Virtual Learning Environment to Encourage Students' Relationships and Cooperative Competence Acquisition

Rosa Estriegana
Computer Engineering Department
University of Alcalá
Madrid, Spain
rosa.estriegana@uah.es

Jose Medina
Computer Science Department
University of Alcalá
Madrid, Spain
josea.medina@uah.es

Rafael Robina
Business and Sociology Department
Univ. of Extremadura
Caceres, Spain
rrobina@unex.es

Roberto Barchino
Computer Science Department
University of Alcalá
Madrid, Spain
roberto.barchino@uah.es

ABSTRACT

Currently, companies and society widely proclaim the importance of solid communication and cooperative skills for professionals. Similarly, in higher education, programs are redefined to allow students to gain communicative and cooperative competences to qualify them for their professional work and the role they will play in society, however, there is a lack of specific guidelines on learning strategies and tools that promote acquisition and development of these competences.

An empirical study is shown to examine how an online learning environment developed from scratch throughout several years and based on web-based resources such as virtual laboratories, interactive activities, educational videos, and a game-based learning methodology combines with active learning, which might impact the student´s relationships and cooperative competence development.

As a result, a case study was carried out through a virtual learning environment. It was created to motivate and to facilitate students' involvement. The analysis was conducted based on the data collected from a core subject of the Computer Engineering and Information Systems degree courses. The answers of an online survey (n=289) were examined by using the structural equation modeling technique (SEM).

The results obtained show that the use of this learning environment have a significant and positive impact on the two dimensions of relational coordination; communication and relationships. Furthermore, the learning environment plays a key role in the acquisition and development of cooperative competence. Additionally, the results indicate that communication and relationship positively influence on cooperative skills.

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CCS CONCEPTS

• Applied computing → Education → Collaborative learning → Computer science education, E-learning

KEYWORDS

Online learning environment; Relational Coordination; Communication; Cooperative competence; Structural Equation Modeling

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1 Introduction

The computing professional no longer fits the old stereotype of an isolated computer programmer working alone, instead, most computer jobs require professionals to interact and cooperate with others. Therefore, to develop students' collaborative or cooperative ability should be one of the main goals of higher education. Nevertheless, while these skills have been considered important, curricula often have not been clear and there are no specific guidelines or information about strategies, activities or learning tools that promote their acquisition and development.

Technology and appropriate instructional strategies can play a key role in addressing this problem. Thus, by combining learning strategies and technology resources, it is possible to create meaningful learning scenarios that increase communicative and collaborative skills and also improve in-depth learning.

In order to increase students' motivation, encourage participation and improve the learning process, we have created an online learning environment (OLE) from scratch, which integrate video teaching, interactive exercises, virtual laboratories and game-based learning [14]. The use of this learning environment has been a key element to promote students' interaction and involvement and to allow active learning method in the classroom. This learning approach is inherently designed for increasing the instructor's accessibility and availability, and this leads to greater confidence among students to intervene, to ask questions and to give answers. This increase in participation and interactions in the classroom has an impact on enhancing student relationships.

This paper outlines an experimental study that analyzes the impact of an online learning environment on Relational Coordination (RC) and argues how the learning environment facilitated by this resources and the game-based learning promotes the development of cooperative competence which is an essential competence so needed and demanded today.

Therefore, the main objective of our study is to analyze how an online learning environment with virtual laboratories, interactive activities, educational videos, and a game-based learning methodology impacts student relationships and the development of cooperative competence. To achieve this, we make contributions in three aspects. First, by evaluating whether the online learning environments have had a significant impact on students' relationship. Second, by analyzing whether the learning environment has led to a significant impact on cooperative competence acquisition. Third, by studying the impact of relational coordination on students' cooperative skills.

2 Literature Review and Theoretical Framework

By combining online learning resources and active learning strategies it is possible to create a meaningful learning environment (LE) that conforms a single whole. This LE will work effectively only if its components are balanced and methodically adequate to program educational objectives.

2.1 Virtual learning tools

The advantages offered by online learning systems and new technological learning tools to improve the quality of educational experiences have been extensively studied and documented over recent years; for example, to increase students' motivation [8], to provide autonomy, flexibility and accessibility to the learning contents, to develop students' autonomous learning ability [16], to increase the efficiency of teaching and to improve students' achievement [31, 33], to acquire and develop competences [11, 12] and also, online learning systems and technological learning tools have a key role to support active learning approach [2]. Additionally, since the global pandemic sparked by Covid-19, online learning tools have been unquestionably essential to education.

2.2 Active learning

In active learning the student plays a central role, the main learning responsibility is moved from the teacher to the student. According to Prince [41] students have to engage in meaningful learning activities and reflect on what they are doing to implement active learning. There is empirical evidence that proves the benefits and the effectiveness of active learning compared to traditional lecturing [3, 21, 41]. Active learning involves students in the learning process, adapts to the learner's style and provides spatial and temporal flexibility [42]. In addition, active learning promotes the acquisition and development of key competences [30, 43].

Just as active learning is supported by technology [2], technological resources do not provide a learning solution by themselves [35]. Thus, thanks to pre-study using online learning environments and technological learning tools, class time can be spent using cooperative and participative learning strategies without sacrificing content. Teachers can foster active learning, propose challenges and collaborative projects for developing students' skills and getting students feel more involved with their own learning.

2.3 OLE

Following previous research, an online learning environment (OLE) integrating web-based resources was developed [14]. The OLE is based on appropriate instructional strategies, incorporating a range of randomly generated interactive and graphical activities such as computer simulation, virtual laboratories or explanatory videos with exercises. The OLE also includes game-based learning aimed at encouraging students to work with the application. So, students can choose the type of activity, watch videos, or see the results of the activities carried out and the badges obtained, comparing them with those of the rest of their classmates, promoting a level of competition that stimulates the students. The purpose of the badges is to increase student motivation, as this is a primary component that positively affects learning [46]. Although students can attempt an unlimited number of exercises, they only have three chances to solve each activity before the correct result is displayed, another activity is randomly generated, and the sequence is initiated. Figure 1 shows the example of one of the interactive exercises and the medals of one of the OLE units.

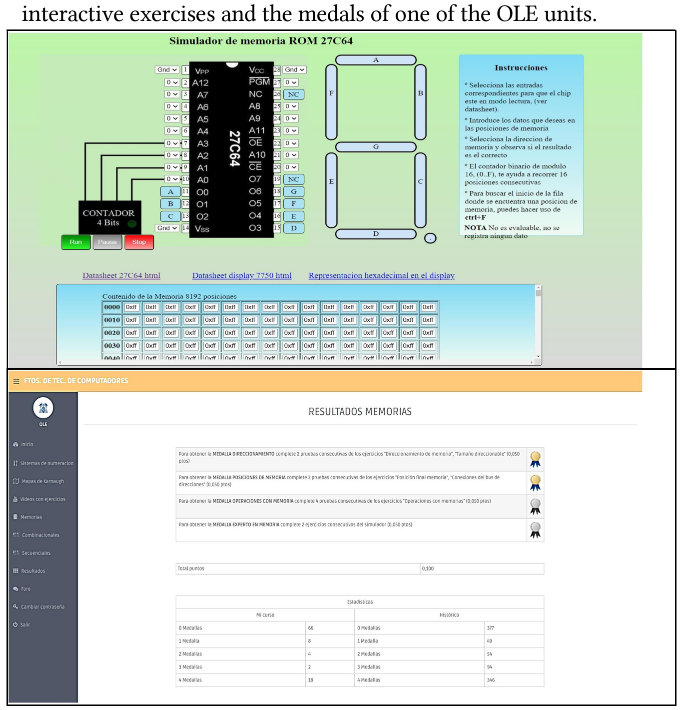

Figure 1: Example of OLE activity and badges

2.4 The relational coordination model

The model of relational coordination (RC) have proved to be a power driver for quality and efficiency outcomes. Relational coordination model [23] emphasizes the need to understand the coordination in relationships and the dynamic of communication at organizations to reach best organizational results. So different researches have applied the RC model in different sectors such as airlines [24], healthcare [25, 34], cloud computing [10], and education [9, 36, 37, 22].

According to the results, the quality relationships and the quality communication increase the degree of satisfaction teacher and students, providing shared knowledge, shared goals and mutual respect mechanisms, supported by a frequent, timely and problem-solving communication what it permits to obtain better results.

However, there is a lack of literature that explores the impact of relationship and interactions in learning environments and its relation with the acquisition of competences.

2.5 Cooperative Competence

Wolz, et al. [48] defined collaborative learning or cooperative learning as the instructional use of small and medium-sized groups through which students work together to maximize their own and each other's learning.

Cooperative competence is the capability of working with others effectively. It means the ability to exchange information and to establish, develop and maintain social relationships. Along with communication competence constitute social skills. Cooperative competence includes interpersonal skills, critical and self-critical capacities, ability to communicate with others and the ability to work in a team. This is a transversal competence, which means that can be used to achieve good performance in a wide variety of different situations or contexts.

In accordance with the collaborative activities, the interaction, and the students' involvement offered by the online learning approach and the interrelationships produced in this particular learning environment, our study suggests that cooperative competence can be acquired or improved.

3 Research Model and Hypothesis

Based on the previous research, a theoretical model was developed to evaluate the impact of the OLE on students' relationship and on cooperative competence acquisition and also to understand the influence of relational coordination on cooperative development. Each of the hypotheses presented below corresponds to each path in the SEM and forms part of the aforementioned objective.

3.1 The Learning Environment (LE)

The Learning Environment (LE) created by combining the OLE resources and active learning strategies increases classroom interaction, encourages students' involvement and creates opportunities for cooperative work. Communication and interaction is achieved through questions and answers between teacher and students. Similarly, Cooperative work is reached when two or more students learn or attempt to learn something together for example using problem solving, discussion and agreement. These types of activities are essential for students, specially, in the first year of university [4] not only by the connection to like-minded or same-age peers but also to get social and academic integration and achievement. In addition, student involvement is increased with challenges and discussions, which enhances student learning in a cognitive and affective way.

Therefore, we hypothesized that the LE created by combining the OLE resources and active learning strategies would positively impact on communication (H1) and on relationship (H2) and also that this LE would be a significant factor that positively influenced on cooperative competence development (H3).

3.2 Communicative and Relationships dimensions

Gittel [25] indicated the RC model is relatively unique including relational coordination dimensions: Common goals, shared knowledge and mutual respect, and specifies how these relational ties are mutually reinforced by communication links that allow effective coordination of work.

According to the model of RC, coordination process takes place through a network of relationship and communication dimensions.

The relationships are based on the relational dimensions included in the model as shared goal, shared knowledge and mutual respect. They enable students and lecturers to coordinate more effectively the work processes in which they are engaged [23, 37].

The communication is based on the communication dimensions included in the model such as frequently, timely, accurate and resolving problems. Thus, a truthful information facilitates teachers and students can teach, learn, help and share at the same time. In addition, frequent and timely communication means that students do not have to wait long for feedback from teachers, which would create uncertainty about their learning tasks [44].

Based on the previous studies, we hypothesized that communication positively influenced on acquisition and development of cooperative competence (H4) and on the other hand, communication would positively impact on relationships (H5). In turn, it seems logical to assume that good and fluid relationships positively influenced on cooperative competence development. (H6)

4 Methodology

Based on other reviewed and validated models and following several criteria as guidelines [40], an online questionnaire was designed to test our hypotheses.

4.1 Instrument

Questionnaires have great utility and accuracy in predictability and offer an easy way to research into the methodology and tools related to competence acquisition in the learning process. The questionnaire follows a 5-point Likert bipolar scale [32], with answers from 1 "completely disagree" to 5 "completely agree", adopting the usual method to measure variables that are not directly quantifiable [26].

Items for each variable in the study were adapted from scales that have been validated in previous studies. Hence, the LE construct use interaction, collaboration and involvement. Questions on Interaction, and Collaboration were adapted from the Distance Education Learning Environments Surveys (DELES) [45]. This instrument assesses students' perceptions of virtual learning environments and has been used in numerous studies with strong reliability and validity [17, 18]. Questions on Involvement were based on the classroom environment instrument: What is happening in this class? (WIHIC) [20], that examine students' perceptions of the classroom by combining some relevant scales from existing questionnaires and validated in several studies [1, 13, 38].

Questions on relational coordination are based on an adaptation of the original questionnaire provided by Gitell [25]. It has been also adapted by De Pablos et al. [9,10] and Gallego et al. [22] in previous research applied to education.

4.2 Participants and data collection

The analysis was conducted using data obtained from students taking the course Fundamentals of Computer Technology, a core subject in the first year of the Computer Engineering and Information Systems degree, whose fundamental goal is to understand the basic level operation of a computer.

Data were collected from students by means of a voluntary and confidential online questionnaire at the end of term. A total of 289 students completed the questionnaire (253 males and 36 females) aged mostly from 18 to 20 years old.

5 Data Analysis and Results

This study employed a regression analysis of latent variables, based on the optimization technique of partial least squares (PLS) to elaborate the model. This study draws on SmartPLS 3.2.6. PLS is a multivariate technique for testing structural models and estimates the model parameters that minimize the residual variance of the dependent variables of the model [26]. It does not require any parametric conditions and is recommended for small samples [29].

To determine sample size, it is necessary to specify the expected effect size (ES) and the significant values for alpha (α) and power (β). These three values are then used to calculate sample size. In this case, a multiple regression study was conducted with four predictors, an average effect size (ES) of .15, an alpha of .05, and a power of .95, in line with Cohen [6], to obtain the sample size. The result of this analysis was N=129 participants. Given that our available study sample consisted of 289 valid cases, our sample comfortably exceeded all criteria for performing an analysis of the measurement models and structural model.

5.1 Measurement model evaluation

Skewness assesses the extent to which a variable's distribution is symmetrical and kurtosis is used to analyze the degree to which values for the variable analyzed cluster around the central area. An excessively peaked distribution indicates a very narrow distribution with most of the responses in the center [27].

According to results, the measurement model is satisfactory. since most kurtosis and skewness values for the indicators were within the acceptable range (-1 to +1), except for a few that exhibited a slight degree of non-normality [27]. However, as the degree of skewness was not severe and because one of the two indicators measured the (reflective) construct, this deviation from normality was not considered an issue and the indicator was retained. All standardized loadings (λ) were greater than 0.707 (Table 1), indicating that individual item reliability was acceptable [5].

Table 1. Outer model loadings

	Coop-Comp	Communic.	LE	Relations
c-coo-1	0.822			
c-coo-2	0.800			
c-coo-3	0.880			
c-coo-4	0.798			
Com-1		0.788		
Com-2		0.767		
Exa-2		0.707		
Frec-1		0.782		
Rsp-2		0.721		
int-1			0.843	
int-2			0.866	
int-3			0.816	
inv-1			0.851	
collab-1			0.862	
collab-2			0.898	
collab-3			0.844	
Con-1				0.842
Obj-1				0.816
Res-1				0.830
Res-2				0.710

Simple reliability of the measurement scales was calculated by means of Cronbach's alpha values, all of which were above 0.70 [39]. Regarding composite reliability, all the indicator values were greater than 0.7 [47], indicating a high level of internal consistency reliability among latent variables. In the analysis of variance, all values for the average variance extracted (AVE) were above 0.50 [19], exceeding the minimum acceptable values for validity (Table 2).

Table 2. Cronbach's alpha coefficients, Rho_A, construct reliability, and average variance extracted

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extract. (AVE)
Coop-comp.	0.845	0.852	0.895	0.682
Communic.	0.817	0.833	0.868	0.568
LE	0.938	0.939	0.950	0.730
Relations	0.815	0.833	0.877	0.642

Additionally, we applied discriminant validity measures using the Fornell and Larcker [19] criterion and the value is higher than other correlation values between latent variables, indicating acceptable discriminant validity of the measurements. On the other hand, as shown in table 3 we also applied discriminant validity measures using the heterotrait-multitrait (HTMT) method [28], which indicates the mean of the heterotrait-heteromethod correlations relative to the geometric mean of the average monotrait-heteromethod correlation of both variables. We used a conservative criterion of .85, which is associated with sensitivity levels of 95% or better. With construct correlations of .70, the specificity rates for HTMT .85 are close to 100%. We found that the HTMT ratio for group-focused and individual-focused transformational leadership, at .83, was below the .85 cut-off, and substantially below the .95 cut-off recommended for conceptually close constructs [28]. This provides good support for our claims of discriminant validity between our individual and group measures [28].

Table 3. Discriminant validity matrix (Heterotrait-Monotrait Ratio Criterion)

	Coop-comp	Comunic.	LE	Relations
Coop-comp.				
Communic.	0.710			
LE	0.846	0.754		
Relations	0.657	0.813	0.659	

5.2 Structural model analysis

The model shown in Figure 2 was constructed from a review and analysis of the literature.

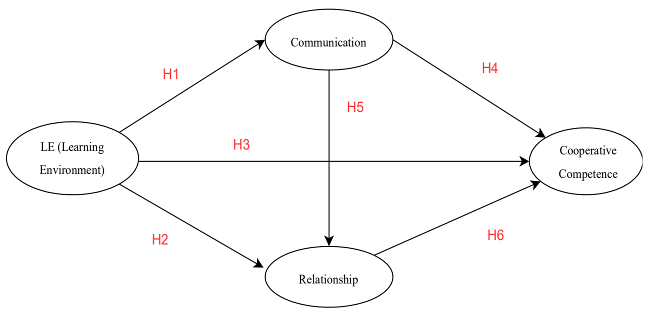

Figure 2: Structural model (baseline model)

The PLS program can generate t statistics for significance testing of both the inner and outer model, using the procedure called bootstrapping [7]. In this procedure, a large number of subsamples (5000) are taken from the original sample with replacement to give bootstrap standard errors, which in turn give approximate T-values for significance testing of the structural path.

The results of the bootstrapping procedure were as follows: All the R^2 (R-squared) values ranged from 0 to 1 (Table 4). The higher the value, the greater the model's predictive capacity for that variable. Because R^2 should be sufficiently high for the model to reach a minimum level of explanatory power, R^2 values must be greater than 0.10 with a significance of t > 1.64 [15].

Figure 3 and Table 4 show the variance explained by R^2 in the dependent constructs and the path coefficients for the model. They were not below 0.10, indicating that the independent explanatory variables were acceptable.

Table 4. Structural model results

	R^2	Samp. Mean (SM)	Stand. Dev. STDEV	T Statisc. |o/STDEV|	P Val.	Q^2
Coop-comp.	0.610	0.616	0.042	14.590	0.000	0.396
Communic.	0.475	0.476	0.050	9.458	0.000	0.251
Relations	0.514	0.518	0.055	9.376	0.000	0.317

Standardized regression coefficients show estimates of structural model relationships, in other words the hypothesized relationships between constructs. Hence, the algebraic sign is analyzed if there is change in sign; the magnitude and statistical significance (T statistics) was greater of 1.64 (t (4999), one-tailed test). Next, the hypotheses were checked and validated, and the relationships were positive, mostly with high significance, as shown in Table 5.

Table 5. Structural model results. Path significance using percentile bootstrap 95% confidence interval (n=5,000 subsamples)

Hy	Resul	Influence	SPC	S.Mean (SM)	S.Dev STDEV	T Statist |O/STDEV|	P Val	Ch+/-
H4	Accep. (*)	Communic-> Coop-comp	0.122	0.121	0.069	1.768	0.039	No
H5	Accep. (***)	Communic-> Relations	0.567	0.567	0.056	10.128	0.000	No
H3	Accep. (***)	LE -> Coop-comp	0.612	0.612	0.055	11.144	0.000	No
H1	Accep. (***)	LE -> Communic	0.689	0.689	0.037	18.769	0.000	No
H2	Accep. (**)	LE -> Relations	0.197	0.198	0.063	3.154	0.001	No
H6	Accep. (*)	Relations-> Coop-comp	0.116	0.119	0.066	1.752	0.040	No

Note: t (0.05, 4999) = 1.645158499, t (4999 0.01.) = 2.327094067, t (0.001, 4999) = 3.091863446 * P <0.05 ** P <0.01 *** P <0.001ns. Not significant based on t (4999), one-tailed test.

When percentile bootstrap was applied to generate a 95% confidence interval using 5,000 resamples, hypothesis H1 to H6 were supported because their confidence interval did not include zero (Table 6). Thus, all hypotheses were confirmed. These results complete a basic analysis of PLS-SEM in our research. The result for PLS-SEM is shown in Figure 3.

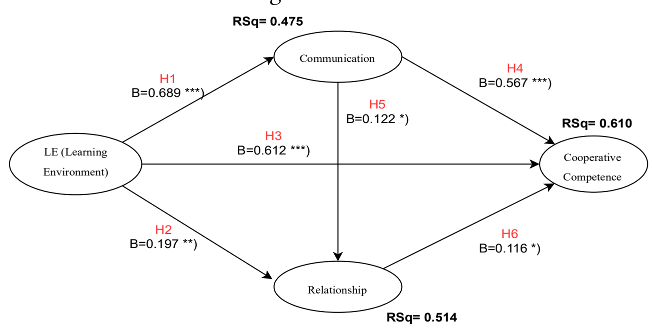

Figure 3: Results of testing model significance * P <0.05 ** P <0.01 *** P <0.001

Table 6 shows the amount of variance that each antecedent variable explained on each endogenous construct. R^2 figures were greater than 0.14 for almost all values. Therefore, cross-validated redundancy measures show that the theoretical / structural model has predictive relevance ($Q^2 > 0$).

6 Discussion

Structural equation modeling (SEM) was employed to examine the impact of an online learning environment with virtual laboratories, interactive activities, educational videos, and a game-based learning methodology on student relationships and the development of cooperative competence.

Table 6. Effects on endogenous variables (extended model)

Dependent Variable	R^2	Q^2	Antecedent	Path Coeff.	Correl.	Explain. Var. (%)
Coop-comp.	0.610	0.396				61.0
			H4: Communic	0.122	0.625	7.62
			H6: Relations	0.116	0.562	6.51
			H3: LE	0.612	0.765	46.81
Communic.	0.475	0.251				47.5
			H1: LE	0.689	0.689	47.5
Relations	0.514	0.317				51.4
			H5: Communic	0.567	0.703	39.86
			H2: LE	0.197	0.588	11.58

According to the results, the proposed model is totally satisfactory. Thus, simple and compose reliability were acceptable. Also, there were high level of internal consistency reliability, among latent variables. The independent explanatory variables, the values for validity and discriminant validity of the measurements were also acceptable. All the hypotheses were checked and validated, and the relationships were positive, mostly with a high level of significance. Therefore, the results confirm our hypotheses.

As shown in Table 6, the LE created by combining the OLE resources and active learning definitely affected communication (H1) explaining 47.5%. Moreover, LE affected relationship (H2) explaining 11.58% Likewise, communication played a key role in relationship dimension (H5), as suggested Gittel [25], explaining 39.86%, which indicates that communication favors relationships between students and teachers, creating a climate that facilitates learning and cooperation.

Of particular note is that, as some authors suggest, active learning enhances the acquisition of key competences [30, 43], and so too does online learning environment [11, 12], therefore, the LE created by combining the OLE resources and active learning strategies strongly affected the cooperative competence development (H3) explaining almost 47%. Contrasting with communication dimension and relationship dimension where the values affecting cooperative competence were (H4) 7.62% and (H6) 6.51% respectively, quite less significant. In view of the results we can see that the OLE tools have a direct influence on the acquisition of cooperative competence and indirectly through Communication and Relationships in line with the results of De Pablos et al. [9], Margalina et al. [36, 37] and Gallego et al. [22].

7 Conclusions

This study contributes to the existing literature on the use of new educational technologies.

Our results indicate the following: First, the structural model developed in this research has proven to be a useful theoretical instrument to test and validate the proposed hypotheses. Second, the virtual learning environments combined with active learning has a significant impact on students' relationship. Technology, with the right instructional approach, can make online learning more participative and collaborative. This learning environment supports and improves students' relationship both inside and outside the classroom. Third, this learning environment leads to a strong and significant impact on cooperative competence acquisition. The learning environment, the participative activities and the use of game based learning allow more interaction and dialogue between learners and contribute to creating a sense of connectedness between learners that promote the teamwork and the development of cooperative skills. Fourth, students' cooperative competence is also affected by relational coordination dimensions (communication and relationships). As expected, improved relationships between students, but above all, effective, frequent and timely communication and sharing of knowledge and goals have an important impact on the acquisition and development of cooperative competence. Consequently, virtual activities based on game-based learning appropriate instructional strategies are key to engage learners in the learning process and to promote involvement and participation. Thus, that kind of activities (in and out the classroom) should be properly designed to improve students' relationships and promote the acquisition and development of cooperative competence.

Some limitations should be noted. First, despite the total variance explained for the dependent variables are quite high, it is possible that other predictors were excluded from the study. Second, our study did not include individual difference factors that might affect the model, such as gender or experience with the OLE. It was not possible to evaluate either of these two factors due to the small sample in both cases. In future work, we intend to develop more modules in OLE to provide greater communication and interactivity between students. We also expect to carry out longitudinal research using similar OLE in other subjects. The proposed study will evaluate how these tools affects other competences.

The study addresses important issues in higher education, namely relationships and the development of key skills such as communication and cooperative competence and, in the light of the results, technology and appropriate instructional strategies can play a key role in promoting the development of these essential skills for the professional future of graduates. Aligned with the results, classes are more effective when students are actively involved in the subject and when communication and interrelationships among all actors are fluid. Therefore, our study may be useful in encouraging other teachers to apply active and participatory learning strategies and to use the online learning tools that support them.

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