Effects of Competitive E-Learning Tools on Higher Education Students: A Case Study

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***Abstract*—Over the last few years, most of the attempts to introduce active learning methodologies in the classroom have made use of Information and Communication Technology (ICT). Many of these efforts have been directed to collaborative scenarios used in remote, blended or face-to-face experiences, in order to take advantage of the flexibility provided by ICT. However competitive learning could also have some positive effects on the success of the learning process, to be added to those of collaborative virtual environments. This paper explores the effects of competitive learning on the satisfaction and the academic achievement of telecommunications students. A tool for active and competitive learning (called QUEST) has been used in the "Communications Networks" undergraduate course. Significant results on the use of competitive e-learning tools in university students' outcomes and satisfaction are presented.**

***Index Terms*—Active learning, collaborative learning, competitive learning, e-learning, higher education, teaching/learning strategies.**

I. Introduction

ACTIVE learning methodologies based on Information and Communication Technology (ICT) are, nowadays, one of the most important tools in addressing the change that is taking place in Higher Education. When active learning is compared to traditional teaching methods, students achieve better comprehension, retain the information longer and enjoy the class more [1]–[4]. In fact, a major benefit of the use of active methodologies is that they contribute to students developing the capacity actively to research and undertake responsibility for their own learning process, and to solve problems with their own resources.

Active learning methodologies can be structured so that students are either forced to compete with one another (competitive approach), work individually (individualistic approach), or cooperate with one another (collaborative approach). Reviews of the literature [5], [6] found cooperative arrangements to be far superior in producing motivation and learning, and largely neglect competitive learning. This paper examines the effectiveness of competitive learning in combination with collaborative learning. In order to provide collaboration and communication facilities, flexibility, and anonymity in the competition when necessary, a telematic tool for active and competitive learning called QUEST (*Quest Environment for Self-managed Training*) was used. The QUEST system allows a combination of competitive and collaborative learning styles (students can collaborate in teams that compete with each other), in an attempt to marry the positive effects of both.

With the aim of studying the effects of competitive e-learning on university students, the teaching of a "Communications Networks" undergraduate course within a Telecommunications Engineering curriculum is analyzed.

The rest of this paper is organized as follows: Section II will review the relevant literature in order to provide a theoretical background for this study. Section III describes the QUEST system. In Section IV the hypotheses guiding this research are reviewed as well as the instruments used, the data collection and the educational design of the case study. The analysis and results of the study are presented in Section V. Finally, in Section VI, conclusions and future research directions are discussed.

II. Literature Review

Much of the literature on active learning [2], [3] shows a significant improvement in long term retention and on the level of understanding. So, for example, according to Dale [7], people are able to remember about 20% of what they listen to (passive), 70% of what they say (active), and 90% of what they say and do (active). Furthermore, active learning improves student attitudes and develops thinking and writing skills, which is why it is recommended as a teaching method to improve learning [8], [9].

Moreover, several studies [4], [10] have revealed interesting results in terms of student responsiveness and satisfaction, as well as a significant correlation between the use of active learning exercises and final exam scores. Felder *et al.* [1] compare outcomes for an active learning group (experimental group) with outcomes for a traditionally-taught comparison group in the chemical engineering curriculum. The results obtained show that retention was higher for the experimental group, who also developed higher critical skill levels, such that the five-year graduation rate in chemical engineering was 85% for the experimental group and 65% for the comparison group.

The development of ICT has enabled the creation of tools which make collaborative work easier, such as communication tools (email, forums, chat, videoconference…), tools for the presentation of ideas (electronic blackboards, applications to access to remote desktops…) or tools to share and manage documents. Some e-learning solutions include several of these tools such as Basic Support for Cooperative Work (BSCW) used by [11]. Using these collaborative telematic tools, the role

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of the teacher can be easily adapted to a new educational model according to which students must actively lead their learning process [12].

Although motivation is one of the most positive aspects of collaborative learning, some students feel more motivated through competition. The idea of competition is usually linked to gaming because of the motivational nature of both. In fact, the incorporation of gaming elements into learning has received increasing attention recently [13], [14]. So, for example, the Joyce system is a competitive board game that allows students to compete against each other or against a simple computer simulated agent. The players have to answer multiple-choice questions correctly in order to win the game [15]. Siddiqui *et al.* [16] present a case of the application of simulation games; they tested a supply chain simulator and observed a higher sense of competition amongst students. In addition, their results clearly show a significant increase in students' motivation. Finally, in [17], a simulation game is developed for teaching communication protocols. It is reported that this method has significantly improved the level of understanding and motivation among students.

Other computer-based interactive games are intended for learning in engineering subjects, through the use of repetition and carefully constructed levels of difficulty [18].

Games have a number of characteristics that make them attractive from a pedagogic and instructional point of view. They capture student interest, encourage active learning and motivate participation. Fasli and Michalakopoulos [19] state that "the nature of the game itself, and the competitive element involved, act as an incentive for all students to put in more effort and even weaker students persist with playing the game". Therefore, there are some systems that implement games for learning, which is an effective method to increase not only motivation but also fun and learning [20].

There are also some interesting examples of competitions for learning. For example, Revilla, a lecturer in the department of Applied Mathematics at the University of Valladolid, has developed a successful project named "Online-Judge"[1], which was given the 2005 Joe DeBlasi international award as the most important contribution to competitive learning. The system allows the correction of a number of computing challenges whose answers can be submitted on-line, as well as participation in on-line contests. Since its launch in 1997, it has received over 4.5 million submissions, reflecting the success of this type of competitive learning project. Lawrence [21] also describes a project for a data structures course based on the idea of competitive programming. It allows students to improve and evaluate their programming skills during an assignment, by competing against instructor-defined code and other students' code. Pedagogical results indicate that the introduction of the competitive tournament increases student motivation and reduces procrastination, a common cause for students failing to complete assignments.

Thus, although some authors do not recommend competitive learning [22], [23] in the literature there are several studies in which good results are obtained when this type of learning is applied [15], [16], [18]–[21], [24]. Moreover, some works study the possible negative factors of competition and compare different competition approaches: anonymous, of known authorship, face-to-face, distance located, etc. Yu *et al.* [25] examine students' preferences with respect to different kinds of competition. The results show that students prefer anonymous rather than face-to-face competition, since the former is more likely to reduce stress and other similar negative emotions. Therefore, although some authors point to the negative effects of competition on interpersonal relationships and emotional states, their studies were primarily conducted in traditional classrooms involving face-to-face situations, where, without the use of networking technologies, the identity of the participants could not be hidden. In this respect, Yu *et al.* [25] also state that it remains to be seen whether the negative effects of face-to-face competition can be mitigated with the anonymity inherent in ICT. An example of the success of this possibility is the QUEST system [26], in which ICT and, more specifically, networking, provide the support of anonymity, that allows teachers to design learning strategies adapted to the anonymous competition mode. Moreover, QUEST allows team competitions, which combine the best of competitive learning with the best of collaborative learning.

III. The Quest System

The QUEST system is an innovative tool for active ICT-based learning, whose aim is the introduction of cooperative and competitive workshops supported by telematics. This system pursues the development of student inquiry, documentation and critical analysis skills, while raising the level of involvement and communication between students and teachers.

QUEST is accessible from every computer with Internet access and, hence can be used in the classroom, at home or in a cybercafé. This level of access is possible because QUEST has been implemented as a module that can be integrated into the e-learning platform Moodle, in order to offer a new type of activity for the courses delivered through that platform.

The QUEST system presents both individual and group work environments, in which a set of intellectual "challenges" must be solved in a time-constrained way. These challenges are proposed to the students by other students and/or by the teachers.

The answers to the challenges proposed can be of any of the types most usual within the current assessment tests, and files in different formats can be attached by the students when the answers to the challenges are submitted.

Once submitted, the tasks are rewarded by means of a variable scoring system. This system obeys a set of rules designed to prevent negative effects such as plagiarism, lack of interest or lack of motivation.

The workshop mainly focuses on competitiveness, collaboration and social acknowledgment as motivation mechanisms and seeks to strengthen these skills in the student's academic work. Hence, workshop sessions are presented as a contest, with the corresponding ranking being based on the scores already obtained by the students with their answers to the set of challenges.

To enrich the learning process by means of collaboration and involvement, the system allows the students to submit challenges and to pre-evaluate the corresponding answers. The scoring method was designed to avoid the negative effects this

[1]http://acm.uva.es

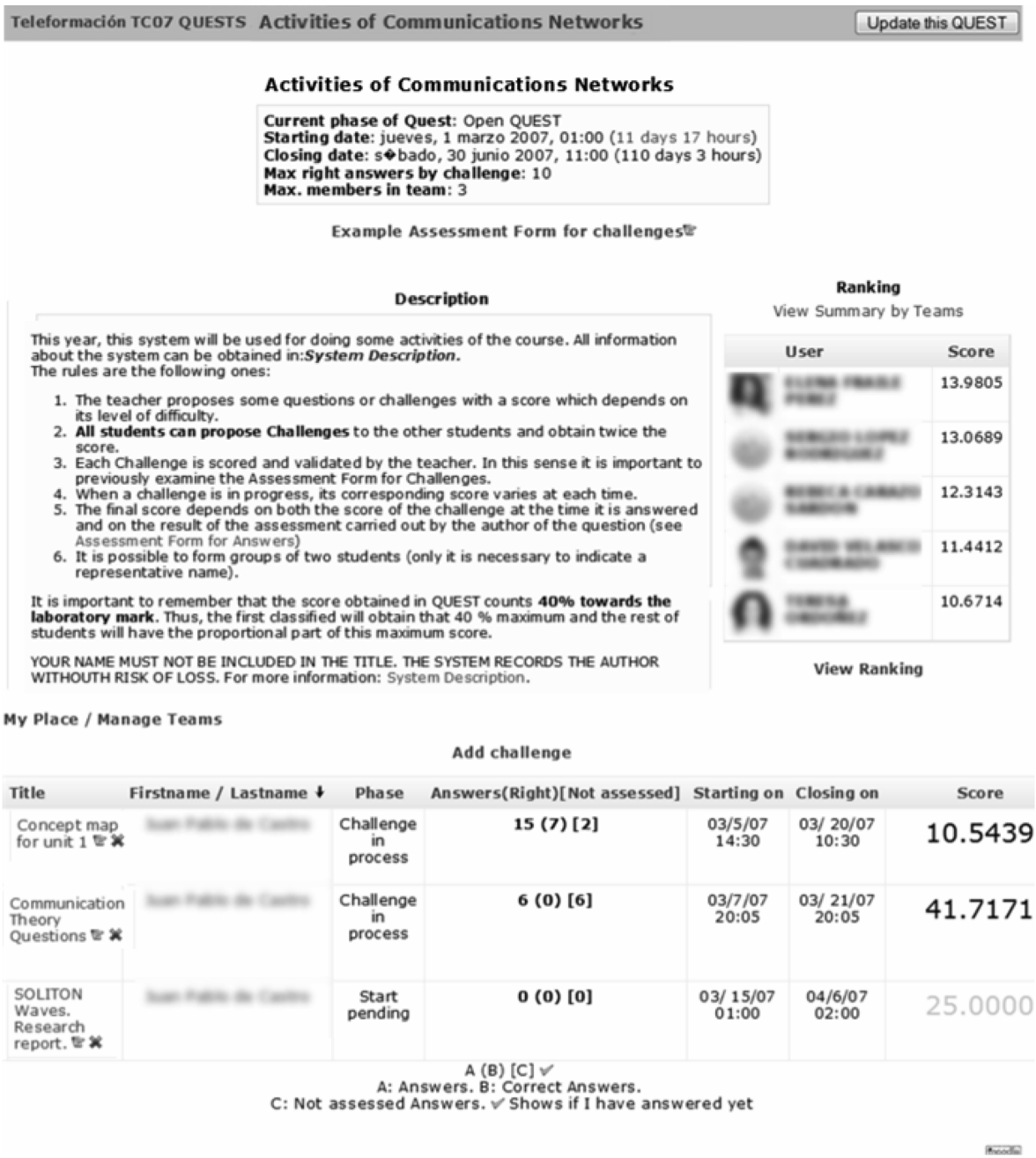

Fig. 1. Main screen of the QUEST system in which the proposed challenges and their current score are shown, as well as a summarized ranking of the best students.

practice may entail, and each new challenge proposed by a student must be scored and validated by the teacher [26].

As shown in Fig. 1, the QUEST system displays a permanently updated and summarized ranking with direct access to a detailed scoreboard. There are both individual and team rankings. Additionally, all the challenges proposed by teachers or students are shown in the main area of the screen.

Since the challenge exists from the time it is created until it is eventually closed, its score varies as shown in Fig. 2. Initially, the score grows to adjust the reward to the difficulty of the question. When the challenge is correctly answered, the score starts decreasing so that the student who is the first to answer correctly is awarded the maximum score.

The final score obtained by students depends both on the score of the challenge at the time it is answered and on the result of the assessment carried out by the author of the question. This assessment must be conducted on the basis of a number of criteria defined by the teacher when the contest is created, and known previously to every participant.

Finally, when the challenge is closed, the students can read all submissions from all the participants anonymously, which can help them to understand and reinforce concepts while maintaining the privacy of the submitting authors. As students have the possibility of generating content that everyone else will be able to access, they tend to aim for a higher level of perfection than they would if their work were private [27].

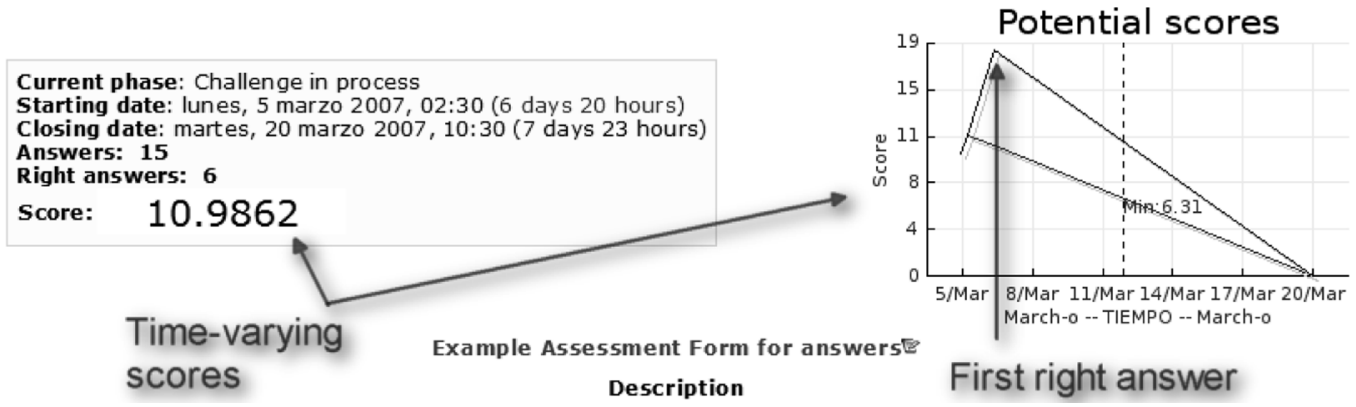

Fig. 2. Variable scoring of a challenge during its life-cycle.

IV. Procedure

Several studies [28]–[32] suggest that students' satisfaction and motivation are important factors in measuring the success or effectiveness of the e-learning process; student satisfaction is associated with student achievement [33] and it is also a key indicator of educational quality [34]. Consequently, this study proposes firstly to measure students' satisfaction with QUEST and their overall educational experience.

Moreover, in order to asses the pedagogical performance of the e-learning system and the effect of competitive e-learning on higher education students, it is very important to determine if students' academic results and the use of this new competitive e-learning tool are correlated.

A. Hypotheses

Taking as a base the reviewed literature, this study proposes the following hypotheses:

- **H1**. The final exam scores of the students who have participated in QUEST will be higher than those of the rest of students.
- **H2**. The final exam scores of the students who have obtained better results in QUEST will be higher than those of the rest of students.

B. Methodology and Instruments

Two instruments were used in this study: a) the students' final exam grades in the different courses and the log of results in QUEST (i.e., the score and the participation of the students in the different QUEST workshops), and b) a ten-item survey based on the instrument developed by [28], which measures students' satisfaction and motivation in e-learning environments. This survey includes items relating to student interaction and collaboration or active learning with the QUEST system.

The second instrument provides students with a five-score Likert-type scale. The scale ranges from "Strongly Disagree" to "Strongly Agree." Students' satisfaction total score can range from a minimum of 10 (very low satisfaction level) to a maximum of 50 (very high satisfaction level).

C. Data Collection

Data were collected on line, using the instruments described previously, during June 2006. The survey was set to collect responses using the "phpEsp" survey system, which presents each question in a similar format to that normally used on paper questionnaires. This fact is an advantage when designing a Web survey [35]. Data submission is anonymous, with no link between a submission and its author.

D. Case Study: the "Communications Networks" Course

The case study reported in this paper takes place in an undergraduate course on Communications Networks. This course is part of the core curriculum of Diploma in Telecommunications Engineering (a specialty in Telecommunication Systems) at the University of Valladolid (Spain). The course deals with the fundamentals of data communication networks (architecture, protocols, and so on) and Internetworking; in terms of the IEEE/ACM Computing Curricula 2004 [36], it covers the units CE-NWK0 through CE-NWK3 and CE-NWK8. This course is placed in the second semester of the first year (of the three-year course), and comprises 30 lecture hours (one 2-hr session per week) and 30 laboratory hours (also one 2-hour session per week) during the 15-wk long semester.

The study was carried out from February until June 2006, with 200 enrolled students. Taking as a criterion the timetable on which the students chose to attend the course and in order to be able to assess the pedagogical performance of the QUEST system, two groups were randomly formed: a QUEST experimental group, whose students would use QUEST, and a control group, which would work in a traditional way.

Also, the activities with QUEST, which were deployed as an additional resource, were carried out during the laboratory hours. Although each challenge was designed to be solved during a single laboratory session, they all were five days long. Thus, the challenges could be also resolved once the session had finished. However, because the QUEST score varied with time, the teachers recommended students to answer the questions as soon as possible.

Students were organized in pairs so that they could collaborate to solve the questions proposed. Challenges ranged from short questions to more complex IP design exercises.

V. Analysis and Results

A. Analysis

The data collected was analyzed for group comparison using the Student T-Test for students' outcomes. This statistic assesses whether the means of two groups are statistically different from each other in order to be able to compare them. In addition, in order to measure the strength of the association between two variables, Pearson's Correlation Coefficient was also used. All the collected data was analyzed with the SPSS 14.0 program for Windows.

Finally, in order to verify that the two study groups (experimental and control) have a normal distribution, the Kolmogorov-Smirnov test has been used ($p > 0.05$). The equality of variances was checked by means of the Levene test. As the two analyzed groups do not have an equal variance, a correction of the Student T-Test, which is also implemented in the SPSS program, was used.

B. Results

The first point to be analyzed in order to determine if the system is successful, is the level of students' satisfaction according to the survey data. A total of 42 experimental group students completed the survey (about 35%). In general terms, the QUEST experience was positively evaluated by students (with an average score of 36.5). Moreover, the students were pleased with the QUEST tool. In short, they liked learning through the participation in contests in order to improve their positions in the ranking, and would like to take another course using QUEST. However, some of them also thought that it was a little stressful. On the other hand, in spite of the competitive nature of QUEST, most students were of the opinion that QUEST had facilitated their relationship with other students.

Maintaining the anonymity of participants is very important in QUEST. The students were asked how they would like to participate in the contests. Forty-three percent answered that they would prefer to participate "in teams with known identity," 36% selected the option "individually and anonymously;" and only 21% preferred to participate "individually with known identity."

The second result to be analyzed is the role of students as content generators. The total number of proposed challenges was 15. These challenges could be submitted by the teachers and, as mentioned above, also by the students. However, in this paper, only four students proposed challenges; specifically three students proposed one challenge and the fourth one proposed two. That is, the students are still reluctant to take the lead actively in their learning process and to be generators of content, and prefer simply to answer the challenges proposed. The average number of answers of each student was 14.4. Since the QUEST experience was mainly carried out during the laboratory hours, most of the students worked on answering challenges instead of proposing new ones. In fact, students preferred to work on proposing challenges at home. It would be interesting to see if the number of challenges proposed by students would increase in a pure remote contest.

Finally, another important question to be answered is whether students' academic results and the use of this new e-learning tool are correlated or not. In this connection, a first significant result is that 56% of experimental group students passed the course as opposed to only 37% of the control group students.

TABLE I
Group Comparison—Students' Academic Outcomes and Participatione in QUEST

	QUEST group students (n = 126)		Control group students (n = 74)		T-Test
	M	SD	M	SD	P
Final exam grade	2.70	1.9968	1.58	0.7343	< 0.001*

* Results are significantly different at p < 0.001 (T-test).

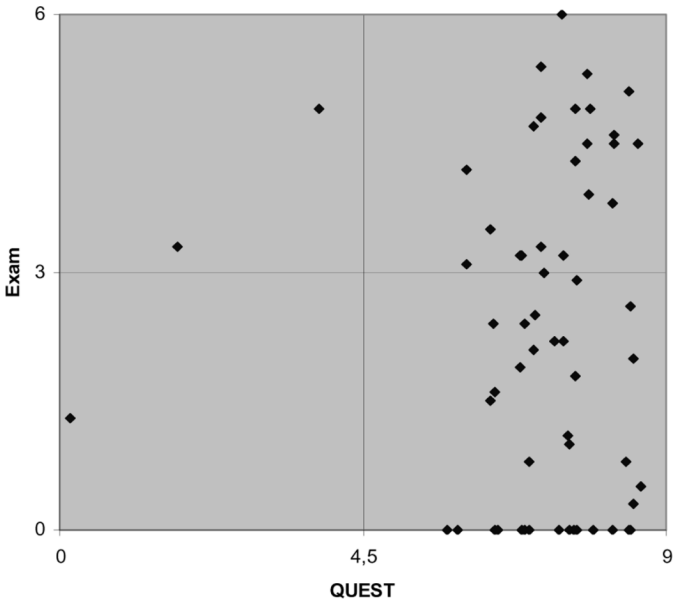

Fig. 3. Grid of exam-QUEST scores.

The data on students' outcomes and participation in QUEST were analyzed for group comparison using the T-test. The results, presented in Table I, show that students' final exam grades[2] are significantly different between the two groups, indicating that the hypothesis H1 is supported, as the outcomes of experimental group students are significantly higher than those of control group students. However, using Pearson's Correlation Coefficient for the experimental group data, the results indicate that the scores in QUEST and the final exam grades are not linearly related ($r = 0.068$, $p = 0.446$), so that the hypothesis H2 is not supported. As the scores in QUEST increase the final exam grades of students does not increase, which can be seen from the diagram represented in Fig. 3.

In short, experimental group students obtain better final academic outcomes, although these are not correlated with their score in QUEST. This result could demonstrate what is stated by students in the survey: QUEST helps students to learn from their mistakes thanks to other students' responses and teachers' feedback, so that those students with worst scores in QUEST learn more and manage to improve their grades.

[2]The minimum and maximum final exam score is 0 and 6, respectively.

VI. Conclusion

The following results and contributions were obtained with respect to the QUEST system, an innovative tool for interaction and cooperative work based on ICT:

- — a new teaching-learning strategy and the corresponding adapted assessment method, based on competitive active methodologies;
- — innovative strategies, such as the partial assessment of students by their classmates, which may be very useful if properly carried out;
- — a new methodology which aims to engender in students the characteristics required by new professional profiles, for example becoming active, independent, strategic, reflective, cooperative, and responsible;
- — integration of the different phases of the learning process (tutorship, assessment, documentation, and so on) into a single environment.

In addition, the results of this paper suggest that the use of competitive e-learning tools have important effects on the students. First, the level of satisfaction with a competitive active e-learning tool, such as QUEST, was positively evaluated by the students. Second, the students who used QUEST obtain better final exam grades although these do not correlated with their scores in the contests. In the future, factors which truly contribute to these positive outcomes should be analyzed. These future studies will require linking the survey data of individual students with their final exam grades, in order to analyze the various factors involved (level of satisfaction, results of exams and QUEST scores). Such studies will focus on exploring how and when competitive learning is most effective.

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