Competitive Polling to Enhance Engagement and Learning Outcomes in a Mechanical Engineering Classroom

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Abstract

Engagement plays a crucial role in shaping students' learning experiences and academic outcomes. This paper studies the impact of competitive polling on student engagement and learning outcomes in a traditional mechanical engineering course, Energy Conversion Systems. Polling has been increasingly used in higher education to promote active learning and increase participation, especially in a class with a large student enrollment. Modern tools, such as Mentimeter, Kahoot, Quizizz, etc., offer competitive polling that creates a gamified environment, fostering real-time student interaction and healthy competition among students.

In this study, Mentimeter was used to conduct competitive polling in class. A mixed-methods approach was employed, incorporating a survey to assess student perceptions of in-class engagement during competitive polling activities and semi-structured interviews to explore the effect on student interest, motivation, and learning outcomes. The survey data revealed that students experienced significantly higher levels of engagement when the competitive elements were introduced. The major ways in which competitive polling makes students feel engaged are competitive interaction, in-time feedback on the answers, ranking with peers, and leaderboard right after each polling question. The survey data also addressed whether the leaderboard caused any negative feelings. 93% of the students did not feel upset with the leaderboard, 7% were neutral, and no students indicated that the leaderboard made them feel upset. Further analysis of the interview results is presented in this paper to discuss the effect of competitive polling on students' interest, motivation, and learning outcomes.

Additionally, competitive polling was implemented as part of the classwork activities in this course. To encourage participation and motivate students to do their best on the polling questions, the classwork rubric was designed to award a full score of 5 points for participation, with an extra 1 bonus point given to students who ranked in the top 50% of the participants. The effectiveness of this rubric in fostering active participation and encouraging greater effort on the polling questions is also discussed in this paper.

Introduction

Student engagement has been recognized as an essential factor in promoting academic achievement [1] and has gained a lot of research interest [2]. Gamification is one of the popular approaches to student engagement and can be described as the incorporation of game design elements into nongame environments to engage individuals and promote desired behaviors [3, 4]. Computer-based technologies are widely involved to support gamification in education [5].

Polling has been increasingly used in higher education to promote active learning and increase

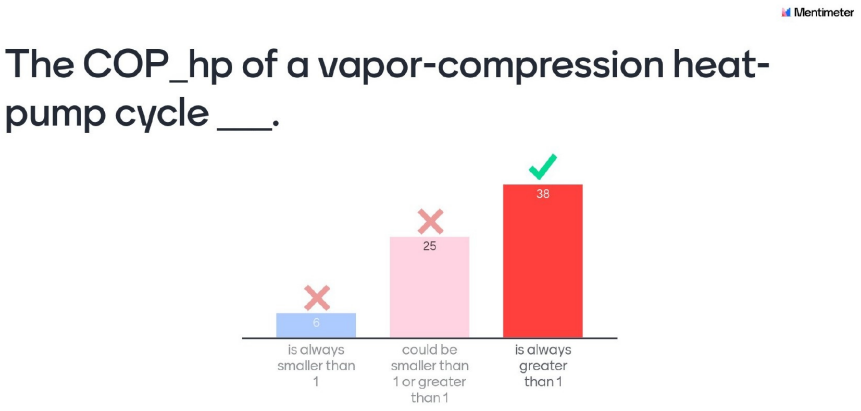
participation, especially in a class with a large student enrollment [6]. Modern web-based tools, such as Mentimeter, Kahoot, Quizizz, etc., offer competitive polling that creates a gamified environment and has recently been incorporated into classroom activities to enhance student engagement and learning outcomes. These tools also attracted the interest of higher education in their teaching practice [7, 8, 9].

However, competitive elements may not always enhance the motivation for participation regarding student engagement. Albert Bandura's motivation theory highlighted self-efficacy and its impact on motivation [10]. Some competitive element settings may undermine self-efficacy, leading to decreased motivation. Studies also show that the introduction of gamification in a classroom may not always benefit students' learning outcomes [11]. The effect of gamification on learning outcomes needs to be further investigated.

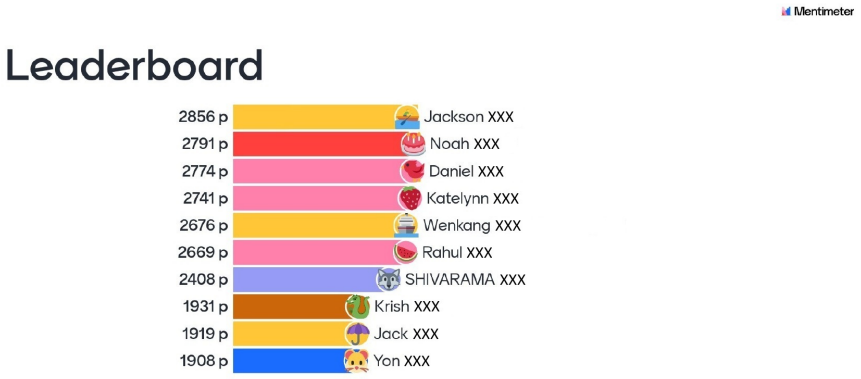
In this study, the Mentimeter Quiz Competition was used to conduct competitive polling in a class of a traditional mechanical engineering course, Energy Conversion Systems. This paper presents a brief description of the typical questions, implementation, and grading rubric of competitive polling as a classwork learning activity, followed by an introduction to the research method that includes surveys and interviews to collect the students' feedback. The results of surveys and interviews are presented and discussed with a focus on student engagement and learning outcomes. The effectiveness of the grading rubric in fostering active participation and encouraging greater effort on the polling questions is also discussed.

Classwork of Competitive Polling

Competitive polling was used as one type of classwork in the course Energy Conversion Systems. Around half of the lectures conducted the competitive polling classwork. Most of the questions in competitive polling are conceptual questions, while some questions involve quantitative calculations. Students are allowed to discuss and exchange their ideas with their classmates when working on the polling questions. The competitive polling user interface is shown in Figure 1. Students can either use a browser on their mobile devices to enter menti.com and the use code or scan the QR code to access the interactive presentation for participation. Students are required to use their real names to participate in the competitive polling since the classwork points will be assigned based on the students' responses. Students must complete answering each question within a designated duration. Then, the answers are displayed with a column chart illustrating the distribution of participants' choices for each multiple-choice question, as shown in Figure 1(a). This is immediately followed by a leaderboard, Figure 1(b), showing the scores, rankings, and names of the top 10 participants. The scores and rankings are cumulative for all the questions completed. To protect the students' privacy, the students' last names have been replaced by XXX in Figure 1(b). The instructor can access the details of performance, e.g., answers and scores, of all participants through a Microsoft Excel spreadsheet provided by the Mentimeter tool. "More points for fast correct answers" was enabled for all the polling questions, which means that the participants are rewarded between 1000 and 500 points for a correct answer, depending on how quickly they submit their response; zero points are assigned to incorrect answers. Incorporating the speed of answering questions into the scoring process aims to enhance the gamification aspect of competitive polling for boosting student engagement and also to facilitate the ranking of participants.



(a) Polling question and results



(b) Leaderboard

Figure 1: User interface of competitive polling.

To encourage participation and motivate students to do their best in the competitive polling questions, the classwork rubric was designed to award a full score of 5 points for participation, with an extra 1 bonus point given to students who ranked in the top 50% of the participants.

Methods

This study has employed a mixed-methods approach, i.e., survey plus interview, to seek how competitive polling impacts student engagement and learning outcomes in a mechanical engineering classroom. The survey instrument was designed with the following questions to assess student perceptions of in-class engagement during the competitive polling activities.

- Does the competitive polling make me engaged in class?
- In what ways does the competitive polling make you feel engaged?

- Does the leaderboard showing the rank of the top 10 participants make me upset?
- Compared to the traditional polling questions without participant ranking, the competitive polling with participant ranking makes me more engaged in class. Please rate your response from 1 to 5, with 1 for "No, I strongly disagree" and 5 for "Yes, I strongly agree".

The survey is optional for students, while they can earn extra homework points through participation. The Energy Conversion Systems class has an enrollment of 77 students, and 71 students completed the survey.

Semi-structured interviews were conducted to explore the effect of competitive polling on students' interest, motivation, and learning outcomes. The interviews provide an opportunity to explore students' experiences and feelings about competitive polling through in-depth conversations. The typical questions in the interviews are as follows.

- How would you describe your overall experience with competitive polling in this course?
- Did competitive polling increase your interest in the course content? And how?
- How did the competitive aspect of the polls affect your motivation to participate?
- Do you think competitive polling changed how much effort you put into learning the course content? And how?
- How did you feel about the leaderboards and rankings displayed after each polling question? And why?
- Did the rubric for the competitive polling motivate you to put more effort into answering the polling questions correctly? Why or why not?

7 students, including 1 female and 6 males, volunteered to participate in the interview and were interviewed.

Results and Discussion

Survey Results and Discussion

Table 1 presents the student demographic data. Male and undergraduate students make up the majority of both class enrollment and survey participants.

As shown in Figure 2, 90% of the participants voted for "4" or "5", 10% voted for "3", and no one

Table 1: Student demographic data of class enrollment and survey participants.

	Class Enrollment	Survey Participants
Total	77 (100%)	71 (100%)
Female	11 (14%)	11 (15%)
Male	66 (86%)	60 (85%)
Undergraduate Student	68 (88%)	63 (89%)
Graduate Student	9 (12%)	8 (11%)

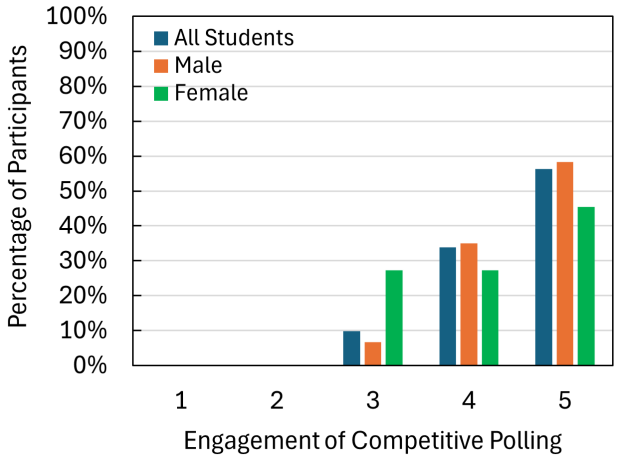


Figure 2: Does the competitive polling make me engaged in class? Please rate your response from 1 to 5, with 1 for "No, not at all" and 5 for "Yes, very much".

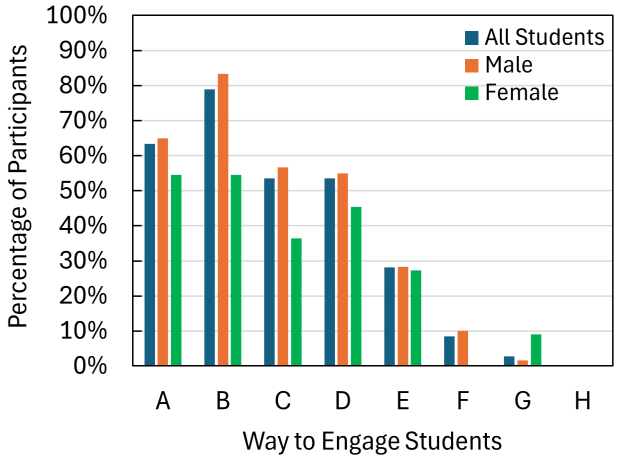


Figure 3: The ways in which the competitive polling makes students feel engaged. A: In-time feedback on the answers. B: Competitive interaction. C: Ranking with peers. D: Leaderboard right after each question. E: Cumulative grades. F: The look of the slides. G: Others. H: The competitive polling does not make me engaged in class.

voted for "1" or "2", which indicates that most of the students agreed that the competitive polling made them engaged in class. Especially, 56% of the participants addressed that the competitive polling made them engaged in class very much. In order to explore the reasons why the competitive polling made students engaged, several optional reasons were provided, and students were allowed to select all items that apply. The results are shown in Figure 3. The option of "Competitive interaction" received the most votes (79%) and was recognized as the most significant element for student engagement. Competitive interaction is one of the characteristics of gamification pedagogies and can considerably contribute to student engagement when gamification pedagogies are applied in teaching practice. The options of "Ranking with peers"

and “Leaderboard right after each question” are the specific format in which the competitive element is presented; they are part of the competitive interaction, and also received relatively high votes, 54% for each. The second recognized reason for student engagement is “In-time feedback on the answers” (63%), which lets students immediately know if they answered the questions correctly. In-time feedback on the answers is not a unique feature of competitive polling, since traditional polling generally also has this function.

When competition is introduced to teaching practice, there are concerns about the negative perception of students. For instance, does the competition cause students’ negative emotions followed by adverse impacts on learning outcomes? To investigate the students’ perception of the competitive interaction, the question, “Does the leaderboard showing the rank of the top 10 participants make me upset” was included in the survey. The leaderboard was addressed in this context because the authors believe it might be the primary factor contributing to students’ negative emotion. As shown in Figure 4, 93% of the participants voted for “1” or “2”, 7% voted for “3”, and no votes were made for “4” or “5”. The data in Figure 4 indicate that the leaderboard does not make the participants upset. Similar questions were also included in the interviews to further explore the underlying reasons. More discussion will be presented in the following section of Interview Summary.

Figures 5 and 6 show the comparison between competitive polling and traditional polling without a competitive element. 89% of the participants agreed or strongly agreed that compared to traditional polling questions without participant ranking, competitive polling made them more engaged. 8% were neutral and 3% voted for disagreement. 86% of the participants selected “the competitive polling makes me more engaged in class” as the reason why they liked the competitive polling more than the traditional ones. 34% voted for “I don’t need to pay for the participation in the competitive polling” as the reason. The tool Mentimeter, used for competitive polling, requires a subscription of the instructor; however, participation is completely free of charge. The iClicker widely used for traditional polling in our institution requires a subscription

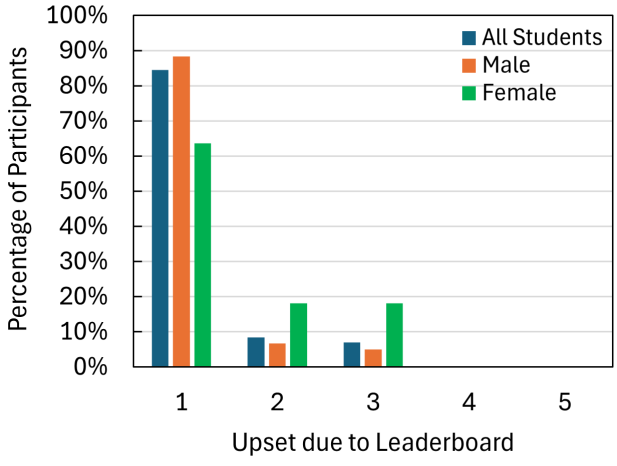


Figure 4: Does the leaderboard showing the rank of the top 10 participants make me upset? Please rate your response from 1 to 5, with 1 for “No, not at all” and 5 for “Yes, very much”.

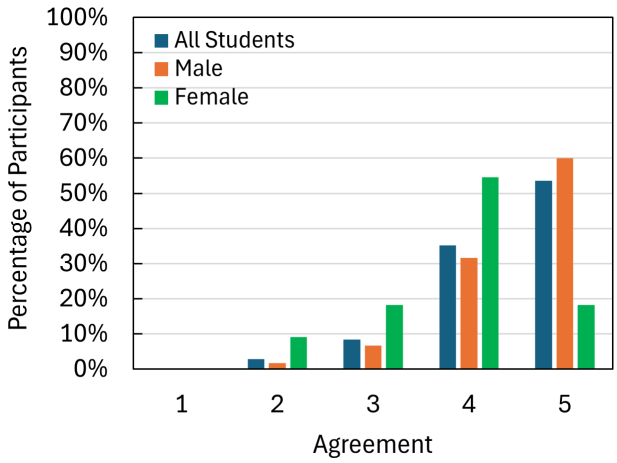


Figure 5: Compared to the traditional polling questions without participant ranking, the competitive polling with participant ranking makes me more engaged in class. Please rate your response from 1 to 5 with, 1 for "No, I strongly disagree" and 5 for "Yes, I strongly agree".

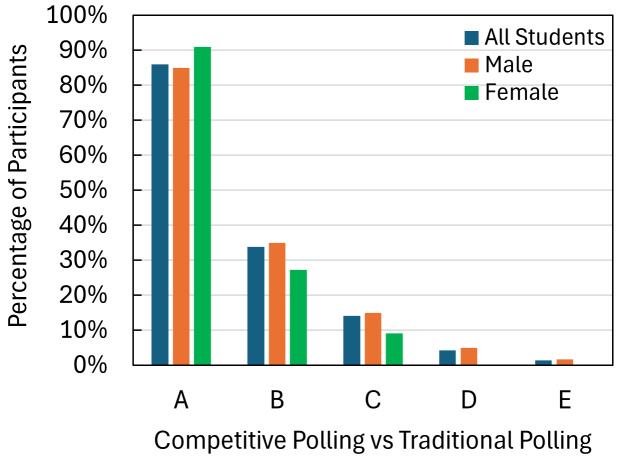


Figure 6: Please check all the items that you agree upon regarding competitive polling and traditional polling. A. I like the competitive polling with participant ranking more than the traditional polling questions without participant ranking because the competitive polling makes me more engaged in class. B. I like the competitive polling with participant ranking more than the traditional polling questions without participant ranking because I don't need to pay for the participation in the competitive polling. C. I like the competitive polling with participant ranking more than the traditional polling questions without participant ranking for other reasons. D. I like the traditional polling questions without participant ranking more than the competitive polling with participant ranking. E. I don't like both the competitive polling with participant ranking and the traditional polling questions without participant ranking.

of the iClicker app by participants, or students can purchase a physical remote to participate in iClicker polling without a subscription. In addition, both Figures 5 and 6 indicate that competitive polling was not favored by a small percentage of students (less than 5%). As indicated in the responses to the open-ended question of "other comments and suggestions", these students believed that the speed of answering polling questions should not factor into scoring and ranking.

To examine the impact of gender on responses to survey questions about competitive polling, the data for all students are broken down into two groups: male and female, which are also presented in Figures 2 through 6. The results reveal some differences in responses between male and female students; however, both groups follow the same overall trend. It is also worth noting that the number of female participants is only 11, which is a small sample size. This limitation may result in less representative findings for female students.

Interview Summary

Across the seven interviews, seven overlapping themes emerged:

1. The competitive element is a significant motivator for student engagement. The desire to win a competition and the sense of satisfaction of appearing on the leaderboard and being recognized by peers drive students to participate in competitive polling. The peer effects [12] are another factor that encourages active participation of students in class.
2. The competitive polling increases the interest of students in the course in an indirect way. Competitive polling does not make course content interesting; however, it helps students master course materials. The sense of mastery leads to the students' feeling of satisfaction that persuades students to come to lectures and to make efforts on assignments.
3. The competitive polling improved students' learning outcomes. The major reasons are: (1) The competitive element fosters a desire to participate in the competitive polling classwork, replacing the sense of being forced to work on the assignments. In their drive to do well and win, students pay closer attention to the lectures and even preview the course content before classes. (2) The feedback right after each polling question allows students to know their mistakes immediately and learn from the mistakes.
4. The leaderboard showing the scores, rankings, and names of the top 10 participants does not cause students upset for a class with a large enrollment, since the students who cannot reach the leaderboard are considerably more than the 10 students on the leaderboard.
5. Although the leaderboard significantly engages students, they may start answering the polling questions less seriously if they make mistakes and feel that they cannot make it onto the leaderboard. This aligns with the motivation theory regarding self-efficacy [10].
6. Conceptual questions are preferred in competitive polling. Three to five questions should be sufficient for competitive polling classwork. Too many questions may tire students and reduce their engagement.
7. The grading rubric for a low-stakes assessment with extra bonus points creates the student perception that participating in competitive polling will not result in any loss, and they may

even receive bonus points. This perception encourages students to participate in competitive polling and motivates them to put in the effort to perform well.

Some examples from the interviews to illustrate these findings are presented as follows.

- An interviewee shared that he had a strong desire to win a competition. He wanted to appear on the leaderboard for his peers to see, which gave him a sense of accomplishment, satisfaction, and happiness. The competitive element of competitive polling is the most significant reason for him to be engaged. He did not think that competitive polling made the course content interesting. However, he believed that competitive polling improved his learning outcomes, and this improvement gave him a sense of mastery of the course content, making the materials feel less challenging. As a result, his interest in this course naturally increased.
- An interviewee considered competitive polling a fun part of a day. When he saw his peers could answer the polling questions correctly while he could not, it lit a fire and made him put more effort into the course content. He sometimes previewed the course materials, hoping it helped him win the Mintimeter game. He believed that these were how competitive polling improved his learning outcomes.
- An interviewee described competitive polling as a double-edged sword. If he did well in the first several questions, he would be excited and would want to continue doing well in the following questions, and he would be very serious in answering questions. However, if he made some mistakes, he felt that he could not reach the leaderboard, so he started to take it less seriously. Despite the double-edged sword, he still believed that participating in competitive polling was like playing a game that persuaded him to go to lectures. He liked the interaction during competitive polling and emphasized that seeing peers make comments or do the reasoning was very fun. Additionally, he could see the students' names on the leaderboard, and the instructor also identified the top 3 students in class. All of these things made him better know his classmates, feel closer to them, and like to attend lecture meetings.
- Another interviewee mentioned that the format and rubric made the competitive polling a formative and low-stakes quiz, so the stress was low for her, and she could pay more attention to the course content instead of the quiz. The stress might increase when she saw her name on the leaderboard and wanted to remain on the leaderboard. She liked the rubric that made competitive polling a low-stakes quiz. Participation will not make students lose anything; instead, if students rank in the top 50%, they can get an extra 1 point, just as they can get an extra bonus. This made her feel good, more willing and confident to participate in competitive polling.

However, the interviews also revealed the diversity in the preference regarding competitive polling. For instance, a student said that knowing there might be a competitive polling classwork at the end of class made him focus on the lecture throughout the session. However, another student preferred the competitive polling in the middle of a class. He believed that the competitive polling in the middle of a class gave him a chance to breathe, refresh his mind, and reset his attention to the lecture. Another example is about the comparison between Mentimeter competitive polling and iClicker traditional polling. Although most of the interviewees clearly

showed their preference for the competitive polling due to enhanced engagement, one student pointed out that the iClicker polling scored each question separately and did not show the cumulative grade and ranking after each question. This scoring strategy reduced the adverse effect of the mistakes made in the previous questions on his motivation to answer the subsequent questions.

In addition, a student shared that he did not read as quickly as his peers and believed that his reading speed limited his performance in competitive polling, preventing him from making it onto the leaderboard. This prompted the authors to reconsider the grading and ranking policy of competitive polling, which awards "more points for fast correct answers", through the lens of motivation theory, particularly in relation to self-efficacy. It also highlighted the need for improvements to ensure equity and inclusion for students who may not read quickly.

Conclusion

Competitive polling was applied as classwork in a traditional mechanical engineering course, Energy Conversion Systems, to enhance student engagement and learning outcomes. A mixed-methods approach was employed, incorporating a survey to assess student perceptions of in-class engagement during competitive polling activities and semi-structured interviews to explore the effect on student interest, motivation, and learning outcomes. The survey and interview results indicate:

- Competitive polling can strongly engage students in class. The competitive interaction is the most significant way for engagement, and the in-time feedback on the answers is the second recognized way. The peer effects are also highlighted for student engagement.
- Compared to traditional polling, the competitive interaction and no cost on the participant side are the main reasons why competitive polling is preferred by students.
- Students believe that competitive polling helps to improve their learning outcomes.
- The leaderboard showing the scores, rankings, and names of the top 10 participants does not make students upset for a class with a large enrollment, i.e., considerably more than 10 students. However, such a leaderboard might cause severe stress for a class with a small enrollment, e.g., a class with the number of students close to or less than 10.
- Although the leaderboard significantly engages students, they may start answering the polling questions less seriously if they make mistakes and feel that they cannot make it onto the leaderboard.
- Conceptual questions are preferred in competitive polling. Three to five questions should be sufficient for competitive polling classwork.
- Competitive polling can be used in the middle of a class to break a long lecture or be conducted at the end of a class as an assessment of the whole session. Instructors may set up the competitive polling classwork in a way that matches the needs of a specific class.
- The grading and ranking policy of competitive polling, which awards "more points for fast correct answers", needs to be reviewed and improved to ensure equity and inclusion for

students who may not read quickly.

- A low-stakes assessment with extra bonus points is an effective way to encourage students to participate in competitive polling and motivates them to strive for good performance.

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