# From top to bottom: How positions on different types of leaderboard may affect fully online student learning performance, intrinsic motivation, and course engagement

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## 1. Introduction

Since the outbreak of the COVID-19 pandemic, many institutions have been using fully online learning, which uses the Internet as the delivery mechanism. Yet, fully online teaching is often seen as a weaker option (Hodges et al., 2020), and is less satisfying (Wang et al., 2019) because it lacks student engagement (Starr-Glass, 2020) compared to in-person courses. No instructor enjoys finding students staring blankly or swiping phones during online classes. Students who are engaged in a course (e.g., complete all course activities) are more likely to achieve satisfactory learning performance (Appleton et al., 2008). Therefore, the important question is how to engage students in online classes. To address this issue, some scholars have been inspired by the game industry to incorporate

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game elements into non-game environments. The aim of gamification is to generate the same thrilling experience as if playing games in non-game contexts to stimulate user engagement (Alhammad and Moreno, 2018). Gamification in educational contexts refers to the process of applying game elements such as leaderboards to motivate learners to participate more actively in course activities (Educause, 2011). Interests in gamification is still going strong with recent research examining its use in various settings including computer science in higher education (Marín et al., 2018) and formative assessment (Zainuddin et al., 2020).

Yet, despite the interest in gamification, evidence of its ability to enhance student learning performance is mixed (Dichev & Dicheva, 2017), and is not fully understood (Sanchez et al., 2019). Gamification has also received much criticism, such as 'gamification is bullshit' (Bogost, 2011), and 'the dark side of gamification' (Toda et al., 2018). Two meta-analyses have systematically synthesised the findings of research on the effects of gamification on students' learning performance. The results reveal small to medium-sized positive effects of gamification ($g$ = 0.49 and 0.50) compared with learning without gamification (Bai et al., 2020; Sailer & Homner, 2020). However, several researchers have argued that gamification itself does not guarantee better learning outcomes; rather, how game elements are used determines performance (Hanus & Fox, 2015).

### *1.1. Purpose of the present study*

Previous research on gamified education typically examined a *combination* of various game elements (Bai et al., 2020). However, to gain a better understanding of gamification, the effects of *individual*, rather than multiple game elements, should be studied because this allows for an unconfounded examination of game elements (Deterding, 2012). Studying the effects of individual game elements on user outcomes such as learning performance, motivation, and engagement can provide a more nuanced understanding of how particular game elements function in a given context (Mekler et al., 2017). This can provide educators with more informed decisions on how individual game elements, such as leaderboards, should or should not be implemented. Unfortunately, few studies to date have attempted to experimentally examine the effects of individual game elements on motivation and performance; hence, the urgent need calls for more such research (Mekler et al., 2017).

In this study, we focused on the use of leaderboards. A leaderboard is one of the most commonly used game elements to measure how an individual performs in comparison with others (Zichermann & Cunningham, 2011). More specifically, we examined how positions on an absolute or a relative leaderboard may affect fully online students' learning performance, course engagement, intrinsic motivation, and perception. Learning performance is defined as students' overall learning outcomes in a course (e.g., final course marks). Course engagement measures how actively a student responds to learning materials and activities in a course (Handelsman et al., 2005). Intrinsic motivation refers to people performing actions for inherent satisfaction; they are motivated by the fun or challenging nature of a task rather than external rewards or pressures (Ryan & Deci, 2000). We addressed the following two research questions in this study:

**Research question 1**: How do different positions on an absolute (or a relative) leaderboard affect students' learning performance, intrinsic motivation, and course engagement in a gamified class?
**Research question 2**: How do students perceive the use of an absolute (or a relative) leaderboard?

## 2. Related literature

Social comparison is one of the most pervasive traits of human social life. People have the tendency to look at other individuals as comparison standards to evaluate themselves (Baldwin & Mussweiler, 2018). More specifically, people have an innate drive to improve their performance and reduce the discrepancies between their own and other individuals' level of performance (Garcia et al., 2013). A leaderboard is a high-score table that displays the performance of a user compared with others (Christy & Fox, 2014; Höllig et al., 2020). The publicly visible positions on a leaderboard earned by different users could serve as social markers (Hamari et al., 2014) to elicit comparisons between people (Huang & Hew, 2018). Leaderboards facilitate such comparison by displaying players' ranking positions (Costa et al., 2013). The ranking position on a leaderboard is commonly viewed as an indicator of a user's reputation and may serve as a mechanism to increase the engagement of participants (Schlömmer et al., 2021).

As mentioned previously, extant research on gamified education has primarily examined a mixture of various game elements rather than on an individual element. Leaderboards were frequently examined in combination with other game elements (e.g., badges) (Bai et al., 2020). The few previous studies that focused specifically on leaderboards have typically investigated whether students' learning outcomes (e.g., learning performance, motivation) improve in the presence versus the absence of a leaderboard (e.g., Ćwil, 2020; Landers et al., 2017; Landers & Landers, 2014; Mekler et al., 2017). Empirical evidence of its effectiveness, however, is mixed, with some studies reporting positive effects from using leaderboards, while others showing no effects (Höllig et al., 2020). For example, several studies indicated positive effects from the use of leaderboards (Christy & Fox, 2014; Landers et al., 2017; Landers & Landers, 2014), while others show no, mixed, or negative effects (Mekler et al., 2017; Mollick & Rothbard, 2014; Zuckerman & Gal-Oz, 2014). Some studies offer the possibility of user characteristics as a potential cause. For example, Jia et al. (2017) found that more extraverted people report more positive experiences with leaderboards, regardless of the domain in which the leaderboards were employed.

Another possible reason for the inconclusive findings may be due to the types of leaderboard used in the previous studies. According to Zichermann and Cunningham (2011), leaderboards can be classified into two types: infinite leaderboards (also referred to as absolute leaderboards) and no-disincentive leaderboards (also referred to as relative leaderboards). Absolute leaderboards display the literal positions of all players and are frequently used in educational settings (e.g., Jong et al., 2018; Tsay et al., 2018; Özdener, 2018). Every participant can view every other person's position on an absolute leaderboard; therefore, participants at the top of the

leaderboard may experience a greater sense of achievement than those at the bottom do (Ortiz-Rojas et al., 2019). The relative leaderboard, in contrast, does not reveal the positions of every participant. Users can only see their positions relative to neighbours below and above them, which potentially reduces discouragement or frustration amongst lower-ranked participants (Ortiz-Rojas et al., 2019). However, whether this is sufficient to actually encourage participants is an open question (Pedersen et al., 2017). In addition, little attention has been paid to how different positions on different types of leaderboards may affect users' performance, intrinsic motivation, engagement and perception, especially in educational contexts. Thus, our study is necessary and timely to help answer these questions in the educational field.

### 2.1. Hypotheses

Research has suggested that *proximity to a standard* is an important variable that can affect the degree of competition in upward comparison with others (Garcia & Tor, 2007; Garcia et al., 2006). As a user gets closer to a standard (e.g., the top ranking in a leaderboard), the degree of competition increases, and this proximity to the standard directly impacts how users value the importance of doing well (Garcia et al., 2006). An absolute leaderboard makes the users more easily perceive how far they are from the standard (i.e., the top ranking). As a result, top-ranked users are likely to be more motivated, as they feel they are close to this standard. In contrast, lower-ranked users perceive a great distance to the top ranking, which may undermine their motivation (Ninaus et al., 2020). Regarding the relative leaderboard, all participants (top-, middle- and bottom-ranked users) feel they are close to the standard, because they can only compare themselves with a few users who are below and above them. Hence, we formulate the following hypotheses:

**H1a**. Top-ranked learners on an absolute leaderboard are more intrinsically motivated than the low-ranked learners.

**H1b**. Learners on a relative leaderboard demonstrate an equal level of intrinsic motivation.

Intrinsic motivation has been shown to be a good predictor of student overall course engagement (Handelsman et al., 2005; Skinner et al., 2008). Accordingly, we deduce the following hypotheses:

**H2a**. Top-ranked learners on an absolute leaderboard demonstrate a higher course engagement level than lower-ranked learners.

**H2b**. Learners on a relative leaderboard demonstrate an equal level of course engagement.

Garcia and Tor (2007) study showed that when participants were not informed of explicit ranking information, they became more cooperative and less competitive. When the threat of explicit comparison (i.e., exact ranking position) is removed in the relative leaderboard, students will not realize the gap between top rankers and themselves and tend to be content with where they are. Consequently, they may not exert extra effort to catch up with the top rankers. In the absolute leaderboard, however, all students may work hard to reach the top ranking, which may likely contribute to their learning performance (King et al., 2010). Hence, we posit that:

**H3a**. Learners on an absolute leaderboard perform equally well in learning performance.

**H3b**. Low-ranked learners on a relative leaderboard perform worse than higher-ranked learners in learning.

## 3. Method

The aim of current study is to understand how students at different positions differ in learning performance, intrinsic motivation, course engagement and perception by use of an absolute (or a relative) leaderboard. Therefore, we conducted two quasi-experiments (Study 1 and Study 2) to address the two research questions mentioned in the introduction. Study 1 ($N = 24$ students) applied an absolute leaderboard in an online postgraduate course about "Engaging Adult Learners" (course duration: one semester, 10 weeks) during the first semester of 2020 at a large public university in East Asia. Study 2 ($N = 26$ students) used a relative leaderboard in another online postgraduate course on "E-learning Management" (course length: one semester, 10 weeks) during the first semester of 2020 at the same university. We conducted these two studies during COVID-19 pandemic period via a fully online synchronous teaching mode. All sessions in the two courses were delivered by a Web videoconferencing service called Zoom.

In this study, we did not make a direct comparison between the two types of leaderboards but compared students' performance and engagement at different positions under the use of one type of leaderboard. The two different courses were taught by different instructors. The two courses were both fully online postgraduate courses, administered in the same university during the spring semester of 2020. Both courses ran from January to April 2022. The students shared the same interest (i.e., interested in the use of technology to enhance learning) in the two courses, as they were in the same master program. The two courses were both elective courses without prerequisite requirements on students' enrolment. A large majority of the participants in two courses did not know each other; only three students (out of a total of 50 students) took both courses at the same time.

Ethical approval to conduct the study was issued by the first author's university. All the participants signed forms giving their consent to participate in the study. To preserve the respondents' privacy, a code number was used to identify each of them. Only one researcher had access to the list of names and codes.

### 3.1. Measures in study 1 and study 2

The same data collection process was used in the two studies. Depending on the students' positions on the leaderboards at the end of the course semester, they were allocated to the top third, middle third, and bottom third ranked groups in the relative and absolute

leaderboard studies.

To measure students' learning performance, a pre-test and post-test design was used. The independent variables in the study were: students' rankings in the leaderbord (top ranks, middle ranks, bottom ranks). The dependent variables were students' learning performance, intrinsic motivation, course engagement, and overall perceptions of the used leaderboard (absolute or relative leaderboard).

A pre-test containing seven short essay questions was conducted to examine the initial differences in the students' prior knowledge. Next, the students' final course grades were used to measure their learning performance. The maximum grade for the two courses was 100.

Students' intrinsic motivation was measured and compared three times (i.e., pre-test, mid-term, post-test) using the interest/enjoyment subscale of the Intrinsic Motivation Inventory (IMI, Ryan, 1982). In this study, we used all seven items from the interest/enjoyment subscale of IMI to measure the students' intrinsic motivation in a gamified class at three stages: (a) pre-intervention, (b) mid-term, and (c) post-intervention stages. An example of the interest/enjoyment item is "*I enjoyed doing this activity very much*". The Cronbach's α is 0.92, 0.92 and 0.87 for pre-intervention, mid-term, and post-intervention measures in the absolute leaderboard study; the Cronbach's α is 0.88, 0.89, 0.91 for pre-intervention, mid-term, and post-intervention measures in the relative leaderboard study.

The Student Course Engagement Questionnaire (SCEQ) proposed by (Handelsman et al., 2005) was conducted to evaluate student engagement in a particular course. We used all 23 items in the questionnaire to measure the four dimensions of course engagement: *skill engagement* (sample item: *Looking over class notes between classes to make sure I understand the material*), *participation/interaction engagement* (sample item: *Asking questions when I don't understand the instructor*), *emotional engagement* (sample item: *Really desiring to learn the material*), and *performance engagement* (sample item: *Getting a good grade*) (Handelsman et al., 2005). The overall internal data structure is congruent with the behavioural and affective constructs of engagement (Herrmann, 2013). The behavioural component depicts students' motives to achieve performance goals rather than mastery learning goals. Performance engagement is related to skill engagement, which focuses on students' learning strategies to deal with difficulties, whereas the affective component describes students' emotional involvement with class materials (emotional engagement) and their willingness to interact with others (participation/interaction engagement) (Handelsman et al., 2005). The SCEQ gives an easily conducted but comprehensive snapshot of student engagement (Handelsman et al., 2005). The Cronbach's α is 0.91 in the absolute leaderboard study and 0.92 in the relative leaderboard study.

To understand students' learning experience and overall perception of the leaderboards used, one open-ended survey (see Appendix 1) was sent out to the participants in the two quasi-experiments, and the overall response rate was 100 %. The open-ended surveys were filled by respondents themselves electronically using a computer at home after the last session of each course. They were given one week to fill the surveys. When the responders answer the questions without the presence of the researchers, it makes the respondent feel more at ease and more willing to provide honest answers when sensitive questions are asked (Leeuw et al., 2008).

A thematic analysis approach was applied to the qualitative data responses. Relevant themes were developed via four stages: initialisation, construction, rectification, and finalisation (Vaismoradi et al., 2016). First, we highlighted meaningful units and coded for abstraction of the original responses. Second, the organised units were classified and compared to uncover repeated patterns. Third, all refined themes were examined and put through another round of group discussion between coders. Finally, a narrative describing the attributes of the finalised themes was developed. We came up with primary themes and sub-themes as divisions to provide a comprehensive description of the data. Two coders conducted the qualitative data analysis and achieved an overall agreement of 82 %. Discrepancies and unmatched coding were resolved via full discussion.

### *3.2. Setting up the leaderboards*

We managed all the online learning materials and activities on Moodle and inserted a plugin called 'Level Up' to set up the two types of leaderboard (Sinnott & Xia, 2020). This plugin logged the students' real-time activity results on Moodle. The students could earn points in line with the points-adding rules, which were pre-specified by the course instructors. The accumulated points determined their positions on the leaderboards. The students could earn points when they completed an online learning activity (see Appendix 2 for details). Jia et al. (2017) suggests that users' perception of a leaderboard is influenced by the perceived fairness, or the rules that determine users' position on the leaderboard. Therefore, we explicitly announced the rules to participants before the intervention in striving to support the users' perceived fairness. The students were not informed of the maximum points that they could earn. The maximum points we assigned in the system were 8,000 points. The points were given in the gamification with the primary aim of motivating students to actively participate in online activities, which include submitting assignments, and actively participating the online disucssion forums. However, these points did not count in the students' final course grades.

Small, specific, and easy-to-achieve activities can help build students' self-efficacy and enhance their goal-setting commitment (Landers et al., 2015; Locke & Latham, 1990). Higher values were reserved for challenging, albeit still attainable tasks that required greater effort and attention (Latham & Steele, 1983), such as *complete all pre- and post-class activities*. We awarded more points for the completion of pre-class activities than post-class ones because we wanted to encourage the students to come prepared in the online class meetings.

### *3.3. Study 1: Absolute leaderboard*

#### *3.3.1. Participants*

This study involved 24 postgraduate students (22 females, two males) in a course entitled "Engaging Adult Learners". The participants' ages ranged from 22 to 30 years ($M = 24.45$, $SD = 2.26$).

### 3.3.2. Absolute ranking setting

Fig. 1 presents the interface of the absolute leaderboard on Moodle. The following information was accessible through the accounts of all students in the class: a) positions on the leaderboard, b) profile photos, c) students' names, d) total collected points.

## 3.4. Study 2: Relative leaderboard

### 3.4.1. Participants

The study involved 26 postgraduate students (24 females, two males) in a course entitled "E-Learning Management". The participants' ages ranged from 22 to 32 years ($M = 24.42$, $SD = 2.\ 65$). All final sample ($N = 26$) reported their ethnicity as East Asian.

### 3.4.2. Relative leaderboard setting

This section presents the interface of the relative leaderboard on Moodle. Five neighbours were displayed on the leaderboard. On the left-hand side of Fig. 2, the differences in points between a participant and neighbours are presented. As shown on the right-hand side, the participant could view five neighbours' a) relative position, b) profile photo, c) student name, and d) total collected points.

# 4. Results

## 4.1. Absolute leaderboard results

### 4.1.1. Effect on intrinsic motivation

As previously mentioned, students' intrinsic motivation was measured three times: pre-intervention, mid-term, and post-intervention (Table 1). The response rates for the first, second, and third measurements were 87.5 % (21 out of 24), 75 % (18 out of 24), and 100 %.

We have earlier hypothesized that top-ranked learners on an absolute leaderboard are more intrinsically motivated than the lower-ranked learners. To determine whether the three position levels statistically affected student intrinsic, motivation, ANOVAs were conducted for the first two measurements (pre-intervention, and mid-term). Results showed no significant effects on student intrinsic motivation were found across the three position levels at the pre-intervention stage, $F\,(2, 18) = 0.85$, $p = .45$, or the mid-term stage, $F\,(2, 15) = 1.71$, $p = .21$. Next, a non-parametric Kruskal-Wallis test was used for the post-intervention measurement. The result showed a significant impact on student intrinsic motivation at the post-intervention stage, $H\,(2) = 6.55$, $p = .038$.

Additionally, Mann-Whitney U-tests were conducted to examine the source of variation based on pairwise comparison. A significant difference was found in favour of the top-ranked students compared with the bottom third students in the post-intervention measurement ($U = 11$, $p = .028$), which is in line with our hypothesis ($H1_a$).

Fig. 3 presents a bar chart with student intrinsic motivation means across the three position levels at the post-intervention stage. It is obvious that the average intrinsic motivation of the top third surpassed the mean of the bottom third group. The means of the top third and middle third did not differ significantly from each other ($U = 19.5$, $p = .195$). The means of the middle third and bottom third did not differ significantly from each other ($U = 15$, $p = .083$).

### 4.1.2. Effect on student course engagement

Descriptively, the middle-ranked students were most engaged with the course ($M = 4.18$ $SD = 0.42$), and the top-ranked students

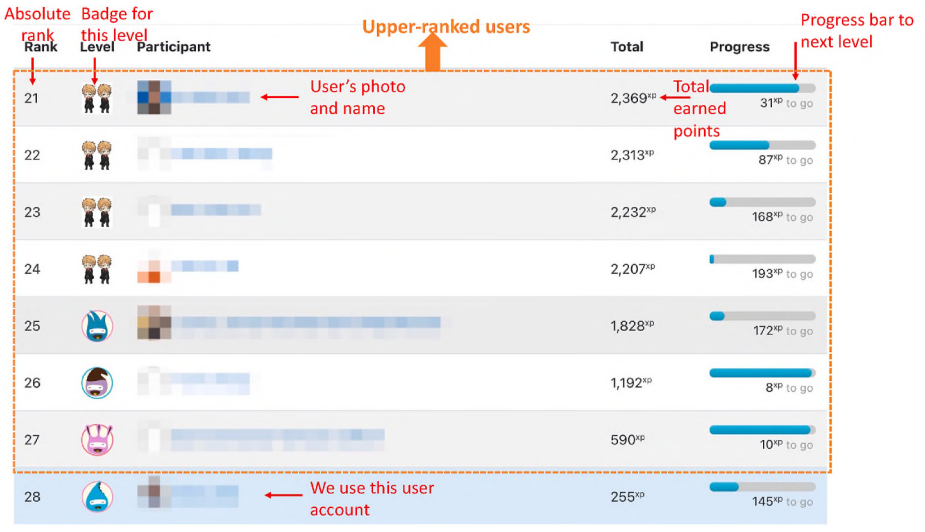


**Fig. 1.** Interface of the absolute leaderboard (displaying everyone).

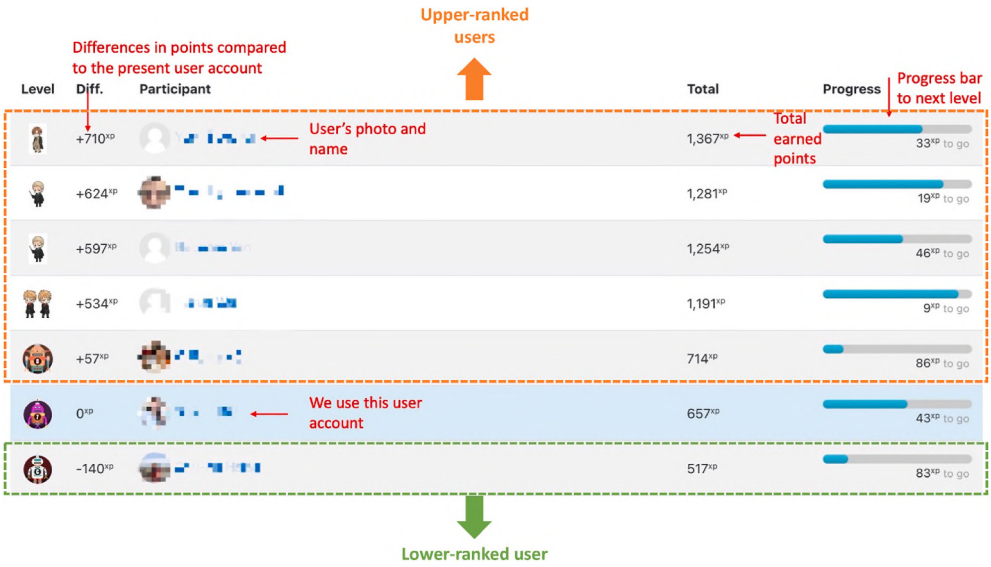


**Fig. 2.** Interface of the relative leaderboard (displaying five immediate neighbours). *Note.* The present user was listed second to the last, so there is only one lower ranked user shown on this student account.

**Table 1**
Student intrinsic motivation to learn, course engagement and learning performance across three levels of position on the absolute leaderboard (learning performance: 100 full mark; intrinsic motivation: 7-point scale, very true – not at all true; course engagement: 5-point scale, not at all characteristic of me – very characteristic of me).

| Variable | Stage | Position level | N | Mean | SD |
|---|---|---|---|---|---|
| Intrinsic motivation | Pre-intervention | Top third | 8 | 5.2 | 0.66 |
| | | Middle third | 7 | 4.67 | 1.14 |
| | | Bottom third | 6 | 4.67 | 0.86 |
| | | Total | 21 | 4.87 | 0.89 |
| | Mid-term | Top third | 7 | 5.18 | 0.49 |
| | | Middle third | 6 | 5.57 | 0.92 |
| | | Bottom third | 5 | 4.63 | 1.11 |
| | | Total | 18 | 5.16 | 0.88 |
| | Post-intervention | Top third | 8 | 5.71 | 0.66 |
| | | Middle third | 8 | 5.29 | 0.68 |
| | | Bottom third | 8 | 4.7 | 0.78 |
| | | Total | 24 | 5.23 | 0.8 |
| Course engagement | Post-intervention | Top third | 8 | 3.96 | 0.31 |
| | | Middle third | 8 | 4.18 | 0.42 |
| | | Bottom third | 8 | 4 | 0.51 |
| | | Total | 24 | 4.04 | 0.40 |
| Learning performance | Pre-intervention | Top-third | 8 | 17.5 | 24.93 |
| | | Middle-third | 8 | 15 | 20.70 |
| | | Bottom-third | 8 | 35 | 25.64 |
| | | Total | 24 | 22.5 | 24.54 |
| | Post-intervention | Top-third | 8 | 83.38 | 4.53 |
| | | Middle-third | 8 | 83.75 | 6.5 |
| | | Bottom-third | 8 | 82.63 | 2.2 |
| | | Total | 24 | 83.25 | 4.56 |

showed the lowest mean level of course engagement ($M = 3.96$, $SD = 0.31$). The result showed that there was no significant difference in student course engagement across the three position levels, $F\,(2, 17) = 0.55$, $p = .59$. This result does not support hypothesis ($H2_a$).

### *4.1.3. Effect on learning performance*

First, the Shapiro-Wilk statistics indicated a non-normal distribution of *pre-test* scores. Correspondingly, a Kruskal-Wallis H test was conducted to examine the students' prior knowledge, and found no significant difference, $H\,(2) = 1.67$, $p = .212$. In summary, the three groups of students (top third, middle third, and bottom third ranked students) showed no significant differences in their initial knowledge.

For the post-test performance scores, we have earlier hypothesized that all learners on an absolute leaderboard would perform

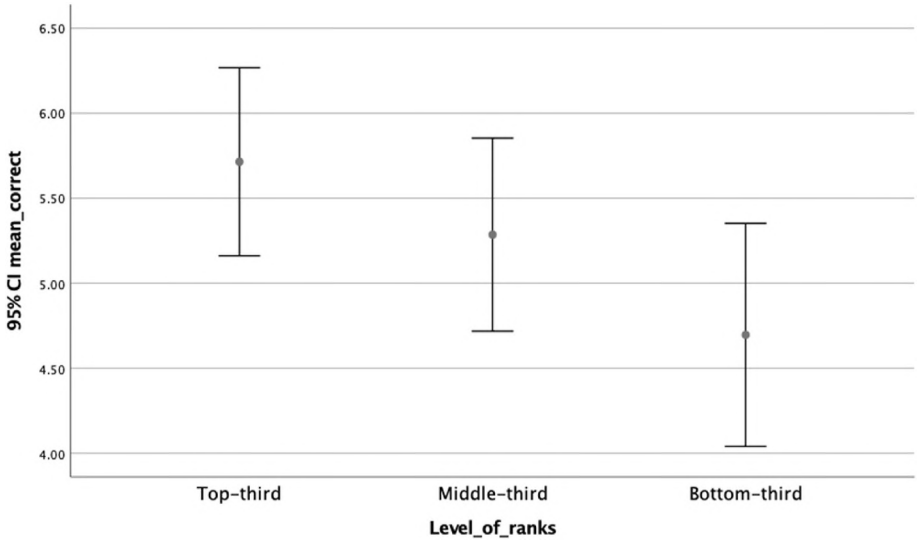


**Fig. 3.** Bar chart of student intrinsic motivation with gamified course means and 95 % confidence intervals across three position levels on the absolute leaderboard at the post-intervention stage.

equally well in learning. Shapiro-Wilk statistics showed that the bottom third samples did not fit the normal distribution ($p = .006$). Therefore, a Kruskal-Wallis H test was used to evaluate the impact of the three position levels on student learning performance, with a non-significant result, $H(2) = 0.64$, $p = .727$. Thus, we affirmed the hypothesis and concluded that there was no statistically significant difference among the three groups in terms of the learning performance after using the absolute leaderboard ($H3_a$).

*4.1.4. Students' perceptions of the absolute leaderboard*

We received responses from 24 participants (100 % response rate) explaining their perceptions of the use of the absolute leaderboard. Table 3 presents the results of the thematic analysis.

Many of the participants (20 out of 24) reported that the gamified course was very interesting and competitive. The top-ranked participants said that they felt proud to see their positions. A top-ranked student said, '*I felt very proud when the leaderboard presented my name. I was also so satisfied when I was at the top of my group*'. Interestingly, the middle and bottom third participants were also motivated by seeing their difference from competent peers: '*I think the leaderboard was interesting, as it provided a new experience in various aspects. For instance, I could compare my thoughts on pre-class tasks with peers*'.

All respondents reported that the use of the absolute leaderboard encouraged them to make an upward comparison with their peers. Slightly more than half of the respondents (13 out of 24) chose to compare themselves with their group members, owing to a strong sense of relatedness. They said that they were more familiar with groupmates and could turn to them for help. A middle-ranked student said, '*I only compared with upper ones in my group. I was also curious about the positions of others from different groups, but I didn't make comparisons with them*'.

Most students (21 out of 24) stated that they continued to work hard after viewing their positions on the leaderboard by completing any unfinished tasks or imitating high-ranked students' online behaviours to earn points. The students made an extra effort when their positions were extremely high or low to maintain a competitive advantage or preserve self-esteem. For example, a top-ranked student stated, '*I made more effort to climb to make sure I was at the top, after knowing my position*'. A middle-ranked student expressed the same feeling: '*when I found that my ranking was higher than the past week's, I was very happy and wanted to get better results. My learning passion and confidence also increased … When the ranking was lower than before, I was worried and tried to improve*'. The bottom-ranked students were also motivated to learn: '*seeing my rank on the leaderboard motivated me to clear all the unfinished tasks, but I was not that ambitious to climb over others; I just wanted to explore more to help improve my learning*' (a bottom third ranked student).

Almost all students (22 out 24) used the discussion forum often to compare opinions with others by checking and replying to others' posts. To some extent, the leaderboard promoted communication and the exchange of ideas amongst the students. A middle-ranked student reported, '*I like to read others' opinions, especially when we answered the same question on the forum, and, sometimes, when I had no ideas, I also liked to get inspiration from their points of view*'. The bottom-ranked students were more likely to compare and exchange ideas with peers: '*I paid a lot of attention to the work of other students, such as forum posts, the slides of their presentations, and so on*'.

Students reported two ways to solve problems in learning: a) *mainly solve the problems via self-reflection and retrieval of literature but also resort to peers* and b) *often work with peers and teachers*. The top-ranked students were more likely to deal with problems by themselves in the first place. A top-ranked student said, '*First, I would review the course materials to see if anything we discussed in the class was related to the problem. Then, I would try to reflect on my prior knowledge and then Google it to seek more information*'. However, the middle- and bottom-ranked students were more likely to turn to others for help directly: '*I would usually ask questions and discuss with my group members and also post questions on the discussion forum to ask for help from teachers and other students*' (a middle-ranked

student); '*When I encounter a difficult problem, I prefer to ask my classmates first*' (a bottom-ranked student).

We also asked students' perception on the public comparison scheme. Fifteen respondents preferred presenting their names on the absolute leaderboard to an anonymous comparison (i.e., names hidden on the leaderboard) to increase the sense of competition and target subsequent competitors. A public leaderboard allowed the students to find top-ranked peers so that they could approach these top-ranked peers for help. Moreover, it helped the students to identify the presence of other competitors to intensify the competitive atmosphere: '*I like the public leaderboard … Just knowing my own position was not enough to perceive my differences with others. However, the public ranking helped me to locate classmates and create a real sense of competition*' (a top-ranked student); '*I prefer the public leaderboard because I can consult with top-ranked students when I encounter problems, as they may have a stronger learning ability*' (a middle-ranked student).

However, most of the bottom-ranked students stated that they would feel more relieved if their names were hidden. Anonymous comparison may be more motivating because it saves face: '*I prefer the anonymous ranking for two reasons: First, we can know our levels in the class and work harder afterward. Second, we do not give a bad impression to others based on our unsatisfactory ranking results*'.

### *4.2. Relative leaderboard results*

#### *4.2.1. Effect on intrinsic motivation*

The response rates for the first (pre-intervention), second (mid-term), and third measurements (post-intervention) were 92.31 % (24 out 26), 88.46 % (23 out of 26), and 96.15 % (25 out of 26).

Although the descriptive statistics showed that although the bottom-ranked students were highly motivated by the relative leaderboard ($M = 4.86$, $SD = 0.86$ for pre-intervention; $M = 4.78$, $SD = 0.73$ for mid-term; $M = 4.84$, $SD = 0.98$ for post-intervention measure, see Table 2), we found no significant variations among the students at the three position levels throughout the intervention (pre-intervention: $H = 2.86$, $p = .24$; mid-term: $F = 0.81$, $p = .46$; post-intervention: $F = 0.53$, $p = .59$. This result supports our hypothesis that top-, middle- and bottom-ranked learners on a relative leaderboard demonstrate an equal level of intrinsic motivation ($H1_b$).

#### *4.2.2. Effect on student course engagement*

The descriptive statistical results showed that the bottom-ranked students perceived a higher level of course engagement than the other two groups did, $M = 3.98$, $SD = 0.48$. However, the result of a one-way ANOVA test suggested there is no significant different in student course engagement among three groups, $F\ (2,\ 21) = 0.82$, $p = .454$. This result supports the proposed hypothesis that top-, middle- and bottom-ranked learners on a relative leaderboard demonstrate an equal level of course engagement ($H2_b$).

#### *4.2.3. Effect on learning performance*

We performed one-way ANOVA to compare the means of the three levels of students. A non-significant difference was found, $F\ (2,\ 23) = 2.22$, $p = .131$. Therefore, the students from the three groups of positions (top third, middle third, and bottom third ranked) had

**Table 2**
Student intrinsic motivation to learn, course engagement and learning performance across three levels of position on the relative leaderboard (learning performance: 100 full mark; intrinsic motivation: 7-point scale, very true – not at all true; course engagement: 5-point scale, not at all characteristic of me – very characteristic of me).

| Variable | Stage | Position level | N | Mean | SD |
|---|---|---|---|---|---|
| Intrinsic motivation | Pre-intervention | Top-third | 8 | 4.29 | 0.46 |
| | | Middle-third | 9 | 4.57 | 0.75 |
| | | Bottom-third | 7 | 4.86 | 0.86 |
| | | Total | 24 | 4.56 | 0.71 |
| | Mid-term | Top-third | 7 | 5.16 | 0.54 |
| | | Middle-third | 9 | 4.79 | 0.68 |
| | | Bottom-third | 7 | 4.78 | 0.73 |
| | | Total | 23 | 4.9 | 0.65 |
| | Post-intervention | Top-third | 8 | 4.54 | 0.84 |
| | | Middle-third | 9 | 4.94 | 0.64 |
| | | Bottom-third | 8 | 4.84 | 0.98 |
| | | Total | 25 | 4.78 | 0.81 |
| Course engagement | Post-intervention | Top-third | 7 | 3.94 | 0.56 |
| | | Middle-third | 10 | 3.69 | 0.51 |
| | | Bottom-third | 7 | 3.98 | 0.48 |
| | | Total | 24 | 3.85 | 0.51 |
| Learning performance | Pre-intervention | Top-third | 8 | 18.25 | 4.71 |
| | | Middle-third | 10 | 15.2 | 9.10 |
| | | Bottom-third | 8 | 10 | 8.82 |
| | | Total | 26 | 14.54 | 8.31 |
| | Post-intervention | Top-third | 8 | 91.07 | 7.28 |
| | | Middle-third | 10 | 76.43 | 10.91 |
| | | Bottom-third | 8 | 68.75 | 13.56 |
| | | Total | 26 | 78.57 | 13.85 |

**Table 3**
Student perceptions of using an absolute leaderboard.

| Primary theme | Sub-theme | Example of quotation |
|---|---|---|
| Feel motivated after viewing my position | As recognition of learning progress | "When the leaderboard presented my name, I feel a little proud. When I was the top in my group I am satisfied." |
| | Obtain instant learning feedback | "If I find my ranking is higher, I will be very happy and want to continue to maintain or get better results. My learning passion and confidence will also increase, and I may browse more learning information." |
| Make upward comparisons with upper-level group members | / | "I would compare myself with upper students. I would make the comparison within my group more often because it is easy to access." |
| Continue to work hard after viewing my position on the leaderboard | Be motivated to climb by completing unfinished tasks, reviewing learning materials, or imitating high-ranked students' online behaviours to earn points | "It motivates me to clear all the unfinished tasks; but I was not that ambitious to climb over others, I've just finished tasks and see if I should explore more for help improve my understanding." |
| | More effort will be invested if the position is low or high | "I will invest more efforts if my rank is quite behind on the leaderboard, but I would keep on being top if the rank is high." |
| Use discussion forum to compare opinions | Check and reply to others' posts and compare own posts with others' to get new ideas | "I like to see other students' opinions especially when we answer the same question on the forum. Sometimes, I will look at other people's views after I finish writing my answers. Many students'answers are great and will give me a new idea. And sometimes, when I have no idea, I also like to find some inspiration from their points of view." |
| Tackle problems in learning mainly via self-study | Mainly solve problems via self-reflection and retrieval of literature, then by resorting to peers | "Firstly, I would review the course materials to see if anything we discussed in the class is related to the difficult tasks. Then, I will try to reflect on my prior knowledge or knowledge I may learn from other courses to connect the issues. And I will also Google it to see more sharing from others and observed some examples if possible." |

no significant differences in their initial knowledge.

A one-way ANOVA test showed a significant difference between the three levels of students in terms of post-test scores, with $F$ (2, 23) = 8.71, $p$ = .002. The top third ranked students ($M$ = 91.07, $SD$ = 7.28) were significantly different from the middle ($M$ = 76.43, $SD$ = 10.91) and bottom third ones ($M$ = 68.75, $SD$ = 13.56) (see Table 2). A further Scheffe post-hoc test suggested that the top-ranked students achieved significantly higher learning performance than the middle third ($p$ = .032) and bottom-ranked ones ($p$ = .002) did. The middle and bottom third groups did not differ significantly ($p$ = .348). This result supported our hypothesis that low-ranked learners on a relative leaderboard perform worse than higher-ranked learners in learning ($H3_b$).

**Table 4**
Student perceptions of using a relative leaderboard.

| Primary theme | Sub-theme | Example of quotation |
|---|---|---|
| Feel motivated after viewing my position | As recognition of learning progress | "There is a sense of accomplishment if my name is listed on the leaderboard. I can feel that I am doing better than others, and this drives me to work harder." |
| | Obtain instant learning feedback | "It encourages me to perform better in class and have a goal of gaining better outcome of the course." |
| Make upward comparisons with upper-level group members | / | "I often make comparison with our groupmates, because I know more about them and communicate with them more often. Groupmates are more accessible." |
| Make a little effort to make progress on learning | No much pressure from others | "I don't think the rank would hurt my confidence, because I think it is aimed to enhance my learning motivation than evaluate the final learning outcome. Therefore, if my rank is not so satisfactory, I would not worry about it too much." |
| | Focus on surpassing my past performance | "The rank position does not matter much to me unless it indicates that I have failed, or I am at the bottom. I am not aiming to surpass my classmates. I am more interested to learn and have improvements when comparing with my past." |
| Use discussion forum to compare opinions | Check and reply to others' posts and compare own posts with others' to get new ideas | "I really enjoy looking through the online courses that other groups created, I could get so many inspiration to reflect our own work, and learn to be critical. And I feel this is a great way to close the distance between me and other classmates, since we are not in the same group, this process will empower me to get closer to their thoughts." |
| Tackle problems in learning through communication with peers | Often work with peers and teachers | "I usually talk to my groupmates for ideas. If I had an initial thought, I would try to write down whatever I have and start to modify and reexamine from there." |

#### 4.2.4. Students' perception of the relative leaderboard

We received 26 students' responses (100 % response rate) explaining their perceptions of the use of a relative leaderboard in a gamified class. Table 4 shows the results of the thematic analysis.

Similar to the absolute leaderboard, students also reported being motivated after viewing their relative positions, which provided *recognition of their learning progress* and *instant feedback*. A top-ranked student stated, '*there was a sense of accomplishment if I noticed no classmates' names above mine. I felt that I was doing better than others, and this drove me to work harder*'. A few middle-ranked and bottom-ranked students reported that they were encouraged to make effort when they saw their distance from immediate upper students and were comforted to learn that there were still some peers below them. '*I felt proud and happy to see my name on the leaderboard as I won a game*' (a middle-ranked student); '*The rank encouraged me to perform better in class and have a goal of achieving satisfactory outcomes in the end*' (a bottom-ranked student).

We summarised three primary themes about students' behavioural aspect*: make an upward comparison with groupmates*, *make little effort to climb*, and *use the discussion forum to compare opinions with others.* Similar to students in the absolute leaderboard, students in the relative leaderboard were also more likely to make upward comparisons with upper-ranked groupmates. This is due to a stronger sense of relatedness with their own groupmates compared to classmates of other groups. *'I often make comparison within our group, because I know more about them and communicate with them more often.'* (a middle-ranked student); *'Generally, I compare myself with the team members to see our differences. If I am not left behind too much, I will feel a little relieved, but if I was too far away from the top, I would feel quite nervous and then work hard to catch up with them'* (a bottom-ranked student).

Contrary to the absolute leaderboard context, the students reported that they made little effort to climb. There was less peer pressure and less self-esteem hurt due to the limited access to competitors' information. Moreover, many of them focused on their own improvement compared with the past weeks: '*The rank position did not matter much to me unless it indicated that I failed my class or I was at the bottom. I was not aiming to surpass my classmates. I was more interested in improving myself compared to past weeks*' (a top-ranked student); '*I focused more on my progress, and this drove me to work hard to surpass my past*' (a middle-ranked student); '*I paid some attention to my position on the leaderboard, and I just worked hard if there were fewer than five peers below me*' (a bottom-ranked student).

Most of the students (22 out of 26) agreed that they used the discussion forum often to compare their opinions with peers'. The students reported more frequently checking and replying to others' posts and comparing their own posts with others' to get new ideas than in non-gamified classes. '*I often checked others' posts in the online forum because they helped me to check and deepen my understanding*' (a top-ranked student); '*I really enjoyed looking through the online forum posts, as I could get many critical ideas to compare and reflect my work*' (a bottom-ranked student).

Most students asserted that they often asked peers and instructors for help when they encountered difficulties in learning. The responses from the three position levels were similar. '*I would search the Internet to find similar problems and their solutions, or I would ask my groupmates to see if they had confronted the same problems*' (a bottom-ranked student).

As for public comparison scheme, fourteen respondents (54 %) showed a positive attitude towards public ranking on the relative leaderboard. The students preferred public comparison to an anonymous display because the former offered opportunities to target competitors and communicate with them easily. A top-ranked student stated, '*I prefer real-name ranking because I like competition and challenge, which can motivate me to work harder. Knowing which peers ranked higher in the class can help me to set them as goals*'. Most of the middle-ranked students reported the same thought: '*I prefer the public leaderboard. As adult learners, we should be psychologically prepared to acknowledge distance from high-performing classmates*' (a middle-ranked student). The bottom-ranked students also agreed that the public relative leaderboard was more helpful in enhancing their learning motivation: '*I like the public leaderboard best because it helped me to know who was doing well and set a person as a target*' (a bottom-ranked student).

## 5. Discussion

### 5.1. Absolute leaderboard

Regarding student intrinsic motivation, the top-ranked participants reported a significantly higher level of interest/enjoyment than the bottom-ranked students at the end of the semester. There were no significant differences between the top-ranked and middle-ranked, and between the middle-ranked and bottom-ranked participants. The absolute leaderboard highlights both winners (proximity to a standard, i.e., near the number one ranking) and losers (away from a standard), enabling all users to view other participant's progression, which can dampen the level of interest/enjoyment among the bottom-ranked participants. As one bottom-ranked participant said: '*I prefer anonymous ranking, so that we can feel free from peer pressure and focus on our own improvement*'. Increased social comparison and competition may hamper lower-ranked students' motivation over time.

Yet despite the difference between intrinsic motivation between the top-ranked and bottom-ranked participants, the SCEQ survey responses showed that there was no significant difference in the perceived course engagement. Many participants, including the bottom-ranked participants, stated in the interviews that they continued to work hard after viewing their positions on the leaderboard by completing any unfinished tasks or imitating high-ranked students' online behaviours to earn points. We may infer that an absolute leaderboard can strengthen participants' sense of comparison and competitiveness. This finding suggests that bottom-ranked individuals were still driven by a sense of competition to do well in the course even though they might not particularly enjoy completing the activities.

The results revealed that top-, middle- and bottom-ranked learners on an absolute leaderboard perform equally well in their learning performance (course grades). By ranking all competitors on the leaderboard, students were well aware of their distance to the standard in this class (i.e., the number one ranking peer), which can intensify their sense of comparison concerns and competitiveness,

as supported by evidence from our interview data. This can drive individuals to improve their performance and simultaneously lessen the distance between their and other participants' level of performance (Garcia et al., 2013). Nevertheless, our interview data suggested that the bottom-ranked participants tended to feel discouraged when they felt that the distance between their and other higher-ranked participants were not reduced.

Participants reported they made upward comparisons with their own group members more often than with other classmates. This supported the previous finding that people perceive more enjoyment and motivation when competing with familiar (e.g., group members) people than with unfamiliar persons (Jia et al., 2017). One possible explanation is that relationship closeness boosts comparison and thus competitiveness (Tesser, 1988). This also conforms to the finding that people feel more threatened by the success of friends than that of unfamiliar people (Zuckerman & Jost, 2001).

Most of the students at the top and middle position levels liked the public comparison on an absolute leaderboard. Publicly recognizing good performance enhances a person's self-esteem and public image (Tesser, 2000; Webster et al., 2003; Wood, 1989). Such recognition has also been viewed as an essential element of motivation enhancement (Harris et al., 2008). However, some students in low positions stated their preference for anonymous ranking. They said that public ranking embarrassed them, as their names could be viewed by all their classmates.

### 5.2. Relative leaderboard

The results indicated that the top-ranked students tended to achieve higher learning performance than the lower-ranked students did. This is in line with the hypothesis we made earlier. All participants (top, middle- and bottom-ranked learners) felt they were close to their standard, because they could only compare themselves to the learners who were below and above them. So, the actual distance in positions was less obvious to participants in a relative leaderboard condition than in an absolute leaderboard. Consequently, being free from peer pressure, most of the lower ranked students tended to be content with their current situation rather than try to catch up with the higher ranked students. The threat of scale comparison in a relative leaderboard class tends to decrease when exact positions are unknown (Garcia & Tor, 2007).

In other words, the sense of comparison and competitiveness in a relative leaderboard class appeared to decrease when students were not informed of their exact positions with respect to all other students' positions in the leaderboard, particularly to the top position (i.e., the number one ranking). By competing with a handful of similar-level peers, we found students at three groups of position reported no significant difference in intrinsic motivation and course engagement. Most students in the relative leaderboard condition reported they made little effort to level up because they were content with current level. This less competitive atmosphere appeared to benefit the bottom-ranked students who only wanted to make comparison with their own past performance, or with their immediate neighbours.

Students reported that they were more likely to solve learning problems with peers and instructors. This is different from the absolute leaderboard result, where most students first try to solve the problem by themselves. This indicated that students became more cooperative and less competitive when they were not informed of explicit ranking information on a relative leaderboard (Garcia & Tor, 2007).

Contrary to the absolute leaderboard results, most of the bottom-ranked students liked the public comparison better than the anonymous one. Comparison with others whose abilities are close to one's own is a pleasurable experience, which seems likely to stimulate the self-enhancement motive (Taylor & Brown, 1988; V.; Wood, 1989). As the relative leaderboard confined users' comparison to a small range, students at different position levels may have perceived no significant differences in terms of intrinsic motivation and course engagement.

### 5.3. Practical implications

This study has some practical implications for the use of leaderboards in gamified classes. The absolute leaderboard appear to promote the sense of comparison and competitiveness more intensively than the relative leaderboard. By displaying all the participants' positions, learners in an absolute leaderboard can easily locate their own proximity to a standard (e.g., the number one ranking) in the competition and the next target to surpass. Therefore, they tend to behave competitively to catch up with higher ranked peers. To mitigate possible of unhappiness among the bottom-ranked participants, an instructor may consider publicly releasing only the information of the top five students, instead of everyone, in an absolute leaderboard. In this way, low-ranked students will experience less discouragement.

An instructor may also consider resetting the absolute leaderboard fortnightly (Pontes et al., 2019) to re-engage students (Sprint & Fox, 2020). The instructors could use an absolute leaderboard and then reset all students' points to 0 to level the playing field. By doing so, students who ranked low on the absolute leaderboard are given the chance to perform better in the next run.

Another option is to use an absolute leaderboard and a relative leaderboard alternatively in a semester. Since qualitative analyses on the participant interview data suggested that the students ranked in the bottom third preferred an anonymous comparison on an absolute leaderboard, but favoured a public comparison on a relative leaderboard, an instructor may consider using an absolute leaderboard for the first half of the semester (showing only the top 5 participants), followed by a relative leaderboard for the second half of the semester.

## 6. Limitation and future work

It is important to note that culture may influence students' perceptions of positions on leaderboards. All the participants in our present study were students from East Asia. A meta-analysis found that East Asian students tend to display significantly less self-enhancement than Westerners do (Heine & Hamamura, 2016). This suggests that East Asians are less likely to take a positive view of themselves. In response to public comparison on the absolute leaderboard setting, the bottom-ranked students said that they were reluctant to view their positions. This may be influenced by the East Asian culture where the notion of saving *face* very important, particularly when one is near the bottom ranking.

In addition, due to the unequal gender composition in these two studies (i.e., female participants accounted for more 90 % of the total sample), caution is needed in interpreting the findings of the current study. Research suggested that there may exist a gender difference between man and woman in terms of competition. According to a Harvard Business Review article, the average woman is less competitive than the average man (Kesebir, 2019). Men's sense of competitiveness may be partially explained by the more positive beliefs they hold about the outcomes of competition than women (Kesebir, 2019).

Future research could build on this study in many ways. First, the study could be extended to directly compare the effects of the two leaderboard types on student learning performance and engagement. Second, whether explicitly disclosing the points-adding rules before the intervention deserves further study to see which condition (i.e., students know points-adding rules or not before the use of leaderboards) can better stimulate their motivation. Third, the points-adding rules could be revised to take the in-class activities and the quality of assignment into account.

Next, we used self-reported data (i.e., questionnaire and open-ended survey) to assess students' intrinsic motivation and course engagement. But the reliability of these kind of data might be compromised by responders' inability to introspect accurately on their own motivation (Bowman, 2011). Future study could use free-choice behaviors to measure students' intrinsic motivation instead of merely replying on their self-reported survey data (Deci & Ryan, 1985).

Finally, future research could replicate the study using a larger sample of participants, as well as involving participants from other cultures. Due to the limited course capacity, samples in our present study were only 24 participants in the absolute leaderboard study and 26 in the relative leaderboard study. The numbers of participants in the three position levels were rather small. A larger sample size with equal gender composition in both two studies would be desirable to increase the generalisability of the results.

## 7. Conclusion

This research used two quasi-experiments to examine the effects of positions on absolute and relative leaderboards on online student learning performance, intrinsic motivation, course engagement, and perceptions. The results of the absolute leaderboard study showed that different position levels did not affect the students' learning performance. Nevertheless, the top-ranked students were more intrinsically motivated than the lower-ranked ones were. We collected the students' responses concerning three aspects of engagement in the absolute leaderboard class. The findings revealed that students in different positions were highly engaged in making comparisons with peers, whereas the bottom-ranked students struggled under the pressure of being identified and losing face. Conversely, in the relative leaderboard class, students at top positions showed a significant higher level of learning performance than middle and bottom peers. Students were more likely to be content with current positions and being free from peer pressure.

## Credit author statement

**Shurui Bai:** Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing - original draft. **Khe Foon Hew:** Conceptualization; Funding acquisition; Methodology; Supervision; Writing - review & editing. **Michael Sailer:** Validation; Writing - review & editing. **Chengyuan Jia:** Writing - review & editing.

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## Appendix 1

Open-ended survey about student perception in using absolute or relative leaderboard.

There are 6 questions below. It would be very helpful if a more detailed answer is given, with some examples and illustration would be better.

Section one: about overall perception.

1) Who do you compare with yourself more often (with upper students or lower students)? Could you name some peers whom you make comparison with more often (their names will never be revealed under any condition)? How do you make the comparison more often (e.g., within your group or across groups)?
2) What are the following actions you take after knowing your rank position? (e.g., more efforts to climb or no care about that, hurts or boots your confidence, with some examples and explanation)
3) Would you like to check other classmates' work (e.g., discussion forum posts)? Give some further explanation on what learning content or activities you would like to check when you compare with others.
4) Have you ever confronted with some difficult tasks that you cannot deal with by yourself at the beginning, then what are the strategies that you usually take to solve them?

Section two: ranking scheme and further suggestions.

5) Which kind of personal comparison information do you think should be presented on the leaderboard and why: anonymous leaderboard (no names of other students are revealed, but you can know your position) or public leaderboard? (names of all students are revealed)
6) Is there any suggestion you want to give on the application of the leaderboard?

## Appendix 2

Points-adding rules for positions on the absolute and relative leaderboards.

| Points | Type | Pre/post-class activity | Trigger | Description |
|---|---|---|---|---|
| 5 | Event | All | Course: course viewed | Number of logging in course Moodle |
| 5 | Event | All | Feedback: course module viewed | Number of clicking the feedback message |
| 5 | Event | All | Feedback: response submitted | Number of message reply |
| 5 | Event | All | Folder: course module viewed | Number of clicking the given folders |
| 5 | Event | All | Folder: zip archive of folder downloaded | Completion of the action of downloading the given folders |
| 5 | Event | Pre-class | Forum: discussion viewed | Number of viewing discussion in the given forums |
| 5 | Event | Pre-class | Forum: user report viewed | Number of checking the user report |
| 5 | Event | Pre-class | URL: course module viewed | Number of clicking the given inserted URL (e.g., class recording video, YouTube tutorials) |
| 10 | Event | Pre-class | Forum: post created | Number of creating a new post under a discussion forum |
| 10 | Event | Pre-class | Lesson: question answered | Number of answering a question in a workshop |
| 15 | Activity | All | View extra useful course relevant readings | Number of viewing an uploaded extra reading material |
| 15 | Activity | Pre-class | Submit individual assignment | Completion of submission of pre-class required individual assignment |
| 15 | Activity | Pre-class | Upload group name and members | Action of creating a new discussion under the forum called "Group Name for Group Activities". |
| 15 | Activity | Pre-class | Submit group work | Completion of submission of pre-class required group work |
| 30 | Activity | Pre-class | View each pre-class activity/learning material | Number of viewing the uploaded reading material which used for in-class discussion |
| 10 | Activity | Post-class | View each in-class learning material | Number of viewing the uploaded lesson slides |
| 20 | Activity | Post-class | View each post-class activity/learning material | Number of viewing the uploaded post-class extended reading material |
| 30 | Event | All | An activity or resource was successfully completed. | Completion of workshop |
| 30 | Event | Post-class | The course was completed. | Completion of the whole course |

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