2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #52529

Collaborative skills and ethical behavior: a gamified flipped classroom case study in a construction execution course

Tathyana Moratti, The University of Georgia

PhD Candidate in the Engineering Education Transformative Practice program.

Han Jin, University of Georgia
Runu Proma Das, University of Georgia
Kyle Shanachilubwa, The University of Georgia
Mathew Baby, University of Georgia
Ricardo Juan José Oviedo-Haito, Universidade Federal De Santa Catarina
Dr. Nathaniel Hunsu, The University of Georgia

Nathaniel Hunsu is an Associate Professor of Engineering Education at the University of Georgia, affiliated with the Engineering Education Transformational Institute (EETI) and the School of Electrical and Computer Engineering. He leads the Engineering Student Learning and Engagement Research (ESLER) group, mentoring students in projects that explore how engineering learners engage with tasks, technologies, and learning environments. His research focuses on conceptual understanding, epistemic cognition, and student engagement, with an emphasis on evidence-based strategies that enhance learning in engineering education. He applies quantitative research designs, systematic reviews, meta-analysis, and assessment instrument development to advance both the theory and practice of engineering education. Dr. Hunsu's work also investigates the use of emerging educational technologies, including AI, XR, and robotics, in fostering active and self-regulated learning. His goal is to bridge research and practice, equipping educators and learners to achieve meaningful, lasting learning outcomes.

Dr. Beshoy Morkos, University of Georgia

Beshoy Morkos is a professor in the College of Engineering at the University of Georgia where he directs MODEL (Manufacturing Optimization, Design, and Engineering Education Lab) Group. His research group currently explores the areas of system design, manufacturing, and their respective education. His system design research focuses on developing computational representation and reasoning support for managing complex system design through the use of Model Based approaches. The goal of Dr. Morkos' manufacturing research is to fundamentally reframe our understanding and utilization of product and process representations and computational reasoning capabilities to support the development of models which help engineers and project planners intelligently make informed decisions. On the engineering education front, Dr. Morkos' research explores means to improve persistence and diversity in engineering education by leveraging students' design experiences.

Collaborative Skills and Ethical Behavior: A Gamified Flipped Classroom Case Study in a Construction Execution Course

1. Introduction

Construction execution encompasses the application of construction knowledge, practices, methods, and accepted standards to achieve effective performance during the construction phase of a project [1]. This application requires a myriad of skills that are difficult for civil engineering students to acquire through traditional pedagogical methods, such as lectures. Although there are different technical skills to be developed, some social skills, such as collaboration [2], [3], [4], [5] and ethics [4], [6], [7], [8], are essential to engineering graduates, particularly for construction execution. Recognizing the difficulties in developing these skills in a conventional classroom, educators employ interactions, active participation, and visual inputs [9] in an approach known as active learning [10], an active focus in construction education research [11].

There is evidence that active learning "works better than more passive approaches" [12]. Active learning leads students to a willingness to learn and an increased comfort level [13] because instructors and students become more confident and involved in the learning process [14]. The core elements of this kind of learning are the students' activity and engagement in the learning process [10]. Among active learning methods, the flipped classroom, also known as inverted learning, has grown in popularity among engineering educators over the past decades because, among other reasons, it is perceived as more effective than conventional teaching methods [15]. In flipped classrooms, what is done inside and outside the classroom is flipped or inverted [16], combining online resources and activities in and out of the classroom in the reverse order of content delivery [17]. Thus, the success of the flipped classroom depends heavily on students' prior preparation, given their capacity to study new material independently [18].

Although literature recognizes the benefit of flipped learning [15], [16], [17], [18], [19], [20], little is discussed about how to promote or motivate students to participate in activities outside the classroom [19]. Motivation has been studied through different lenses due to its importance in students' engagement in learning [21], [22], [23], [24], [25], [26], [27]. Particularly, the lack of students' engagement in advance preparation in a flipped classroom leads to it being an "ideal venue for combining multiple methods of active learning" [19]. An active learning method that can be combined with the flipped classroom is gamification. Gamification has gained relevance among engineering educators [28], [29], [30] due to students becoming more engaged and motivated [30], [31], [32], [33], [34], [35], [36], [37]. However, little is known about whether the flipped classroom and gamification together can promote or prevent the development of collaboration and ethical behavior. To investigate this gap, two research questions were defined:

RQ1: Does gamification foster the development of civil engineering students' collaborative skills in a gamified flipped classroom intervention?

RQ2: Does gamification enable civil engineering students' ethical behavior in a gamified flipped classroom intervention?

2. Theoretical Background

2.1. Gamification in Engineering Education

Gamification has become a prevalent strategy in higher education to enhance student motivation, engagement, and academic performance [38], [39]. In the context of engineering education, the emphasis on iterative, challenge-based learning in gamification aligns well with problem-solving engineering curricula [40]. Common game elements, such as points, leaderboards, and immediate feedback, are shown to boost participation and task completion [30], [41]. However, if poorly implemented, gamification can backfire, fostering anxiety, disengagement, or competition-induced stress [42], [43]. Domínguez et al. (2013) [44] found that gamification misaligned with learning goals led some students to perceive it as a distraction rather than a support mechanism. Recent studies [45], [46] further reveal that social dynamics within gamified environments can amplify inequities and foster exclusionary behaviors if not carefully monitored. Therefore, gamification in engineering education must be not only engaging but also ethically and socially meaningful.

2.2. Collaborative Skills in Engineering and Gamification

Collaboration is a critical competency in engineering, encompassing teamwork, communication, conflict resolution, and shared accountability [47]. Gamification has been shown to foster collaboration by embedding game mechanics that encourage positive interdependence and mutual success [30]. Team-based game mechanics, such as shared tasks and cooperative challenges, can foster this interdependence [41]. However, competition-based gamification may have unintended consequences: low-performing students may feel discouraged, leading to disengagement and reduced collaboration [42]. Moreover, if leaderboards or point systems overemphasize individual performance, they may undermine trust and collaboration, particularly among students with diverse academic backgrounds. A recent research [48] emphasizes the need for adaptive gamification frameworks that tailor collaborative challenges to learners' skill levels, ensuring equitable participation and sustained group cohesion. Thus, while gamification has collaborative potential, its design must be intentionally aligned with educational values to support inclusive team-based learning [48].

2.3. Ethical Behavior in Engineering Gamified Classrooms

Ethical reasoning and decision-making are essential yet challenging aspects of engineering practice, especially when students are placed in competitive or high-pressure scenarios [49]. Classroom environments, particularly gamified ones, must simulate the moral complexities of real-world engineering tasks to effectively develop ethical competence [50]. Ethical behavior in gamified flipped classrooms involves respecting rules, not disrupting the class environment, and avoiding deception. However, gamification introduces emotional intensity and competitive pressures that may tempt students to compromise ethical standards [33], [51]. For instance, Toda et al. (2018) [45] observed that students sometimes prioritized winning over collaboration or fairness, especially when extrinsic rewards were emphasized.

3. Method

This exploratory case study was conducted in a Construction Execution course offered during the sixth semester of a six-year civil engineering program at a private university in São Paulo, Brazil. The university primarily serves middle-class students, many of whom work full-time during the day to finance their studies and therefore attend evening classes. The course covers core topics related to construction project execution, including construction product development, site layout, earthmoving, shoring, foundations, structural systems, masonry and partitions, flooring and ceiling systems, waterproofing, internal finishes, façades, and roofing. The primary learning objective is to enable students to identify and understand the activities associated with a construction project across its various phases. Additionally, the course aims to develop students' ability to distinguish among different construction methods and techniques and to evaluate their respective characteristics.

The course consists of 16 weekly sessions, each lasting 100 minutes. All instructional materials, including lecture slides, were made available through the university's online learning management system. In the first semester, the instructor employed a traditional lecture-based approach. In this context, students frequently exhibited signs of fatigue at the beginning of class, largely attributable to full-time daytime employment. This challenge, compounded by the limitations of a conventional instructional strategy, prompted the instructor to explore alternative approaches to increase student attentiveness and engagement. As an initial adjustment, course materials, including videos from construction companies and suppliers, were made available prior to class; however, few students reviewed the content in advance. Consequently, class sessions remained heavily lecture-driven, occupying more than 90% of class time, and were perceived as monotonous, leading to diminished student interest.

This lack of students' engagement in advance preparation in a flipped classroom motivated the authors to investigate whether the gamification theory [52], [53] could engage students in studying the available materials in advance to enable the flipped classroom. In this previous study [54] the problem-based research approach [55] was selected, along with a gamification design composed of five elements [56]: (1) points, (2) levels, (3) time, (4) feedback, and (5) leaderboard. The game was designed to be performed in groups, and after selecting the elements, a set of rules (mechanics) [57] was defined, such as, (1) a representative of each group needed to press a buzzer to have the right to answer, (2) the group who had the right to answer had one minute to discuss it, (3) only the representative would answer the question to the whole class, (4) other groups would correct the answer, (5) the game-points earned by each group in all rounds were transformed into a grade for formative assessment. The buzzer was a custom-built physical device used to facilitate the quiz-based classroom game and promote higher student engagement. However, as students became emotionally invested in the competition, a lack of collaborative skills and unethical behavior surfaced, prompting a deeper inquiry into the side effects of gamification. This inquiry motivated the authors to define the research questions of this current study, considering the same dataset collected for the previous study [54].

3.1. Data Collection and Analysis

This practice-focused case study was conducted in a class with 59 junior Civil Engineering students (Male: 34; Female: 25) who signed the consent form to meet the ethics research requirement. In the previous study [54], there were two surveys: the Student Game Questionnaire (SGQ; see Figure 1), which was completed at the end of each class, and the Student Final Questionnaire (SFQ), which was completed at the end of the course. Two open-ended questions in the SGQ caught the authors' attention, where students shared their perceptions of the gamified flipped classroom. Therefore, we use the two SGQs' open-ended questions to answer the research questions of this study. The SGQ is administered as a Google Form, and as the questions don't measure the same construct, the internal consistency could not be calculated. Other sources of data to answer this study's research questions include Teaching Assistant (TA) reports, verbal feedback, and the instructor's observations.

Did you read the materials before class? (Possible answers: yes / no)
Did you watch the videos before class? (Possible answers: yes / no)
Did you research beyond the available materials? (Possible answers: yes / no)
What did you think of today's class?

	1	2	3	4	5	
Terrible	○	○	○	○	○	Great

What did you learn in today's class?
What could have been better in today's class?

Figure 1. Student Game Questionnaire (SGQ)

In the SGQ, the frequencies for the answers of the `Yes/No` and Likert scale questions were calculated and plotted in graphs. The answers to the open-ended questions were coded in NVivo 12 PRO by one of the authors using thematic analysis with grounded theory [55], [58] and a codebook was established. Another author coded the students' answers using the codebook. The inter-rater reliability between the two coders was assessed using Cohen's Kappa [59] with the resultant acceptable strength of agreement (k) being over 0.81, indicating almost perfect agreement [59].

3.2. The intervention

The total of 16 classes for the semester included five that used the gamified flipped classroom, called rounds. During the first round, students were agitated and noisy, reducing the time available for the learning process and complementary activities, such as registering attendance and completing the SGQ. For this round, verbal feedback from students and TA´s report indicated that 100% of the students suggested the creation of rules to avoid a lack of ethics, such as making noise, and cheating by use of smartphones to come up with answers. As one student stated, the lack of this type of rule made the experience terrible.

In the second round, two separate QR codes were implemented to register attendance and to receive responses to the SGQ. Some rules, including ethical conduct, were formalized, such as a ban on using smartphones during the game, pressing the buzzer only when needed, and limiting each group to one consecutive question. In addition, Group 7 had only one member at the beginning of the second round, with the remaining six members giving up on the game. This one student was permanently relocated to another group, resulting in a game with seven groups. The first two rounds of the game did not result in a good environment for the students or the instructor.

Although ethical conduct rules were defined in Round 2 of the game, some students persisted in disrupting the class to prevent other groups from winning. Hence, in this class, the instructor decided not to have the game, but rather employ a traditional lecture along with a reflection on how a lack of ethics was inhibiting their own learning. In this third round, the students' lack of engagement was visible, with many leaving before the end of the class. Along with the responses to SGQ, the TA also noted in the report that 'because it was a lecture class, after a while it got very tiring, even though the content was important and interesting.' The TA also stated in the report that this class was very important because it helped the students understand that they had caused chaos during the game.

In the fourth round, before starting the game, the instructor presented two consolidated sets of rules: content and behavioral rules, with the latter referring to a set of practices to avoid unethical behavior, such as making noise. This resulted in a game that flowed very well, with a full classroom and no students leaving in between. The day of the fifth and final round of the gamified class was atypical, with many students not attending, citing cancelled classes by other professors in lieu of the next day being a public holiday. The 14 students who attended this class stated that they were in class only because of the game, and they wanted to win the reward: a personalized T-shirt. Because there were only engaged students, and a smaller number of them, all students could interact with each other and with the instructor. At a time when the dispute between the groups was quite fierce, the group that was winning asked the instructor if all the students present could win a T-shirt. This is because they felt some of their teammates did not contribute to gaining points in previous rounds and, mainly, in this final round. In response, the instructor enquired of the members present in the winning group about members who were not present, missing out on winning the T-shirt. The reply to this enquiry was that they did not care, as only those who were present deserved to win the reward, even if they were from another group. This suggests that these students were empathetic and collaborated with their classmates present in the class.

The gamified flipped classroom implementation ended up in four rounds, as there wasn't a game in the third round. In each round, the rules were refined based on students' feedback, received verbally during the class, from SGQ answers, and from the TA's reports. The sequence of these rounds and the respective improvements to the rules are depicted in Figure 2.

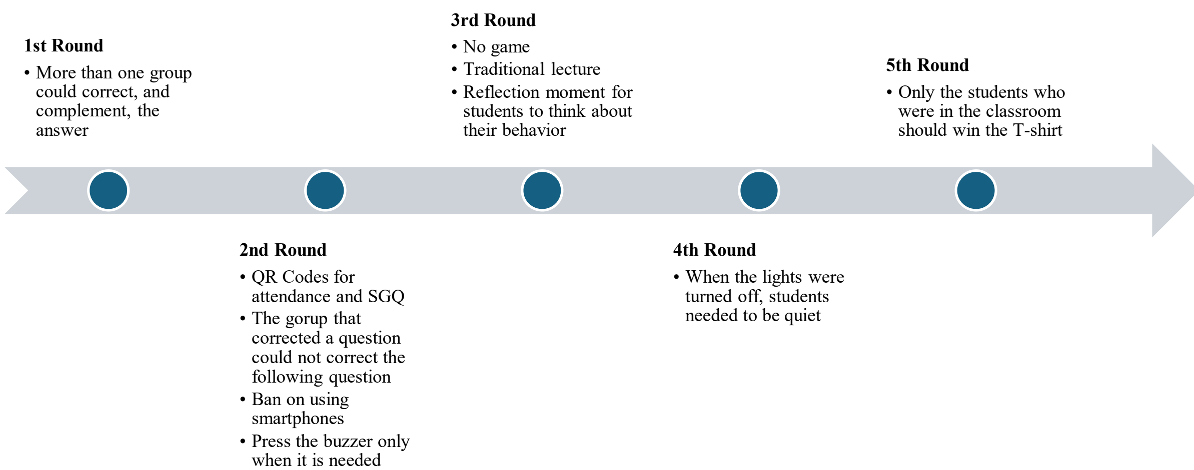

Figure 2. Rules Changes Across the Rounds

4. Results and Discussions

This section reports and discusses the responses to the SGQ, along with the TA's reports, verbal feedback, and the instructor's observation. In general, low rates of SGQs' student responses were observed. When surveying student perceptions, these low rates are relatively frequent [60], [61], and it does not affect the reliability of the results [60]. In this study, the limited time for the students to respond was a contributing factor for these low rates, because the link was presented at the end of each class when students wanted to go home. Figure 3 shows the attendance and number of SGQ answers per round in Chart (a). The fourth round has the highest attendance, and in the fifth round, almost all the students (11 out of 14) answered the SGQ. The answers to the `Yes/No` questions are shown in Charts (b-d). Likert scale answers are shown in Charts (e-h).

As in Chart (b) in Figure 3, for all rounds, almost 100% of the respondents studied the material before class. Also, Chart (c) shows that in the second and fourth rounds, more than 60% watched the videos. Hence, charts (b and c) suggest a high level of engagement in advance preparation in a gamified flipped classroom, as almost 100% of the students studied the materials before class, and a high percentage watched the videos in the gamified flipped classes (Rounds 2, 4, and 5). Charts (e-h) suggest that students' positive perception of the gamified flipped classroom gradually increased, mainly due to rule changes based on feedback on the question: 'What could have been better in today's class?' In the second round, some responses to this question were related to students' lack of ethics, such as, 'they should be more disciplined in the classroom'; 'students' childishness in competing for points and not for learning'; others related to the game mechanics, for instance, 'reduce the number of complements to only once.' All answers to this question were used to conduct the analysis and to create the coding scheme. The inter-rater reliability was assessed using Cohen's kappa (k) at the coding-node level, and the strength of agreement was k=0.89, indicating almost perfect agreement between the two coders [59]. Table 1 presents the coding categories and their respective frequencies.

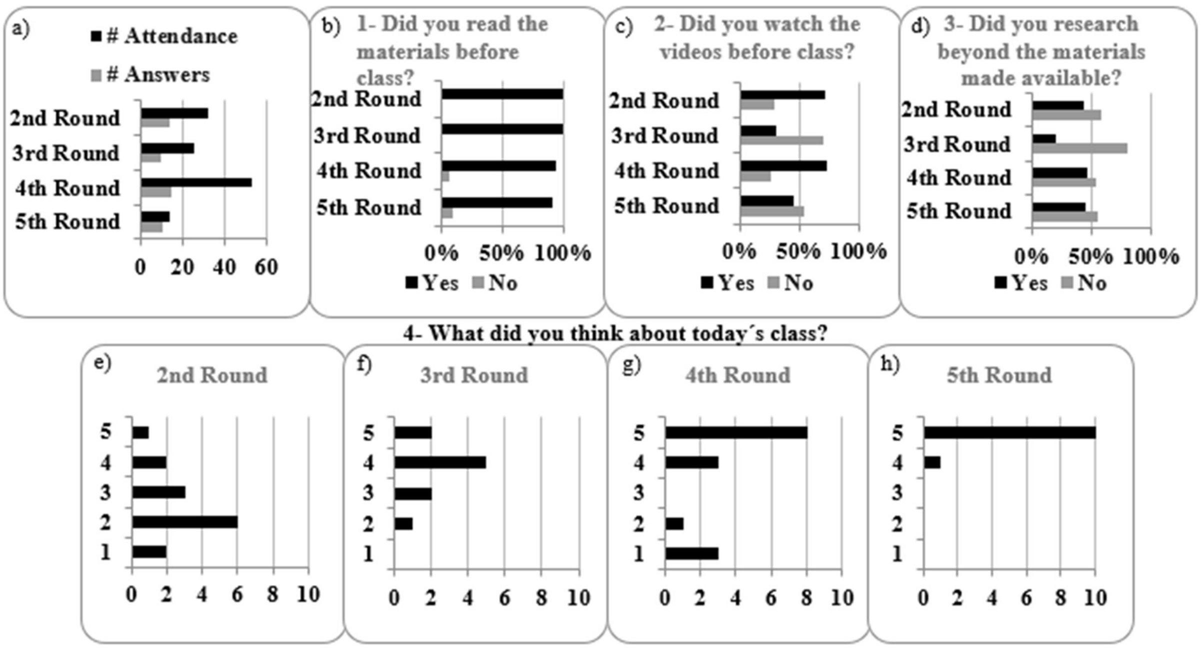

Figure 3. Dashboard of student responses to SGQ questions

Table 1. Coded answers to the question 'What could have been better in today's class?'

#	Category	Frequency (%)
1	Ethical challenges	18.52
2	Positive perception of the gamified flipped classroom	16.05
3	Neutral	13.58
4	Suggestions for course improvement	11.11
5	Suggestions for game improvement (mechanics)	11.11
6	Negative impact on collaboration	8.64
7	Negative impact on learning	8.64
8	Suggestions for game improvement (behavioral)	8.64
9	Negative classroom environment	3.70

Table 1 shows that 'Ethical challenges' is the first category (≈19%), indicating that students perceived their behavior should have been better in the gamified flipped classroom. Some sub-categories were: 'Shouting or talking at the same time' (28%), 'Lack of respect' (22%), and

‘Lack of manners’ (22%). This aligns with the TA report, as 100% of the students suggested creating rules to address a lack of ethics, such as making noise or cheating by using a smartphone. Additionally, from the instructor’s observation, this category was identified as the main challenge in handling the gamified flipped classroom, with the noisy classroom environment hindering learning, and some students cheating by checking their smartphones for answers to questions. This finding answers **RQ2** by suggesting that the gamified flipped classroom does not enable civil engineering students' ethical behavior when there are no rules to prevent unethical actions. Previous literature didn’t present rules to inhibit unethical behavior. Therefore, behavioral rules were co-constructed with students’ feedback, and engineering educators need to include such rules when implementing a gamified flipped classroom.

The second category is the ‘Positive perception of the gamified flipped classroom’ (≈16%), which appeared in the fourth and fifth rounds. Examples of responses in this category were ‘Class was good’ (47%), and ‘Good rules’ (20%). This indicates that the new rules promoted the desired effect and that students had a positive perception, rather than a sense of an unfair game. The ‘Neutral’ category (≈14%) is related to responses such as ‘Nothing’ (75%) or ‘Anything’ (8%). The suggestions for the course and the game rules (mechanics) improvement presented the same percentage (≈11%). Examples of course improvement were to ‘Use another method’ (44%), such as students’ presentations, or ‘Cancel the game’ (22%). These responses were received during the first and second rounds. Examples of game improvement (mechanics) were ‘Complement points modification’ (33%) and ‘Remove points from students who shout’ (22%). Some of these suggestions were incorporated into the mechanics of the game, such as allowing more than one group to complement an answer, to enable more groups the opportunity to earn points.

The negative impact on collaboration and learning, as well as the suggestions for game improvement regarding behavioral rules, showed the same percentage (≈9%). Some subcategories of the impact on collaboration were ‘Focus on competition’ (43%), and ‘Focus on rules’ (29%). The negative impact on learning examples was ‘Competition over learning’ (57%), and ‘Sense of lower performance’ (14%). These categories appeared in the first two rounds and are aligned with the instructor’s observation, who noticed that the designed collaborative environment, through a group competition that could lead to higher student performance, wasn’t being achieved, probably due to the high level of competitiveness the gamified flipped classroom promoted among students.

Similarly to this finding, Burguillo (2010) [33] found that students often prioritize winning over learning. Additionally, because the points from the games, after all rounds, accounted for 25% of the final grade, students were concerned about their grade. One example of this concern is this statement: ‘People are too worried about the points being distributed in the games; they think they won’t be able to reach the grade.’ Some examples of the ‘Suggestions for game improvement (behavioral)’ category were ‘More organization’ (57%) and ‘More silence’ (29%). The rule requiring silence when the lights were turned off was incorporated in the fourth round. The last category, ‘Negative classroom environment’ (≈4%), is related to ‘Messy and noisy’ (60%).

The open-ended question, “What did you learn in today’s class?’ presented answers like ‘the minimum, because there is a lot of mess and the topic of each question is taught only the basics.’ This quote is aligned with one student's feedback, who said that the experience was terrible. All the answers to this question were used to conduct the analysis and to create the coding scheme.

The inter-rater reliability was assessed using Cohen's kappa (k) at the coding-node level, and the strength of agreement was k=0.87, indicating almost perfect agreement between the two coders [59]. Table 2 presents the coding categories and the respective frequency.

Table 2 shows that around 34% of the answers were related to knowledge acquisition, indicating alignment between the questions and the answers. Some subcategories were 'Foundations' (38%), 'Preliminary services' (17%), 'Structure' (13%), and 'Retaining system' (13). The second category, 'Resource or strategy of learning' (≈21%), was related to 'Learning from peers' (33%) and 'Slides' (33%). The 'Positive perception of the gamified flipped classroom' (15%) also appeared in this question for the fourth and fifth rounds. The subcategories were related to the intensity of learning, such as 'A lot' (70%), and not a specific topic. Another category that was repeated in this question is the 'Negative impact on learning' (≈11%) for the first and second rounds. Some examples are 'Learned Nothing' (56%) and 'Learned the basic, minimum' (33%).

Table 2. Coded answers to the question 'What did you learn in today's class?'

#	Category	Frequency (%)
1	Knowledge Acquisition	33.96
2	Resource or strategy of learning	20.75
3	Positive perception of the gamified flipped classroom	15.09
4	Negative impact on learning	11.32
5	Negative impact on collaboration	7.55
6	Ethical challenges	3.77
7	Negative classroom environment	3.77
8	Neutral	3.77

Even though this question was about the learning content, some negative impacts related to collaboration (≈8%), ethical challenges (≈4%), and classroom environment (≈4%) emerged. Together, these negative categories account for around 15% of the coding frequency. This suggests that, despite the gamified flipped classroom promoting students' engagement and motivation to study in advance (see Figure 3; charts b and c), it also had side effects. Additionally, around 4% answered 'Yes' to this question, which was considered a 'Neutral' category due to the impossibility of measuring learning or the impact.

Regarding the civil engineering students' collaborative skills, which is the focus of **RQ1**, the findings of this study are insufficient to state that the gamified flipped classroom fosters them. From Tables 1 and 2, the 'Negative impact on collaboration' didn't show high percentages, being around 9% and 8%, respectively. Furthermore, it was observed that collaborative behavior emerged when students felt it was fair for other students to also win, as in the fifth round. Therefore, this implementation indicates that collaborative skills may be hindered when competitiveness is high. Conversely, it can be promoted through a gamified flipped classroom if there is a sense of fairness.

Through the progressive improvement of the game design, it was found that the implementation of behavioral rules is a crucial element for a gamified flipped classroom. Behavioral rules seem to develop civil engineering students' collaborative skills and enable ethical behavior in a gamified flipped classroom, as students feel they are participating in a fair game. Also, the willingness to win at any cost probably increased because the game points would count as a formative assessment. Thus, the game design may not incorporate the game points as part of the final grade. As discussed by Toda et al. (2018) [45], unexpected behavior among students can occur when incorporating game elements, as students become excited by classroom dynamics. In this case, the willingness of students to win leads to a lack of ethics. Moreover, as gamification is not experienced uniformly, and students' prior achievement level matters [62], low-performance students might experience demotivation to play games [42]. This is also aligned with Bandura's self-efficacy framework [63], which contends that students with low self-efficacy may avoid completing a specific task. Specifically in this study, six students from Group 7 dropped out of the game. Therefore, educators may have a contingency plan in case low-performance students don't want to play the game.

5. Conclusions

This study aimed to determine whether a gamified flipped classroom could foster the development of collaborative skills and enable ethical behavior among civil engineering students. Particularly, this educational game design used a custom-built physical device that enhanced students' engagement and led to high-level competition. This characteristic, combined with the lack of behavioral rules in the first and second rounds, suggests that the development of collaboration skills was prevented, as students felt the game was unfair. Additionally, the lack of this type of rule indicates that ethical behavior in a gamified flipped classroom wasn't enabled, as there was no regulation to prevent students from shouting or cheating. Therefore, to effectively implement a gamified flipped classroom that promotes collaboration and ethical behavior, engineering educators should incorporate behavioral rules into the game design.

Additionally, it was noted that the competition to earn points, which would be part of students' grades, tends to harm the learning process because students are more interested in winning points than learning. Therefore, engineering educators may not consider the game points as part of the final grade. Given the findings of this study, future work could (1) use more structured measures of collaboration and ethical behavior to quantify the impact of the intervention; (2) compare designs in which there are high competitive and high cooperative environments to identify the differences in impact of both designs; (3) consider not including game points as part of the grade to test design effects more systematically; and (4) identify key elements for designing a gamified, flipped classroom to mitigate the side effects of gamification.

6. Limitations

This case study has some limitations that should be considered. First, the study involved only one cohort of 59 students in a specific engineering course. Thus, the sample size is relatively small, and the context is unique. As a result, the findings are primarily exploratory and may not be directly applicable to other educational settings or different student groups. The second limitation concerns data collection. The response rate for the SGQ was low, as not all students completed it at the end of every class. This means the gathered feedback might not fully represent the views of the entire class, potentially affecting the accuracy of conclusions. Additionally, the questionnaire itself used a combination of different question formats, such as yes/no, Likert scale, and open-ended questions. This mix of formats makes it challenging to assess the internal reliability of the survey instrument as a whole.

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