Observing Undergraduate Students' Emotions in Gamified and Non-Gamified Educational Systems: A Qualitative Case Study

Pasqueline Dantas Scaico, Wilk Oliveira, Juho Hamari, SeyedHasan MilHosseini
Tampere University
Tampere, Finland
{pasqueline.dantasscaico, wilk.oliveira, juho.hamari, seyedhasan.mirhosseini}@tuni.fi

Andrea Brambilla
University of Milan
Milan, Italy
a.brambilla98@campus.unimib.it

***Abstract*—Contribution: In this full research paper, we contribute to the gamification literature by exploring students' emotions when completing educational tasks in a gamified and non-gamified education system, qualitatively explaining some triggers for their emotions. Background: An emotion is a spontaneous, short-lived, and subjective response to whatever is happening. Despite the various existing theories, we draw on Ekman's theory, which identifies seven basic emotions: anger, fear, sadness, happiness, contempt, surprise, and disgust. In education, gamification has been widely used with one of its objectives being to provoke positive emotions in students. However, little is known about students' emotions when using gamified and non-gamified educational systems. Research Questions: Advancing the literature, we answered the following research question: what emotions are experienced by students when performing tasks using a gamified and non-gamified educational system? Methodology: For up to 30 minutes, nine males and seven females completed educational tasks in general knowledge, English, and reasoning. Some interacted with a gamified version of an educational platform, which included 10 gamification elements based on Self-determination theory, while others engaged with the same tasks in a non-gamified version of the same system. During system usage, we employed the Noldus Observer XT and FaceReader systems to map students' emotions over time. After system usage, semi-structured interview data provided a deeper understanding of why certain emotions were experienced. Finally, we conducted a Thematic Analysis to qualitatively interpret the data. Findings: Participants remained indifferent most of the time in both settings, indicating that the gamification elements had no extra role. The most frequent emotion was anger, an emotion experienced when a goal is prevented from being pursued. They also experienced some disgust. Those exposed to gamification elements were more likely to be happy and equally likely to be sad. In terms of gender, male participants felt more anger and disgust, while women felt more happiness and sadness.**

***Index Terms*—Gamification, basic emotions, students' experience, eye-tracking, thematic analysis**

This work has been supported by the Academy of Finland Flagship Programme [Grant No. 337653 - Forest-Human-Machine Interplay (UNITE)]. The authors would like to thank the company *Eagle Soluções Educacionais e Tecnológicas Adaptativas Ltda./EAGLEEDU* for providing the system Eagle-edu free of charge for research purposes through the internal research collaboration project 2022/6202-3.1.

The second author is a partner at the company that granted the rights to use the system Eagle-edu free of charge for research purposes in this project.

I. Introduction

The human mind is built upon our thoughts and the emotional side of our cognitive processes is expressed through our feelings, moods, and emotions [1]–[3]. Studying emotions leads to a broader understanding of how people interpret the world, learn from interacting with it, and create value in what happens [4]–[6]. At the same time, gamification, *i.e.*, "the design that provides motivational benefits similar to those games usually create" [7], [8], has been widely applied in education [8]. This field is the most common context for empirical research with gamification [9]. People use resources associated with memory, have different cognitive workloads, and evaluate the value of a learning experience based on how they feel [3], [10]. It is common to find prior studies focused on the psychological outcomes of the adoption of gamified strategies [8], [9]. They have been contributing to building knowledge related to how students access and use knowledge to complete assignments [11].

However, research on emotional aspects of gamification experiences remains scarce [11], [12]. This gap may be explained because research efforts have focused on understanding how enjoyable the educational experience is when gamification is applied [13]. Gamification research needs to complement the knowledge of cognitive processes with more knowledge of emotions so that we can better understand, as the authors affirm: "whether positive emotional responses from gamified strategies are something to be labeled as 'good' and negative ones as 'bad' as some practitioners believe".

To advance towards facing this problem, in this paper, we present the results of an exploratory case study with 17 undergraduate and graduate students in STEM (science, technology, engineering, and math fields). We describe their emotions when completing educational tasks via a gamified system compared to a non-gamified system, and qualitatively explain some triggers for what they felt. Thus, we qualitatively answer "what emotions are experienced by students when performing tasks using a gamified and non-gamified educational system?".

To answer the proposed research question, within 30 min-

utes, nine males and seven females participated in educational activities related to general knowledge, English, and reasoning in a controlled environment. Some individuals interacted with a gamified iteration of an educational platform, which incorporated 10 gamification elements based on the principles of Self-determination theory [14]. Meanwhile, others completed the same tasks using a non-gamified version of the same system. Throughout the system usage, we utilized the Noldus Observer XT and FaceReader systems to track students' emotional responses over time. Following the system usage, semi-structured interviews provided deeper insights into the reasons behind specific emotions. Lastly, we conducted a Thematic Analysis to qualitatively interpret the collected data.

In both scenarios, participants predominantly maintained a neutral stance, suggesting that the gamification elements did represent an important role in their emotions. The prevailing emotional response observed was anger, which arises when individuals encounter obstacles preventing them from achieving their goals. Additionally, participants reported feelings of disgust. Notably, those exposed to gamification elements exhibited a higher likelihood of experiencing happiness and an equal likelihood of feeling sadness. Gender differences were observed, with male participants expressing more anger and disgust, while female participants leaned toward happiness and sadness. Through their discussions, we gained insights into moments of frustration (a manifestation of anger) and mild aversion (akin to disgust). Our findings contribute to education and gamification with insights related to students' emotions in gamified tasks.

II. Background

In this section, we introduce the core construct studied in this work, *i.e.*, basic emotions. We then present the literature related to emotions, education, and gamification.

A. Basic emotions

An emotion is a spontaneous, short-lived, and subjective response to whatever is happening [15]. Emotions are not only a way of observing objects or events in the world but also the beliefs that we frame about them [1]. Emotions fall under a cognitive component, even though we are not always aware of them [16].

Despite the various theories that exist, we draw on Ekman's theory. According to Ekman [17], emotions are innate and biologically rooted which means that people from different cultures and backgrounds express and recognize them in similar ways [18], [19]. Ekman [20] defined a scheme for decoding every movement that a human face can make. It functions as a language to describe how facial muscles work when people express emotions [20]. In Figure 1, it is possible to understand which set of movements of eyebrows, lips, and muscles near the nose express disgust. One of the most robust ways to distinguish one emotion from another is to map facial muscle movements and is one way to compare facial expressions in different groups of people [21].

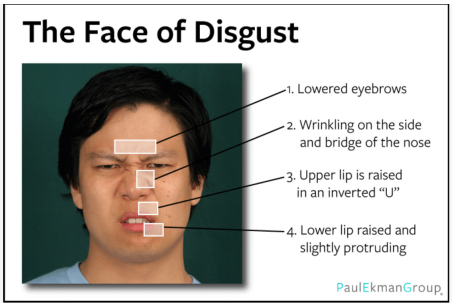

Fig. 1. Facial muscle movements when a person feels disgusted (based on Paul Ekman Group's website [22])

Ekman's theory states the range of human emotional experiences in six basic emotions [17], [18], [21]:

1) **Happiness** is characterized by a perception of joy, satisfaction, and positive well-being. It is often triggered by positive experiences, accomplishments, or interactions with others. Happiness and enjoyment can be interchangeable terms. It is a connection or sensual pleasure.
2) **Sadness** is marked by feelings of sorrow, grief, or disappointment. Sadness can be elicited by various factors such as loss and failure. What causes sadness varies based on personal and cultural notions of loss. Sadness is considered a negative emotion.
3) **Fear** is an emotion featured by a sense of imminent danger, threat, or harm. It plays a crucial role in survival by prompting individuals to avoid or confront potential dangers. It is also considered as a negative emotion.
4) **Anger** arises when we are blocked from pursuing a goal and/or treated unfairly. Frustration is an emotional response in the range of anger.
5) **Surprise** is triggered by sudden events. This emotion serves to alert individuals to significant changes in their environment. It is the briefest of the universal emotions and its function is to focus our attention on determining what is happening and whether or not it is dangerous.
6) **Disgust** represents a strong aversion to something offensive. It can arise from stimuli perceived through our physical senses (sight, smell, touch, sound, taste), as well as from actions, appearances, or even ideas.

Even though emotions may be positive or negative, in the process of measuring emotions, when measuring facial expressions, neutral responses can occur, and they mean that people feel nothing in particular or have no preference for anything [23]. Although positive and negative emotions seem to belong to different domains and are therefore mutually exclusive, individuals can experience them at the same time [24].

In the following section, we present some studies in the area of gamification in education that have explored the emotional components of people's experiential learning processes. There are not many studies on higher education and STEM fields. Given the robustness of the research method adopted, our study may be one of the few to observe how students feel as we have

done.

B. Related work

In the face of an educational experience, individuals are emotionally involved, whether positively or negatively [25]. Research consistently shows emotions as a force that impacts learning [26], as they affect and drive essential cognitive processes related to attention, problem-solving, and critical thinking [3], [27]. They also affect engagement, motivation, and willingness to pursue academic goals [28].

Game designers understand emotions as a key component for the experience [29]. Fun and enjoyment are usually thought in terms of sparkling positive emotions such as amusement, surprise, and personal accomplishment over difficulty [30]. Deterding [31] discussed how the adoption of gamification elements can support how individuals meet the basic needs of autonomy, competence, and relatedness, and guide them to experience positive emotions and avoid others as frustration.

There seems to be a sense that gamified solutions should be designed to be fun and engaging, otherwise users will not enjoy and engage with the experience [32]. Research has explored the balance between positive and negative emotional experiences that gamified tasks can elicit, particularly in the health domain [33], [34]. When it comes to educational research, it does not yet seem accurate to suggest that any negative emotional response necessarily interferes with learning and engagement [30]. Taub *et al*. [35], for instance, developed within a game-based digital environment, revealed that students who were exposed to situations of confusion, caused by the demand for complex reasoning processes that would presumably lead to frustration and boredom, adopted more efficient learning strategies.

Recent studies have helped advance the literature toward understanding student emotions in educational systems, however, little is known about may students can experience different emotions in gamified educational systems. Thus, as far as we know, we are pioneers in conducting a study focusing on the emotions of undergraduate and graduate students in an attempt to contribute to filling some of the existing gaps.

III. Study Design

We used an interpretive phenomenological design to answer the following research question "what emotions are experienced by students when performing tasks using a gamified and non-gamified educational system?". This method was chosen because we wanted to understand how students make sense of their emotions taking into account their context and personal meaning-making. In this section, we present the design, from a project to the data collection and analysis.

A. Project landscape

This study was an outgrowth of a larger project aimed at identifying multiple aspects of students' experiences through an educational system, where 68 undergraduate students participated in a between-subjects controlled experiment conducted as part of this project. We used a recruitment system from the Finnish university's decision laboratory where this study was conducted. An exploratory case study was conducted with a small sample of these students to describe their emotions and qualitatively explain what factors were influential in triggering them. During the experiment, students were individually assigned to a booth (see Figure 2).

Fig. 2. Booth used by participants during the experiment

They were given a time window to complete the questions (from 15 to 30 minutes). There was no countdown inside the booths. They completed questions in a quiz format. The questions covered topics related to logical reasoning, English, and general knowledge. Participants were randomly assigned to two distinct groups. One of them interacted with the Eagle-edu gamified system, which was set up with ten elements based on Self-Determination Theory (SDT) [14]: acknowledgment, chance, competition, economy, imposed choice, level, objective, point, progression, and statistics. These elements are explained in the taxonomy presented by Toda *et al*. [36]. The other group used the same system without any element of gamification.

Regarding the gamification design, in this investigation, the gamification components were incorporated and are consistent with the taxonomy delineated by Toda *et al*. [37]: **Chance** (commendations for specific player actions, symbolized within the system by the exhibition of students' badges); **Randomness** (elements of unpredictability and chance influencing the likelihood of certain events or results, manifested in the system through various decision-making scenarios, *e.g.*, selecting among treasure chests); **Competition** (scenarios where multiple players vie for a shared objective, depicted in the system by

a leaderboard showcasing up to 10 students); **Economy** (in-game financial dealings, the capitalization of gaming assets, among others, and represented in the system by currency that can be exchanged for virtual goods); **Imposed choice** (choices that players must make to progress in the game, represented in the system by a randomly presented option to augment their reward); **Level** (sequential levels in a game offering players incremental benefits as they advance, represented in the system by stages (*i.e.*, Bronze, Silver, Gold, Ruby, and Diamond)); **Objective** (measurable or spatial targets, ranging from short to long term, represented in the system by a mission tree); **Point** (metrics for evaluating player achievement, represented in the system by experience points (XP)); **Progression** (mechanisms that enable players to ascertain their location and progression within a game, represented in the system by a progression indicator in the activity tree); and **Stats** (conspicuous data available to the player, pertaining to their gaming performance and represented by all information regarding user advancement). Some of the gamification elements are illustrated in Figure 3 and Figure 4. Examples of feedback in both versions of the system are shown in Figure 5 and Figure 6.

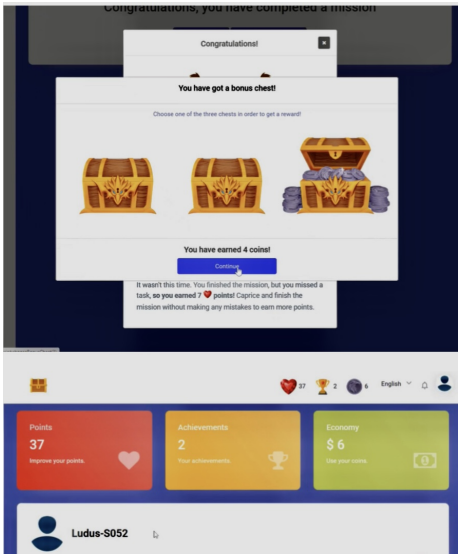

Fig. 3. Points, economy, achievements, coins, acknowledgment

The recruitment process for the qualitative study took place immediately after the participants completed the assignment. All of them were invited to participate in an interview in the following days. As we interviewed the students who volunteered, convenience was the sampling method adopted.

Thematic Analysis [38] was used to interpret the themes built upon our qualitative data set. In this section, we describe the main characteristics of the participants, and the context in which the study took place and we present details of how the data set was collected and analyzed.

B. Participants

Participants were recruited via Tampere University DMLab pool, utilizing ORSEE3 software for coordination [39]. Data

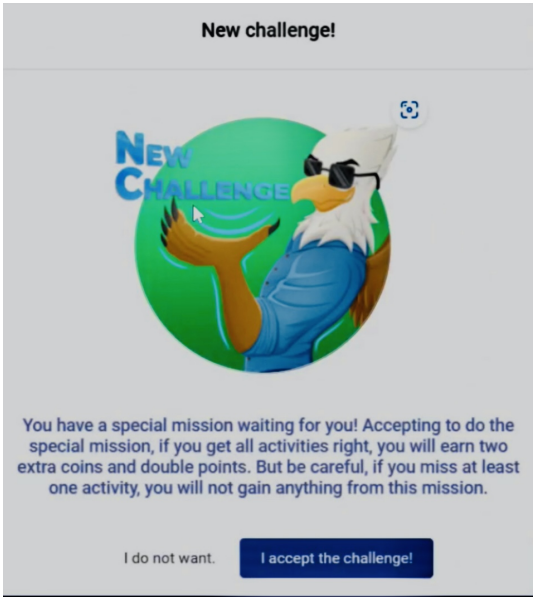

Fig. 4. Imposed choice

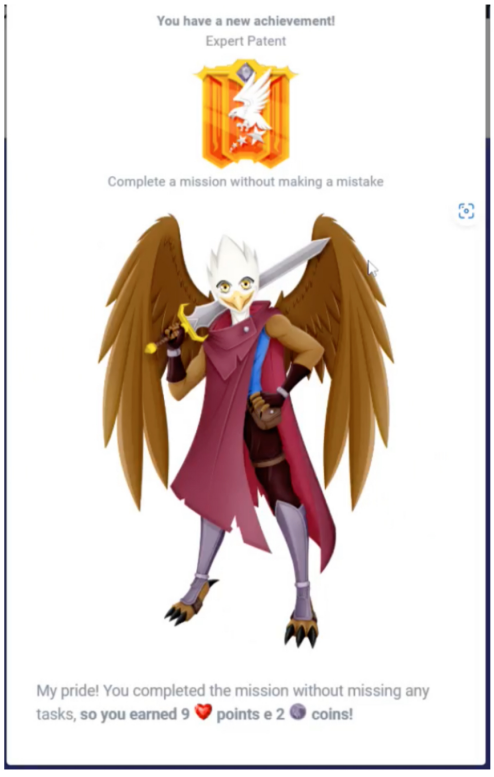

Fig. 5. Feedback with gamification elements

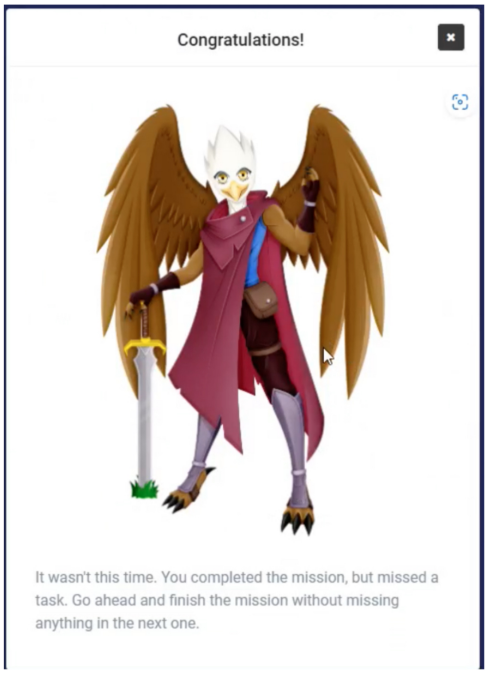

Fig. 6. Feedback without gamification elements

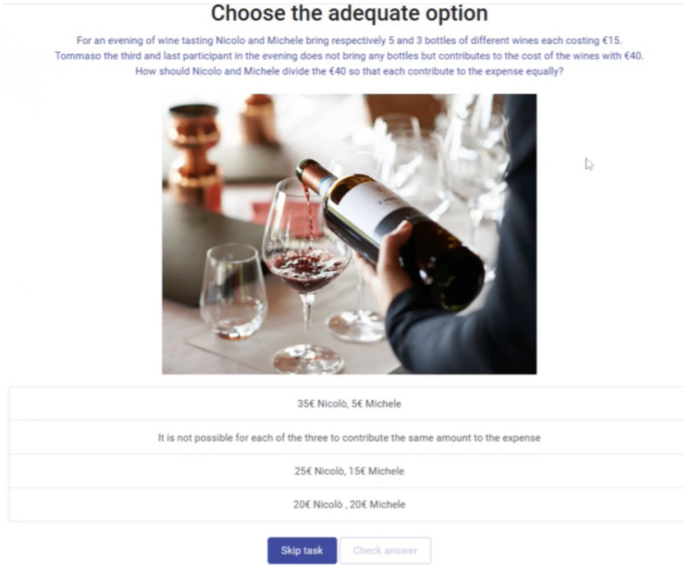

Fig. 7. Example of question related to logical reasoning

were collected from 17 students. Most of them consider themselves gamers, are from European countries, attending undergraduate or graduate programs at a Finnish university. All of them have a technical background in STEM (Science, Technology, Engineering, and Mathematics), such as data science, mathematics, statistics, computer science, engineering, and chemistry. They ranged in age from 20 to 46, averaging 27 years old. 10 students (6 males, 3 females, and 1 who preferred not to disclose their gender) interacted with the non-gamified version of Eagle-edu and 7 (3 males and 4 females) interacted with its gamified version. All research procedures were conducted in strict adherence to the guidelines established by the Finnish National Board on Research Integrity (TENK).

C. Study' context

We designed 25 questions in English, which were partly based on a famous and standard test for admission to a Faculty of Medicine in Italy - a national test and covers many different topics. Not all the questions were from there, especially the general knowledge ones, where we decided to explore different subjects. In Figure 7, there is an example of a question related to logical reasoning.

The level of difficulty was based on another test suitable for people who want to become university students. All the changes to the standard questions were aimed at transforming something designed for an international context since a Finnish university was our study setting and had this characteristic. The questions were made as general and understandable as possible for everyone.

The questions were the same for all participants. However, they interacted with them in different ways depending on which version of the system they were assigned to. For example, for those using the gamified version only, the questions were displayed in three groups and students could choose which topic they wanted to start with.

D. Data gathering and analysis

We recorded participants' facial expressions to measure emotions over time in a reliable way. The Noldus Observer XT and FaceReader systems were used to read and interpret these data, respectively. FaceReader has the capability to detect emotional changes triggered by experimental manipulation [40] and is 99% accurate in analyzing emotions [41]. The booths have a camera positioned to capture the student's face (Figure 8).

We combined data corresponding to participants' facial muscle activities with the qualitative data set based on the semi-structured interviews to understand their emotions.

The interview outline included a core set of open-ended and probing questions designed to encourage participants to create a narrative of their experiences. Questions have been added along the way to allow for a more in-depth understanding of specific responses. Two researchers were present during the interviews, but only one was the interviewer. After each interview, there was a discussion, and notes were taken. The combination of multiple data sources strengthened the instrument of data collection and also supported triangulation. All data were anonymized and interviews were transcribed verbatim. Following the steps of the Thematic Analysis technique [38], we read the transcriptions several times to become fully familiar with the data set. We followed a deductive coding strategy since we searched from their discourses any mention of emotions.

Fig. 8. View from a face captured by the camera inside a booth. The image was manipulated to preserve the participant's anonymity but still how facial muscles are mapped

IV. Findings

Initially, it's essential to emphasize that the objective of our research is not to conduct any form of confirmatory analysis or examine associations between variables. Consequently, by utilizing the facial data of participants (*i.e.*, captured via Noldus Observer XT and FaceReader systems), we were able to triangulate this data to better understand the emotional experiences of the students.

The predominant emotional response observed for all participants was neutral. That is, participants from both instructional settings remained indifferent most of the time. When analyzing the emotions of each group of participants, anger was the most common emotion experienced (see Figure 9). Anger was followed by happiness. As we can see, participants exposed to the gamification elements were much more likely to be happier.

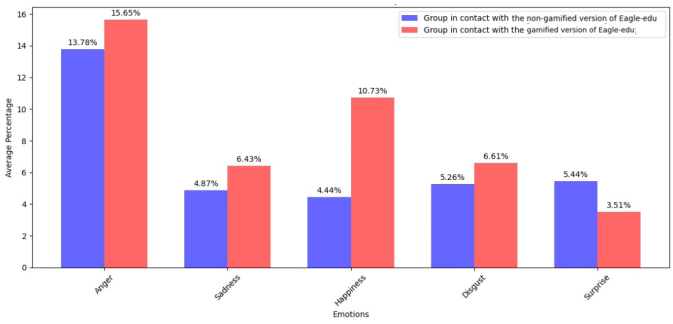

Fig. 9. Emotions observed for all participants

Considering the participants' gender, the emotional response remains neutral. The most frequent emotion was anger again. Male participants exhibited higher average scores for anger and disgust while females felt higher levels of happiness and sadness as presented in Table I.

TABLE I
FEMALE AND MALE PARTICIPANTS' AVERAGE SCORES FOR MOST COMMON EMOTIONS

Gender	Neutral	Anger	Sadness	Happiness	Disgust
Females	54.53	15.38	7.80	9.40	4.74
Males	57.71	15.34	4.34	5.07	7.30

The graph (Figure 10) shows in another way how the participants felt when their gender was considered.

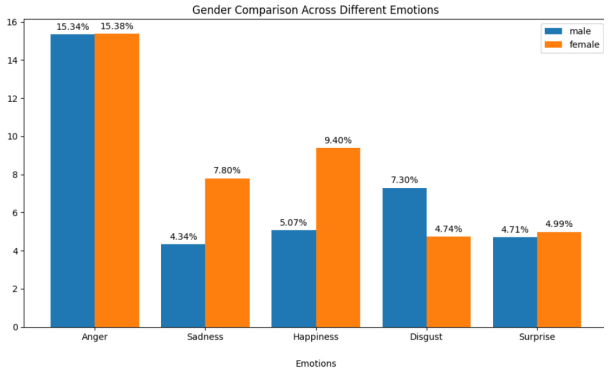

Fig. 10. Gender Comparison across Emotions

In the interviews, we asked the students to remember and talk about what they felt when they were in the booths. Most of them had difficulty remembering or talking about their emotions. The following type of response was common:

> "*...since I got one answer wrong, it kind of felt bad. I cannot express that in words, but just indeed, there was some sort of a bad feeling.*"

Participants were capable to report if they felt positive and/or negative emotions. Also, remember feeling entertained, frustrated, satisfied, enjoyed, or curious. Then, the observational data set built from the Noldus Observer was fundamental to map accurately their emotions. As high percentages of anger and disgust were found for all participants, we went through their discourses to understand some of the reasons.

We understood when frustration, which is an expression of anger, and dislike, a least intense feeling of disgust, occurred. Anger was mostly associated with failure. The logical reasoning tasks were the source of dislike for many participants. The question illustrated in Figure 7 was the major source of the students' perceptual level of anger and disgust. This result is interesting when we consider their technical backgrounds. Many were too confident in their skills and had impulsive attitudes. The following excerpts illustrate their sense of "injustice":

> "*There was one exercise I solved wrong. It was like a typical probably mathematician. I read only two first sentences. [...] I was like: this is clear! I was a hundred percent of the answer and I made the mistake because I didn't read the whole task. Oh*

my God, this is so obvious! Why? This is such a stupid mistake!"

When we analyze some of the discourses of those who completed the tasks in the gamified version of the system and expressed some degree of disgust (as something along the lines of "*I dislike...*"), we can perceive that the fact that they noticed that these were academic tasks, *i.e.*, that they were not fully immersed in a playful experience, explains some of what we observed in the data set:

"*I will be the student using that platform for learning and the idea is to have it more as a game and not as a test that's the feeling that I got I think*"

We looked at the discourse for those who experienced more happiness and sadness to try to understand what may explain these emotions. Expressions of happiness, expressed in the discourse as satisfaction, enjoyment, entertainment, and curiosity were related to their success and immediate feedback provided by the platform Eagle-edu. The general knowledge questions aroused more curiosity. Eventually, they realized the nature and difficulty of the questions. Therefore, when they got some of them wrong, they could not cope with the idea of failing.

It seems that the way the tasks were designed provoked many of the emotions found. If the logical reasoning tasks elicited negative emotions, they were also a site of sparkling enjoyment. Many talked about how satisfied they felt to have the opportunity to test themselves.

"*I felt that the experience was enjoyable. I liked it. I like testing myself. I like getting myself evaluated. I would have loved actually maybe to get even the results but I didn't get them*"

They also talked about the balance of challenge and skill they realized because of the nature of the assignment. Participants who were exposed to the gamified version of the system felt happier. Happiness was associated with competing with others, having the chance to make choices (autonomy), and facing a make-it-or-break-it situation (challenge-skill balance). The sense of autonomy and competence perceived by some participants satisfies basic needs, as explained by Self-Determination Theory [14], and is a driving force of motivation. Considering this, we can assume that the presence of gamification elements may have been a strength of their experience.

"*Soon my curiosity turned into, well, I knew how it worked now and I could go through it quicker.*"

Sadness appeared in several forms associated with failure: perceiving oneself as slower than others; and doing tasks incorrectly, especially when these were related to one's background - data science students felt sad when they failed on math questions and when they realized they had misused the time given to them.

In summary, the results demonstrate that there are not significant differences in the emotions of the two groups. The questions completed by the students were central to what they felt. Fear does not appear in any of the groups. Failure, for example, was associated with anger or sadness, but not with fear. Although two emotions stood out. We found that happiness and sadness were experienced more by the female participants. We found some reasons to explain the happy and sad moments experienced by all participants, but our findings could not reach an explanation for each of those emotions with the depth and assertiveness we would have liked. Perhaps one of the most surprising findings was that even though students felt negative emotions most of the time, the educational experience was rated as enjoyable and valid to be part of.

A. Discussion

Although gamification in education is a growing field, results related to the effects of gamified systems, often called game-based learning or games for education, are controversial and limited [42] [43]. The current study describes the emotions experienced by two groups of college students when given an educational task. Their emotions were recorded using eye-tracking equipment. 17 students volunteered to be interviewed and to talk about what they felt.

Our results show that participants remained indifferent most of the time in both settings. The most frequent emotion was anger, an emotion experienced when a goal is prevented from being pursued. They also experienced disgust. Those exposed to the gamified setting were more likely to be happy and equally likely to be sad. It must also be taken into account that the questions were not part of a real environment in which students could be poorly evaluated and this could have an impact on their academic life.

In general, students were unable to recall specific events that could be associated with what they were feeling. By looking at the emotions of each student in the group that interacted with the gamified tasks, we found that the frequency of emotions related to happiness and sadness was higher. Then, it is reasonable to assume that being exposed to the gamification design built into Eagle-edu may have influenced how they perceived the tasks. That is, how they interpret the learning environment and the instructional design were influenced by their characteristics, technical background, and beliefs.

Research on emotions in computing education and related fields explores how emotional factors affect learning experiences, engagement, and outcomes in fields such as computer science, programming, and related disciplines. Affective computing has been improving feedback systems to adapt to the environment depending on students' emotional responses [44] [45]. To avoid disengagement, intelligent tutoring systems recognize emotional states and provide encouragement [46].

To the best of our knowledge, there have been no previous studies on the facial expressions identified by FaceReader in response to changes in STEM students' emotions while completing educational tasks. This work contributes to the field of education and gamification, particularly for practitioners and empirical researchers interested in understanding the deeper nuances of an educational experience.

In our study, negative emotions were experienced more than positive ones, even when some of the participants interacted with gamification. When it comes to understanding gamified experiences, research mainly focuses on highlighting positive effects. From an instructional point of view, our findings support that provoking negative emotions is not necessarily disadvantageous since all participants described the experience as rewarding and worthwhile.

Sethi [47] stated that from an emotional perspective, gamified strategies should likely motivate users of a gamified system if they can reduce the occurrence of emotions such as fear, envy, and anger. Our results did not converge in this direction, but it is important to consider the specific context of our study, which includes the experimental nature of the setting and the amount of time students spent interacting with the Eagle-edu platform on their own. 17 minutes was the average amount of time, which may not have been enough for them to develop a negative perception of the experience, even if they felt more negative emotions.

B. Limitations

This qualitative study has inherent limitations that should be considered when interpreting our results. Initially, with only 17 participants (nine males and seven females and one who preferred not to disclose their gender), the study may lack sufficient statistical power to fully explore all necessary information. Additionally, the uneven gender distribution could introduce bias regarding emotional responses. Furthermore, the limited 30-minute duration for task completion might not adequately capture the full range of emotional responses or deeply assess participants' emotions. Differences in individual perceptions of task difficulty across general knowledge, English, and reasoning tasks could also confound the results.

The artificial experimental setting may not accurately reflect real-world educational environments, where external factors and longer usage periods could influence emotions differently. Although the Noldus Observer XT and FaceReader systems are advanced tools for mapping emotions, questions remain about their accuracy and reliability in capturing the entire spectrum of emotional responses. Emotional states are complex and may not be fully captured by these tools alone. For some, the interview was conducted 10 days after interacting with the Eagle-edu. Therefore, we know that this may have been an interference that cannot be left unmentioned. Although we encouraged them during the interview to remember the moment they were in the booths, important memories may have faded.

The implementation of 10 gamification elements based on SDT may not fully encompass all relevant motivational factors related to gamification, potentially limiting the interpretation of results. Inconsistencies in task presentation or interactions with the gamified and non-gamified systems could introduce variability, affecting the reliability of findings. The study primarily focuses on immediate emotional responses and may not capture the long-term effects of gamification on student engagement and learning outcomes. Additionally, the study does not account for participants' cultural and educational backgrounds, which could influence their emotional responses and perceptions of gamification. Emotions were recorded throughout the time students were in the booths, including when they completed a final survey that took a few minutes. The data were not cleaned to account for these final moments, which will need to be changed in future analyses.

V. Research Agenda

Based on our study examining the emotions experienced by students when performing tasks using gamified and non-gamified educational systems, we identified several possibilities for future research to expand upon our findings and address the identified limitations.

Initially, considering the sample size of our study, we believe that **future studies should include larger and more diverse participant samples to enhance the generalizability of the findings**. This includes considering a broader range of ages, educational backgrounds, and cultural contexts to understand how these factors influence emotional responses to gamification. While we conducted a controlled experiment, which provides several advantages, **future studies could conduct longitudinal research to investigate the long-term effects of gamification on students' emotional experiences and learning outcomes**. This would provide insights into how sustained interaction with gamified systems influences engagement and motivation over time.

We concentrated the tasks on three different topics. Therefore, **future studies have the opportunity to explore the impact of different task durations and levels of complexity on emotional responses**. Extending the task duration beyond 30 minutes and including a variety of task difficulties can help determine how gamification influences emotions under different learning conditions.

Future studies could also utilize more comprehensive qualitative methods, such as focus groups or in-depth case studies, to gain a deeper understanding of the nuances behind students' emotional experiences. This could involve exploring not only the immediate emotional responses but also the contextual factors that influence these emotions.

Additionally, **future studies could investigate the emotional responses to gamification across different cultural contexts to identify potential cultural differences in how gamification is perceived and experienced**. This can provide insights for designing adaptive gamified learning environments. In this paper, we did not analyze the 10 gamification elements. We believe it is important for **future studies to explore questions such as "Is it possible that emotions differ by gamification element?" Or "do emotions differ by task?"** Lastly, **future studies might consider incorporating additional or alternative technologies for emotion detection, such as wearable devices or advanced biometric sensors**, to validate and complement the findings obtained from Noldus Observer XT and FaceReader systems.

REFERENCES

[1] M. C. Nussbaum, *Upheavals of thought: The intelligence of emotions*. Cambridge University Press, 2001.

[2] H. Okon-Singer, T. Hendler, L. Pessoa, and A. J. Shackman, "The neurobiology of emotion–cognition interactions: fundamental questions and strategies for future research," *Frontiers in human neuroscience*, vol. 9, p. 58, 2015.

[3] C. M. Tyng, H. U. Amin, M. N. Saad, and A. S. Malik, "The influences of emotion on learning and memory," *Frontiers in psychology*, vol. 8, p. 235933, 2017.

[4] T. Hascher, "Learning and emotion: Perspectives for theory and research," *European Educational Research Journal*, vol. 9, no. 1, pp. 13–28, 2010.

[5] S. D. Pollak, L. A. Camras, and P. M. Cole, "Progress in understanding the emergence of human emotion." *Developmental psychology*, vol. 55, no. 9, p. 1801, 2019.

[6] K. Hoemann, C. Nielson, A. Yuen, J. W. Gurera, K. S. Quigley, and L. F. Barrett, "Expertise in emotion: A scoping review and unifying framework for individual differences in the mental representation of emotional experience." *Psychological Bulletin*, vol. 147, no. 11, p. 1159, 2021.

[7] J. Hamari, *Gamification*. The Blackwell Encyclopedia of Sociology, 2019, ch. Gamification, pp. 1–3. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/9781405165518.wbeos1321

[8] J. Koivisto and J. Hamari, "The rise of motivational information systems: A review of gamification research," *International journal of information management*, vol. 45, pp. 191–210, 2019.

[9] J. Majuri, J. Koivisto, and J. Hamari, "Gamification of education and learning: A review of empirical literature," in *Proceedings of the 2nd international GamiFIN conference, GamiFIN 2018*. CEUR-WS, 2018.

[10] H. T. Schupp, J. Stockburger, M. Codispoti, M. Junghöfer, A. I. Weike, and A. O. Hamm, "Selective visual attention to emotion," *Journal of neuroscience*, vol. 27, no. 5, pp. 1082–1089, 2007.

[11] J. K. Mullins and R. Sabherwal, "Gamification: A cognitive-emotional view," *Journal of Business Research*, vol. 106, pp. 304–314, 2020.

[12] M. Sailer, J. Hense, H. Mandl, and M. Klevers, "Psychological perspectives on motivation through gamification," *Interaction Design and Architecture(s) Journal - IxD&A*, 2013.

[13] M. T. Cardador, G. B. Northcraft, and J. Whicker, "A theory of work gamification: Something old, something new, something borrowed, something cool?" *Human resource management review*, vol. 27, no. 2, pp. 353–365, 2017.

[14] E. L. Deci and R. M. Ryan, "Self-determination theory," *Handbook of theories of social psychology*, vol. 1, no. 20, pp. 416–436, 2012.

[15] R. W. Levenson, "The intrapersonal functions of emotion," *Cognition & Emotion*, vol. 13, no. 5, pp. 481–504, 1999.

[16] L. Mortari, "Emotion and education: Reflecting on the emotional experience emotion and education," *European Journal of Educational Research*, vol. 4, no. 4, pp. 157–176, 2015.

[17] P. Ekman, T. Dalgleish, and M. Power, "Handbook of cognition and emotion," *Chihester, UK: Wiley*, 1999.

[18] P. Ekman and W. V. Friesen, "Constants across cultures in the face and emotion." *Journal of personality and social psychology*, vol. 17, no. 2, p. 124, 1971.

[19] P. Ekman, "Facial expressions of emotion: New findings, new questions," 1992.

[20] P. Ekman, W. V. Friesen, and S. S. Tomkins, "Facial affect scoring technique: A first validity study," *Semiotica*, 1971.

[21] P. Ekman, "An argument for basic emotions," *Cognition & emotion*, vol. 6, no. 3-4, pp. 169–200, 1992.

[22] ——. (2022) Paul ekman group' website. [Online]. Available: https://www.paulekman.com/

[23] K. Gasper, L. A. Spencer, and D. Hu, "Does neutral affect exist? how challenging three beliefs about neutral affect can advance affective research," *Frontiers in Psychology*, vol. 10, p. 485127, 2019.

[24] P. B. Warr, J. Barter, and G. Brownbridge, "On the independence of positive and negative affect," *Journal of Personality and Social Psychology*, 1983.

[25] S. Zhao and J. Song, "Unpacking the emotional experiences of learners in a blended learning context," *Frontiers in Psychology*, vol. 13, p. 879696, 2022.

[26] R. J. Dolan, "Emotion, cognition, and behavior," *science*, vol. 298, no. 5596, pp. 1191–1194, 2002.

[27] F. Wortha, R. Azevedo, M. Taub, and S. Narciss, "Multiple negative emotions during learning with digital learning environments–evidence on their detrimental effect on learning from two methodological approaches," *Frontiers in psychology*, vol. 10, p. 479184, 2019.

[28] D. K. Meyer and J. C. Turner, "Re-conceptualizing emotion and motivation to learn in classroom contexts," *Educational Psychology Review*, vol. 18, pp. 377–390, 2006.

[29] N. Lazzaro, "Why we play games: Four keys to more emotion without story," in *Game Developers Conference*, vol. 8, 2004, p. 14.

[30] K. Robson, K. Plangger, J. H. Kietzmann, I. McCarthy, and L. Pitt, "Is it all a game? understanding the principles of gamification," *Business horizons*, vol. 58, no. 4, pp. 411–420, 2015.

[31] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining" gamification"," in *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*, 2011, pp. 9–15.

[32] P. Sweetser and P. Wyeth, "Gameflow: A model for evaluating player enjoyment in games. comput. entertain. 3, 3 (july 2005), 3," 2005.

[33] P. Saleme, T. Dietrich, B. Pang, and J. Parkinson, "Design of a digital game intervention to promote socio-emotional skills and prosocial behavior in children," *Multimodal technologies and interaction*, vol. 5, no. 10, p. 58, 2021.

[34] H. Järvenoja and S. Järvelä, "Emotion control in collaborative learning situations: Do students regulate emotions evoked by social challenges," *British Journal of Educational Psychology*, vol. 79, no. 3, pp. 463–481, 2009.

[35] M. Taub, R. Azevedo, R. Rajendran, E. B. Cloude, G. Biswas, and M. J. Price, "How are students' emotions related to the accuracy of cognitive and metacognitive processes during learning with an intelligent tutoring system?" *Learning and Instruction*, vol. 72, p. 101200, 2021.

[36] A. M. Toda, A. C. Klock, W. Oliveira, P. T. Palomino, L. Rodrigues, L. Shi, I. Bittencourt, I. Gasparini, S. Isotani, and A. I. Cristea, "Analysing gamification elements in educational environments using an existing gamification taxonomy," *Smart Learning Environments*, vol. 6, no. 1, pp. 1–14, 2019.

[37] A. M. Toda, W. Oliveira, A. C. Klock, P. T. Palomino, M. Pimenta, I. Gasparini, L. Shi, I. Bittencourt, S. Isotani, and A. I. Cristea, "A taxonomy of game elements for gamification in educational contexts: Proposal and evaluation," in *2019 IEEE 19th international conference on advanced learning technologies (ICALT)*, vol. 2161. IEEE, 2019, pp. 84–88.

[38] V. Braun and V. Clarke, *Thematic analysis.* American Psychological Association, 2012.

[39] B. Greiner, "Subject pool recruitment procedures: organizing experiments with orsee," *Journal of the Economic Science Association*, vol. 1, no. 1, pp. 114–125, 2015.

[40] K. Schoeps, S. Velert Jiménez, P. Mesa-Gresa, J.-A. Gil-Gomez, and I. Montoya-Castilla, "Analysing facial expressions of basic emotions with facereader: An experimental study," *Psicológica Journal*, 2022.

[41] S. Stöckli, M. Schulte-Mecklenbeck, S. Borer, and A. C. Samson, "Facial expression analysis with affdex and facet: A validation study," *Behavior research methods*, vol. 50, pp. 1446–1460, 2018.

[42] K. Seaborn and D. I. Fels, "Gamification in theory and action: A survey," *International Journal of human-computer studies*, vol. 74, pp. 14–31, 2015.

[43] A. Manzano-León, P. Camacho-Lazarraga, M. A. Guerrero, L. Guerrero-Puerta, J. M. Aguilar-Parra, R. Trigueros, and A. Alias, "Between level up and game over: A systematic literature review of gamification in education," *Sustainability*, vol. 13, no. 4, p. 2247, 2021.

[44] R. A. Calvo and S. D'Mello, "Affect detection: An interdisciplinary review of models, methods, and their applications," *IEEE Transactions on affective computing*, vol. 1, no. 1, pp. 18–37, 2010.

[45] D. J. Nicol and D. Macfarlane-Dick, "Formative assessment and self-regulated learning: A model and seven principles of good feedback practice," *Studies in higher education*, vol. 31, no. 2, pp. 199–218, 2006.

[46] B. Smit and E. Stavrulaki, "The efficacy of a mindfulness-based intervention for college students under extremely stressful conditions," *Mindfulness*, vol. 12, pp. 3086–3100, 2021.

[47] M. K. Sethi, "Psychological perspectives on motivation through gamification," *Interaction Design & Architecture(s) Journal (IxD&A)*, 2024.