ON THE USE OF COLLABORATIVE CARD-BASED GAMES TO INCREASE THE MOTIVATION OF UNIVERSITY STUDENTS

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Abstract

It has been reported that the interaction between students in collaborative activities serves to increase the cognitive level and the academic performance. At the same time, the use of games in the classroom is a powerful strategy to draw the students' attention and increase their motivation. This work proposes the use of card-based games within the problem-solving lecture in order to include some competition and gamification. The approach is inspired in the popular Kings League game, using cards that provide some kind of power to the holder. The game has a total of eight original cards that are designed with a clear didactic approach to appropriately gamify the activity within the classroom. The proposed innovation has been applied to a course on Electrical Machines at the University of Malaga. The students' response to surveys and some social indices confirm that students show a good acceptance of the experience and that the proposed game increases to some extent the sociability within the classroom.

Keywords: Game-based learning, active learning, engineering.

1 INTRODUCTION

Traditional teaching approaches rely to a great extent on the transmission of knowledge from the lecturer to the student in a mostly unidirectional manner [1]. However, the collaboration and interaction between students has proven to increase the cognitive level and the academic performance [2]. In addition, collaboration is key to develop different transverse competences that are recognized to be crucial for future professional development [3] and to avoid exclusion within the classroom by promoting engagement and sense of group [4]. In a parallel manner, games have become a powerful tool to engage and motivate students [5,6]. In some cases, the general perception is that games are fundamental for kids learning, but at the end of the day we all behave like kids when we enter a game. For this reason, games also have a great potential among undergraduate students to enhance the teaching-learning experience [7,8]. This is especially relevant in engineering studies where the level of motivation is low and innovation is crucial [9,10], and for this reason much attention has been paid to a specific design of the curriculum [11].

A common strategy among university professors who want to promote active learning is to divide the classroom into different groups and let them solve subject-related problems. In such methodologies, the teacher acts as a guide and a reference for consultation, and the students are in the center of the teaching-learning process, taking an active role [12]. Although this methodology is active and effective, it can be enhanced if it is empowered with some gamification elements.

For this reason, this proposal suggests the use of card-based games within the problem-solving lecture in order to include some competition and gamification. The number of games that can be imagined has no limit, but in general it is more effective to adopt structures that are familiar to the target participants. In this case the approach is inspired in the popular Kings League game, using cards that provide some kind of power or special capability to the holder. Based on this initial point, the lecturers have specifically designed cards that promote the interaction between students. For the sake of example, the card Polymorphism allows the holder to exchange two students that are in different groups, or the card Mercenary Contract permits the inclusion of another member into your group. At the same time, some cards are designed to include the lecturer participation, like in the case of Invoke the Oracle, that allows the teacher to solve a specific part of the problem to the team that holds the card. A full description of the cards can be found in section 2.3.

The game has a total of eight original cards that are designed with a clear didactic approach to appropriately gamify the activity within the classroom. It is worth noting in any case that the activity is simple to implement, it is not time consuming (once the cards have been designed) and it is fully

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transferable to any other subject since the game only requires that students solve some kind of problem, this being open to any area of knowledge.

The proposed innovation has been applied to a course on Electrical Machines at the University of Malaga, showing good acceptance among students. The results include a mixture of students' survey (SEEQ [13]), and social measurements, confirming interest of the proposal and its capability to increase the social interaction between students.

2 METHODOLOGY

This section describes the context of the innovation (section 2.1) and includes all details of the proposed card-based game (section 2.2).

2.1 Context

The subject Electrical Machines 2 (EM2) at the School of Industrial Engineering in the University of Malaga (Spain) has been selected to implement the developed card-based game. According to the official program of EM2, it is a 6 ECTS subject. This course has been selected as a case of study due to its particular features from the perspective of the student population: high number of students of diverse degrees which are sharing the same classroom for EM2. To be more specific, EM2 is common for three different degrees from Malaga University: Degree in Electrical Engineering (EE), Double Degree in Electrical and Mechanical Engineering (EME) and Double Degree in Electrical and Electronical Engineering (EEE). As a consequence of the notable number of participants of this subject (75 learners in the course 2022-2023), the promotion of the active role of students could be considered as an especially complex task. For this reason, the implementation of games in groups can be a suitable solution to enhance the active participation of students in the teaching-learning process, increasing at the same time their social interactions.

EM2 is a mandatory subject in the degree of EE and a basic formation course for the scholars of both double degrees (EME and EEE). EM2 is lectured in the second semester of the third course of the EE Degree and in the Double Degree of Electrical and Electronical Engineering. However, EM2 is timely located in the second semester of the fifth course of EME Degree. Therefore, the previous social interaction of students of EME with the rest of EM2 scholars is reduced. In addition, an heterogenous population can be found by the professor if the cutting-edge mark to access to the degree is considered as the basis of the comparison. Table 1 shows the cutting-edge marks to access the degrees and the number of students of each degree in EM2 (course 2022-2023). As detailed in Table 1, the population of the classroom is heterogeneous according to the required cutting-edge scores to access to the degree. The mentioned situation can be mitigated to some extent with the application of active methodological tools.

Table 1. EM2 population

Degree	***Cutting-edge mark***	***Number of Students in EM2***
Electrical Engineering	5.00/14	33
Electrical and Electronical Engineering	7.85/14	17
Electrical and Mechanical Engineering	11.3/14	25

2.2 Description of the game

The gamified sessions are inspired in the Kings League game and, for this purpose, they are performed employing magic cards (Figure 1). Therefore, these solving-problem lectures, using a card-based game with special features, aims to be a motivational teaching-learning experience that increases the teamwork skills and provides a long-life learning.

It should be noted that the groups of students participating in these sessions are the same as those designed by the professors at the beginning of the course, following a heterogeneity criterion. The session begins assigning their workstations in the classroom, then the students are informed that this solving-problem session will be performed with a card-based game.

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After shuffling the deck of cards, each group is given two magic cards. Each card is self-explanatory of the capabilities it provides. Nevertheless, the learners do not know the capabilities of all the cards beyond those they hold. This fact results in an increasing interest and a higher engagement with the session development. Besides the teacher will solve the possible doubts about the card capabilities that may arise.

Once all the student groups are familiar with the cards they hold and the teachers have solved the possible doubts about the card capabilities that may arise, some rules are explained:

1 The student groups will have 20 minutes to complete a problem.

2 Each group can use their magic cards whenever they wish.

3 The cards can be used only during the current problem resolution, i.e., they cannot be accumulated for subsequent problems.

4 To use a card, the group must inform previously any professor.

5 A magic card can only be employed if another group has not notified the teacher that they have finished their exercise and are ready to solve and discuss it with the rest of the classmates.

6 If a student group tries to solve the exercise on the blackboard, and does it correctly, they are rewarded with one point, thus increasing their group's score. If, conversely, the exercise is not solved correctly, other group can try to resolve it and get the reward.

7 At the end of each problem, all magic cards must be returned to the teachers to keep playing again with the following problem.

8 It is not allowed to use any books, class notes or online material.

In this manner, known the rules, the solving-problem lecture proceeds as normal as other collaborative work sessions until any group decides to use one of its cards. At this moment any professor checks that the action this group intends to perform is possible and, if so, it is executed immediately. For example, if the group termed A wants to employ Card 3 – *Mercenary contract* (see Figure 1.c), the teacher checks the validity of this card and, promptly, the group A selects a member of another team to collaborate in solving the problem under development.

For the sake of the motivation, while a group intends to solve the problem and discuss it with the rest of their classmates on the blackboard, the professor encourages the rest of the teams to carefully check the resolution development. In this way, the rest of the groups can highlight possible errors and prevent the challenger group from achieving the reward and a better position in the final ranking. As it can be observed, this gamified session takes advantage of the additional competitiveness to motivate and promote a long-life learning.

2.3 Cards description

As described in subsection 2.2, the solving-problem sessions are enriched with the use of some cards that are given to students at the beginning of the session, thus altering the usual development of this type of sessions and also adding surprise and novelty as motivating elements. These cards have been specifically designed by the professors not only to entertain, but also to promote social interaction among groups. The designed cards are shown in Figure 1 and the description can be found below:

- Card 1 – *Polymorphism*: the holder of the card can exchange two students from different groups for the rest of the session (Figure 1.a).

  This card allows enrolling a new member but forcing to loss an original component. The latter must occupy the position of the enrolled student.

- Card 2 – *Mirror rancor*: if another group applies a card to the holder of this card, he/she can reflect its effect (Figure 1.b).

- It is a card that provides a defensive tool. Its employment permits redirecting the capability of any other card to any of the other groups.

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- Card 3 – *Mercenary contract*: the holder of the card can select and enrol any student into his/her group (Figure 1.c).

  A powerful card that provides the capability of recruit any student in the session with any *quid pro quo*, thus modifying the group heterogeneity planned by the professors.

- Card 4 – *Invoke the oracle*: the student can ask the professor to solve a part of the problem (Figure 1.d).

  The holder should select the part of the problem to be solved by the teacher since this help may be key to solving the problem.

- Card 5 – *Ostracism*: the student you select is kept apart from the other players (Figure 1.e).

  Also, a powerful tool that allows some of the best players to be removed from session only during the developing problem. The condemned student must remain in isolation in a separate area in the classroom (Figure 3).

- Card 6 – *Time distortion*: the time is stopped for the rest of the groups, and they cannot work or talk for 2 minutes (Figure 1.f).

  It is important that the holder group selects the adequate moment to obtain an important advantage over the rest of groups.

- Card 7 – *Knowledge castling*: you can exchange the solution of the problem with the team you select (Figure 1.g).

  The employment of this powerful card does not remove the targeted group from the session. This group has the possibility to continue with the exchanged exercise or to start again and continue participating.

- Card 8 – *Arcane consultation*: you can use books and online material while solving the problem (Figure 1.h).

  This card offers the recourse of employing all type of technical material to solve the problem. Its use is an element that, for any group, can compensate for certain shortcomings or, for other groups, can be a knowledge enhancer.

3 RESULTS

This section explores the impact of the proposed card-based game in two different aspects. Firstly, a survey will be used to check how students perceive the quality of the innovation (subsection 3.1), and secondly some social indices will be used to quantify the degree of sociability improvement that is obtained along the course (subsection 3.2).

3.1 Evaluation of the quality

This section explores the perception of the students in relation with the subject where the innovation took place. To this end, a student evaluation of educational quality (SEEQ) that consists of 32 items is used. This questionnaire has been already tested and its properties have been validated in multiple occasions [13], hence here it is directly used to have some input on the opinion of the students. It is worth noting that from the questionnaire it is possible to obtain a general perception but also to split the opinion of the students in different dimensions, including learning, enthusiasm, organization, group interaction, individual relationship, amplitude, exams, assignments, and overall experience. This provides a valuable information about the strong and weak points of the teaching process in various aspects.

Figure 4 shows the average score of the different items of SEEQ, where the different dimensions have been labelled above the bars. Results indicate a general satisfaction with the subject and the teaching procedure, as are scored in between 4 and 5 (being 5 the maximum mark). Focusing on the different dimensions, the experience is marked with 4.85 over 5, whereas the enthusiasm is 4.69 over 5, hence confirming an overall satisfaction with the subject and teaching approach. Other dimensions with high scores include dimension groups (4.66) and individual interaction (4.68), this suggesting that the proposal eases the interaction between peers.

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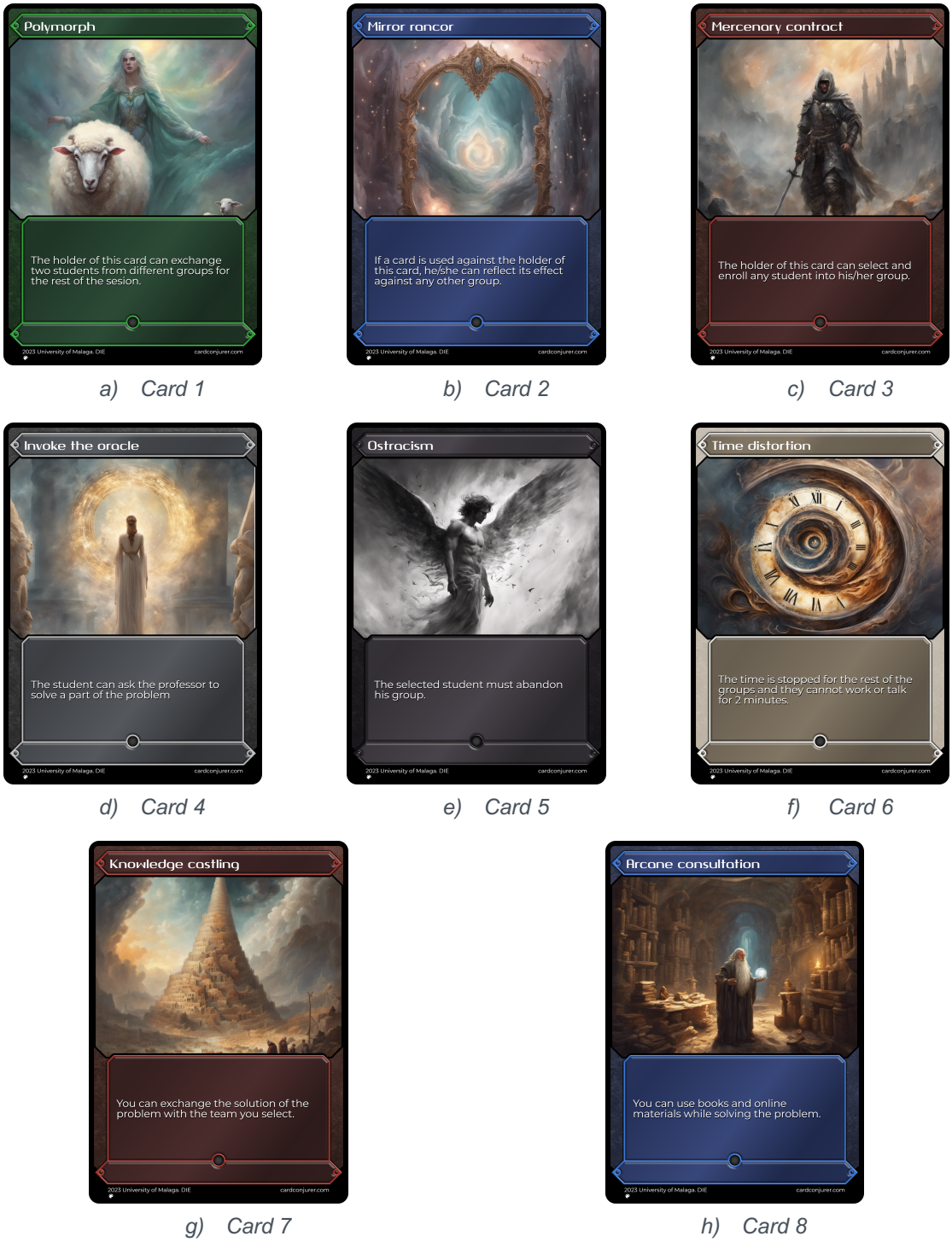

a) Card 1 b) Card 2 c) Card 3

d) Card 4 e) Card 5 f) Card 6

g) Card 7 h) Card 8

Figure 1. Card design for gamified problem-solving sessions. From top to bottom and left to right: a) Card 1-Polymorph, b) Card 2- Mirror rancor, c) Card 3- Mercenary contract, d) Card 4- Invoke the oracle, e) Card 5- Ostracism, f) Card 6- Time distortion, g) Card 7- Knowledge castling and Card 8- Arcane consultation

Figure 5 also displays the results from the SEEQ questionnaire but using a box plot for a better visualization and insight. It can be observed that the average scores are high, and the standard deviation of the response is low, except for some isolated points. Because the marks are close to 5 in some cases the quartiles are not even shown in some items (e.g., experience and group interaction) after excluding the atypical data.

To sum up, the overall experience of the students with the proposed methodology is very positive in all aspects. Students thinks that the subject stimulates them and eases the technical discussion.

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Furthermore, their perception is that the interaction with the lecturer and peers is good. This interaction is key to increase the sociability within the classroom, as it is shown next.

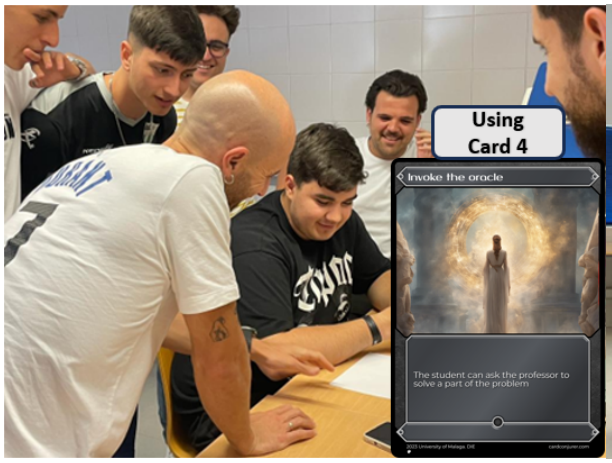

Figure 2. Students attending the gamified session

Figure 3. Ostracized player by a Card-5 holder.

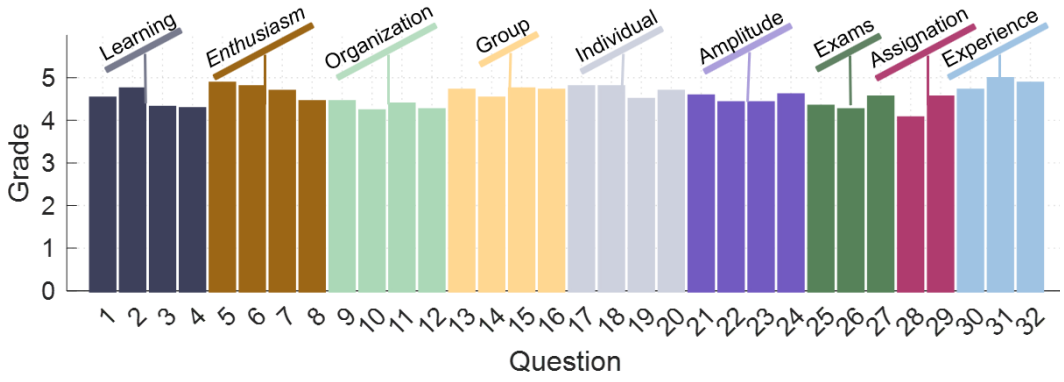

Figure 4. Bar diagram of the average scores in the SEEQ questionnaire grouped into different dimensions.

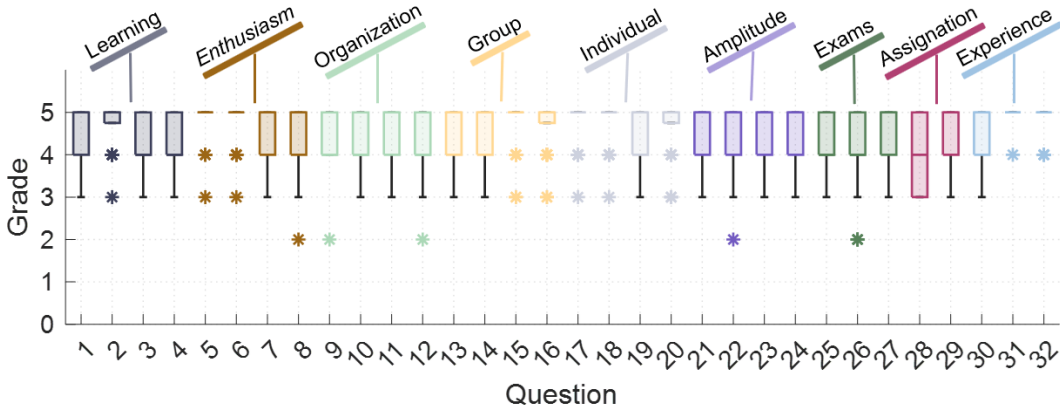

Figure 5. Box plot of the average scores from the SEEQ questionnaire grouped into different dimensions.

3.2 Sociability measurements

Even though SEEQ suggests that students perceive the innovation as a good tool to promote collaboration and peer interaction, some social measurements were performed to confirm this statement. It should be noted that students come from different degrees, and this hinders to some extent the full interaction because there is a tendency to remain with the zone of comfort (i.e., to interact only with the students of your own degree).

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The measurement consisted of a simple procedure where students select which classmates would be the better candidates to jointly make a startup company that develops a new generation of electric vehicles. The results of this question are collected before and after the innovation in order to assess the evolution. The quantification of this social interaction has been done on the basis of some indices that have been designed for this specific purpose:

- The Popularity Index (I_{pop}), that accounts for the number of classmates that have selected a certain student with respect to the total number of classmates:

$$I_{pop} = \frac{Classmates\ that\ chose\ the\ student}{Number\ of\ people\ surveyed} \cdot 100 \quad (1)$$

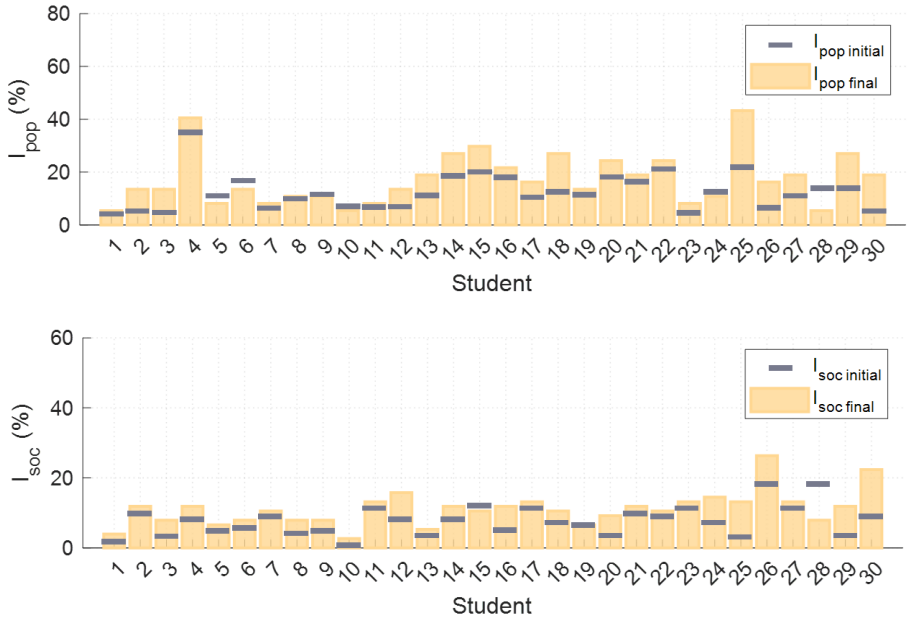
- The Sociability Index (I_{soc}), whose aim is to calculate the number of classmates that a certain student has chosen:

$$I_{soc} = \frac{Classmates\ chosen\ by\ the\ student}{Total\ number\ of\ students\ in\ the\ course} \cdot 100 \quad (2)$$

- The Mixture Index (I_{mix}), that determines the percentage of classmates that are chosen from a different degree:

$$I_{mix} = \frac{Classmates\ chosen\ from\ another\ degree}{Total\ number\ of\ students\ in\ the\ course} * 100 \quad (3)$$

Figure 6 shows the aforementioned indices both before and after the proposed innovation. Popularity and sociability indices confirm that, with the exception of some cases, the genera trend is to increase the social interaction within the classroom. Mixture index also shows a more profound interaction not only with the peers of a certain degree, but also with the classmates from other related degrees. Specifically, the sociability/popularity index shows an average value that rises from 7.82 to 10.2, this confirming that the selection of other classmates has increased by 30%. With regard to the mixture index, it is also increased by 45%. Results confirm that the interaction between peers and across degrees has increase, even when some students are in the third course and others in the fifth course and come from different groups.



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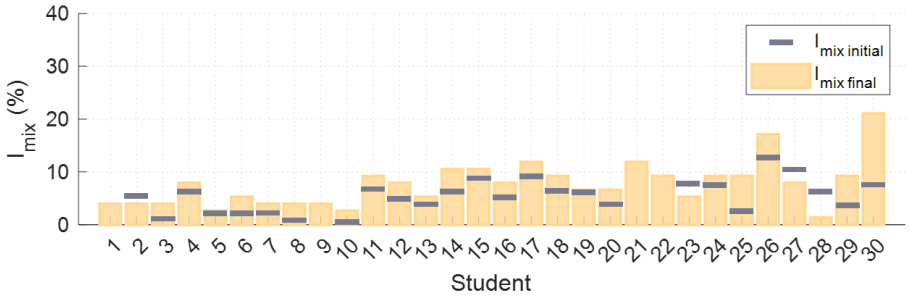

Figure 6. Indices before (grey lines) and after (yellow bars) the course for students that participated in both tests: Popularity Index (upper plot), Sociability Index (middle plot) and Mixture Index (lower plot).

4 CONCLUSIONS

Although collaborative activities improve the academic performance, they can be enhanced if they are properly gamified. This experience combines the use of group activities within a card-based games that increases the students' engagement and motivation. The proposed innovation is low-cost, does not consume much time and can be extended to different subjects since the cards are designed with a general perspective. The design is done with a didactic approach to increase the mixture between groups and to favour positive competition among students. The results show that the general acceptance of students is very positive, especially in the dimensions related to the students' interaction. This fact is confirmed with an analysis of the social interaction in the classroom since the indices resalted to popularity, sociability and mixture clearly increase after the innovation is performed.

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