

Enhancing Engagement, Emotional Connection, and Sense of Group Belonging to Improve Academic Outcomes in the Third-Year Heat Transfer Course of the Industrial Technologies Engineering Program

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1. Introduction

Emotional aspects in teaching and learning processes receive significant attention in academic literature. Recent studies have shown that sense of belonging and emotional engagement are key factors in improving student performance and fostering meaningful learning experiences [1]. Higher education has adopted pedagogical strategies designed to strengthen emotional bonds between students, instructors, and course content, creating more collaborative and productive environments. For instance, Northey et al. (2017) explored real-time collaborative learning and its impact on academic engagement and performance, emphasizing the role of technological tools in strengthening emotional connections [2]. Zumbrunn et al. (2014) emphasize that belonging serves as a mediator between classroom support, motivation, and academic performance [3]. Yi et al. (2024) highlight how belonging, academic self-efficacy, and emotional resilience influence engagement and performance, even in online learning environments [4].

In engineering education, Nerona (2019) found that collaborative learning significantly improves academic performance by promoting social interaction and teamwork [5]. Lönngren et al. (2024) explore how emotions play a central role in engineering education, highlighting the need for pedagogical strategies that integrate emotional elements to enhance learning [6]. Furthermore, Miesner and Schallert (2024) underscore how instructor actions and perceived connectedness can increase interest in engineering courses [7].

Aligned with these findings, this study examines how changes to the so-called "class grade" assessment criteria can promote emotional engagement and a sense of group belonging, ultimately improving academic outcomes. The study specifically focuses on the third-year Heat Transfer course in the Industrial Technologies Engineering program at the Universidad Politécnica de Madrid. This course is organized in five teaching groups that follow the same curriculum, coordinated to ensure consistent assessment across groups. Students may choose continuous assessment or a final exam. In continuous assessment, students complete jointly designed evaluations, graded collectively. Additionally, each instructor awards a "class grade" worth 10% of the final mark based on personalized criteria. Traditionally, this grade has reflected homework performance and attendance on randomly selected days. However, for this work, new criteria were introduced in one group that not only created opportunities for students to score points but also fostered an inclusive environment where they felt heard, valued, and emotionally connected to the subject. This work analyses the impact of these new criteria on academic outcomes and the overall teaching-learning environment.

2. Heat Transfer course in the Industrial Technologies Engineering program

The Heat Transfer course is a core subject within the Industrial Technologies Engineering program at Universidad Politécnica de Madrid, enrolling 397 students in 2024-25 distributed across five teaching groups, each taught by a different instructor. This study focuses on group M3, which consists of 72 students. The course is organized into 36 sessions of 65 minutes each, combining theoretical concepts with problem-solving exercises to balance conceptual understanding and practical application. The syllabus follows a structured progression, beginning with fundamental principles such as physical quantities, units, and energy balances, and advancing through heat conduction, convection, heat exchangers and finally radiation. The course natural duration is 12 weeks.

Assessment is conducted through two alternatives: continuous evaluation combined with a final exam or a single final exam. Continuous evaluation includes two scheduled non-releasing tests, accounting for 40% of the final grade, and the "class grade" contributing 10%. The tests consist of multiple-choice and numerical problems, and students are allowed to use the official handbook and calculators. The final exam constitutes 50% of the overall grade of the continuous evaluation grade and students must score at least 3.5 out of 10 on this exam. The second evaluation option involves a single final exam, which is identical to the one used in the first option and accounts for 100% of the final grade. Students do not need to choose an evaluation method in advance, as their final grade is based on the most advantageous result.

The "class grade", which accounts for 10% of the final score in continuous evaluation, is assigned by each instructor based on their own criteria. Traditionally, it has been determined primarily by homework and, to a lesser extent, by random attendance checks or other subjective measures. For this study, all other elements of the course program, evaluation methods, and organization remain unchanged from the original subject program. The only modification introduced concerns the criteria for assigning the class grade, which are explained in detail in the following section. Additionally, any deviations by instructors of the other four groups from the traditional class grade criteria, as well as other factors that may influence student outcomes, are not considered in this study since they were not monitored.

3. Class Grade Evaluation Criteria

In the studied group M3, the allocation of the "class grade," accounting for 10% of the final score (equivalent to 1 point out of 10 total points in the overall continuous evaluation), was divided into 10 equal parts. Each part, informally referred to as a "mini-point," carried a value of 0.1 points. Students were informed that specific contributions would be rewarded with a mini-point. The qualifying contributions initially included the following:

- Asking questions related to the subject matter that were of general interest.
- Identifying and correcting mistakes made by the instructor.
- Providing insights or comments that enhanced the understanding of the subject.
- Proposing suggestions to the instructor to improve the overall effectiveness of the classes.
- Highlighting student needs that the instructor may not have identified and that could hinder the learning process.

These contributions could be made during class sessions or, to accommodate students who felt less comfortable speaking in class, through alternative means. These included tutoring hours, speaking directly with the teacher after class, or written communication via email, Teams, or Moodle.

Midway through the course, students proposed additional ways to earn mini-points. Since these suggestions were considered beneficial to the general learning environment, they were integrated into the "class grade" assessment system starting in week 7 of the 12-week course. The expanded criteria included:

- Achieving top positions in knowledge-check quizzes conducted during class.
- Volunteering to solve problems on the board.
- Presenting summaries of content covered in previous classes to facilitate collective review.

In addition to serving as a mechanism for students to accumulate points towards the maximum 10% of the final grade, these evaluation criteria also aimed to foster engagement, emotional connection, and a sense of group belonging. The various contributions offered students opportunities to take ownership of the course and feel that their input shaped its progression. This sense of involvement became evident in the classroom atmosphere, characterized by healthy competition for mini-points, expressions of gratitude for helpful contributions from peers, enthusiasm to participate, and a sense of camaraderie and mutual support between students and the instructor. The following section examines how these evaluation methods influenced student performance by analysing the relationship between class grade progression and at the end of the course with scores on evaluation tests and final exam results. These outcomes are also compared with the average performance of students across all groups.

4. Results

Figures 1 and 2 show the relationships between cumulative class grades and performance in the two continuous evaluation tests. The first test was conducted in week 8, and the second at the end of the course, in week 13. In these graphs, students who did not take the tests were assigned a score of 0, what is considered appropriate in this context as it highlights the connection between academic performance and course engagement, noting that non-participation can be interpreted as a loss of connection to the course. Figures 1 and 2 also include the average grade of all the heat transfer groups, both calculated after excluding non-attendees (Avg. grade without non-att) and after assigning zero points to non-attendees (Avg. grade with non-att = 0).

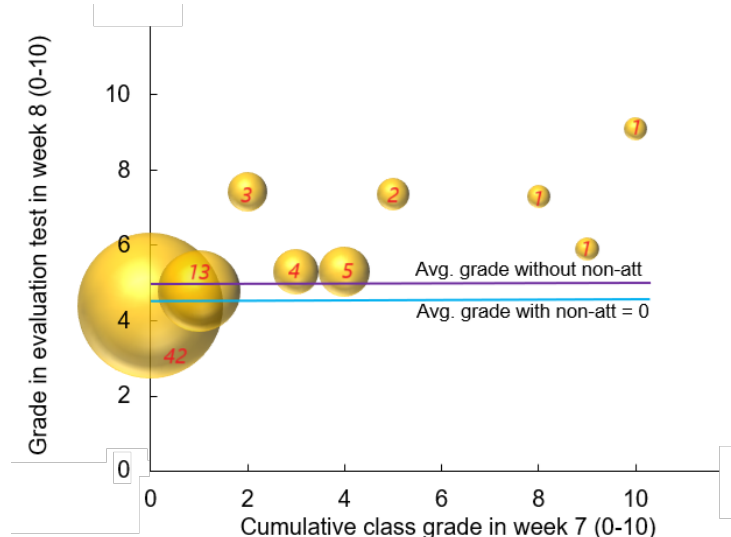


Fig. 1. Average grades obtained in the first evaluation tests as a function of cumulative class grades in week 7 for students of group M3. Number of non-attendees (NA): 4 NA with 0 point in cumulative class grade and 1 NA with 1 point in cumulative class grade (7 % of non-attendance). The average grade of all groups is 5.1 if it is calculated with the exclusion of non-attendees, that represent 12% of the enrolled students. The average grade of all groups is 4.4 for both tests calculated with the assignment of zero to non-attendees.

Figure 1 shows the relationship between cumulative class grades by week 7 and performance in the first test of continuous evaluation. The general trend suggests that students with higher cumulative class grades achieved better results, indicating a

correlation between early course engagement and academic performance. However, data in Figure 1 can be categorized in 3 groups for a more detailed discussion. The group with class grade in week 7 between 0 and 1 showed limited adherence to the class grade scoring criteria which appears to have translated into poorer test performance. Students with cumulative grades between 2 and 5 points clearly performed above the course average. Their results suggest that the revised criteria for assigning class grades played a role in fostering learning by promoting emotional connection with the course and group, as intended. Finally, there is a high-performance group, comprising students who had obtained more than 5 mini-points by week 7, who achieved top scores in the evaluation test. Although this group is relatively small, it likely includes students with stronger academic skills and capacities, which enabled them to achieve highly in the class grade scoring system regardless of the criteria used. Consistently, they also obtained the highest cumulative class grades.

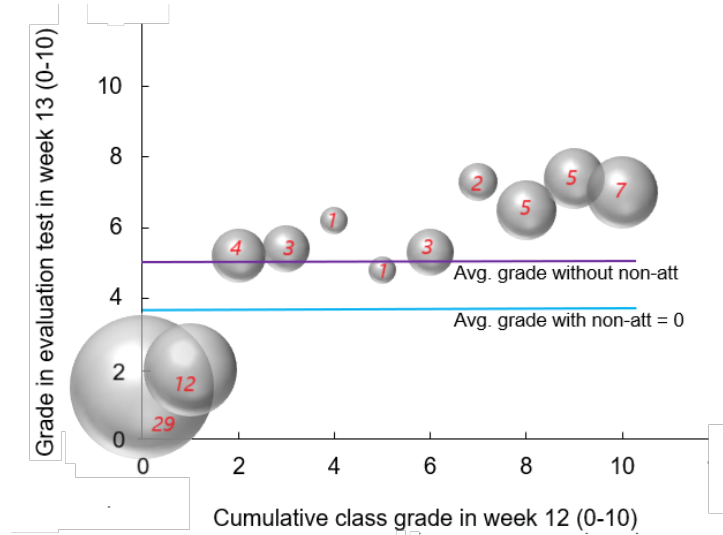


Fig. 2. Average grades obtained in second evaluation tests conducted in week 13 as a function of cumulative class grades in week 12 for students of group M3. Number of non-attendees (NA): 15 NA with 0 point in cumulative class grade, 4 NA with 1 point in cumulative class grade and 1 NP with 6 points in cumulative class grade (27 % of non-attendance). The average grade of all groups is 5.1 if it is calculated with the exclusion of non-attendees, that represent 28 % of the enrolled students. The average grade of all groups is 3.7 for both tests calculated with the assignation of zero to non-attendees.

Figure 2 extends the analysis extracted from Figure 1 by representing the cumulative class grades at the end of the course (week 12). More students had increased their cumulative grades, partially by the pass of time and partially by the beneficitation from the additional opportunities introduced in week 7 to earn mini-points. It can be observed that clearly the higher the class grade at the end of the course the higher the test grade suggesting a sustained impact of the new class grade assessment strategy. Students with 0–1 mini-points in week 12 clearly performed poorly or did not participate in the second test.

Figure 1 and 2 together show a clear link between the class grade and the evaluation tests performance. Comparing both figures, it can be observed how students that overpass the average grade is increased from the first to the second test, even if the comparison is done to the average value for which non-attended has been excluded.

Table 1. Statistical comparison of student attendance and test performance

Global ratio of non-attended students to first test	12%
Ratio of non-attended students to first test in M3	7%
Global ratio of non-attended students to second test	28%
Ratio of non-attended students to second test in M3	27%
Global ratio of students with first test grade over the average (non-att. excluded)	48%
Ratio of students with first test grade over the average in M3 (non-att. excluded)	25%
Ratio of students with class grade in week 7 over 2 and first test grade over the average in M3 (non-att. excluded)	100%
Global ratio of students with second test grade over the average (non attendees excluded)	49%
Ratio of students with second test grade over the average in M3 (non attendees excluded)	57%
Ratio of students with class grade in week 12 over 2 and second test grade over the average in M3 (non-att. excluded)	97%

Table 1 summarizes some statistical indicators comparing group M3 with the overall performance of all groups in the Heat Transfer course. Group M3 showed lower non-attendance rates in both the first (7%) and second tests (27%) compared to the global rates of 12% and 28%, respectively. For the first test, only 25% of M3 students scored above the average (excluding non-attendees),

compared to 48% globally. However, 100% of students with a class grade above 2 by week 7 achieved scores above the average, indicating that early engagement positively influenced performance. In the second test, 57% of M3 students scored above the average, surpassing the global percentage of 49%. Furthermore, 97% of those with a class grade above 2 by week 12 outperformed the average. These metrics reinforce the hypothesis that fostering emotional engagement and a sense of belonging leads to improved academic outcomes.

To inform about the student perception of the new system for class grade scoring, all the comments on this matter included in official teaching surveys are transcribed in Table 2. The responses received were predominantly negative, suggesting that students who felt disadvantaged by the mini-point system were more likely to participate in the survey. This phenomenon, known as response bias, is common in voluntary feedback collection, as dissatisfied individuals are often more motivated to voice their concerns.

Table 2. Transcription of the student feedback about the new class grade criteria (translated to English)

<p>"The way the class grade is assigned is different from the other groups. In other classes, just attending is enough to get the full point, whereas in this class, if you don't solve exercises on the board or correct mistakes in class, you don't get any points. This creates a slight unfairness in the final grading"</p>
<p>"I didn't like the class grade system"</p>
<p>"The 10% class grade through 'mini-points' does not seem like the most optimal way to assess students"</p>
<p>"Although I don't think the mini-point system is inherently bad, the way they are distributed is subjective and unfair. Some people get points for correcting a small mistake when copying a number from the board, while others, who ask interesting questions or complete tasks, get overlooked. Being more extroverted shouldn't be rewarded over being introverted, as it has nothing to do with the subject matter or the willingness to learn."</p>
<p>"I don't think the way class points are awarded is appropriate. Giving points for correcting something irrelevant while not giving them for asking a question, or sometimes awarding them and sometimes not, makes it confusing for students and disrupts the class more than it proves we are paying attention. If attendance is going to be considered, it should be done in a different way—or not considered at all".</p>

From these comments, it is evident that some students may have misunderstood two key aspects of the mini-point system: first, this system was not intended as a way to assess attendance, but rather as a component of the progressive learning evaluation. Second, earning mini-points was not limited to in-class participation; students could also engage through email, online platforms, or by speaking with the instructor after class—all of which were valid ways to accumulate points. It is important to emphasize that this information was repeatedly communicated in class.

5. Conclusions

The implementation of the mini-point system fostered student engagement, emotional connection, and group belonging, positively impacting academic performance. Results show a clear correlation between class grade accumulation and test scores. Despite some negative feedback, response bias likely influenced perceptions. Future studies should explore long-term effects and optimize assessment criteria to further enhance student learning experiences.

6. References

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