Motivation and Emotions in Competition Systems for Education: An Empirical Study

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***Abstract*—A lack of student motivation is a problem in many courses in electrical engineering. Introducing competition between students can enhance their motivation, but it can also generate negative emotions. This paper presents an empirical study of students in a telecommunications engineering degree; it measured their level of motivation, and their emotions about competition in education in general, and in particular about the Information System for Competition based on pRoblem solving in Education (ISCARE). ISCARE makes adaptive matches, pairing students who share a similar knowledge level. The study results show that students had moderate levels of motivation and experienced no negative emotions while using ISCARE. Under certain circumstances, therefore, competition in education, using technology systems that provide competition, can produce motivation without generating negative emotions. Female students and students with low ISCARE scores were less motivated and experienced more negative emotions. In addition, motivation and emotions toward ISCARE were more positive than they had been toward competition in general.**

***Index Terms*—Assessment, competition, emotions, intelligent tutoring systems, motivation.**

I. Introduction

MOTIVATION is a key factor in the learning process. If students are well motivated, they will be more focused and concentrated on their learning activities and will tend to study longer. Many studies have demonstrated the relationship between motivation and learning outcomes (e.g., [1] and [2]) and have developed ways to increase student motivation during the learning process (e.g., [3] or [4]).

Many students of electrical engineering lack motivation in some of their courses. Symptoms of this include inattention, investing little time in their coursework, and lacking enthusiasm for the learning activities. This problem has been observed in many previous studies (e.g., [5] and [6]).

Competition during the learning process could introduce an additional motivational component, as students like to interact with classmates, compare their progress, and address challenges. However, competition could also generate negative emotions, as students might feel anxiety over their performance in competition, and frustration or disappointment if they do not obtain good results.

The effect on student motivation and emotions might depend on the type of competition and its design. The Information System for Competition based on pRoblem solving in Education (ISCARE) therefore includes features to increase motivation and avoid negative feelings during competition.

To increase motivation, ISCARE has students compete in several rounds, earning points not only by correctly solving the exercises, but also by doing better than their opponents. They can see their opponent's progress and their own in real time during the competition. They also can see global tournament and partial round ratings, or compare their own results to those of their classmates to see everyone's progress during the tournament.

To reduce the negative emotions that competition can generate, ISCARE uses an artificial intelligence algorithm to pair students with similar levels of knowledge. As a result, students are less likely to be frustrated by competing against those with a higher level of knowledge, and students who lose are more likely to feel that they are close to achieving the objective, and have the potential to win and earn more points. Furthermore, ISCARE has no elimination system, so all students compete in the same number of rounds, thus avoiding negative feelings of being "left out."

The study's research questions are the following.

- Did ISCARE motivate students? Did ISCARE cause negative emotions? To what extent? (See Section IV-B.)
- Was there a difference between students' perception of their motivation and emotions toward competition before their interaction with ISCARE, and toward ISCARE after their interaction? (See Section IV-C.)
- Are there differences between male and female students' motivation and emotions toward competition systems? (See Section IV-D.)
- Are students' motivation and emotions related to their ISCARE scores? (See Section IV-E.)

II. Related Work

Some authors (e.g., [7]) argue that competition does not increase motivation; others argue that it does (e.g., [8] or [9]).

Even when it is assumed that it does, there are authors who argue that competition can generate certain problems, such as disappointment and lack of confidence and interest [10], lack of efficacy [11], or poor attitudes toward errors [12]. These problems can inspire negative feelings in students. For example, there is a relationship between self-confidence and emotions [13].

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Various competition systems for education have been proposed to try to mitigate these problems. The system presented in [14] introduces virtual pets so that students see virtual characters instead of themselves and are thus not directly involved. The work in [15] uses a crossword puzzle that combines cooperation and competition. Other systems have included collaboration in the competition. Among these is [16], in which the competition, in groups, implements something similar to the Champions League, with an elimination round; all students, therefore, do not play the same number of rounds or receive the same number of exercises. Other competition-based systems that are not one-on-one are the Joyce [10] and the QUEST [17] systems. The Joyce system uses a graphical interface with a board table on which the student player advances by solving questions. The QUEST system is challenge-based, with students' scores being determined by how fast and in what order they answered. The system in [18] also allows one-on-one competition, but instead of having to answer a set of questions over a certain period of time, it is the first student with the correct answer who wins the point. The equal opportunity tactic (EOT) competition system [19] takes the knowledge level into account for its matches, but uses different data for the adaptation. Hence, for example, the time to solve the problem is taken into account, but not previous results against other students. The EOT competition system was implemented in the AnswerMatching game to teach arithmetic, not to measure motivation and emotions.

In the study reported here, ISCARE was used rather than one of the already-existing systems because these did not provide some specific conditions and features. First, in order to measure only the competitive effect, a purely competitive system was required that included neither cooperative nor collaborative features. Second, to increase motivation and reduce negative feelings, some specific competition features were required, as discussed above (e.g., the ability to match student opponents based on their knowledge levels). Finally, to be adaptable to various topics and types of questions, the competition system had to be generic. No prior system met all these requirements.

This study evaluates the arguments for and against competition systems' impact on motivation and emotions, within specific educational settings. The participating students were asked to self-report their level of motivation and emotions. Previous studies have proposed survey methodologies for motivation or emotions (e.g., [20]–[22]) in areas other than competition in education.

In terms of differences between men and women with regard to competition, research evidence suggests that men enjoy competition more than women [23] and that men perform better than women under competition conditions [24], but that these results might depend on the cultural context [25]. Since there are differences in their attitude toward competition, differences between men's and women's motivation and emotions are to be expected in this study.

III. Experimental Framework

This section provides an overview of ISCARE, a Web-based application that was presented in detail in [26], with its various educational settings being detailed in [27].

In ISCARE, students compete in a number of rounds. Each round pits students one on one against another classmate with a different opponent in each round. Each student pair has to solve a set of exercises within a set time; the exercises can be either multiple choice or "fill in the blank."

After each round, students are ranked by their scores, which are used by the pairing algorithm. A student's score after each tournament round is the sum of the points earned in every round. Students can earn a maximum of two final points in each round. One of these depends on a student's performance on the set questions. Another point depends on the student's result relative to that of his or her opponent. Results in a match can be 1–0, 0.75–0.25, or 0.5–0.5. More details of ISCARE's scoring system is available in [26, Sec. 6].

Students are paired adaptively to match students with similar scores (which after several rounds will imply similar knowledge levels). For each match, there is a difference between the students' scores. The algorithm gives the optimal set of matches to minimize the sum of the differences in scores for individual matches. For this purpose, several algorithms found in the literature can be used in ISCARE. For this experiment, the Edmonds algorithm [28] was used. Details and a comparison of these algorithms (e.g., in terms of computational complexity) are in [26, Subsection 4.2].

ISCARE tends to increase the score of less able students; competing against peers with a similarly low knowledge level, they have more chance of earning the point that depends on the match comparison. This reduction of the score difference between less and more able students might help avoid frustration among less able students.

Fig. 1 shows the ISCARE screen seen by a student solving a multiple-choice exercise (exercise 8 out of 12 for this round). The right-hand side shows evolution of the round in real time. Here, 4 min and 58 s are left. Out of a maximum of 14 points, the student with the identifier 715 has obtained three points and solved eight exercises, while the opponent has obtained one point and solved four exercises. The final point for the round, that one that depends on the student's performance, would be the result of dividing the points obtained by 14. Also displayed are the maximum number of tournament points possible at that stage (four, since this was the second round) and the individual tournament points of the student and their opponent.

The experiment was carried out twice, in the 2011 and 2012 offerings of a second-semester, fourth-year Computer Architecture Laboratory course in the Telecommunications Engineering program at the Universidad Carlos III de Madrid, Madrid, Spain. The course covers the in-depth theory and practical aspects of some concepts of operating systems, in a total of 18 sessions, four theoretical and 14 practical.

There were a total of 51 participants, 13 of them in the 2011 offering (11 men and two women), and 38 of them in the 2012 offering (26 men and 12 women). There was no control group, this not being required by the research questions. Students worked with ISCARE during the last two sessions in the 2011 offering and only in the last session of the 2012 offering. The competition covered all the topics taught in the course.

The 2012 competition had four rounds covering the following topics: shell script (round 1), makefile (round 2), FAT file systems (round 3), and system calls (round 4). The 2011 competition had an extra round (5) that addressed concepts drawn from the topics of all the previous rounds. In each round, students had to solve 12 problems within 10 min. Each student

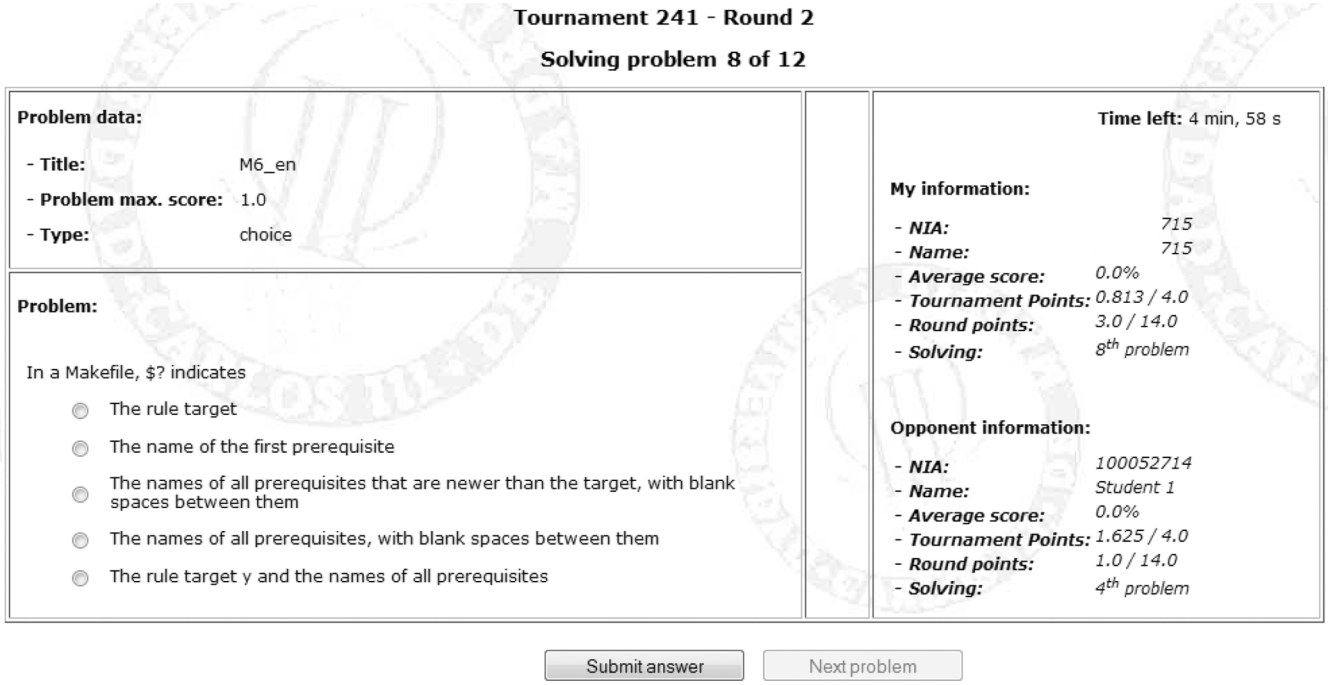

Fig. 1. ISCARE system screen.

sat at a dedicated computer, as this was an individual activity and competition.

Before using ISCARE, students completed a survey about their motivation and feelings about competition systems. After using ISCARE, they completed a second survey, about their motivation and feelings about ISCARE.

IV. Results and Discussion

A total of 41 students (29 men and 12 women) were considered in the analysis, of the 51 students who participated in the experiment. Ten students' data were discarded because they did not answer at least one of the four questions about motivation and emotions (in either the first or second survey). Some of these students came late, so they did not fill in the first survey; others had to leave early, and still others simply did not answer all the questions.

A. Students' Initial Perceptions of Competition

Before their interaction with ISCARE, students rated the following statements from 1 (completely disagree) to 7 (completely agree).

1) The idea of competing motivates me (pre-interaction motivation).
2) The idea of competing makes me feel some negative emotions (pre-interaction emotions).

Figs. 2 and 3 present the results for these two questions. The mean for the *pre-interaction motivation* was 4.39, with the 95% confidence interval being within the range [3.74, 5.04]. This means that, on average, students initially felt rather neutral about their motivation for competition. However, a high diversity of data can be observed from the histogram and the standard deviation in Fig. 2. Thus, an adaptive system that personalizes competition activities for some students but not for others might make sense. Moreover, the confidence

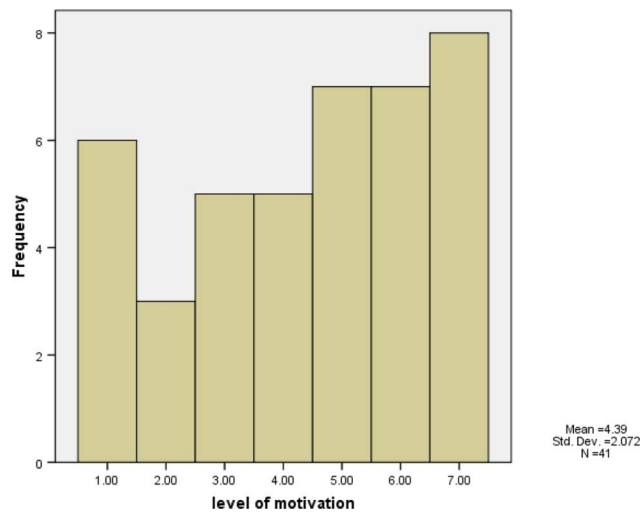

Fig. 2. Histogram of students' agreement with the statement "the idea of competing motivates me" ($1 =$ completely disagree/$7 =$ completely agree).

interval of 95% for the mean of the *pre-interaction emotions* is [2.13, 3.09], which means that most students did not feel that competition would cause negative emotions; see Fig. 3.

B. Motivation and Emotions Toward ISCARE

After using ISCARE, students were asked two questions.

1) The use of the competition system motivated me (post-interaction motivation).
2) The use of the competition system made me feel some negative emotions (post-interaction emotions).

Figs. 4 and 5 present the results for these two questions. Students felt moderately motivated by the ISCARE as the mean for motivation was 5.05, with the 95% confidence interval being [4.61, 5.49]. Again, the diversity of the data is high (see Fig. 4),

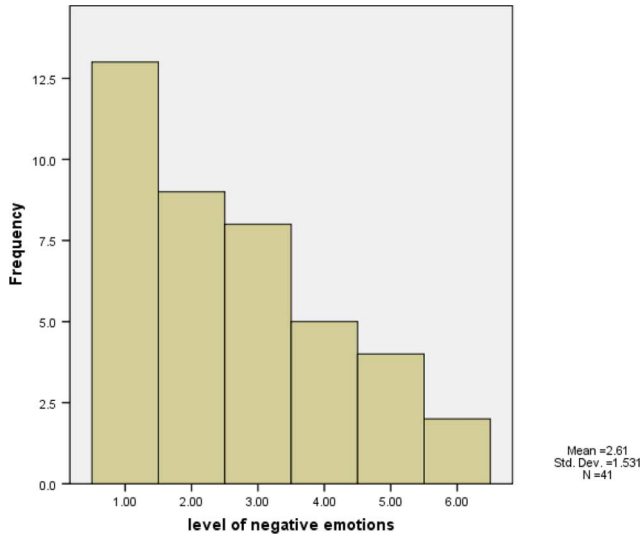

Fig. 3. Histogram of students' agreement with the statement "the idea of competing makes me feel some negative emotions" ($1 =$ completely disagree/$7 =$ completely agree).

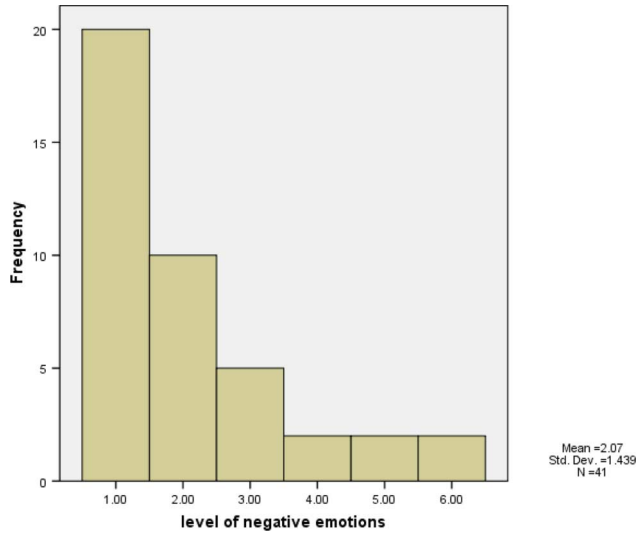

Fig. 5. Histogram of students' agreement with the statement "the use of the competition system made me feel some negative emotions" ($1 =$ completely disagree/$7 =$ completely agree).

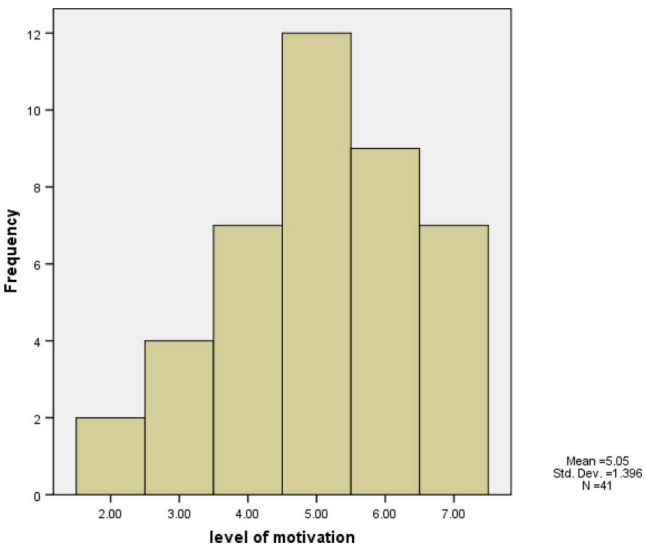

Fig. 4. Histogram of students' agreement with the statement "the use of the competition system motivated me" ($1 =$ completely disagree/$7 =$ completely agree).

which might indicate the usefulness of an adaptive system providing competition activities to some users but not to others. Moreover, ISCARE did not generate negative emotions, illustrated in Fig. 5, as the mean for the emotions is with 95% confidence in the interval [1.62, 2.53].

The Pearson correlation between the pre-interaction motivation and the pre-interaction emotions is $(\mathrm{r} = -0.234, \mathrm{p} = 0.140)$, while the Pearson correlation between the post-interaction motivation and the post-interaction emotions is $(\mathrm{r} = -0.537, \mathrm{p} = 0.000)$. Therefore, before the students' interaction with ISCARE, there was no clear relationship between students' answers about motivation and emotions, but there was afterwards. This might be because students who achieved poor results in competition cannot be motivated toward the tool and felt negative emotions, while students who did well on the platform were motivated and did not feel negative emotions. Therefore, this correlation was significant only after the activity; without any interaction, these effects were not felt, so there was no correlation between the two concepts.

C. Comparison Between Pre- and Post-Interaction Motivation and Emotions

The results of a dependent t-test between the means for post-interaction motivation with ISCARE and pre-interaction motivation toward competition are $(\mathrm{t} = -2.58, \mathrm{p} = 0.014, \mathrm{n} = 41)$. This implies that students' perceptions of their motivation toward ISCARE after using it were significantly better than their previous perceptions of their motivation toward competition had been. This might be explained by several hypotheses, among them the following.

- ISCARE's features make competition a more encouraging experience than students might have expected.
- Competition is not always looked on favorably in society, so students may be conditioned to think that competition may not be good. Interaction and experience with a competition system may have changed their minds.

In addition, the results of a dependent t-test between the means for post-interaction emotions and pre-interaction emotions are $(\mathrm{t} = 2.29, \mathrm{p} = 0.027, \mathrm{n} = 41)$. These results mean that students' perceptions of their emotions toward ISCARE were significantly better than their earlier perceptions of their emotions toward competition. Although in general the students did not initially experience particularly negative emotions toward competition, their feelings improved somewhat, at least toward ISCARE after their interaction with it.

D. Means and Confidence Intervals for Motivation and Emotions by Gender

Table I shows the means and the confidence intervals by gender for pre-interaction motivation, pre-interaction emotions, post-interaction motivation, and post-interaction emotions.

There was a clear difference between men and women regarding their motivation and emotions toward competition systems before their interaction with ISCARE, with the men being

TABLE I
MEANS AND CONFIDENCE INTERVALS REGARDING MOTIVATION AND EMOTIONS DIVIDED BY GROUPS OF MEN AND WOMEN

Group	Mean	Confidence interval 95%
Men: pre-interaction motivation	4.90	[4.15, 5.64]
Women: pre-interaction motivation	3.17	[1.96, 4.37]
Men: pre-interaction emotions	2.24	[1.70, 2.79]
Women: pre-interaction emotions	3.50	[2.58, 4.42]
Men: post-interaction motivation	5.45	[5.01, 5.89]
Women: post-interaction motivation	4.08	[3.13, 5.04]
Men: post-interaction emotions	1.83	[1.40, 2.26]
Women: post-interaction emotions	2.67	[1.45, 3.89]

more motivated toward competition systems and feeling fewer negative emotions than did the women. Through the application of an independent t-test, a statistically significant difference in pre-interaction motivation between men and women can be observed $(\mathrm{t} = 2.602, \mathrm{p} = 0.013, \mathrm{n} = 41)$, and the same is the case for pre-interaction emotions between men and women $(\mathrm{t} = -2.555, \mathrm{p} = 0.015, \mathrm{n} = 41)$.

Taking into account women's and men's perceptions of their motivation and emotions toward ISCARE after their interaction with it, there is a statistically significant difference in post-interaction motivation between the two groups in favor of men, as indicated by the results of the independent t-test $(\mathrm{t} = 3.152, \mathrm{p} = 0.003, \mathrm{n} = 41)$. However, there is not a statistically significant difference between men and women in their perceptions of their post-interaction emotions $(\mathrm{t} = -1.742, \mathrm{p} = 0.089, \mathrm{n} = 41)$. These results indicate that the interaction with ISCARE reduced the difference in men's and women's perceptions of negative emotions.

A conclusion is that since men are more motivated for competition and feel fewer negative emotions about it than do women, competition systems in general and ISCARE in particular might be more suitable for men than for women. Therefore, adaptive systems that select different types of activities (e.g., competition-oriented or not) according to the user profile might make sense.

E. Correlations Between Scores and Motivation and Emotions by Gender

Table II shows the correlation between the scores obtained in ISCARE and pre-interaction motivation, pre-interaction emotions, post-interaction motivation, and post-interaction emotions for all students, but also distinguishes the differences between men and women. There is no relationship between student scores and their initial motivation toward competition systems, but there is a relationship after the interaction with ISCARE, so students who obtained better scores on the platform felt more motivated toward ISCARE. This can mean that the score obtained by students in a competition system can affect their motivation toward competition. This also implies that appropriate action should be taken for students who performed badly so that their motivation will not decrease.

In addition, there is a relationship between the students' scores and their emotions toward ISCARE, but not between their scores and their initial emotions toward competition. This means that students with lower scores in ISCARE had more negative emotions toward ISCARE. However, this result does not imply that ISCARE does not mitigate negative emotions.

TABLE II
CORRELATIONS BETWEEN SCORES AND MOTIVATION AND EMOTIONS DIVIDED BY GROUPS OF MEN AND WOMEN

Group	Pearson correlation	Significance
All: pre-interaction motivation	0.097	0.545
Men: pre-interaction motivation	-0.043	0.825
Women: pre-interaction motivation	0.313	0.322
All: pre-interaction emotions	-0.285	0.071
Men: pre-interaction emotions	-0.321	0.089
Women: pre-interaction emotions	-0164	0.611
All: post-interaction motivation	0.324	0.039
Men: post-interaction motivation	0.029	0.883
Women: post-interaction motivation	0.800	0.002
All: post-interaction emotions	-0.496	0.001
Men: post-interaction emotions	-0.309	0.103
Women: post-interaction emotions	-0.745	0.05

On the contrary, this result suggests that reducing score differences between students (which is what ISCARE does) might reduce negative emotions. Nevertheless, ISCARE does not completely eliminate score difference between students.

The correlation between the students' perceived emotions toward ISCARE and their scores is greater than the correlation between their initial perceptions of their emotions and their scores. Thus, after students' interactions with the platform, once they know their real scores, the correlation is greater.

An analysis of the data by gender reveals that there is no significant correlation between scores and initial perceptions about motivation or emotions in competition systems either for men or women. However, there is a significant correlation between women's perceived motivation toward ISCARE and their final scores that does not exist for men. Similarly, there is a significant correlation between women's perceived emotions toward ISCARE and their final scores that does not exist for men. After the interaction with ISCARE, the relationship between perceived motivation and emotions and the final scores is much stronger for women, which suggests that the result of the competition might affect women more than men.

V. CONCLUSION

This study shows that the motivation of students toward ISCARE was moderately good and that ISCARE did not produce negative emotions in students. Therefore, competition can be beneficial in electrical engineering education in certain specific settings such as those in ISCARE.

The focus of this study is on motivation and emotion measures, but not on the further effects of motivation and emotions on learning. Although there are works that relate learning outcomes to motivation, this might change with context, so it might be examined in a follow-up study.

Students' perceptions of their motivation and emotions toward competition in education were more negative than they were toward ISCARE. This study does not try to quantify the superiority of ISCARE over other systems. One of the objectives was to quantify the degree of improvement in students' perceptions after their interaction with ISCARE. It is not easy to draw conclusions from this result. It may simply be that students were more aware of ISCARE from their recent experience of it, but did not recall or had not had other experiences with

competition systems. Another hypothesis is that societal prejudices about competition may fade when students interact with ISCARE with its specific competition setup, as the experience changes their perception.

The results suggest that certain groups have more positive perceptions of their own motivation and emotions toward competition. For example, women perceived their own motivation and emotions toward competition less favorably than did men, and the final results in the competition had a strong effect on their change of perception.

A relationship can be observed between the scores obtained in ISCARE and students' perceived emotions and motivation toward this system. However, several students are motivated and feel no negative emotions even when they receive low scores. This might denote an attitude to overcome the adversity by these students, but additional corrective measures might be considered for students with poor results, such as providing them with specific recommendations.

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