasoning.^[31] Positive emotions in medical students are associated with a reduction in cognitive biases and more precise approaches to clinical reasoning. In contrast, anxiety and stress are associated with impaired working memory and immediate recall, subtle changes in clinical reasoning, and impaired technical and clinical functioning. The role of emotions in understanding how clinical reasoning develops in health professionals has largely been ignored. One of the reasons for this shortcoming can be attributed to the strong impact of clinical reasoning models that exist by default in medical education research. These models describe intuitive clinical reasoning, emotion-driven and intuitive responses, and rapid, unconscious, and non-analytical reasoning. According to this model, the default state of information processing is based on the intuitive system, which is entirely prone to error.

In contrast, the logical and conscious state of reasoning is the preferred form of reasoning. In these models, trust in conscious and analytical thinking is recommended as a strategy to reduce diagnostic errors. Such an advice emphasizes the importance of well-defined reason and logic and its priority over emotions. However, given that emotion and cognition are closely related, this artificial dichotomy of conscious/rational thought and subconscious/error-prone intuition can negatively affect physicians' perceptions. Intuitive understanding is fundamental because it is the unconscious or implicit solution to a problem. Although intuition is not an emotion, emotions may be related to the ability to evaluate implicit solutions.

Furthermore, clinical reasoning and learning can greatly benefit from emotions as a moderating factor.^[1] Lajoie *et al.*^[25] found that emotions experienced before attempting to resolve a clinical case predict the time spent in the various stages of resolving the case. Additionally, the emotions that participants experienced while solving the case were reported to affect their diagnostic performance. These findings reveal the relationship between emotions and the practice of clinical reasoning in medical education.

Self-regulated learning

An individual's thoughts and actions taken to achieve learning goals are called self-regulated learning.^[25] This form of learning can be defined as a self-directed process in which students change their mental abilities and academic skills.^[32] According to self-regulated learning theories, students must be motivated to use these strategies for success, apart from knowledge of cognitive and metacognitive strategies. In this regard, three motivational components are related to the components of self-regulated learning: (a) the affective component, which is students' emotional reactions to the task (pride, anger, etc.), (b) the expectancy component, which is the student's belief in the ability to do a job, and (c) the value component, which is related to the student's goals and beliefs about the importance of the job. Research shows that these three components are positively related to self-regulated learning. Students enjoy the learning process more when they believe in their ability to perform tasks successfully. It also makes sense for these people to experience more emotions, such as hope and pride, than the students with low self-efficacy. Emotions affect self-directed learning by influencing motivation and metacognition.^[17] Positive emotions facilitate people's self-regulation through deep, flexible, and complex learning strategies.^[24]

A summary of the literature review in this section is given in Table 1.

The conceptual framework of this section is given in Figure 2.

Academic achievement

Academic achievement and learning involve "knowledge," "skills," and "attitudes,"^[33] and emotions affect all three parts. Positive emotions improve curiosity and attention to work, have fewer cognitive resources, strengthen intrinsic and extrinsic motivation, and facilitate deep, flexible, and complex learning strategies and self-regulatory learning, increasing students' success.^[24] Chin *et al.* found a significant relationship between students' positive emotions and their performance. Also, Pekrun *et al.* showed that positive activation of emotions such as pleasure, hope, and pride has a significant relationship with students' midterm exam scores. In general, research reviews have shown that positive emotions predict academic achievement.

On the other hand, opposite effects are expected with negative emotions.^[25] Negative feelings like boredom and frustration are detrimental to learning and progress because they can disrupt information processing, reduce motivation, and distract students from learning. One longitudinal study showed that negative emotions such as anger, anxiety, frustration, shame, and boredom could predict students' final grades.^[14]

Effectiveness of new educational strategies

Some new educational technologies have effectively optimized learning outcomes by meeting the emotional needs. For example, computer-based learning environments (CBLEs) can reinforce emotions by targeting a person's value assessment and control over assignments. This can be achieved with proper design of the environment and feedback consistent with student performance, designing meaningful and credible assignments (such as the inclusion of applications) with the ability to provide learners with autonomy through access to additional information (e.g., medical glossary and diagnostic tests) and the possibility of receiving

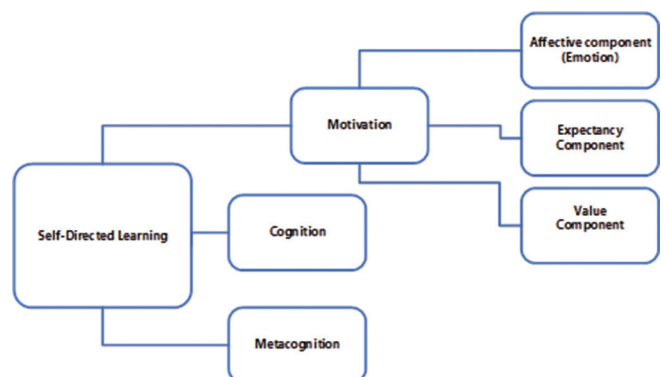


Figure 2: Conceptual framework

Table 1: Text review of important consequences of emotions in medical education

Concept	Author	Title	Year	Results
Clinical reasoning	Lajoie <i>et al.</i> ^[25]	Examining the role of self-regulation and emotion in clinical reasoning: Implications for developing expertise	2018	Emotions and clinical reasoning affect each other Emotions experienced before proceeding predicted the overall diagnostic function These findings to demonstrate effective educational design and scaffolding
	Li <i>et al.</i> ^[31]	The frequency of emotions and emotion variability in self-regulated learning: What matters to task performance?	2021	The frequency of emotions in both preconceived notions and performance of the self-regulated learning harms the performance of learners' clinical reasoning, which may be due to interference with cognition and motivation and a lack of focus on their decisions and executive behaviors. Thus, inhibiting changes in emotions in the early stages of clinical reasoning can have positive results. In contrast, the frequency of emotions in the self-reflective stage can have a positive effect on performance
Self-regulated learning	Hayat <i>et al.</i> ^[24]	Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: A structural equation model	2020	The general expectancy value theory of motivation suggests that the emotional component, which includes students' emotional reactions to task (pride, anger, etc.), may be related to self-regulated learning components such as metacognitive strategies
	Lajoie <i>et al.</i> ^[25]	Examining the role of self-regulation and emotion in clinical reasoning: Implications for developing expertise	2018	Findings show the interaction of emotions on SRL. In particular, the emotions that occur before resolving a case predict the time spent in the performance phase and self-reflection. The reduction in time spent in the preconceived notions, performance, and self-reflection can be predicted, respectively, with negative inactive emotions, positive activating emotions, and negative activating emotions while solving the case
	Jakobsen <i>et al.</i> ^[32]	Emotions and clinical learning in an interprofessional outpatient clinic: A focused ethnographic study	2018	Under certain circumstances, learning frustration may reinforce metacognitive engagement, especially in high-performing students with high self-confidence levels in their academic ability. Students are likely to adjust their learning using metacognitive and extra-emotional strategies and to adapt their knowledge and skills to the needs of managing difficult and surprising situations in the outpatient clinic
Academic achievement	Ghanbari <i>et al.</i> ^[33]	Practical points for brainfriendly medical and health sciences teaching	2019	Feeling fear or excitement in a particular situation increases the likelihood of recalling it in more detail and making a deeper connection. Some emotions affect cognition by producing or inhibiting chemical mediators in the brain. For example, negative emotions such as anxiety reduce mental activity due to the suppression of glucocorticoid hormones affecting cognition. A positive experience, even a memorable one, also increases dopamine production
	Hayat <i>et al.</i> ^[24]	Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: A structural equation model	2020	Emotions are a significant factor directly or indirectly associated with learners' achievements; satisfaction; physical and mental health; motivation; learning strategies; cognitive sources; self-directed learning; quality of teacher-learner interactions; class education; concentration; information processing, storing, retrieving, and learning; and, consequently, academic achievement
	Hayat <i>et al.</i> ^[14]	Medical student's academic performance: The role of academic emotions and motivation	2018	Academic emotions are classified as positive emotions, including enjoying learning and the hope of success and pride, and negative emotions, including anger, boredom, anxiety, hopelessness, and shame, that can promote or demote students' self-regulation, motivation, memory, cognitive resources, sense of belonging, and, subsequently, academic achievement Emotions can impact students' academic achievements through two ways of influencing the intrinsic motivation for learning (interest in learning) and extrinsic motivation (gaining positive or avoiding negative outcomes)
New educational strategies	Wijekumar ^[34]	Influence of emotions on digital learning	2021	Emotions affect participation in computer-based learning environments. Positive emotion was associated with the highest performance and negative emotion with the lowest

Contd...

Table 1: Contd...

Concept	Author	Title	Year	Results
				performance. Students performed relatively well on diagnostic criteria with low-intensity negative emotions
				Teachers and students rapidly moving toward digital learning may experience negative emotions
	Jarrell <i>et al.</i> ^[20]	The link between achievement emotions, appraisals, and task performance: Pedagogical considerations for emotions in CBLEs	2016	Enjoyment and high positive emotionality are not always conducive to learning and performance Positive emotions have also been associated with academic overconfidence Learners higher in positive emotionality might have been overconfident in their task performance, given their greater confidence in their solution and lower performance on diagnostic accuracy
	Behrens <i>et al.</i> ^[35]	Exploring undergraduate students achievement emotions during ward round simulation: A mixed-method study	2019	No significant correlation between achievement emotions and performance during ward round simulation
	Keskitalo <i>et al.</i> ^[9]	Exploring learners' emotions and emotional profiles in simulation-based medical education	2021	Simulation-based education evokes positive emotions. These feelings increased at the end of the course and, as a result, exceeded the learners' expectations. This positive learning experience facilitates learning through cognitive, verbal, and decision-making flexibility
	Yu <i>et al.</i> ^[36]	Effects of high-fidelity simulation education on medical students' anxiety and confidence	2021	Medical students must be repeatedly exposed to simulation education experiences to have a sense of psychological stability and competently deliver medical treatment in a clinical setting
	DeMaria <i>et al.</i> ^[18]	Adding emotional stressors to training in simulated cardiopulmonary arrest enhances participant performance	2010	Stress can impair memory retrieval in a crisis. However, one nonmedical study found severe stress associated with higher decision-making performance scores
	Hautz <i>et al.</i> ^[22]	Shame in medical education: A randomized study of the acquisition of intimate examination skills and its effect on subsequent performance	2017	State shame does not constitute relevant intrinsic cognitive load in CBE acquisition Students training with a standardized patient experienced more shame during training, spent more time with the patient, and documented more breast lumps than those training on a mannequin

CBE=Clinical breast examinations

help (such as a different option). Moreover, it should be kept in mind that evaluation strengthens the value and ability of the student to control homework. On the other hand, it has been shown that strong positive emotions, such as enjoyment in CBLE, can be negatively associated with learning. For example, high levels of enjoyment may impair learning through exploratory learning (reading irrelevant materials) or engaging in extracurricular activities (such as testing the features of used software).

On the other hand, teachers and students who rapidly switch to digital learning may experience negative emotions. Developing and testing strategies that foster positive emotions and strengthening self-regulatory skills that can reduce negative emotions are recommended to increase the effectiveness of digital education.^[34] Overall, literature shows that, compared with intense positive emotions, low-intensity emotions are more beneficial in CBLE. Negative emotions with low intensity and high activating nature are also associated with better performance in CBLE. In other words, instead of asking "What should we worry about?," we should consider "At what level of emotional intensity should an intervention

be made?" Of course, it should be noted that this low intensity of emotions has made research in this field challenging. This low intensity can limit statistical variance, thus making it difficult to understand the subtle relationship between emotions and their effect on learning and performance.^[20]

Simulation-based medical education can be described as "hard fun" because through the challenges, it creates positive experiences that may lead to increased learning and performance. In fact, learners report more positive than negative emotions when simulating.^[8,35,36] However, some learners may need guidance and support to reduce anxiety. The knowledge gained from the studies on the use of emotions in simulation can be used to successfully design teaching and learning promotion.^[7] High-fidelity simulation increases the level of anxiety and learning in learners. DeMaria *et al.*^[18] showed that emotional stressors were associated with long-term practical knowledge in novice trainees. In the medical simulation literature, there is very limited data on the effect of emotions on learning. These data suggest that positive emotions such as pride,

pleasure, and hope lead to interest and encouragement in reading. In simulation-based education, negative emotions such as anxiety, shame, and hopelessness are also seen. In a study by Behrens *et al.*,^[35] it was found that in the simulated clinical round, moderate anxiety levels, although negative, had a positive effect on learning because they made students feel the need to study better. In general, placing students in complex simulation situations can increase feelings of positive academic achievement, such as pleasure and pride, and feelings of moderate negative academic achievement, such as anxiety. Positive emotions, pride, and joy are considered a motivation for learning. The same is true for moderate levels of anxiety. These results show the importance of including emotions in the educational design of learning activities based on complex simulations.

The use of standardized patients has a special place in modern medical education that can evoke different emotions. For example, in the study by Hautz *et al.*,^[22] clinical breast examinations (CBE) trainin/g was compared between standard patients and mannequins. They found that examining a standard patient resulted in a different level of embarrassment and accuracy than examining a mannequin. Shame can curb motivation and create a desire to avoid similar situations in the future. It may also potentially limit training time and reduce the desire for the examination. Therefore, shame is usually considered undesirable for learning. However, McConnell and Eva^[27] recently described a challenging paradox: while dissatisfying with the profession, adverse events can also be beneficial for learning. They stated that a person who experiences an emotional reaction reconsiders the event more in his/her mind and memorizes the event more. Students who have a higher level of shame during the training perform fare better than those who experience a gradual increase in shame from education to assessment; this is attributed to the intense mental training of the educational event by the trainees under the influence of emotion. The feeling of shame increased gradually in students who used mannequins for breast exams from the intervention to the final performance appraisal. Still, in the standard patient group, the severity of the embarrassment decreased slightly. Although it is theoretically expected that the more embarrassed student would avoid similar future situations, on the contrary, Hautz *et al.*^[22] observed that higher embarrassment during training in the standard patient group may lead to greater empathy with patients with CBE, resulting in a higher motivation for accurate examination, which is of practical importance to educators. Using trained individuals, whether standard patients or teaching colleagues, for the training, such as CBE or pelvic exam training, can be effective.

Discussion

Emotions are multifaceted relationships between mental and objective variables mediated by the nervous and hormonal systems and have cognitive and physiological effects on humans.^[1,6,7] Furthermore, in studying the relationship between emotion and learning, it is of special importance to differentiate between emotions and mood by considering that emotions have episodic characteristics. In contrast, mood has a more persistent nature.

Emotions are categorized based on their value and stimulus capacity. The value of emotions is defined by their positive, negative, or neutral nature. On the other hand, the capacity of emotions is related to their activating/inactivating power.^[1,6,21,22]

From a biological point of view, emotional and cognitive systems cannot be separated in the brain. This means that these two systems show vast and complex interactions differently. Meanwhile, the study of the role of emotions in the learning process of medical students is of interest to many medical education researchers. Emotions affect learning through their effects on memory, cognitive resources, cognitive strategies, and motivation.^[6,13,15,25]

Present literature has shed light on emotions' effect on important concepts of medical education, such as learners' self-regulation, academic achievement, and clinical performance.^[14,20,24,25] Activating positive emotions, such as the pleasure of reading, is associated with deeper learning approaches. By facilitating the transfer of past experiences to recent experiences and cognitive flexibility, emotional experiences prevent cognitive errors, enhance the ability to make decisions based on logic or intuition in critical cases, and improve clinical reasoning.^[1,25] On the other hand, negative emotions encourage people to focus on details related to learning, which may be useful in tasks requiring intense attention to detail. Also, due to the role of emotions, the effectiveness of new education methods in medicine, such as CBE, the use of simulators, and standard patients, can be increased.^[22,23,35]

Limitation and Recommendation

The present review article might be subject to potential bias, including the impact of authors' viewpoints and gaps in literature search, which might have resulted in omitting relevant scientific studies. Although we used a comprehensive search method to find a few articles in this field, the possibility of gaps in literature search that might have resulted in the omission of some relevant scientific documents cannot still be ruled out. Moreover, the literature review was confined to relevant articles

published until 2020. Hence, studies that have been published since 2020 have not been included in the current article. Therefore, a review of studies after this time is recommended.

Conclusion

Given the diversity of human learning and the role of emotions as one of the factors, further studies in this field can be useful. The effect of positive and negative stimuli on learning has been discussed, but the extent to which they have the same impact on learning should be considered, no matter how severe it is. Finally, all of these studies should lead to practical solutions to create a more sustainable learning environment and more effective teaching and learning because of the empowering role of medical graduates.

Acknowledgements

This study is based on a Ph.D. thesis (reference number: 397438) funded by the Research Department of Isfahan University of Medical Sciences.

The authors would like to thank Dr. Hadi Azimi for his kindness in reviewing English and Isfahan University of Medical Sciences for supporting this research project.

Ethical statement

The name of the ethics committee: Ethics Committee of Isfahan University of Medical Sciences, Isfahan, Iran.

Approval ID: IR.MUI.MED.1397.178

Date of approval: 12-23-2018

Financial support and sponsorship

This study is a product of the project registered by Isfahan Medical Education Research Center, No. 397438.

Conflicts of interest

There are no conflicts of interest.

References

1. LeBlanc VR, McConnell MM, Monteiro SD. Predictable chaos: A review of the effects of emotions on attention, memory and decision making. *Adv Health Sci Educ* 2015;20:265-82.
2. Sheikhbardsiri H, Sheikhasadi H, Mahani SA, Mohamadi MMD. Emotional intelligence and learning strategies of postgraduate students at Kerman University of Medical Sciences in the southeast of Iran. *J Educ Health Promot* 2020;9:66.
3. Jennings PA, Greenberg MT. The prosocial classroom: Teacher social and emotional competence in relation to student and classroom outcomes. *Rev Educ Res* 2009;79:49.
4. Tyng CM, Amin HU, Saad MNM, Malik AS. The influences of emotion on learning and memory. *Front Psychol* 2017;8:1454.
5. Kremer T, Mamede S, Martins MA, Tempiski P, van den Broek WW. Investigating the impact of emotions on medical students' learning. *Health Prof Educ* 2019;5:111-9.
6. Artino AR Jr, Holmboe ES, Durning SJ. Can achievement emotions be used to better understand motivation, learning, and performance in medical education? *Med Teach* 2012;34:240-4.
7. Omid A, Haghani F, Adibi P. Clinical teaching with emotional intelligence: A teaching toolbox. *J Res Med Sci* 2016;21:27.
8. Keskitalo T, Ruokamo H. Exploring learners' emotions and emotional profiles in simulation-based medical education. *Australas J Educ Technol* 2021;37:15-26.
9. McConnell MM, Monteiro S, Pottruff MM, Neville A, Norman GR, Eva KW, *et al.* The impact of emotion on learners' application of basic science principles to novel problems. *Acad Med* 2016;91:S58-63.
10. Artino AR Jr, Naismith LM. 'But how do you really feel?' Measuring emotions in medical education research. *Med Educ* 2015;49:140-2.
11. Gooding H, Mann K, Armstrong E. Twelve tips for applying the science of learning to health professions education. *Med Teach* 2017;39:26-31.
12. O'Callaghan A. Emotional congruence in learning and health encounters in medicine: addressing an aspect of the hidden curriculum. *Adv Health Sci Educ* 2013;18:305-17.
13. Artino AR Jr, Holmboe ES, Durning SJ. Control-value theory: Using achievement emotions to improve understanding of motivation, learning, and performance in medical education: AMEE Guide No. 64. *Med Teach* 2012;34:e148-60.
14. Hayat AA, Salehi A, Kojuri J. Medical student's academic performance: The role of academic emotions and motivation. *J Adv Med Educ Prof* 2018;6:168-75.
15. Crowe S, Clarke N, Brugha R. 'You do not cross them': Hierarchy and emotion in doctors' narratives of power relations in specialist training. *Soc Sci Med* 2017;186:70-7.
16. Friedlander MJ, Andrews L, Armstrong EG, Aschenbrenner C, Kass JS, Ogden P, *et al.* What can medical education learn from the neurobiology of learning? *Acad Med* 2011;86:415-20.
17. Mills LM, Boscardin C, Joyce EA, Ten Cate O, O'Sullivan PS. Emotion in remediation: A scoping review of the medical education literature. *Med Educ* 2021;55:1350-62.
18. DeMaria S Jr, Bryson EO, Mooney TJ, Silverstein JH, Reich DL, Bodian C, *et al.* Adding emotional stressors to training in simulated cardiopulmonary arrest enhances participant performance. *Med Educ* 2010;44:1006-15.
19. Gifford H, Varatharaj A. The ELEPHANT criteria in medical education: Can medical education be fun? *Med Teach* 2010;32:195-7.
20. Jarrell A, Harley JM, Lajoie SP. The link between achievement emotions, appraisals, and task performance: Pedagogical considerations for emotions in CBLEs. *J Comput Educ* 2016;3:289-307.
21. Jarrell A, Harley JM, Lajoie S, Naismith L. Success, failure and emotions: Examining the relationship between performance feedback and emotions in diagnostic reasoning. *Educ Technol Res Dev* 2017;65:1263-84.
22. Hautz WE, Schröder T, Dannenberg KA, März M, Hölzer H, Ahlers O, *et al.* Shame in medical education: A randomized study of the acquisition of intimate examination skills and its effect on subsequent performance. *Teach Learn Med* 2017;29:196-206.
23. Fraser K, Huffman J, Ma I, Sobczak M, McIlwrick J, Wright B, *et al.* The emotional and cognitive impact of unexpected simulated patient death: A randomized controlled trial. *Chest* 2014;145:958-63.
24. Hayat AA, Shateri K, Amini M, Shokrpour N. Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: A structural equation model. *BMC Med Educ* 2020;20:1-11.
25. Lajoie SP, Zheng J, Li S. Examining the role of self-regulation and emotion in clinical reasoning: Implications for developing expertise. *Med Teach* 2018;40:842-4.

26. Kremer T, Mamede S, van den Broek WW, Schmidt HG, do PT Nunes M, Martins MA. Influence of negative emotions on residents' learning of scientific information: An experimental study. *Perspect Med Educ* 2019;8:209-15.
27. McConnell MM, Eva KW. The role of emotion in the learning and transfer of clinical skills and knowledge. *Acad Med* 2012;87:1316-22.
28. Bynum WE IV, Artino AR Jr, Uijtdehaage S, Webb AM, Varpio L. Sentinel emotional events: The nature, triggers, and effects of shame experiences in medical residents. *Acad Med* 2019;94:85-93.
29. Bynum WE IV, Artino AR Jr. Who am I, and who do I strive to be? Applying a theory of self-conscious emotions to medical education. *Acad Med* 2018;93:874-80.
30. Whelan B, Hjörleifsson S, Schei E. Shame in medical clerkship: "You just feel like dirt under someone's shoe". *Perspect Med Educ* 2021;10:265-71.
31. Li S, Zheng J, Lajoie SP. The frequency of emotions and emotion variability in self-regulated learning: What matters to task performance? *Frontline Learn Res* 2021;9:76-91.
32. Jakobsen F, Musaeus P, Kirkeby L, Hansen TB, Mørcke AM. Emotions and clinical learning in an interprofessional outpatient clinic: A focused ethnographic study. *J Interprof Care* 2019;33:57-65.
33. Ghanbari S, Haghani F, Akbarfahimi M. Practical points for brain-friendly medical and health sciences teaching. *J Educ Health Promot* 2019;8:198.
34. Wijekumar KK. Influence of emotions on digital learning. *Educ Technol Res Dev* 2021;69:55-7.
35. Behrens CC, Dolmans DH, Gormley GJ, Driessen EW. Exploring undergraduate students achievement emotions during ward round simulation: A mixed-method study. *BMC Med Educ* 2019;19:1-7.
36. Yu JH, Chang HJ, Kim SS, Park JE, Chung WY, Lee SK, *et al.* Effects of high-fidelity simulation education on medical students' anxiety and confidence. *PLoS One* 2021;16:e0251078.