Online-Journals.org

iJIM International Journal of Interactive Mobile Technologies

iJIM | eISSN: 1865-7923 | Vol. 18 No. 7 (2024) | OPEN ACCESS

https://doi.org/10.3991/ijim.v18i07.48471

PAPER

Analysis of Learners' Emotions in E-Learning Environments Based on Cognitive Sciences

Faranak Sahraie[1], Ahmad Rezvanfar[1], Seyed Hamid Movahedmohammadi[1], Martin Ebner[2](✉), Amir Alambeigi[1], Mohammadreza Farrokhnia[3]

[1]University of Tehran, Karaj, Iran

[2]Graz University of Technology, Graz, Austria

[3]Department of Learning, Data Analytics and Technology, Instructional Technology Section, University of Twente, Enschede, the Netherlands

mebner@gmx.at

ABSTRACT

The present study aimed to examine students' emotions in e-learning classes through facial expressions and investigate the influence of different instructional methods on students' emotional responses. In this study, we examined the facial expressions of 17 undergraduate students using three different methods of presenting educational content (PowerPoint, video, and Kahoot) in online classes and analyzed the data with face reader software. The findings demonstrated that students experienced various positive and negative emotions with different methods of content delivery. Furthermore, comparing the three methods revealed that the Kahoot method elicited the highest average of positive emotions among students compared to the other two methods. This difference can be attributed to the visual attractiveness and interactive nature of the Kahoot environment. Additionally, this study highlights that simply incorporating multimedia materials, such as PowerPoint presentations and videos, is not sufficient to enhance effectiveness and cultivate positive emotions in e-learning. While multimedia materials serve as supportive tools and enhance visualization, interaction at various levels (content, teacher, peers, etc.) is necessary. Nevertheless, the significance of this research lies in the innovative application of a tool for analyzing emotions in online learning classrooms, thereby enhancing the measurement of genuine and objective emotional responses in e-learning environments.

KEYWORDS

emotions, cognitive, facial expressions, e-learning environments

1 INTRODUCTION

Emotions have a direct impact on human activities, such as learning, and are widely recognized as a key factor in learning enviroments because they play a vital role in students' learning progress [1, 2, 3]. Emotions are described as subjective experiences that change according to the situation in which they occur [4]. They are experienced in various situations and serve a variety of functions in the

The authors hereby confirm that they have obtained the consent of the persons depicted in the photographs for publication.

Sahraie, F., Rezvanfar, A., Movahedmohammadi, S.H., Ebner, M., Alambeigi, A., Farrokhnia, M. (2024). Analysis of Learners' Emotions in E-Learning Environments Based on Cognitive Sciences. *International Journal of Interactive Mobile Technologies (iJIM)*, 18(7), pp. 34–52. https://doi.org/10.3991/ijim.v18i07.48471

Article submitted 2024-01-11. Revision uploaded 2024-02-20. Final acceptance 2024-02-23.

academic environment, including promoting or undermining behavioral and cognitive engagement [5], self-regulation of learning tasks [6], and achievement [7]. Students' cognitive performance in relation to each of the three specific cognitive processes involved in learning—attention, memory, and reasoning—depends on their emotional state [8, 9].

Positive emotions, such as enjoyment, are believed to help students regulate their learning, while negative emotions, such as anxiety, may lead to dependence on external guidance [10]. According to research, students who are anxious, angry, or sad may have difficulty learning [11], as these emotional states can hinder their ability to acquire new knowledge and content [12]. When either positive or negative emotions are not directly related to the learning task, they can consume cognitive resources necessary for task completion and, therefore, impair cognitive performance [10, 13].

On the other hand, due to the COVID-19 pandemic, there has been an increase in the use of computer-based multimedia educational technologies, such as. learning management systems (LMSs) [14] and intelligent educational systems (ITSs) [15]. One of the primary issues with e-learning is undoubtedly the lack of emotional and social interactions between teachers and students [16]. which are integral to effective learning experiences [17]. E-learning environments often lack the necessary dynamics and typical features of traditional face-to-face classrooms [18]. They cannot automatically discern what excites learners [19]. Moreover, due to the spatial separation between the instructor and the learner, it is difficult for teachers to identify the emotions of students and detect issues arising from confusion or distress [20]. Therefore, when designing e-learning courses, it is essential to prioritize emotional factors to foster learner engagement [21], enhance learning progress [22], and promote long-term retention [23]. This approach entails designing learning environments in a way that induces positive emotions and supports emotional well-being.

In pursuing this objective, it is crucial to evaluate the effectiveness of the design, including the incorporated learning materials and tasks, in evoking positive emotions. Various methods have been employed to measure human emotions across disciplines. These include subjective (or psychological) feelings, which involve self-reports of emotions [24], and physiological estimation using devices installed on the human body, such as those monitoring heartbeat, blood pressure, and sweating [25]. However, recent advancements in data fusion and Machine Learning (ML) have enabled computers and other devices to detect, identify, and analyze emotions in a more accurate and effective manner [26]. In this context, researchers in computer science have explored the detection of emotional states through different methods, including facial expressions [27]. Facial expression stands out as one of the most powerful, natural, and immediate means for human beings to convey their emotions and intentions [28]. Research suggests that only 7% of the communication message in human face-to-face contact is attributed to language, while 38% is attributed to extra-language cues, and a significant 55% is attributed to facial expressions [29].

Drawing upon advancements in emotion detection and the acknowledged importance of emotions within e-learning environments, this study aims to delve into learners' facial expressions to discern their emotional responses when exposed to diverse content delivery techniques in e-learning settings. Specifically, our primary objective is to investigate the emotional experiences of students in e-learning classes and delineate the factors that shape their emotional states within online learning environments, with the ultimate goal of fostering positive emotions among learners. In alignment with this objective, the research questions are as follows:

1. How can positive and negative emotions of learners be distinguished based on the analysis of facial expressions in e-learning?
2. What impact do different methods of content presentation have on learners' emotional responses in e-learning environments?

The article is structured as follows: Section 2 offers an overview of the interplay between emotions, cognition, and e-learning, elucidating the theoretical framework. Section 3 outlines the research methodology. Section 4 details the experimental procedure and presents the results. In Section 5, the findings are analyzed and discussed. Finally, Section 6 concludes the article.

2 THEORICAL FRAMEWORK

2.1 Emotion, cognitive, and learning

At no level, at no state, even in adulthood, can we find a behavior or a state that is purely cognitive without affect, nor a purely affective state without a cognitive element involved [30, 31]. Humans are affective beings, motivated to action by a complex system of emotions, drives, needs, and environmental conditioning in addition to cognitive factors [32, 33].

Emotional experiences are ubiquitous and crucial in academic environments, as they play a significant role in moderating almost every aspect of cognition. Numerous studies have found that emotions influence human cognitive processes such as attention [34], learning and memory [35, 36], reasoning [37], and problem-solving [38, 39].

According to Damasio [40], there is a particular region in the human brain where systems concerned with emotion/feeling, attention, and working memory interact so intimately that they constitute the source for the energy of both external action (movement) and internal action (thought animation, reasoning). According to research findings, emotions have a significant impact on academic education and learning, either facilitating or hindering it [41]. In other words, academic emotions are directly and indirectly associated with students' academic outcomes, goal orientation, self-concept, mental and physical well-being, motivation, learning environments, cognitive resources, self-regulated learning, quality of teacher-student interactions, classroom instruction, concentration, information processing, storage and retrieval, learning, and academic progress [42]. Tests, exams, tasks, and deadlines are associated with a range of emotions, including annoyance, anxiety, and boredom [41].

There has been a lot of research done on the importance of emotional elements in learning. According to Reschly et al. [43], frequent positive emotions during school are associated with higher levels of student involvement, while frequent negative emotions are associated with lower levels of engagement. Kim et al. [44] used motivation, emotion, and learning strategies as predictors of achievement. They also discovered that emotions such as boredom, happiness, and anger significantly influenced students' performance in a self-paced online mathematics course. According to Pekrun et al. [45], self-regulated learners experience positive emotions such as hope, enjoyment, and pride in learning while managing and regulating negative emotions such as anger, anxiety, boredom, and frustration [45].

As a result, educational theorists, instructors, and students have determined that education must emphasize the social-emotional components of learning [46, 47, 48].

Inevitably, addressing students' and teachers' social and emotional learning needs influences the educational attitudes and practices of all those involved [48].

Emotional learning, as one type of cognitive learning, is the blending of thinking and feeling in how people learn [49]. This process involves acquiring skills to recognize and manage emotions, develop care and concern for others, make responsible decisions, establish positive relationships, and handle challenging situations effectively [9]. In this regard, educational processes and emotional learning encompass more than just acquiring knowledge. They also include social-emotional processes such as engagement, interpersonal connections, and personal interactions with other learners and with the teacher [50]. Consequently, the human interaction element enhances the participants' mental wellbeing. Additionally, a learning approach that enhances each learner's personal well-being will benefit students' civic growth as the future generation of citizens [51].

Emotional processes, therefore, seem to be a significant aspect that should be taken into account in the learning and teaching processes. Numerous studies in a wide range of fields, including neuroscience, education, and psychology, have demonstrated that emotions play an important role in learning and cognition [39, 52, 36].

2.2 Emotions and e-learning

In e-learning environments, when students lack direct interaction with teachers and peers, they may likely face emotional challenges. If students stare at indifferent computer screens for a long time, they may not experience interactive pleasure and emotional stimulation, leading to feelings of antipathy [53].

In fact, when learners possess emotional competence, they encounter the challenge of maintaining motivation to learn, particularly in an online learning environment. Therefore, an online learning environment should be designed in a way that promotes positive emotions in learners and minimizes negative emotions.

In designing the e-learning environment, it is crucial to consider the emotional dynamics of students and adapt the content and teaching-learning strategies accordingly. In this regard, employing teaching-learning methodologies that are suitable for the content and paying attention to students' needs and characteristics can enhance the learning process and promote positive interaction between teachers and students. These strategies should be designed in such a way that they allow the teacher to adjust the content based on the emotional changes of the students. In addition, utilizing various teaching methods and a variety of media in content delivery can enhance efficiency. For example, the use of images, videos, sounds, diagrams, and interactive activities can cater to students' needs and learning styles in various ways [54].

In the design and production phase of a virtual curriculum, using multimedia capabilities, various information resources, and communication and personalization features can help create credible and high-quality content, design diverse learning activities, and provide learner-centered teaching methods and assessments [55, 56]. Addressing a learner's affect can be a significant part of emotional design, enabling academics and educators to comprehend and support the complex role of emotions in learning to enhance the efficiency and effectiveness of the learning process [33]. How to measure the cognitive emotions of learners in the e-learning system and achieve harmonious emotional interaction has become an important research topic in e-learning [57].

The existence of systems that respond to changes in emotional experiences suggests that advancements in technology and scientific understanding have the potential to fulfill this expectation. Encouraging developments are being made in the realm of affective computing. this suggests that emotionally intelligent human-computer interactions (HCI) are not only possible but also necessary for enhancing the well-being of users and improving efficiency [58]. Currently, online learning models are still under development. Considering the emotional dimension in the development of e-learning models can improve and enhance the theory and practice of online education and learning.

2.3 The theoretical framework of research

Several theories support the role of emotions in the e-learning environment, including the Community of Inquiry (CoI) Theory [59], the Social and Emotional Learning Theory (SEL) [48], the Control Value Theory of Achievement Emotions (CVT) [60], the Cognitive Affective Theory of Learning with Media (CTML) [61], and the Integrated Cognitive Affective Model of Learning with Multimedia (ICALM) [62]. This theory was developed from Meyer's theory [2005], with motivational and metacognitive elements as mediators of multimedia learning.

According to the studies, the theoretical framework of this study is based on Moreno and Mayer's [62] Integrated Cognitive Affective Model of Learning with Multimedia (ICALM). The main thesis of this theory is that affective processes are intertwined with, and inseparable from, cognitive processes. The cognitive-affective processing of multimedia stimuli involves affective processes that place demands on cognitive resources, and vice versa [33].

The cognitive theory of multimedia learning (CTML) is founded on the assumptions that, first, learners have separate channels for processing auditory/verbal and visual/pictorial information, and second, learners' cognitive architecture is intrinsically constrained in terms of the amount of information processed in each channel at any one time. Third, in order to facilitate meaningful learning, learners must select relevant information, organize it into visual and verbal models in working memory, and integrate these models with prior knowledge from long-term memory [63, 64].

The Integrated Cognitive Emotional Learning Model with a Multimedia Framework (ICALM) [65] also considers a separate channel for emotion processing in addition to cognitive processing. As learners organize visual and verbal mental representations in working memory, the affect that involves evaluation is experienced by the learner as interest and motivation, impacting the organization of these mental representations. The ICALM asserts that interactions between cognition and emotion can manifest during the process of selecting, organizing, and integrating [33].

Positive affect can serve as a signal that needs and goals have been met, resulting in enhanced availability of cognitive resources during learning [66] and a greater inclination to adopt a more creative thinking style [38, 64]. Contrariwise, negative affect may suggest that specific requirements or objectives remain unfulfilled, consequently diminishing the cognitive resources available for education and impeding both creativity and academic achievement [4]. Furthermore, in the context of multimedia instruction, positive affect can enhance intrinsic motivation and improve learning outcomes [62, 67, 36].

According to the Cognitive Emotional Learning Theory integrated with the multimedia framework, learning is facilitated by understanding emotions through

identifying the cognitive components and the behaviors they trigger. For this reason, the theory is deemed appropriate for the current study because it clearly demonstrates the link between emotions and education, as well as the significance of being aware of a learner's emotions when they are engaged in a learning process.

Therefore, emotional design can make learning and teaching more compatible with the emotionally grounded process of how the human mind works and changes. As a result, digital learning environments can meet the holistic needs of individuals through emotional design. Overall, incorporating emotional design principles into digital learning environments can lead to more engaging, personalized, and effective educational experiences that address the holistic needs of learners.

In this study, we utilized emotional design as an effective element to influence learners' emotions by presenting educational content using various methods. In this study, three distinct techniques were used to present educational content. Includes the following:

1. The content was presented using the PowerPoint approach, incorporating graphics, diagrams, and slides with text to effectively convey the topic.
2. Content representation using educational video playback: In this strategy, a brief educational video was utilized to communicate the content, while the professor provided explanations throughout the video playback.
3. Presentation of content using Kahoot: In this approach, the Kahoot tool was utilized to present the content. This tool features an engaging graphic and audio interface designed to enhance students' attention and participation [68]. Research indicates that in higher education, instructional strategies such as Kahoot! Having a favorable impact on classroom dynamics, student motivation, and engagement can increase academic performance [69].

These three approaches have been utilized to analyze and evaluate the emotional states of the students to determine the influence of each approach on their experiences and feelings.

Over the past decades, research on emotion recognition and its impact on learning systems has significantly increased. Based on this brief review of the literature, it is evident that learners' emotions can impact learning performance. Numerous innovative approaches and strategies for emotion recognition in e-learning have also been introduced. But the impact of various content presentation methods in e-learning environments on learners' emotions has not been explored in any of these studies. However, our study focuses on the factors influencing students' emotional states in online learning environments. Based on this, we utilized various methods to present content in an e-learning environment. Our objective is to determine the most effective methods for presenting content to enhance the quality of e-learning environments.

3 METHODOLOGY

The structure of the study was as follows:

Among the three methods of identifying emotions discussed in the introduction, the technique for identifying emotions from facial expressions was utilized in this study due to the availability of resources. By setting up experimental scenarios for students, data were gathered. For this purpose, a group of students participated in three different learning tasks: presenting content using PowerPoint, an educational video, and an educational Kahoot tool.

Participants

This study was conducted in the Faculty of Agriculture and Natural Resources at Tehran University. A sample of 25 undergraduate students in agriculture fields volunteered to participate in the experiment. During the experiment, several samples were eliminated due to issues with the webcam and system. Ultimately, 17 films without any issues were collected from 17 healthy male and female students (7 boys and 10 girls) aged between 19 and 30 years old.

Procedure

Upon entering the laboratory, the students were informed about the purpose of the experiment. By signing a consent form, students allowed us to capture their facial expressions and use their data anonymously for future research. We promised participants that their raw data would not be made publicly available. The students sat on comfortable chairs in front of computers equipped with webcams, sets of speakers, mice, and keyboards. Then they were asked to participate in the online ecology class.

Experimental method

In this study, the content was presented to students in three ways. Each session lasted for five minutes. The summary of presentation methods is as follows:

- The first method involves delivering a brief speech on the ecology lesson using PowerPoint slides.
- The second method involves playing a short educational video about the ecology lesson, which includes explanations and the teacher's voice.
- The third method involves providing educational content related to the ecology lesson on the Kahoot platform, which is a learning tool.

To maintain consistent experimental conditions, all three classes were taught by the same teacher. Finally, approximately 51 recordings totaling 285 minutes were made by 17 undergraduate agricultural students.

FaceReader™ software was used to analyze the collected videos. FaceReader™ is an automated system designed to recognize various specific features in facial images, including six basic or universal expressions: happy, sad, angry, surprised, scared, and disgusted. In addition, it can detect the neutral state and analyze contempt. This software also calculates action units, valence, arousal, gaze direction, head orientation, and personal characteristics such as gender and age.

4 RESULTS

First, the average of the primary emotions identified by FaceReader was calculated for each presentation method in the online environment. Second, a screenshot of a page showing one of the students learning with three different methods of content presentation is displayed, highlighting the visible differences in emotions. Finally, the Friedman test was used to compare the averages of the three methods.

Table 1 presents the results of the average and standard deviation of emotions identified by the FaceReader software for each of the three educational content presentation methods.

The analysis of the PowerPoint method reveals that most students experience negative emotions, such as sadness and anger, during class. However, their facial expressions are mostly neutral. According to Table 1, the highest average of

negative emotions (sadness) is associated with the PowerPoint method (0.162). In the method of presenting content using educational videos, the highest average of negative emotion is related to sadness (0.109) after the neutral state. However, the analysis of the Kahoot method shows that after the neutral state, most students demonstrate the highest level of positive emotions, such as happiness (0.206), during class.

Table 1. Mean score of facial expressions in different content presentation methods

Dependent Variable	PowerPoint		Video		Kahoot	
	Mean N = 17	Std. Deviation	Mean N = 17	Std. Deviation	Mean N = 17	Std. Deviation
Neutral	.675	.133	.714	.107	.545	.149
Happy	.032	.064	.062	.110	.206	.142
Sad	.162	.146	.109	.088	.094	.107
Angry	.087	.095	.094	.109	.059	.104
Surprised	.023	.037	.015	.017	.018	.020
Scared	.009	.012	.014	.023	.023	.036
Disgust	.020	.024	.021	.033	.045	.048
Contempt	.013	.016	.009	.009	.024	.029

By analyzing the screen of some individuals using the Kahoot method, it can be observed that the emotions of the learners are more influenced by this method.

As shown in Figures 1 and 2, students' emotions during the PowerPoint and instructional video methods are consistent and do not exhibit significant fluctuations. Furthermore, negative emotions persist consistently without much variation. In the Kahoot method, however, there are more emotions present, accompanied by fluctuations. This indicates that the individual is more engaged in the learning process.

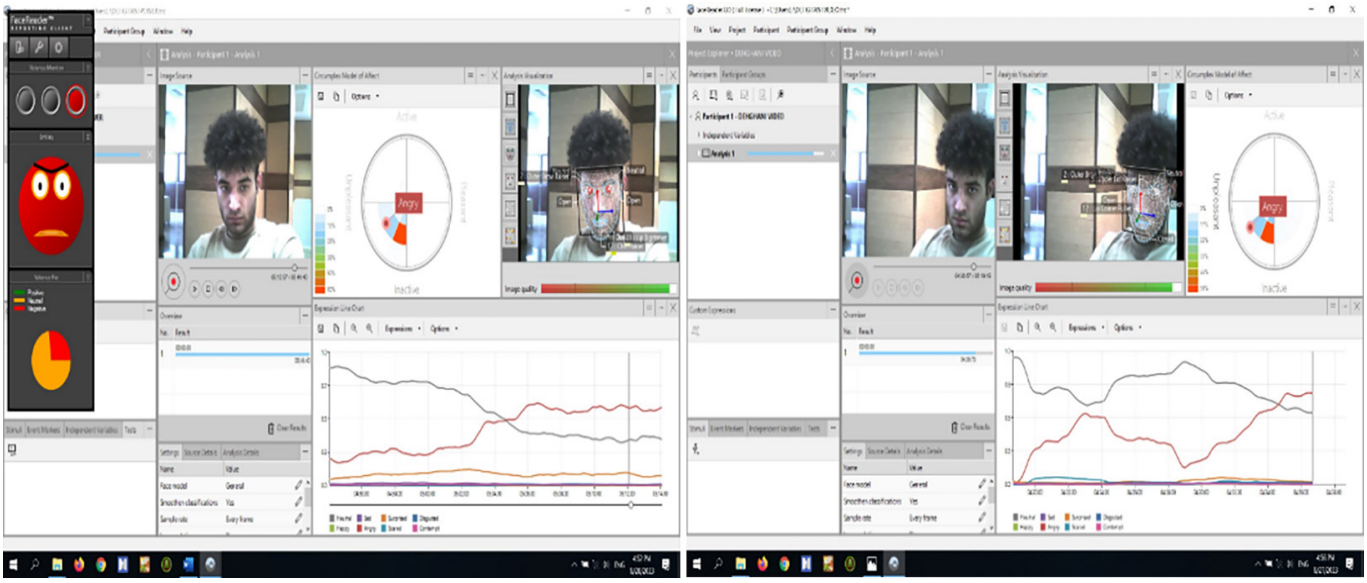

Fig. 1. Screen and emotion chart of a participant in the PowerPoint (Right), educational video (Left) method

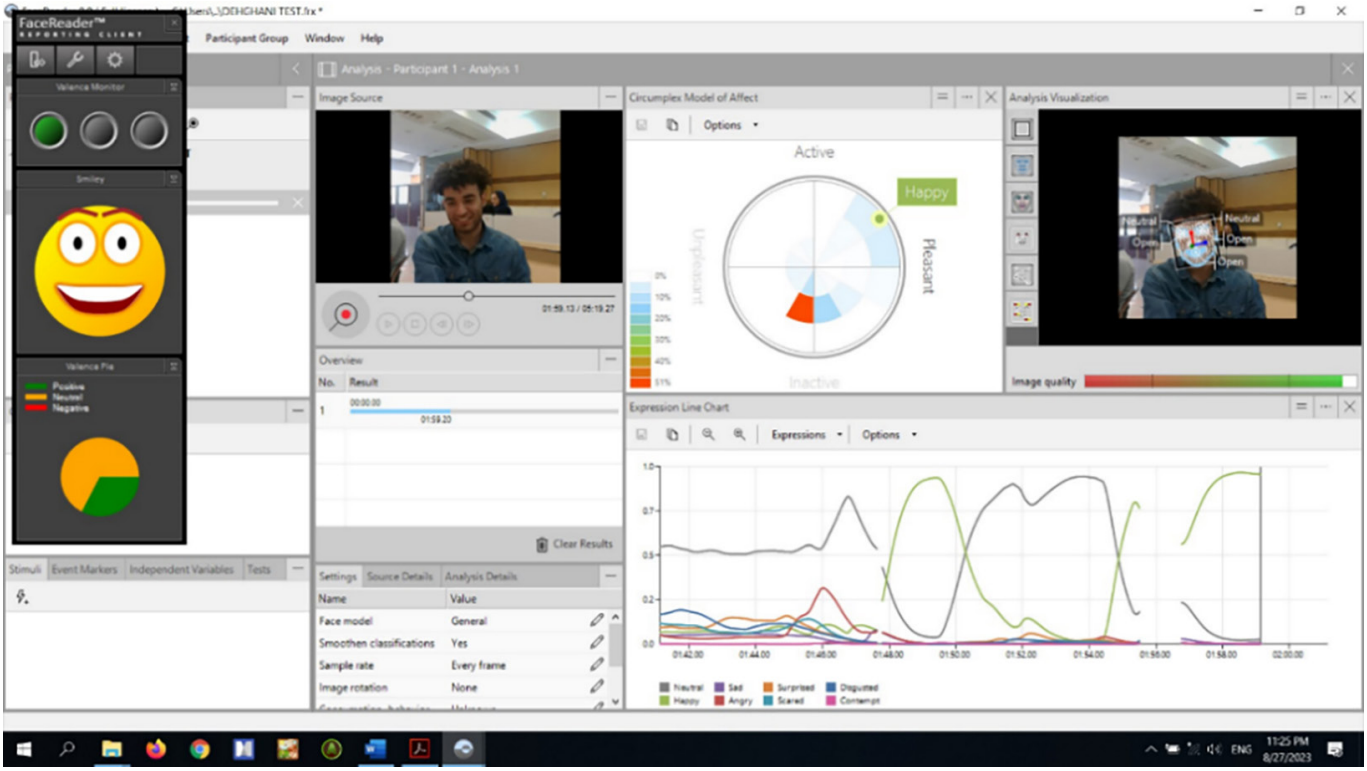

Fig. 2. Screen and emotion chart of a participant in the Kahoot method

In order to address the second question, the research examines the influence of various content presentation methods on learners' emotions in e-learning environments. The analysis presented indicates that there is a significant difference in neutral emotions (F: 16.209; $P < 0.005$), happiness (F: 24.364; $P < 0.005$), sadness (F: 6.706; $P < 0.005$), and disgust (F: 6.303; $P < 0.005$) based on different content presentation methods (refer to Table 2).

Table 2. Changes in emotions according to different methods of presenting content based on Friedman's test

Emotion	Test Statistics	df	P Value	N
Neutral	16.209	2	0.000	17
Happy	24.364	2	0.000	17
Sad	6.706	2	0.035	17
Angry	5.647	2	0.059	17
Surprised	2.127	2	0.345	17
Scared	5.839	2	0.054	17
Disgusted	6.303	2	0.043	17
Contempt	5.463	2	0.065	17

In order to identify the location of the differences, a post-hoc analysis was conducted using the Bonferroni correction method, which yielded a significance level of $p < 0.017$. The results are as follows (refer to Table 3):

- There was no significant difference between PowerPoint and video methods in terms of neutral emotions (z = –1.345; P = 0.179). However, there was a significant difference in neutral emotions between the PowerPoint and Kahoot methods (z = –2.485; P = 0.013). According to the mean values presented in Table 1, the average neutral emotion in the PowerPoint method (.675) is higher than in Kahoot (.545), indicating that students experienced a higher level of neutral emotion in the PowerPoint method compared to Kahoot. In the Kahoot method, the average neutral emotion of students decreased.
- There was a significant difference between the video and Kahoot methods in terms of neutral emotions (z = –3.243; P = 0.001). According to the mean values presented in Table 1, the average neutral emotion in the video method (.714) is higher than in Kahoot (.545), indicating that students experienced a higher level of neutral emotion in the video method compared to Kahoot. In the Kahoot method, the average neutral emotion decreased for students.
- There was a significant difference between the PowerPoint and Kahoot methods in terms of happiness (z = –3.621; P = 0.000). According to the mean values presented in Table 1, the average happiness in the PowerPoint method (0.032) is lower than in Kahoot (0.206), indicating that students experienced a higher level of happiness with the Kahoot method compared to PowerPoint. Additionally, there was a significant difference in happiness between the video and Kahoot methods (z = –3.244; P = 0.001). Considering the mean values for these two methods, the average happiness in the Kahoot method (0.206) is higher, indicating a greater level of happiness in the Kahoot method compared to the video method. However, there is no significant difference in feelings of happiness between the video and PowerPoint methods.
- There was a significant difference between the PowerPoint and video methods in terms of sadness (z = –2.723; P = 0.006), with the mean results indicating that sadness was higher in the PowerPoint method (0.162) compared to video. There was also a significant difference in sadness between the PowerPoint and Kahoot methods (z = –2.391; P = 0.017). Considering the mean values for these two methods, sadness was higher in the PowerPoint method compared to Kahoot. However, there is no significant difference in feelings of sadness between the video and Kahoot methods. Generally, the level of sadness is higher in both the video and PowerPoint methods compared to Kahoot.
- Furthermore, there was no significant difference in feelings of disgust among any of the content delivery methods (PowerPoint and video; PowerPoint and Kahoot; video and Kahoot). The mean differences between these methods are very negligible, indicating that there is no substantial variation in terms of disgust across different content delivery methods.

Table 3. Post hoc analysis using the Bonferroni correction method

		Neutral	Happy	Sad	Disgusted
PowerPoint – Video	**Z**	–1.345[b]	–1.960[b]	–2.723[b]	–.057[c]
	Asymp. Sig. (2-tailed)	.179	.050	.006*	.955
PowerPoint – Kahoot	**Z**	–2.485[b]	–3.621[b]	–2.391[b]	–2.250[c]
	Asymp. Sig. (2-tailed)	.013*	.000*	.017*	.024
Video – Kahoot	**Z**	–3.243[b]	–3.244[b]	–1.255[b]	–1.775[c]
	Asymp. Sig. (2-tailed)	.001*	.001*	.209	.076

Note: *Significant level with 95% confidence.

In general, the comparison of the three teaching methods shows that in the method of content delivery using PowerPoint and educational videos, students exhibit the highest level of negative emotions after the neutral state, and the level of emotional arousal is lower in these two methods. In the KAHOOT gamified teaching method, the highest average of emotions is related to positive emotions and joy.

Figure 3 displays the graph of neutral, happy, and sad emotions for various content presentation methods. As you can see, the highest average happiness is related to the content presentation method using Kahoot, while the lowest average neutral feeling is associated with the Kahoot method. In the presentation method using PowerPoint, the lowest average level of happiness is observed.

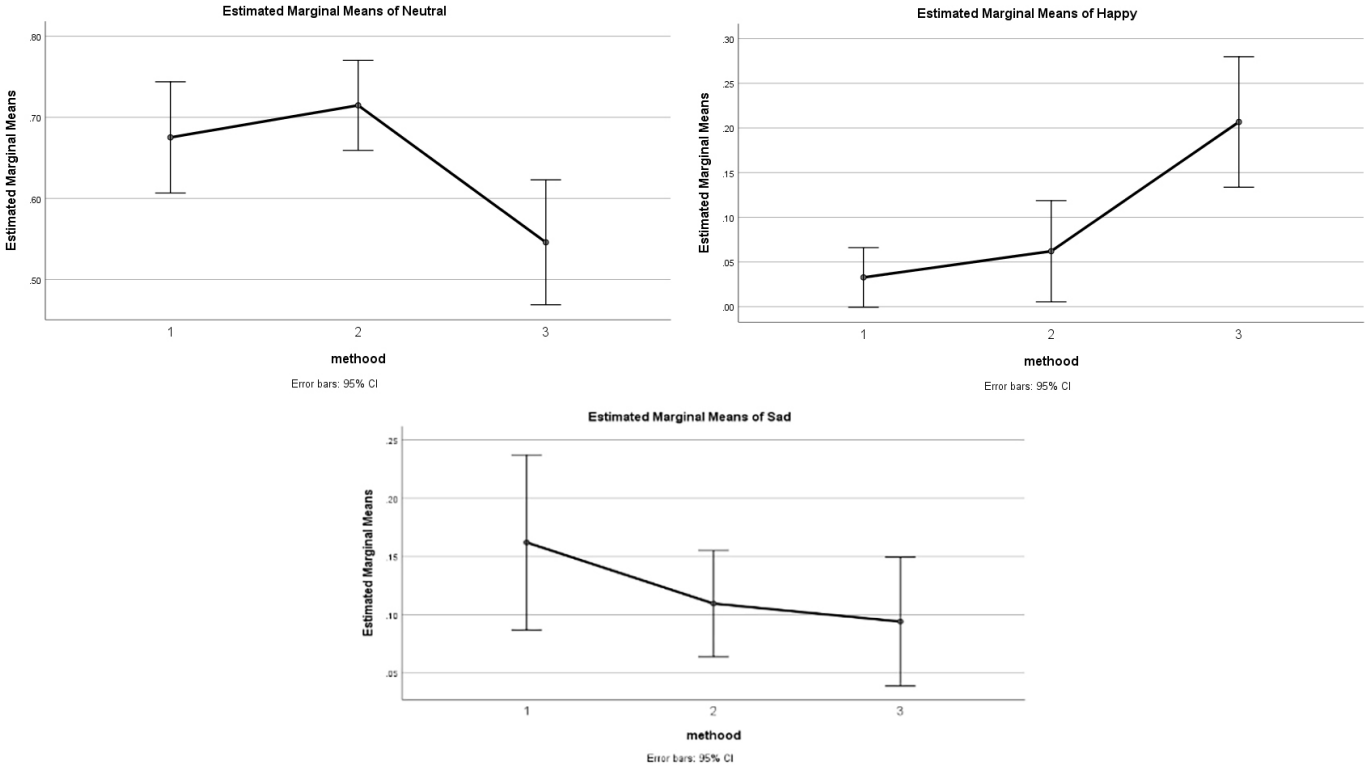

Fig. 3. Level of neutral, happy, and sad emotion in different methods of presenting content

5 DISCUSSION

The present study aimed to examine students' emotions in e-learning classes through facial expressions and investigate the influence of various instructional methods on students' emotional responses. The content presented in this research is related to the ecology lesson in the field of agriculture. The content was delivered to students using three different methods: PowerPoint presentations and lectures, video educational with explanations from the teacher, and interactive Kahoot activities.

In line with the main goal of the study, the collected data was analyzed using facial expression recognition software. The facial expression recognition software is capable of identifying six basic or universal emotions: happiness, sadness, anger, surprise, fear, and disgust. Additionally, it can detect neutral expressions and analyze contempt. In this study, we identified the positive and negative emotions of students

using various methods to present educational content in online environments. However, there are some issues that researchers need to consider when using this software. For example, the method is sensitive to lighting conditions, and the accuracy of detecting emotional expressions heavily depends on the quality of the cameras capturing facial movements [70, 71]. Furthermore, it is important to note that the total number of basic emotions identified by Face Reader is lower than the percentage of overall neutral expressions [72]. This suggests that the method achieves higher accuracy in identifying neutral emotions compared to other emotions. Nevertheless, the contribution of this research lies in the novel application of a tool for analyzing emotions in online learning classrooms, thereby adding value to the measurement of genuine and objective emotional responses in e-learning environments.

In response to the second research question, the analysis of the results indicates that presenting educational content using the Kahoot tool has elicited more positive emotions in students compared to the other two methods (PowerPoint and educational video). Additionally, the average neutral emotion in the Kahoot method is lower than in the other two methods. This suggests that the interactive and feedback-based learning environment is more dynamic, leading to higher student engagement and active involvement in class activities. Factors such as visual appeal and the creation of an interactive and competitive environment in the Kahoot method can have a positive impact on eliciting positive emotions. This finding is consistent with the results of previous studies [66, 62, 67, 36]. According to Reschly et al. [43], positive emotions are associated with higher levels of student engagement during class, while negative emotions are linked to lower levels of involvement. Recent studies also confirm this finding and demonstrate that methods such as Kahoot have a positive impact on classroom dynamics and student participation [73, 74], foster a positive learning environment [69], and increase motivation [75] in higher education settings.

In fact, the Kahoot teaching method emphasizes the interaction and active participation of students. It provides facilities that allow students to engage with the content, interact with fellow students, and communicate with the instructor during the learning process. These interactions and immediate feedback can contribute to positive emotions in students and enhance their learning. Social interactions and feedback in this method can play a crucial role in generating positive emotions, increasing motivation, and fostering a desire to learn in students. Considering that individuals respond differently to instructional and interactive methods, some students may be more responsive to the Kahoot method and active interactions, leading to more positive emotions and improved learning outcomes. The benefits of the Kahoot method as an active and interactive approach in education have been validated by many individuals. This often leads to increased enthusiasm and improved performance by students in the learning process.

The use of PowerPoint in education often leads to a higher occurrence of negative emotions. This is because educational material is typically delivered through lectures using PowerPoint slides, where students have minimal engagement in the learning process. This lack of involvement and active engagement can lead to disengagement from the subject and a loss of concentration. Factors such as boredom with educational content, lack of contact with the instructor and educational material, and an overall sense of social isolation can all contribute to the experience of unpleasant feelings. In reality, presenting instructional subjects in class without interpersonal contact might be exhausting. Numerous studies demonstrate that when students lack direct engagement with their teachers and peers in e-learning environments, they may face emotional challenges [53].

In the educational video method, students' negative emotions, such as sadness, are more common. In fact, our goal in using video instruction was to present the content visually and engagingly to enhance students' understanding. The expression of negative emotions by students can be attributed to the lack of interaction between the instructor and students. In this method, a brief instructional video, along with the instructor's explanations, was provided to the students, and it was discussed by the teacher. On the other hand, studies have shown that the effectiveness of learning through videos depends on the level of interaction. Students in e-learning environments where interactive videos are presented demonstrated better learning performance and higher levels of satisfaction compared to other video environments [76]. But compared to the presentation method using PowerPoint, it is more memorable and has the potential to increase the motivation of learners in online courses [77]. Some studies have compared the educational video method in the e-learning environment with the face-to-face lecture method, and the findings have shown that e-learning yields better learning outcomes than face-to-face lectures. Therefore, the utilization of well-designed and properly implemented e-learning can be beneficial. It should be noted that each training method has its advantages and limitations, and the results of individual reactions may vary. Utilizing a variety of educational and interactive methods can yield the best results in the learning process for students.

6 CONCLUSION

In this study, we examined the facial expressions of 17 undergraduate students majoring in agriculture at Tehran University. The study utilized three different methods of presenting educational content (PowerPoint, video, and Kahoot) in online classes, along with face reader software.

The findings demonstrated that students experienced various positive and negative emotions with different methods of content delivery. Furthermore, comparing the three methods revealed that the Kahoot method elicited the highest average of positive emotions among students compared to the other two methods. This difference can be attributed to the visual attractiveness and interactive nature of the Kahoot environment. This finding suggests that interactive electronic learning can generate positive emotions and create a more dynamic learning environment, as well as reduce feelings of fatigue and monotony in education. As a result, learners' motivation to continue their learning is sustained. Therefore, online learning environments should be designed to evoke positive emotions in learners while reducing their negative emotions. Additionally, this study highlights that simply incorporating multimedia materials, such as PowerPoint presentations and videos, is not sufficient to enhance effectiveness and cultivate positive emotions in e-learning. While multimedia materials serve as supportive tools and enhance visualization, interaction at various levels (content, teacher, peers, etc.) is necessary [76]. However, further research is needed in this area to explore and implement interactive and engaging methods in content design and online learning environments.

This study also has certain limitations. Firstly, the sample size is small, and therefore, the findings may not be generalizable to a larger population. Secondly, emotions in e-learning environments are influenced by various factors, including personality differences, cultural backgrounds, and mood, which can be important areas for future research. Thirdly, facial expression analysis is just one of several methods for detecting emotions. Hence, future research should consider combining

facial expression analysis with other measures, such as self-reporting and brain signals, if feasible. In our future studies, we intend to expand this research from various perspectives and explore the impact of happiness within the Kahoot method.

Despite the aforementioned limitations, the present study has two strengths. Firstly, it introduces an innovative method of experimentation and facial expression analysis using FaceReader software in electronic learning environments. This method brings forth new perspectives for studying emotions. Secondly, to the best of our knowledge, this is the first study to examine the relationship between various methods of content delivery in electronic learning environments and students' emotions.

These strengths contribute to the existing literature by providing valuable insights into the emotional experiences of students during online learning and the effectiveness of various content delivery methods. The innovative approach of using facial expression analysis adds depth to the understanding of emotional responses. Additionally, the examination of various content delivery methods enhances our knowledge of effective instructional strategies in e-learning environments.

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8 AUTHORS

Faranak Sahraie, Phd student, Department of agricaltural extension and education, Agricultural colledge, University of Tehran, Iran.

Ahmad Rezvanfar, Professor, Department of agricaltural extension and education, Agricultural colledge, University of Tehran, Iran.

Seyed Hamid Movahedmohammadi, Professor, Department of agricaltural extension and education, Agricultural colledge, University of Tehran, Iran.

Martin Ebner, Adjunct Professor, Graz University of Technology, Graz, Austria (E-mail: mebner@gmx.at).

Amir Alambeigi, Assistant Professor, Department of agricaltural extension and education, Agricultural colledge, University of Tehran, Iran.

Mohammadreza Farrokhnia is an Assistant Professor of Instructional Technology at the University of Twente. He is passionate about harnessing the power of cutting-edge technologies—including computer-supported collaborative learning environments, simulations, VR (Virtual Reality), and serious games—to enhance the learning experiences of students at various educational levels. His primary focus is on facilitating students' conceptual understanding of STEM-related topics and equipping them with essential 21st-century skills, such as creative thinking and problem-solving (ORCID: https://orcid.org/0000-0002-0150-5372).