Positive interdependence in blended learning environments. Is it worth collaborating?

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Introduction

During the past few years, as a result of technological development, Computer-Supported Collaborative Learning (CSCL) is becoming one of the most impacting learning and teaching approaches in higher education. CSCL is a constructivist theory that defends the social nature of learning (Koschmann, 1996; Stahl, 2006). It is concerned with extending face-to-face collaborative learning to virtual collaborative learning using software packages (Stahl, Koschman, & Suther, 2006). As a consequence, introducing CSCL means tackling at least two challenges jointly: collaborative learning and the use of communication and information technologies.

Learning to work in teams is one of the main competences for 21st-century citizens (Fischer, Rohde, & Wulf, 2007). Learning focused on the collaborative construction of knowledge is generally defined as a situation in which particular forms of interaction are expected to occur that generate significant advancement of shared ideas in a learning community (Dillenbourg, 1999). In collaborative learning, students work in groups or communities that share motivation, goals and resources to learn in particular conditions. Sometimes, it is not well understood how to implement collaboration in the classroom**.** Different studies have shown that just asking students to collaborate does not necessarily turn into a high-quality learning (Neugebauer, Ray, & Sassenberg, 2016). Effective collaborative learning is achieved by promoting positive interdependence (Deutsch, 1949; Johnson & Johnson, 2004)**.** It requires participants to tackle socio-affective and sociocognitive challenges both individually and collaboratively. During this process, students exchange knowledge, which may lead to sociocognitive conflict. In such cases, students have to argue and negotiate in order to specify, carry out, and assess a strategy that allows them to deal with a demand. This could consist of doing some activity together, solving a problem, or building new knowledge for the community (Laal, & Laal, 2012). The resolution of sociocognitive conflicts creates more complex knowledge structures (Fischer, Bruhn, Grasel, & Mandl, 2002).

From different pedagogical frameworks, research has found that the use of educational technologies can contribute to improving opportunities for collaborating and therefore the quality of learning (Alvarez, & Mayo, 2009; Mehlenbacher, 2010). Technology facilitates some temporal and geographical independence during collaborative learning. When students and teachers are connected to an online environment, they can communicate in both a synchronous and in an asynchronous way (Gutiérrez-Braojos & Salmerón-Pérez, 2015). Another advantage associated with these kinds of environments is the possibility of registering participants' activity. This provides a large amount of data which, if suitably analyzed, could help both the teacher and the students in their reflection-valuation work and the optimization of learning-teaching processes, as well as in the quality of educational environments (Long & Siemens, 2011).

CSCL is not just employed in purely online learning. In higher education, in most cases, it can be used in hybrid modalities. From suitable pedagogical approaches, university students' learning quality can be powered through hybrid environments. In such contexts, technological tools are used to increase opportunities for learning collaboratively compared to purely face-to-face modalities (Gutiérrez-Braojos, & Salmerón, 2015). At this point, it is thought that teachers face the challenge of assembling a hybrid modality that includes both face-to-face and online learning. This chapter provides an exploratory analysis about the effects of different types of interdependence on hybrid learning environments.

Social interdependence theory and collaborative learnings

One of the key notions that allows us to recognize the importance of collaborative learning in higher education is positive interdependence, which is one of the main ideas within Social Interdependence Theory (Deutsch, 1949). Living in society obliges people to establish interrelations, in such a way that someone's actions may affect another's goal achievement (table 1). Social interdependence arises in the more general case: outcomes of all individuals are affected by each other's actions.

Table 1. Interrelations among individuals. Source: Johnson & Johnson (2005)

		Own actions facilitate one's goal achievement	
		Yes	No
Others' actions facilitate one's goal achievements	Yes	Interdependence	Dependence
	No	Independence	Helplessness

Social Interdependence Theory assumes that goal structures determine how individuals interact, and, in turn, the interaction patterns determine the outcomes of certain situation. In this context, a *goal* is understood as a desired future of the state of affairs; thus, a *goal structure* is a specification of the type of interdependence among individuals' goals. Deutsch (2006) identified two basic kinds of goal interdependence: i) positive interdependence, which appears in situations where the probability of one person's goal attainment is positively correlated with the probability of another obtaining his goal, and ii) negative interdependence, which arises in the opposite case (the higher the probability of one individual's goal attainment, the lower the probability of another obtaining his goal). Likewise, an *interaction* is defined as a set of individuals' simultaneous or sequential actions that affect the outcomes of the other individuals involved in the situation (Johnson & Johnson, 2005). Social Interdependence Theory describes three types of interactions: i) promotive interactions, which are based on actions that increase the likelihood of others' success in achieving their goals, ii) oppositional interactions, which are based on actions that increase the likelihood of one's own success and reduce other individuals' possibilities of achieving their goals, and iii) no interactions, which occur whenever individuals take actions that promote their own success without affecting the goal attainment of others. Positive interdependence gives rise to promotive interactions, whereas negative interdependence results in oppositional interactions (Johnson & Johnson, 2005). Deutsch (2006) pointed out that few situations are totally positive or negative, and described goal structures as a continuum whose polar ends are positive and negative interdependence. Likewise, interactions arise as a result of another continuum of actions that are regulated by psychological processes (substitutability, cathexis and inducibility; Johnson & Johnson, 2005). A deep understanding of cooperation and competition would make it necessary to take all of these variables into account. Instead, we consider two goal structures and three types of interactions for the sake of simplicity.

Social Interdependence Theory can be applied to analyze different contexts such as constructive/destructive processes of conflict resolution or cooperative/competitive processes of problem solving or learning (Deutsch, 2006). Within a learning group (a classroom, for instance), cooperative relations arise when the goals of the members are positively interdependent (promotive interactions), whereas competitive relations emerge when there is negative interdependence among goals (oppositional interactions). If there are no interactions, members are working individually in the community. In learning situations, there is one *a priori* goal structure of positive interdependence, due to the fact that all the members share the same goal: to learn. However, in practical situations, competitive relations are observed in the classroom. This might be caused by personal concerns, marks or disagreements between classmates, which may lead to misunderstanding of one's own goals. Moreover, according to Deutsch's 'crude law of social relations', the community may evolve in a self-perpetuating way, so that competition elicits competitive behavior (Deutsch, 1985). As a consequence, the teaching method plays an essential role in emphasizing positive interdependence, which leads to cooperative learning relations. The question of whether these teaching conditions have positive effects on learning is then posed.

Interdependence and sociocognitive conflict

Deutsch (2006) stated that the teaching method employed in the classroom should lead to cooperative relations, and Johnson & Johnson (1989) claimed that cooperative processes generate higher group productivity, more favorable interpersonal relationships, better psychological health, and higher self-esteem of the members in a learning group.

Neo-Piagetian theories are some of the socioconstructivist approaches that care about conditions of social interaction in learning processes (Mugny & Pérez, 1988). These theories are based on Piagetian postulates, but they point out the relevance of social interaction in learning processes and outcomes. According to neo-Piagetian authors, in social interaction situations, learners can show opposing centrations or different levels of development that lead to sociocognitive conflict. It is social and cognitive because divergent reasonings are expressed, first, on a relational level, i.e., confrontations have an interpersonal basis that is prior to the intrapersonal one (Doise, Mugny, & Perret-Clemot, 1975; Mugny & Doise, 1983). These learners can share and discuss their controversy through constructive dialogue. Hence, learning improvements will arise from the capacity of learners to coordinate viewpoints and integrate them in a representation at a higher level than the previous one (Lacasa, 1993).

However, as mentioned above, not all sociocognitive conflict situations lead necessarily to learning improvement. In social interaction situations, individuals can experience two mechanisms of sociocognitive conflict regulation: epistemic and relational (Doise, & Mugny, 1984; Mugny & Doise, 1978; Mugny, Tafani, Butera, & Pigiere, 1999). The regulation centered on epistemic conflict assumes that the learner focus his/her attention on the purpose of the shared task. In this case, s/he collaborates to build an emerging and agreed knowledge, which accumulates more explanatory/decisive power than the knowledge built separately by each of the agents (Butera & Mugny, 2001; Doise, & Mugny, 1984; Mugny, Tafani, Butera, & Pigiere, 1999). The regulation focused on relational conflict pays attention to the assessment and affirmation of self-competence. Thus, whereas the regulation of epistemic conflict leads learners to improve their understanding and knowledge (by valuating and validating each participant's centrations), relational regulation leads to the defense of one's own capacity or competence through the affirmation of one's point of view. In other words, learners make an effort to be right, because they need to protect their identity, although it implies missing an opportunity to learn. This means that in the regulation of relational conflict, arguments try to protect or prove one's own competence (make learning difficult), whereas in the epistemic regulation, discussion is oriented toward resolving the conflict. It brings improvements in the quality of reasoning and opens up the viewpoints of the agents involved in the knowledge problem (Mugny & Doise, 1978). Thus, learning progression will come from the coordination of viewpoints and their integration, which leads to a shared representation at a higher level of abstraction.

Studies about competitive and collaborative learning dynamics indicate that it is probable that sociocognitive conflict is regulated in a relational way when students participate in competitive learning environments. This may decrease motivation, learning attitudes, and academic achievement (Butera, Darnon & Mugny, 2010). In different studies, Mugny and his colleagues proved that receiving criticism (when not freezing the epistemic process) may influence the receiver, driving him/her to integrate criticism and use it to improve his/her learning (for reviews, see Doise & Mugny, 1984; Pérez & Mugny, 1993; Mugny, Butera, Quiamzade, Dragulescu & Tomei, 2003; Quiamzade, Mugny & Butera, 2013). Therefore, when the climate is not perceived as a threat, the cognitive component exceeds the social one. In this case, we could say that regulation of conflict is more focused on oneself and the interlocutor. Individuals in conflict question the validity of every point of view, regardless of the source of information. In this case, participants not only take into account their own viewpoint, but also they are able to empathize and, hence, are more likely to progress (Mugny, De Paolis & Carugati, 1984; Mugny, Doise & Perret-Clermont, 1975–1976; Mugny, Giroud & Doise, 1978–1979).

Beyond collaborative learning: intergroup competition?

Several authors have proposed combining collaborative and competitive learning (Yu, Han & Chan, 2008). When students work under collaborative conditions with intergroup competition, groups can compete with each other. With this combination, a greater effort to achieve a competitive goal is generated within each group, while, simultaneously, collaboration between members of the group makes learning easier (through sociocognitive conflict) and allows the individual to counteract negative emotional effects (since s/he is part of a group).

Table 2. Summary of research about collaborative (C) and intergroup competitive (IC) learning

	C Improve cognitive competencies or creativity	**Cognitive competencies are not measured**	**IC improve cognitive competencies or creativity**
C Improve attitudes or climate	Johnson & Johnson (1989); Butera et al. (2010);Yu, Han & Chan, (2008)	Ke & Grabowski (2007)	Borstein &Erev (1994)
Attitudes or climate are not measured	Quiamzade et al. (2013); Cheville et al. (2005)		Wood et al. (2005); Christy & Fox (2014); Baer et al. (2010); Oldham y Baer (2012); De Dreu et al. (2015)
IC improve attitudes or climate	Yu (2001)	Tauer & Harackiewicz (2004); Gneezy & Nagel (2002);	Cheng-Huan & Chiung-Hui (2016); Romero (2012);

Some studies have explored the significance of these ideas and found that collaborative learning with intergroup competition is more effective than pure collaborative and inter-individual competitive learning. Several of these papers found that collaborative learning conditions are more beneficial in promoting engagement with learning than noncompetitive conditions (Bornstein, Gneezy and Nagel, 2002; Cheng-Huan, Chiung-Hui, 2016; Ke & Grabowski, 2007; Tauer & Harackiewicz, 2004; Romero, 2012). Other studies found that when an external (to groups) threat arises, under collaborative learning with intergroup competition, rivalry causes greater positive interdependence and cohesion within the groups (Yu, 2001). Likewise, other authors point to the effects on the quality of cognitive learning (Baer, Leenders, Oldham, & Vadera, 2010; Bornstein & Erev, 1994; Cheng-Huan, & Chiung-Hui, 2016; Christy & Fox, 2014; De Dreu, Dussel & Ten Velden, 2015; Wood, Campbell, Wood, & Jensen, 2005). Nevertheless, other investigations found negative results when intergroup competition was implemented, compared to collaboration (without competition), with regard to different dimensions such as quality of learning (Yu, 2001) or creativity (Cheville, McGovern & Bull, 2005). In sum, the results seems to be inconclusive.

Problem and objective

Based on the CSCL approach, several researchers have shown the efficacy of using computers to support collaborative learning (Dempsey et al., 1996; Ke & Grabowski, 2007), but few studies have analyzed the impact of face-to-face learning environments on the student's activity within virtual collaborative learning environments (Christy & Fox, 2014). Therefore, we wonder whether collaborative or competitive conditions impact students' learning in a hybrid environment.

In this study, we pose the following question: In a hybrid environment, what learning condition in the face-to-face environment is the most effective in producing greater participation and learning in the virtual community? Thus, the objective of this study is to analyze the effect of different conditions of face-to-face learning (cooperative, inter-group competition, and inter-individual competition, see condition parameter in methodological issues heading) on the participation and learning of students in the virtual community.

Methodological issues

The empirical study we present here belongs to a broader investigation within a major research project supported by the Spanish Ministry of Culture, Education, and Sports ('Jose Castillejo' program). This investigation takes into account three parameters according to a Latin squares design (table 3). In this section, we describe the main features of the whole design, but, due to the complexity of the analysis needed to understand all the relationships, the following section contains only one part of the results. Thus, the effect of the conditions on the learning can be studied without the noise that other parameters could produce.

Learning environment

The experience took place in an educational research course. Using the Knowledge Building framework, Gutiérrez-Braojos, & Salmeron, (2011) suggest that work in the classroom should be structured around three activity spheres of constructive activity: individual, collaborative in small groups, and communitary. Analogous to professional research activity, these authors think that paying attention to such spheres may optimize the effectiveness of a learning environment. This proposal has been followed in this study, and so students worked in each of the spheres.

Individual sphere: activity is carried out by a single student in one portfolio per content unit. The portfolio includes personal reflections about the topics and also some ideas of other schoolmates that had the most impact. The choice of each of the selected ideas must be justified. Results concerning this sphere are not included in the following section because they are not related to the researchers' objective.

Small group-based collaborative sphere (face-to-face sphere): activity in four small groups of three members each in the classroom in order to create comprehension of the subject per content unit.

Virtual community sphere: collaborative activities were designed to reflect and solve collaborative tasks on knowledge problems per content unit in the Knowledge Forum virtual platform (Version 5, see figure 1) to facilitate asynchronous communication (Scardamalia, 2004). The Knowledge Forum environment includes: i) a main menu with tools designed to edit collaborative knowledge building. To this aim, KF offers an interface that provides interaction scaffolds to facilitate collective knowledge building (e.g. ‘I need to understand’; ‘a better theory’; ‘putting our knowledge together’), ii) a configuration menu to set up the basic functions of the virtual environment (type of scaffold to use, display of contributions’ authorship, etc.), iii) tools to browse and create discussion windows, and iv) a menu to analyze and assess activity within the platform.

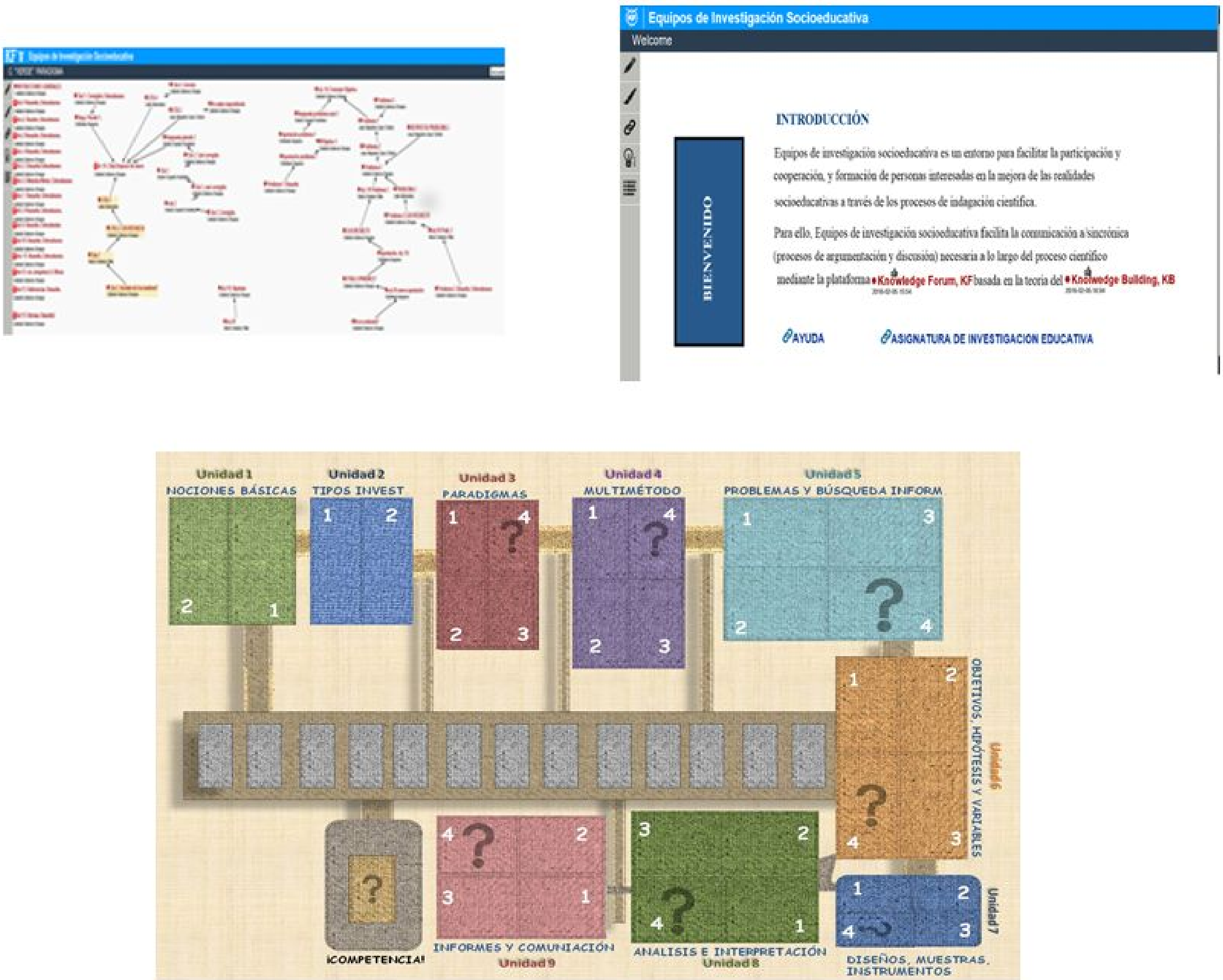

Figure 1. Menus in the Knowledge Forum environment

Participants

The participants in the full investigation were 36 undergraduates enrolled in the subject of educational research, which was part of a four-year Pedagogy degree program. The results presented below belong to a smaller group of 12 students (91.66% females), the one with the highest performance in the virtual community. The students’ participation in the virtual environment was obligatory, making up 40% of the final grade.

Method

A Latin Squares design was applied to carry out the full investigation. It took three parameters into account (table 3):

The '*Phase' parameter* refers to the time spent working on each unit of content. This study analyzes three units of contents in the subject of research methods in education. These units of contents correspond to three phases. All groups have the same tasks in the same phase. In each of these phases, students work through individual, small group, and virtual community spheres.

The '*Group category' parameter* refers to three levels of performance based on students´ university entrance marks (high, medium, and low performance). Because only the highest-performance students are analyzed in this study, 'group category' is fixed here. Consequently, results for this parameter are not included in the following section.

The '*Condition' parameter* refers to conditions of collaboration and assessment of the learners in the small group (face-to-face) sphere, where students were distributed in 4 small groups of 3 members each. There were three goal structures or conditions, and all the small groups worked under the same condition in each phase. Condition A (collaboration): the groups collaborated with each other to resolve the activities proposed. Each student who participated in this condition got a point bonus when every group correctly resolved the activities of the units. Condition B (intergroup competition): groups competed each other to resolve activities. The first group to correctly resolve the activities got a bonus point. Condition C (inter-individual competition): this was a 'contradictory' condition. Students could only collaborate with students in their group. However, only those students who correctly and first solved the activities in the face-to-face sphere got bonus points, regardless of the group membership base.

Table 3. Diagram of the Latin Squares design. Configuration of phases 2 and 3 were selected depending on phase 1, which was chosen by chance. In this chapter we analyze the highlighted diagonal

Phase / **Condition**	PHASE 1	PHASE 2	PHASE 3
Condition A	High-performance	Low-performance	Medium-performance
Condition B	Medium-performance	High-performance	Low-performance
Condition C	Low-performance	Medium-performance	High-performance
Groups Composition	Random	Consistent combination 1	Consistent combination 2

Information-gathering instruments and application procedure

Data were collected in three activity spheres, but this study does not present results on the sphere of individual activity. Thus, useful information was collected from two sources: the small group (face-to-face) sphere and the virtual community sphere.

Small group sphere: information about positive interdependence was obtained by applying the positive interdependence subscale (Gaith, Shaaban, & Harkous, 2007). This subscale is one part of a bigger scale, the Classroom Life Measure (Johnson, & Johnson, 1996). The subscale is composed of 6 Likert-type items on a 5-point scale, where a rating of "1" indicates that the item is very untrue, and "5" is very true, for their group. In the present study, the Cronbach´s alpha values were good in two of the learning conditions (collaboration learning condition: .96; competition intergroup: .94); and Cronbach´s alpha value was acceptable in the remaining learning conditions (individual competition: .694). The instrument was administered in the presence of the teacher during tutorial classes.

Virtual community sphere: Information about participation and learning was collected through automatized records on the Knowledge Forum platform. In all, 150 contributions were recorded. A contribution refers to a student's written message in the KF with the purpose of participating in the discourse on a specific topic, and it was considered a unit of analysis in this study. Every contribution was rated using the The Structure of Observed Learning Outcome taxonomy (SOLO, Biggs & Collis, 1982), which has been widely used to evaluate the learning on virtual platforms, specifically to analyze the correction, structural complexity, and originality of the knowledge reflected in the contributions (e.g. Brown, Smyth, & Mainka, 2006; Hatzipanagos, 2006; Holmes, 2005; Gutiérrez-Braojos, & Salmerón-Perez, 2015; Schrire, 2006). The SOLO taxonomy has five levels of complexity, meta-categorized in two levels (Figure 2).

On the one hand, the superficial level comprises three type of contributions: i) pre-structural contributions refer to incorrect or disconnected contributions to relevant knowledge for the community that are overly simple; ii) unistructural contributions are overly simple; iii) multi-structural contributions provide a large number of content elements, but in a disorganized way, lacking a coherent conceptual structure (multi-structural level). On the other hand, the deep level includes relevant contributions that coherently integrate important aspects of the task requirements (relational level) and/or contributions that involve generalizations, knowledge transference, and novelty. (extended abstract level).

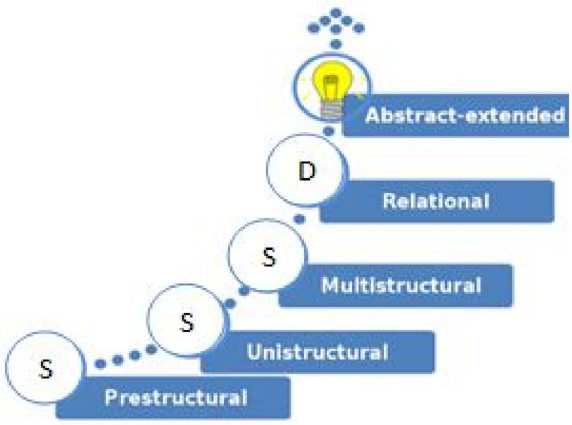

Figure 2. SOLO Taxonomy.

Variables and analytical procedure

To fulfil the objectives, the analyses were divided into two main stages. In the first one, the analysis of the level of positive interdependence is tackled. The second one corresponds to the analysis of the number of contributions in the virtual sphere; number of deep cognitive contributions; and surface cognitive contributions in the virtual sphere. In both stages, analyses were organized in two phases. First, a descriptive analysis was applied according to learning conditions A, B and C. Second, a Friedman´s test was carried out in order to identify significant differences in the variables depending on the learning conditions. In addition, the following formula was applied to calculate the size of the effect:

$$d = \frac{Z}{\sqrt{N}},$$ Z= Wilcoxon's statistic, N= size of the sample

Hypotheses

Students working under collaborative conditions show higher levels of positive interdependence. In addition, more collaborative conditions in the small group sphere turn into cognitively deeper contributions in the virtual community sphere. In turn, students in the intergroup competition condition show greater positive interdependence and cognitively deeper contributions than students in the inter-individual competition condition.

Analysis of interdependence in the face-to-face sphere

First, an analysis of groups' positive interdependence depending on the learning conditions in the face-to-face sphere was performed. Friedman's test shows significant differences between the conditions (table 4).

Table 4. Comparative analysis between learning conditions (Friedman´s Test).

Variables	Average range			χ^2	*p*-value
	Condition A: Collaboration	Condition B: Competition intergroup	Condition C: Competition inter-individual		
Positive interdependence	2.96	2.04	1	23.532	.000

A *post hoc* analysis between pairs of conditions (Wilcoxon's test) indicated that the groups in the collaborative conditions (with and without intergroup competition) reveals a higher level of positive interdependence than the group in condition C. Moreover, the group in the collaborative conditions shows significantly higher levels of positive interdependence than the others, with effect size values greater than 0.8 (table 5).

Table 5. Comparison of interdependence applying the Wilcoxon W test

Dependent variables	Initial N of cases (I)	Initial N of cases (J)	*Z*	*p*	*d*
Positive Interdependence	Condition A	Condition B	-2.943	.003	.84
		Condition C	-3.063	.003	.88
	Condition B	Condition C	-.3.068	.002	.88

Analysis of learning activity in the virtual sphere

First of all, a descriptive analysis of activity in the Knowledge Forum platform was performed. It shows that students provided 150 contributions. A content analysis of the contributions using the SOLO taxonomy reveals that 54.67 % of the participants exhibit deep cognitive complexity (relational or abstract-extended contribution), whereas 32.67 % exhibit surface cognitive complexity. The rest of the contributions were not taken into account. Regarding learning conditions, content analysis found that students in the collaborative conditions provide a greater number of contributions with deep cognitive complexity (71.15% deep contributions; 15.38% surface contributions) than those in the intergroup competition condition (43.13% deep contributions; 45.10% surface contributions) and those in the inter-individual competition condition (48.94% deep contributions; 38.30% surface contributions) (Figure 3).

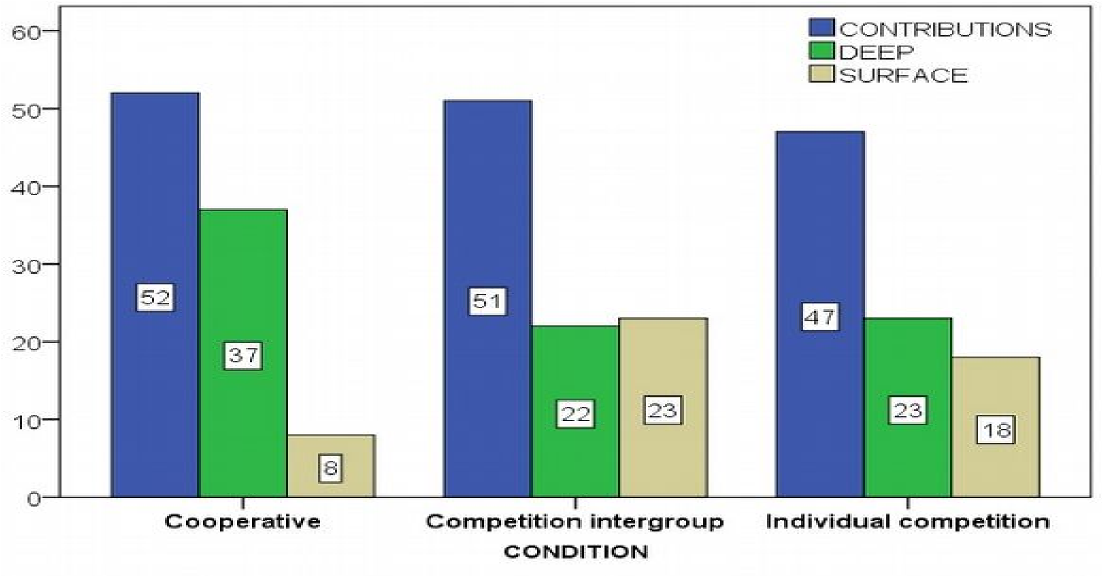

Figure 3. Contributions in the virtual Sphere categorized according to the SOLO taxonomy.

The results show that when students work in the collaborative condition, they generate a greater number of contributions that are cognitively deeper. Moreover, a lower number of surface contributions are recorded in this case. In addition, coefficients of variation were calculated. The results indicates that in inter-individual competitive conditions, students' involvement in the virtual community becomes heterogeneous. Furthermore, it is observed that when the group works in cooperative conditions without competition, it is more homogeneous on the deep contributions variable than in the other conditions (table 6).

Table 6. Descriptive analysis: activity on the KF platform using the SOLO Taxonomy

	Condition A				**Condition B**				**Condition C**			
	$\bar{x}$	σ	$\hat{x}$	Cv (%)	$\bar{x}$	σ	$\hat{x}$	Cv (%)	$\bar{x}$	σ	$\hat{x}$	Cv (%)
Nº Contributions	4.33	2.61	3	62	4.25	2.49	7	59	3.92	3.58	1	91
Deep	3.08	2.11	3	68	1.83	1.65	0b	90	1.92	2.31	0	120

Surface	.67	.778	0	116	1.92	.99	2b	52	1.5	1.31	1	87

b: Statistics table shows that there are multiple modes. SSS shows the lowest values.

Friedman´s test did not reveal significant differences in the number of contributions depending on the learning conditions, but it did find significant differences in the cognitive quality of the contributions (table 7).

Table 7. Comparative analysis regarding the virtual learning conditions. Friedman´s Test.

Variables	Average range			χ^2	p-value
	Condition A: Collaboration	Condition B: Competition intergroup	Condition C: Competition inter-individual		
Contributions	2.17	1.96	1.88	.65	.723
Deep contributions	2.67	1.63	1.71	10.722	.005
Surface contributions	1.46	2.54	2	7.86	.020

Table 8. Comparison applying the Wilcoxon W test

Dependent variables	Initial Nº of cases (I)	Initial Nº of cases (J)	Z	p	d
Deep	Condition A	Condition B	-2.549	.011	.73
		Condition C	-2.17	.030	.60
	Condition B	Condition C	-.264	.79	.07
Surface	Condition A	Condition B	-2.719	.007	.78
		Condition C	-1.852	.064	.53
	Condition B	Condition C	-1.115	.265	.32

A *post hoc* analysis between pairs of conditions (Wilcoxon's test) indicated that the group under collaborative conditions shows a significantly greater number of deep contributions than the other conditions. In addition, there are significant differences in the surface contributions. The groups in the collaborative conditions (without intergroup competition) provide a lower number of surface contributions (table 8).

Discussion and conclusions

This empirical study intended to understand the influence of goal structures on university students' learning in a blended environment. To this aim, an exploratory analysis was performed that focused on measuring positive interdependence, participation, and complexity of the students' contributions within a virtual environment. The existence of significant differences between contributions across distinct learning conditions was also analyzed. These results are part of a more complex investigation that, in turn, is part of a major research project supported by the Spanish Government.

The results showed that students showed higher levels of positive interdependence when they worked under collaborative learning conditions in the face-to-face sphere. Moreover, intergroup competitive conditions led to more positive interdependence than inter-individual competitive conditions. Concerning participation, although there were no significant differences regarding the number of contributions, it was observed that students who worked under collaborative learning conditions in the face-to-face sphere provided more cognitively complex contributions and less surface contributions than the rest of the conditions. A large enough size effect was found in this case. Nevertheless, contrary to what we expected, we did not observe significant differences between the two types of competition. In short, teaching methods based on goal structures that stress cooperative relations foster higher quality learning than competitive conditions. Therefore, this study supports Johnson & Johnson (1989) and Deutsch's (Deutsch, 2006) theses. These results are also in agreement with the conclusions of Butera et al. (2010) and Quiamzade et al. (2013), who found that collaborative conditions help to improve learning better than competitive orientations. Likewise, this research allows us to conclude that collaboration without competition was more effective than other conditions where competition and collaboration were balanced, which was also observed by Cheville et al. (2005). Regarding the comparison of intergroup competition and inter-individual competition, however, no significant differences were found with respect to the quality of learning. These results contrast with those of Cheng-Huan & Chiung-Hui (2016), Wood et al. (2005), and Christy & Fox (2014), who noticed higher quality learning in individuals who worked in intergroup competitive conditions, and with Baer et al. (2010), Oldham & Baer (2012) and Romero (2012), whose results suggest more creativity in these conditions. These differences between our discoveries and the previous literature are meaningful.

The distribution of knowledge in the virtual community is one dimension of special interest in the Knowledge Building pedagogy, which includes the notion of collective cognitive responsibility for the building of knowledge (Scardamalia, 2002) as a main feature of collaborative learning. In this study, the coefficient of variation in cognitively deep contributions is smaller than in the other conditions. This result points to greater collective cognitive responsibility in the collaborative group. Specifically, the coefficient of variation indicates that there is greater cognitive responsibility of a greater number of students in conditions of collaboration without competition. The results reveal that when students participate in collaborative learning environments without competition, in a face-to-face environment a greater number of participants generate more contributions with cognitive quality, and fewer contributions with low cognitive quality in the virtual environment learning. We suggest that collaborative learning with competition is another mode of competition learning, but that this mode is closer to the category of competition than to the category of collaboration. Accordingly, in this study, designing learning environments in conditions of collaboration without competition in face-to-face environments facilitates the cognitive responsibility of the collective and better achievements in the community to a greater extent. We did not find any benefits of intergroup competition or individual competition over collaborative learning without competition. Therefore, collaborative learning designs without any competition could be considered more consistent with the goal that underpins the main right to education: each student is able to reach what he has to reach, taking advantage of the abilities of each and every agent in the learning community (teacher and students) to do so.

These studies could show relevant insights about how to increase participation and improve achievement of students in the CSCL approach. However, the size of the sample employed does not allow us to generalize. In this regard, we suggest the replication of this study in different contexts, including a broader profile of students (several ages and degrees). In addition, there are some future lines of research that can be explored to continue the understanding of positive interdependence and collaborative learning. One of them is related to Deutsch's theory, where goal structures define a 'one dimensional' continuum of possibilities whose ends are positive and negative interdependence. When intergroup competition come into play, this framework seems to break down. It is not clear what level of positive interdependence should be expected *a priori* in an intergroup competitive (with internal collaboration) goal structure. Our findings show a significant intermediate level between pure collaboration and inter-individual competition (table 5), but this level is not translated into an intermediate quality of learning (table 8). Moreover, some studies present a different picture, where intergroup competitive conditions reach the highest levels of cognitive competencies (right row in table 2). Then, the question is how to fit intergroup competition within Social Interdependence Theory (is it some kind of "neutral" condition? Should the theory open up more dimensions?) or, equivalently, how to interpret the notion of positive interdependence for these type of goal structures. Another interesting line of research points to enhancing collaborative learning conditions. In this study, the rating of the contributions was performed by researchers. Within the Knowledge Building pedagogy, the community is responsible for assessment (Scardamalia, 2002), and so it would be interesting to make progress towards this total responsibility. We propose to provide students with tools to rate the contributions in the virtual environment and analyze the influence of this situation on both learning and engagement with community. In this regard, measures of collective cognitive responsibility that are independent of external judges are needed. As mentioned above, the coefficient of variation of deep contributions could be a suitable measure, but other statistics can also be used to this end. The power of such tools to calibrate the engagement of students in learning in hybrid learning environments has to be analyzed in depth.

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