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**Computer-Supported Collaborative Learning: An analysis of the relationship between interaction, emotional support and online collaborative tools.****Dr. Nuria Hernández-Sellés<sup>a</sup>**

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**ABSTRACT**

Research has already outlined the enormous potential of Computer Supported Collaborative Learning (CSCL) to facilitate effective learning processes in higher education. There is still need, though, to build up a validated model able to portray the relationships between the key elements to design and carry out online collaboration methodologies. The purpose of this study is to establish a global model, with the aim to understand the key factors affecting online collaborative learning and to analyze their interrelation, examining the influence of interaction, intra group emotional support and online collaborative tools in learning in CSCL. The study was conducted with 106 students in the context of 5 university degree subjects that implied working on CSCL projects. At the end of the projects, the students filled out a questionnaire and the resulting data was analyzed using the partial least squares (PLS) technique. The research model proved to have a good predictive level, fulfilling the 6 hypotheses proposed. Results reveal the relevance of interaction, considering teacher-student interaction as well as student-student interaction in groups during the collaboration process. Emotional support linked to intragroup work reveals itself as a fundamental pillar in collaborative learning. On the other hand, online collaborative tools have proved to contribute to interaction between group members and to sustain emotional support. Consequently, in order to model cognitive presence, social presence and teaching presence during CSCL it is necessary to promote a fluent and satisfactory interaction, rooted on the learning process and on emotional support as well as on effective management of the online tools facilitating collaboration. Results also suggest the convenience of further research on other types of interaction in the context of CSCL.

**Keywords:** cooperative/collaborative learning; Higher education; Teaching/learning strategies; computer-mediated communication.

**Highlights**

- Analysis of the key elements in Computer Supported Collaborative Learning.
- Intra-group emotional support is the element with the greatest impact in Collaborative learning.
- Student interaction in work groups plays a key role as a mediating factor.
- Online collaborative tools have a positive influence in intragroup interaction as well as on emotional support.
- Teacher-student interaction influences student interaction in work groups.

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**Computer-Supported Collaborative Learning: An analysis of the relationship between interaction, emotional support and online collaborative tools.****ABSTRACT**

Research has already outlined the enormous potential of Computer Supported Collaborative Learning (CSCL) to facilitate effective learning processes in higher education. There is still need, though, to build up a validated model able to portray the relationships between the key elements to design and carry out online collaboration methodologies. The purpose of this study is to establish a global model, with the aim to understand the key factors affecting online collaborative learning and to analyze their interrelation, examining the influence of interaction, intra group emotional support and online collaborative tools in learning in CSCL. The study was conducted with 106 students in the context of 5 university degree subjects that implied working on CSCL projects. At the end of the projects, the students filled out a questionnaire and the resulting data was analyzed using the partial least squares (PLS) technique. The research model proved to have a good predictive level, fulfilling the 6 hypotheses proposed. Results reveal the relevance of interaction, considering teacher-student interaction as well as student-student interaction in groups during the collaboration process. Emotional support linked to intragroup work reveals itself as a fundamental pillar in collaborative learning. On the other hand, online collaborative tools have proved to contribute to interaction between group members and to sustain emotional support. Consequently, in order to model cognitive presence, social presence and teaching presence during CSCL it is necessary to promote a fluent and satisfactory interaction, rooted on the learning process and on emotional support as well as on effective management of the online tools facilitating collaboration. Results also suggest the convenience of further research on other types of interaction in the context of CSCL.

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**1. Introduction**

Computer Supported Collaborative Learning (CSCL) has constituted a dominant presence in online education, due to its great potential to articulate learning processes based on knowledge co-construction, and, consequently, it has become a research trend (Dillenbourg, 2003; Fischer, Rohde, & Wulf, 2007; Stahl, Koschmann, & Suthers, 2006). Collaborative learning promotes situations where built knowledge occurs sustained on small group exchanges, usually involving the aim to solve a problem or create a project, that is based on unstructured problems that involve an intense process of cooperation and negotiation to provide a solution, to create a product, or both (Scardamalia & Bereiter, 1994; Johnson & Johnson 2004). Extensive research has proven that well-structured collaboration, promoting learning through socio-cognitive processes of negotiation grounded on socio-emotional presence, improves learning and individual performance, as well as students' satisfaction (Johnson, Johnson, & Stanne, 2000; Oakley, Felder, Brent, & Elhajj, 2004; King, 2007; Medina & Suthers, 2008; Kwon, Liu, & Johnson, 2014).

The most focal research streams in collaborative learning refer to representation, discourse and pattern, covering methodology, interaction, and teaching assistance; factors influencing CSCL, focusing on critical thinking, argumentation, technological guidance, and theory-driven characteristics; and intervention and comparison, examining technological and contextual settings as well as scripting in collaboration processes (Tang & Lin, 2014).

Beyond the relevance of each of these elements, in order to move forward to a deep understanding of the opportunities and challenges of collaborative learning, it would be necessary to build up a holistic vision that promotes the identification of interrelations between its key factors. Based on this perspective, and grounded on previous research on the field, this article establishes and assesses a model integrating some of the key constructs of CSCL and its influence on collaborative learning in virtual environments. Specifically, this model explores the relationships across teacher-student interaction, student interaction in work groups, intra-group emotional support, online collaborative tools, and collaborative learning.

**2. Conceptual framework**

Learning grounded in collaboration is rooted on structured interaction, scaffolded and facilitated by the instructor. Most interaction frameworks in distance education have evolved from the following proposals: (a) in his theory of transactional distance, Moore (1989) proposed an interaction framework that incorporated learner-instructor interaction and learner-learner interaction to learner-content interaction, where teacher's roles are associated with providing a structure or course design that incorporates dialogue; (b) Garrison and Shale (1990) emphasized that learning, and therefore distance education, is sustained on interactions among teachers, students and content, standing up for this vision to guarantee the quality of learning processes; (c) Hillman, Willis, and Gunawardena (1994) incorporated learner-interface interaction which refers to the interaction of students with the different media incorporated in a learning action.

Following these traditions, the Community of Inquiry (CoI) framework provided an integrated perspective of constructivist approaches to learning and the mediation of technologies (Garrison, Anderson, & Archer, 2000). The Community of Inquiry constitutes three elements essential to technology mediated education: cognitive presence, social presence, and teaching presence. *Cognitive presence* refers to meaning construction grounded in communication; *social presence* involves the recognition and projection of personal characteristics and is required to promote cognitive presence; and *teaching presence* is defined as the design and facilitation of learning processes structured around cognitive and social presence.

Collaborative learning is sustained in group interaction, as a means to promote socialized learning, involving cognitive, social, and teaching presence. Therefore, the Community of Inquiry framework has been used as the structure to build up a conceptual framework to collaborative learning.

### 2.1. Cognitive presence in online collaboration processes.

Cognitive presence in collaboration is rooted on the construction of shared meaning, that occurs when group members share their knowledge and the group makes an effort to build up a common construct based on individual inputs, trying to make sense of every contribution. Integrating involves the creation of new constructs evolving from those individual bits into a group creation; that is how group interaction promotes restructuring of previous knowledge, affecting individual cognitive processes and at the same time there is a group socio-cognitive negotiation where shared knowledge occurs (Stahl, 2004; Stahl, 2006; King, 2007; Borge, Ong, & Rosé, 2018). Cognitive presence in collaborative learning has been identified in the literature as *knowledge convergence* which is grounded both on cognitive convergence and on divergence; research provides evidence that collaborative interactions over time flow from divergence to convergence (Puntambekar, 2006; Weinberger, Stegmann, & Fischer, 2007).

On the other hand, it is necessary to highlight the evidence that even in well-articulated collaborative processes students tend to interact at a basic level; they often fail to construct counterarguments and fail to build up solid arguments, they are inconsistent with their previous knowledge and experience, therefore consistent cognitive processes are not likely to occur. Students need guidance and structure to sustain how they make sense and regulate what is called the socio-metacognitive expertise (King 2007; Weinberger et al., 2007; Prichard, Bizo, & Stratford, 2010; Borge, Ong, & Rosé, 2018).

### 2.2 Enhancing social presence in online collaboration.

In order to start the path to higher level learning, group members need to regulate other aspects that sustain knowledge co-construction and have to be integrated with cognition, such as emotions and motivation (King, 2007; Näykki, Isohätälä, Järvelä, Pöysä-Tarhonen, & Häkkinen, 2017).

Social presence is associated to the projection of the personal characteristics of students in the community and to those aspects where individuals encounter to start up a group process oriented to a common goal, such as getting to know each other, committing to social relations, developing trust between members, building up feelings of belonging and establishing a sense of community (Garrison et al., 2000, Rovai, 2002; Kreijns, Kirschner, & Jochems, 2003). The sense of community increases communication and support between group members (Rovai, 2002).

On the other hand, poor teacher-student or student-student socialization leads to poor collaboration and rare group exchanges and consequently to feelings of isolation and academic failure (Garrison & Cleveland-Innes, 2005; Garrison et al., 2010; Onrubia & Engel, 2012). As a contrast, teacher and students' motivation and bonding associated to interaction create learning communities with a sense of

belonging and a potential for persistence and goal attainment (Rovai, 2002; Garrison, 2006; Pérez-Mateo & Guitert, 2012; Strijbos, Martens, & Jochems, 2004).

Social interaction does not happen spontaneously, even though teachers often assume it is a characteristic of groups. When that is given for granted, it is most likely that groups socialize at a very low level, leading to individual feelings of isolation, to little social presence and therefore to poor cognitive presence (Kwon et al., 2014; Reyes, Brackett, Rivers, White, & Salovey, 2012). One of the key elements to sustain socialization in online education is the media employed to display friendly content and to facilitate fluent communication processes (Strijbos et al. 2004).

### *2.3 Structuring online collaboration through teaching presence.*

Research has dealt with the identification of the challenges and opportunities faced by teachers and instructional designers to model learning environments with the conditions for effective cognitive and social interaction and to promote effective teacher-student and student-student interaction; collaborative learning requires technological as well as pedagogical and social aspects to be taken into consideration grounded on careful planning, curricular and pedagogical implementation (Sims, 2003; Stahl et al., 2006, Authors, 2014; Garrison, Cleveland-Innes, & Fung, 2010; Onrubia & Engel, 2012, Hernández et al., 2014).

Pedagogically, the literature suggests that collaborative learning requires the design of complex analytical tasks involving problems, processes and discussion leading to decision and action (Bell, 2010). Teachers need to design problems or projects that incorporate subject competences and establish bases to promote the acquisition of other cross-curricular competences associated with collaboration (Prichard, Bizo, & Stratford, 2006; Williams, Morgan, & Cameron, 2011). Students' communication improves when teachers systematize a model to transmit the kind of exchanges expected, explaining the link between group socialization and project results (Strijbos et al., 2004; Dillenbourg & Hong, 2008; Haake & Pfister, 2010; Onrubia & Engel, 2012; Sobreira & Tchounikine, 2012). Group building is a decisive phase, since building up common bases within groups (grounding) overcomes obstacles such as low participation and involvement rates (Dillenbourg, 2002; Kirschner, 2002; Isotani, Inaba, Ikeda, & Mizoguchi, 2009; Authors, 2014a).

In order to promote collaboration and social learning, it is necessary to design assessment methods that address the distinctive characteristics of learning in virtual environments, aligning the constructivist paradigm of collaborative learning with formative collaborative e-assessment that integrates process and peer assessment with task results (Lee, Chan, & Van Aalst, 2006; Pachler, Daly, Mor, & Mellar, 2010; Gikandi, Morrow, & Davis, 2011). Assessment needs to incorporate the social dimension that grounds and nurtures collaboration, this is how peer assessment and process assessment integrate the cognitive and social elements constituting processes leading to significant learning (Strijbos et al. 2004; Pachler et al. 2010; Pérez-Mateo & Guitert, 2012). On the other hand, students' active participation in assessment promotes collaboration and trains them to monitor group relations and autonomy which are long-life learning competences (Macdonald, 2003; Lee et al., 2006; Evans, 2013).

The election of technologies should allow for the structuring of teacher-student and student-student exchanges (synchronously or asynchronously) and should make it possible to observe group processes, that is to sustain communication, collaboration and coordination (Strijbos et al. 2004). Collaborative tools should be designed to sustain problem solving, integrating social resources that facilitate learning (Lu, Lajoie, & Wiseman, 2010; Pachler et al. 2010).

Regarding teacher roles in collaborative learning, and rooted on the previous discussion, teachers need to unfold roles apart from that of the subject or course expert; managing technologies, designing cognitive and social presence, choosing the right task type, interacting as models to students, advising them both at the academic and personal levels and finally modelling complex e-assessment that commit students and involve them in the learning process (Garrison & Cleveland-Innes, 2005; Abdu, De Groot, & Drachman, 2012; Authors, 2013). Teacher presence is necessary to avoid feelings of isolation and is required to promote interaction in groups and to ground the basis for the social presence necessary to promote cognitive learning (Akyol, Garrison & Ozden, 2009; Garrison et al., 2010; Kwon et al., 2014; Vuopala, Hyvönen, & Järvelä, 2016). Teaching presence is mainly needed at the design phase and during the course at the phase of group formation and to provide the background to understand what is required from groups as well as to providing feedback or answers when necessary (Chapman & Van Auken, 2001; Strijbos et al., 2004; Bangert, 2008; Abdu et al., 2012).

The literature has identified interaction, intra-group emotional support to sustain cognitive processes and the role of technologies as some of the focal elements that sustain collaboration (Tang & Lin, 2014). Regarding interaction, it is necessary to link its complex dimensions: teacher-student interaction, student-student interaction, particularly student interaction in work groups, and students' interaction with the media intervening in the learning process. The literature has also insisted on the relevance of intra-group emotional support to sustain cognitive processes in collaboration and it would also be necessary to research on the role of technologies to influence such kind of support.

### 3. Hypotheses development and research model

This study examines the influence of interaction, intra-group emotional support and online collaborative tools on learning, within the context of collaborative learning. The purpose is to establish a global model, as depicted in Fig. 1. with the aim to build up an understanding of the key factors affecting online collaborative learning and on their interrelation.

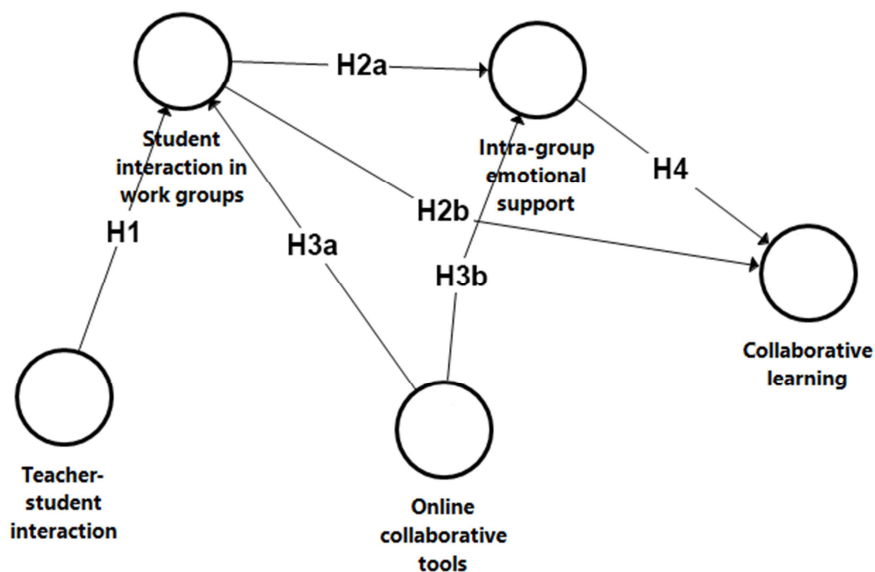


Fig. 1. Research Model.

The study key constructs: collaborative tools, intra-group emotional support, students interactions in work groups and teacher-student interactions, have been established on the basis of the literature review on the most relevant aspects influencing online collaborative learning as well as on variables identified in other studies, which have been adapted to the present study (Ku, Tseng, & Akarasriworn, 2013; Alçayir & Alçayir, 2016; Manca & Ranieri, 2016; Molinillo, Aguilar-Illescas, Anaya-Sánchez, & Vallespín-Arán, 2018). Discussions on the hypotheses formulated in the research model are presented next.

**3.1. H1. Teacher-student interaction has a positive and significant influence in students' interaction in their work groups.**

In technology mediated education teachers need to articulate interaction with students to prevent feelings of loneliness, which are directly linked to limited student interaction, and therefore to poor collaboration and learning (Garrison & Cleveland-Innes, 2005; Garrison et al., 2010; Onrubia & Engel, 2012). Teacher-student interaction promotes teaching engagement in the process which is directly connected to students teaching perceptions (Paswan & Young, 2002) and to overall students' satisfaction (Lee, Srinivasan, Trail, Lewis, & Lopez, 2011).

To promote feelings of belonging and satisfaction, students require immediate feedback from teachers and require timely feedback from instructors (Kuo, Walker, Schroder, & Belland, 2014). Teachers who provide early feedback on the quality of students' interactions and opportunities to analyze it, promote more fluent and significant interaction during collaboration (Prinsen, Terwel, Volman & Fakkert, 2008). On the other hand, it is not easy to decide when an interaction is necessary; collaborative learning self-regulation requires guidelines without direct teacher intervention (Dillenbourg, 2002; Donnelly &

Fitzmaurice, 2005). Teacher-students interaction should mainly focus on the definition and discussion of group management and to interventions when required, that is, when students need redirections from teachers to promote significant interactions leading to learning (Chapman & Van Auken, 2001; Srijbos et al., 2004; Bangert, 2008; Abdu et al., 2012).

**3.2. H2a. Student interaction in work groups has a positive and significant influence in intra-group emotional support.**

Collaborative learning is necessarily grounded on students' interaction in work groups to regulate and coordinate processes that lead to the planning and development of joint activities, to promote a deeper sense of understanding and accomplishment and to enhance students' motivation (Garrison et al., 2010; Hostetter & Busch, 2013; Kwon et al., 2014). Lack of interaction is identified by students as a source of frustration and a drawback to achievement; students value interaction and social presence as a means to promote collaboration and interactive students serve as models to others, leading to group interaction (King, 2007; Akyol et al., 2009; Kwon et al., 2014; Capdeferro, & Romero, 2012; Vuopala et al., 2016).

Student-student interaction is also related to emotional intra-group support; when students interact to manage group coordination, they release anxiety and build up a feeling of support (Kwon et al., 2014; Reyes et al., 2012; Vuopala et al., 2016). Following this stream, research such as Molinillo et al. (2018) and Blasco-Arcas, Buil, Hernández-Ortega, & Sese (2013) has proved that emotional support and commitment of students in their groups have a positive influence in active and collaborative learning.

**3.3. H2b. Student interaction in work groups has a positive and significant influence in collaborative learning.**

Studies report that the high level of student-student interaction promoted by social technologies positively influences collaborative learning performance (Blasco-Arcas et al., 2013). In this matter, it is important to design feedback systems to assist learning and to draw back feelings of isolation, leading to poor interaction and academic failure (Prinsen et al., 2008; Reyes et al., 2012; Kuo et al., 2014). Additionally, research such as Ku et al. (2013) and Authors (2012) evidence that students who have experimented online collaborative learning state that they feel they have learnt more than they would have done so working individually. Also, as pointed by García-Valcárcel, Basilotta, & López (2014), collaborative learning is a useful strategy to improve the acquisition and retention of knowledge, helping students to confront situations such as problem solving, expressing ideas and thoughts of critical thinking development. All of these conform a framework for students to develop significative knowledge construction processes mediated by peer interaction (Hew & Cheung, 2008).

**3.4. H3a. Online collaborative tools have a positive and significant influence in students' interaction in their work groups.**

It is fundamental that in online collaborative learning environments students have access to effective tools for collaboration (synchronous or asynchronous) that allow for fluent interaction and peer support; these tools would sustain the development of group tasks, supporting and enhancing communication, collaboration and coordination (Srijbos et al. 2004, Authors, 2014b). Students should have access to a varied set of tools and applications that provide the right context to start up significative interactions involving real collaboration, that integrate social resources and allow for problem and project solving considering the cognitive and social aspects of positive interaction (Lu et al., 2010; Pachler et al. 2010; Authors, 2014b).

**3.5. H3b. Online collaborative tools have a positive and significant influence in intra-group emotional support.**

Technology mediated education and collaborative learning require the use of synchronous and asynchronous tools to promote social interaction and active learning. Web-based social tools have proven to be effective in connecting individuals, both in the cognitive level and in the socio-emotional level (Bowman & Akcaoglu, 2014; Hamid, Waycott, Kurnia, & Chang, 2015). Students feel they experience greater interaction when using social technologies and there is evidence of greater occurrence of exchanges linked to curriculum and to emotional support and socialization (Hamid et al., 2015).

**3.6. H4. Intra-group emotional support has a positive and significant influence in collaborative learning.**

Student engagement through emotional interaction is directly related to academic success, whereas emotionally unresponsive learning environments affect academic performance (Reyes et al., 2012). Student-student emotional support embraced through interaction is necessary to build a sense of community leading to cooperation, commitment, individual accountability and satisfaction, which are requisites to collaborative learning (Kreijns et al., 2003; Zhan, 2008). Regarding this matter, research such as Kwon et al. (2014) has illustrated how successful groups are characterized by creating a sense of community which is visible in facts such as continuous encouraging of group members, the sharing of personal aspects and in general in the developing of socio-emotional aspects that ground a basis for individual accountability and trust. Therefore, as stated by Ku et al. (2013, p. 928) “collaborative learning is an effective pedagogy to promote students’ engagement and learning in the online environment”.

#### 4. Methodology

##### 4.1 Procedure and participants

The research context entails a group of five online subjects from a Spanish University; two subjects from a Degree of primary education and three subjects from a Degree of pre-primary education. The sample collected was of 106 questionnaires, representing 83.46% of the student population.

All these subjects implemented an online collaborative project that lasted 3 months and shared instructional design as well as teachers coordination, in order to guarantee coherence. Collaboration was structured in the following main phases 1) Task communication through a collaboration script including suggestions to draft group agreements, proposals for project planning, role assignment, a description of the media provided for interactions and a background of attitudes and skills necessary for collaboration; 2) Spontaneous group formation; 3) Drafting of group agreements; 4) Teacher revision of group agreements and feedback to groups; 5) Project development involving students interacting in group works with teacher supervision and feedback; 6) End of the project involving intergroup contrast of results; 7) Online self-assessment and peer-assessment, incorporating both process and results; 8) Teacher group assessment and individual adjusted assessment.

##### 4.2 Data collection instrument

An ex post facto design based on a survey method was used (McMillan & Schumacher, 2010). The instrument for gathering information was an anonymous questionnaire that the researchers gave to the students, who participated voluntarily. The answers followed a five-point Likert scale ranging from "totally disagree (1)" to "totally agree (5)". Table 1 shows the descriptive statistics of the 25 items used and the 5 constructs in which they were distributed. This questionnaire was developed based on scales that have already been validated in research focused on online collaborative learning (Blasco-Arcas et al., 2013; Ku et al., 2013; Kwon et al., 2014; Martin & Rimm-Kaufman, 2015).

Before it was applied, the questionnaire was reviewed by a panel of 5 experts in research methodology, collaborative work and education technology, who analyzed aspects such as the uniqueness, relevance and importance of each item. A pre-test was also carried out to validate the questionnaire with 25 students who were chosen randomly and proportionally from among the different subjects that were part of the study. Minor changes were made based on the feedback provided by the specialists and students mainly to improve how some items were written to obtain a better understanding.

**Table 1**  
Questionnaire items and descriptive statistics.

Construct	Item number	Description	Media	Typical deviation
Teacher-student interaction	TSI_1	The teachers guided their students in the process of forming the collaborative work groups.	4.15	.940
	TSI_2	The teachers accompanied the students in an appropriate way to favor learning within their work group.	4.26	.820
	TSI_3	The teachers guided their students to develop teamwork skills that allow them to work more	4.34	.779

Construct	Item number	Description	Media	Typical deviation
		effectively.		
	TSI_4	The teachers contributed to developing links with the learning community formed by each work team and with the other students of the subject.	4.20	.801
Student interaction in work groups	SIWOG_1	My team carried out an effective management and organization process.	4.25	.760
	SIWOG_2	The organization has encouraged group members to take responsibility for their work within the team.	4.24	.806
	SIWOG_3	The organization has facilitated learning related to the tasks to be fulfilled throughout the course.	4.27	.779
	SIWOG_4	The design of the organizational guidelines has allowed us to work as a team more effectively.	4.09	.867
	SIWOG_5	The organization has favored the cohesion of the work team.	4.12	.889
	SIWOG_6	The interaction process among group members has favored the development of teamwork skills.	4.18	.798
Intra-group emotional support	IGES_1	Personal links have been established in the collaborative work groups.	3.85	1.213
	IGES_2	My work group members have given me support, help and encouragement at times when it was necessary.	4.41	.820
	IGES_3	Teamwork has contributed to making me feel more involved in studying the subject.	4.13	.962
	IGES_4	Having contact with the team has helped me carry out the academic tasks of the course.	4.27	.916
Online collaborative tools	OCTO_1	The virtual campus tools have helped the work team members to collaborate.	3.91	1.034
	OCTO_2	The team's discussion forum allowed a fluid exchange of information.	3.95	1.013
	OCTO_3	The team's discussion forum allowed establishing personal links.	3.68	1.277
	OCTO_4	The chat has allowed me to establish personal connections with the members of my team.	3.14	1.476
	OCTO_5	I consider that enough tools are provided in the virtual campus for collaborative learning to be carried out.	3.56	1.161
Collaborative learning	CL_1	Collaborative learning has helped me achieve good academic development.	4.10	.731
	CL_2	Teamwork has allowed me to complement my knowledge with that of my colleagues.	4.22	.812
	CL_3	I have learned more interacting with my teammates than when I work alone.	3.98	1.079
	CL_4	Interacting with my teammates, I have improved the grades I would have obtained working individually on the task.	3.64	1.022
	CL_5	The time allocated to organizing the group work is compensated by the learning that I have acquired.	3.79	.942
	CL_6	Having contact with the group has helped me to continue my studies to complete them.	3.94	1.156

## 5. Analysis and Results

To evaluate the proposed model, as well as test the study hypothesis, a multivariate analysis was carried out applying a structural equation model (SEM) with partial least squares (PLS), using the statistical program SmartPLS version 3.2.7.

There are several reasons that justify the suitability of using this technique. Firstly, it is not necessary to have large samples (Hair, Hult, Ringle, & Sarstedt, 2017). Secondly, unlike structural equation models based on covariance, PLS does not require multivariate normality of observations (Esposito Vinzi, Trinchera, & Amato, 2010). This is especially useful because, after carrying out the Kolmogorov-Smirnov normality test with the SPSS program, it was not possible to guarantee that most of the data would follow a normal distribution. Thirdly, as PLS is now increasingly applied in the field of education (Marcoulides & Chin, 2013), it can be used as a strategy for developing exploratory models, as is the case with the present research (Barclay, Higgins, & Thompson, 1995). Finally, PLS is an especially suitable technique for predicting and evaluating the relationships of latent variables (unobservable constructs) based on indicators in complex models (Chin, 2010; Kerlinger & Lee, 2002).

As with any SEM methodology, the use of PLS requires two development phases (Henseler, Ringle, & Sinkovics, 2009). The measurement model is analyzed and evaluated in the first phase, which implies validating the proposed model based on the reliability and validity of the constructs and their indicators (Baghaei & Tabatabaee Yazdi, 2016). And the structural model is elaborated in the second phase, which includes obtaining various coefficients for evaluating the research hypotheses formulated (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005; Henseler & Chin, 2010).

### 5.1 Measurement model

The reliability and convergent validity results of the model constructs are shown in Table 2. Cronbach's alpha coefficient reaches adequate values for reliability, as they are all above 0.70 (O'Dwyer & Bernauer, 2014). Likewise, values well above 0.5 were obtained for the composite reliability indices (Bagozzi & Yi, 1989), which confirms the internal reliability of each construct.

Concerning the convergent validity, the average variance extracted (AVE) exceeds the minimum score of 0.5 proposed by Hair, Ringle, & Sartedt (2011), so it can be seen that more than 50% of the variances of each construct is due to its indicators.

In addition, following Falk & Miller (1992), the load acceptance level was set to values greater than or equal to 0.505 and this index is satisfactorily exceeded.

**Table 2**  
Reliability and convergent validity.

	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Teacher-student interaction	0.878	0.915	0.728
Student interaction in work groups	0.883	0.912	0.633
Intra-group emotional support	0.849	0.898	0.688
Online collaborative tools	0.848	0.849	0.537
Collaborative learning	0.855	0.892	0.581

Three methods were used to verify the discriminant validity. The first one consisted of determining whether the loadings of each indicator in their respective constructs were greater than the cross loadings of the other constructs (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). In this sense, the indicators of the model correlated more with their own construct than with the other constructs.

Likewise, based on the criterion of Fornell & Larcker (1981), we analyzed whether the square root of the AVE of each construct was greater than the correlation between that construct and all the others. Finally, the heterotrait-monotrait ratio (HTMT) was checked to determine whether the correlation between two constructs was less than 0.9 (Henseler, Ringle, & Sarstedt, 2015); this was fulfilled in all cases.

After verifying that the measurements of the constructs met the necessary psychometric requirements in terms of reliability and validity, the structural model was developed to contrast the hypotheses proposed in the study.

### 5.2. Structural model

To evaluate the structural model, the significance level of the relationships established between the constructs and their predictive capacity were analyzed. Figure 2 shows a graphic representation of the structural model, while Table 3 presents a summary of the results of contrasting the hypotheses proposed

in the study. Likewise, following Henseler, Hubona, & Ray (2016), the SRMR indicator (Standardized Root Mean Square Residual) was used to evaluate the goodness of fit of the structural model. The value obtained indicated an acceptable adjustment (Hu & Bentler, 1999; Hooper, Coughlan, & Mullen, 2008).

In the latent variables contemplated (Figure 2), it can be seen that 53.3% of the variance of the construct "collaborative learning" is explained by the latent variables "intra-group emotional support" and "student interaction in work teams"; 47.7% of the variance of the endogenous variable "intra-group emotional support" is explained by "student interaction in work teams", a latent variable that in turn is explained, with 13.9%, by the construct "teacher-student interaction".

The Stone-Geisser or  $Q^2$  test was also used to evaluate the predictive relevance in each of the endogenous variables of the model. The  $Q^2$  values represent the degree to which the exogenous variables predict their endogenous constructs, so that values higher than 0 indicate that the model has an acceptable level in terms of predictive relevance (Doleck, Bazalais, & Lemai, 2017). As shown in Figure 2, all  $Q^2$  values are greater than zero, so it can be said that there is an adequate level of predictive relevance.

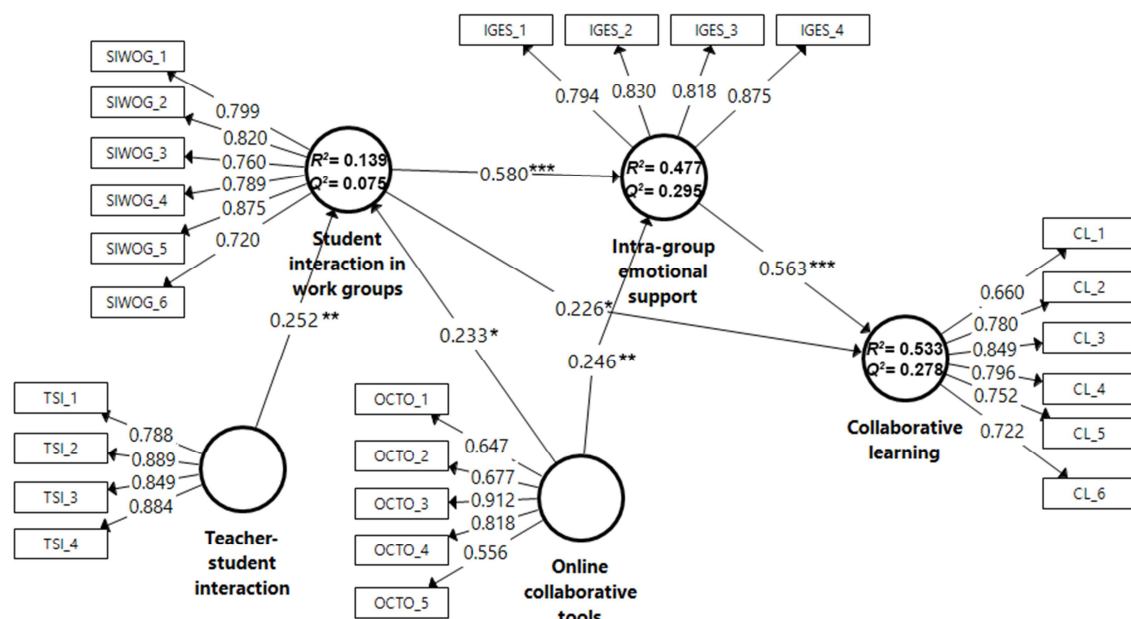


Fig. 2. Results for the research model using PLS.

Note: \*\*\* = significant at  $p < 0.001$ ; \*\* = significant at  $p < 0.01$ ; \* = significant at  $p < 0.05$ .

The values obtained for contrasting the six hypotheses formulated (Table 3) show that the model supports all of them. As well as the standardized regression coefficients ( $\beta$ ), Table 3 shows the associated T statistics and the significance levels ( $p$ -value), which together make it possible to establish whether the hypotheses are supported in the proposed model. The  $f^2$  coefficients were also determined since it is not only relevant to know whether the relationship between the variables is significant, but also to analyze the size of the effect between them (Chin, Marcolin and Newted, 1996).

**Table 3**  
Summary of results and contrast of hypotheses.

Hypothesized path	$\beta$	T Statistic	$p$ -value	$f^2$
H1. Teacher-student interaction → Student interaction in work groups	0.252	2.845	0.004	0.072
H2a. Student interaction in work groups → Intra-group emotional support	0.580	8.993	0.000	0.594
H2b. Student interaction in work groups → Collaborative learning	0.226	2.058	0.040	0.063
H3a. Online collaborative tools → Student interaction in work groups	0.233	2.297	0.022	0.061
H3b. Online collaborative tools → Intra-group emotional support	0.246	2.904	0.004	0.107
H4. Intra-group emotional support → Collaborative learning	0.563	4.829	0.000	0.392

The results obtained show that teacher-student interaction has a positive and significant effect in relation to the interaction processes that students develop in their respective teams (H1;  $\beta=0.252$ ;  $p<0.01$ ;  $f^2=0.072$ ). In this line, studies such as those of Kwon et al. (2014) emphasize that, in situations of online collaborative work, the interaction between teachers and students should not be restricted only to cognitive aspects, as this does not guarantee that a fluid exchange of ideas, opinions and co-construction of meanings among the students will occur spontaneously. Therefore, as evidenced by Molenaar et al. (2012) and Tseng & Yeh (2013), so that there is a real and fruitful interaction between the work groups, the teacher needs to plan and develop key aspects such as those related to emotional help or guiding or orientating the students, especially during the first phases of collaboration.

A positive and significant relationship with a high effect size was found between the student interaction in work teams and the intra-group emotional support (H2a;  $\beta=0.580$ ;  $p<0.001$ ;  $f^2=0.594$ ). These results are in line with those obtained in other studies (Molinillo et al., 2018; Vuopala et al., 2016; Blasco-Arcas et al., 2013), which have shown how mutual help and the emotional commitment of students (within the context of their online work groups) have a positive influence on achieving active and collaborative learning. In addition, the interpersonal relationships generated through interaction within a climate of trust, contribute to the development of feelings of belonging to the group, which favors the participation of students and their learning outcomes (Kwon et al., 2014).

A positive and significant relationship was identified for student interaction in work teams with respect to the collaborative learning variable (H2b;  $\beta=0.226$ ;  $p<0.05$ ;  $f^2=0.063$ ), although with a low effect size. Similarly, studies such as those carried out by Ku et al. (2013) show that those students who have really worked collaboratively in virtual environments perceive that they have learned more than they would have learned individually; therefore, as pointed out by Hew and Cheung (2008), the interaction that is generated within the work groups helps its members develop meaningful learning collaboratively.

The data also show that collaborative tools have a positive and significant influence, with a medium-low effect size, with respect to the student interaction in work teams (H3a;  $\beta=0.233$ ;  $p<0.05$ ;  $f^2=0.061$ ) and intra-group emotional support (H3b;  $\beta=0.246$ ;  $p<0.01$ ;  $f^2=0.107$ ). In fact, in online collaborative environments, various studies have revealed the important role played by communication tools, both synchronous and asynchronous, in promoting social interaction and active learning among students (Authors, 2014b). In addition, as pointed out by Hamid et al. (2015), the collaborative tools of the so-called social web, are a vehicular element that encourage the appearance of a greater number of exchanges of various kinds, not just related to the curriculum, but also emotional support.

Specifically, it is possible to see how the intra-group emotional support in each work group has a positive, significant relationship with a high effect size in relation to collaborative learning (H4;  $\beta=0.563$ ;  $p<0.001$ ;  $f^2=0.392$ ). These results are clearly in tune with other studies, such as those of Reyes et al. (2012) and Zhan (2008), which have demonstrated how the commitment of students through emotional interaction is directly related to academic performance.

## 6. Discussion and conclusions

The purpose of this study was to establish an empirical global model, with the aim to understand the key factors affecting online collaborative learning and to analyze their interrelation, examining the influence of relationships across teacher-student interaction, student interaction in work groups, intra-group emotional support, online collaborative tools and collaborative learning.

Overall, the proposed research model has a good predictive level, fulfilling the 6 hypotheses proposed. The confirmation of the formulated hypotheses make it possible to identify the factors that contribute to developing effective online collaborative learning. Specifically, *intra-group emotional support* is the core element from which cognitive presence, social presence and teaching presence are configured. These results are coherent with previous studies (Molinillo et al, 2018; Grieve, Padgett & Moffitt, 2016; Reyes et al., 2012). Therefore, building strong socio-emotional bonds in the work teams is the basis for generating a climate of trust as well as a sense of group belonging and responsibility. All this enables the development of genuine collaborative learning (Kwon et al., 2014).

In addition, interaction is revealed to be a key aspect, in particular, *teacher-student interaction* and *interaction among students in the work group* are especially relevant.

In a CSCL context, an efficient teacher-student interaction should be a compound of quality feedback, support and motivation and management (Packhan, Brychan, & Miller, 2006). The challenge is that even at well-articulated collaborative processes, it is common to face poor student-student interaction unless teachers promote it at higher levels (King, 2007). In this regard, the literature identifies that teacher-student interaction is often limited to the cognitive level and when teachers assume that social interaction

will take place naturally, students feel psychologically isolated; as a result, there is little social student-student interaction (Kwon et al., 2014). Therefore, organizational, emotional and educational support provided by the teacher in the early phases of collaboration are key aspects to promote scaffolding processes that sustain group regulation, enhancing interaction, communication and individual acquaintance of group members (Molenaar, Roda, Van Boxtel, & Sleegers, 2012; Tseng & Yeh, 2013). Moreover, teachers should help group members avoid internal conflicts and promote attractive and motivating learning situations. This will have a positive influence on active learning (Molinillo et al., 2018).

On the other hand, regarding interaction among students, the literature makes reference to the existence of a positive relationship between student-student interaction and active learning (Blasco-Arcas et al, 2013). This study supports this direct relationship and has proved that there is an indirect impact between student interaction in work groups and collaborative learning through intra-group emotional support. In this sense, several studies have confirmed that high levels of interaction and commitment with other students helps more active learning development (Cho & Kim, 2013; Martin & Rimm-Kaufman, 2015)

Finally, *online collaborative tools* have been found to be fundamental for facilitating interaction between students as well as to promote intra-group emotional support. Both these aspects are directly related to effective collaborative learning. These communication tools facilitate teachers' interaction with students, which is essential for providing pedagogical guidance, assistance and technical support (Lee et al., 2001), and they also promote social presence. Online tools and their use are perceived as fundamental by students; they facilitate communication in work groups and are necessary for group organization and directly related to cognitive tasks (Authors, 2014b).

Although collaboration is a natural event in life and abilities to cooperate are necessary both in personal and professional contexts, research into collaboration skills provides evidence that their acquisition constitutes a challenge for individuals. Thus, training in collaboration is usually necessary to gain the necessary skills for teaching presence, social presence and cognitive presence.

Therefore, for CSCL to work well teaching staff need to be trained to be able to meet the requirements of this work proposal and commit to the cognitive, social and personal development of their students (Kozlowski & Ilgen 2006, Prichard et al., 2010; Näykki et al., 2017).

In addition, university institutions need to provide the material and functional conditions for supporting the development of effective CSCL proposals and, at the same time, offer teachers flexible training opportunities that give them knowledge and the ability to use collaborative technology tools, as well as manage groups at the technical, pedagogical and emotional levels.

## 7. Limitations and future research

This study has potential limitations. Results derive from a cross-sectional survey, therefore causal relationships in the model should be interpreted with caution. In this sense, it would be adequate to replicate the study in different moments under similar analysis conditions. It would also be interesting to increase the number of participants, as well as their degree of heterogeneity, distributed among universities offering online education and counting on different academic fields that have used CSCL in their subject learning.

On the other hand, future research should be grounded on a larger number of constructs such as: interaction between students and learning contents, students' learning styles, students' satisfaction, students' perceived learning, students' motivation and students' expectations.

## References

- Abdu, R., DeGroot, R., & Drachman, R., (2012). Teacher's role in computer supported collaborative learning. *Proceedings of the 7th Chais Conference for Innovation in Learning Technologies*, 1-6. Raanana: The Open University of Israel.
- Akyol, Z., Garrison, D.R., & Ozden, M.Y. (2009) Development of a community of inquiry in online and blended learning contexts. *Procedia - Social and Behavioral Sciences* 1(1), 1834-1838. doi:10.1016/j.sbspro.2009.01.324
- Authors (2012).
- Authors (2013).
- Authors (2014a).

- Authors (2014b).
- Baghaei, P., & Tabatabaee Yazdi, M. (2016). The logic of latent variable analysis as validity evidence in psychological measurement. *The Open Psychology Journal*, 9, 168–175. doi:10.2174/1874350101609010168
- Bagozzi, P., & Yi, Y. (1989). On the Use of Structural Equation Models in Experimental Designs. *Journal of Marketing Research*, 26(3), 271-284. doi:10.2307/3172900
- Bangert, A. (2008). The influence of social presence and teaching presence on the quality of online critical inquiry. *Journal of Computing in Higher Education*, 20, 34–61. doi:10.1007/BF03033431
- Barclay, D., Higgins, C., & Thomson, R. (1995). The Partial Least Square (PLS). Approach to causal modeling: Personal computer adoption and use as an illustration. *Technology studies*, 2(2), 285-309.
- Bell, S. (2010) Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 83(2), 39-43. doi:10.1080/00098650903505415
- Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance. *Computers & Education*, 62, 102–110. doi: 10.1016/j.compedu.2012.10.019
- Borge, M., Ong, Y.S. & Rosé, C.P. (2018) Learning to monitor and regulate collective thinking processes. *IJCSSL*, 13 (1), pp. 61-92. doi:10.1007/s11412-018-9270-5
- Bowman, N. D., & Akcaoglu, M. (2014). “I see smart people!”: Using Facebook to supplement cognitive and affective learning in the university mass lecture. *Internet and Higher Education*, 23, 1–8. doi: 10.1016/j.iheduc.2014.05.003
- Capdeferro, N., & Romero, M. (2012). Are online learners frustrated with collaborative learning experiences? *The International Review of Research in Open and Distance Learning*, 13(2), 26–44. doi:10.19173/irrodl.v13i2.1127
- Chapman, K. J., & Van Auken, S. (2001). Creating positive group project Experiences: An examination of the role of the instructor on students' perceptions of group projects. *Journal of Marketing Education*, 23(2), 117–127. doi:10.1177/0273475301232005
- Chin, W. W. (1998). The Partial Least Squares Approach to Structural Equation Modeling. In Marcoulides, G. A. (Ed.), *Modern methods for Business Research* (pp. 295- 336). New York: NY: Psychology Press.
- Cho, M.-H., & Kim, B. J. (2013). Students' self-regulation for interaction with others in online learning environments. *Internet and Higher Education*, 17, 69-75. doi: 10.1016/j.iheduc.2012.11.001
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates. doi:10.1002/bs.3830330104
- Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In Kirschner, P. A. (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen: Open Universiteit Nederlands.
- Dillenbourg, P. (2003). Preface. In Andriessen, J., Baker M. & Suthers D. (Eds.), *Arguing to learn: Confronting cognitions in computer-supported collaborative learning environments* (pp. 7-9). Kluwer: Dordrecht.
- Dillenbourg, P. & Hong, F. (2008). The mechanics of CSCL macro scripts. *International Journal of Computer-Supported Collaborative Learning*, 3(1), 5-23. doi:10.1007/s11412-007-9033-1
- Doleck, T., Bazalais, P., & Lemani, D. J. (2017). Examining the antecedents of social networking sites use among CEGEP students. *Education and Information Technologies*, 22(5), 2103-2123. doi:10.1007/s10639-016-9535-4
- Donnelly, R. & Fitzmaurice, M. (2005). Collaborative project-based learning and problem-based learning in higher education: A consideration of tutor and student roles in learner-focused strategies. O'Neill, S. Moore & B. McMullin (Eds.), *Emerging Issues in the Practice of University Learning and Teaching* (pp. 87-98). Dublin: AISHE/HEA.
- Esposito Vinzi, V., Trinchera, L., & Amato, S. (2010). PLS path modeling: From foundations to recent developments and open issues for model assessment and improvement. In Esposito Vinzi, V., Chin, W. W., Henseler, J., & Wang, H. (Eds.), *Handbook of partial least squares: Concepts, methods and applications* (pp. 47-82). Berlin: Springer. doi:10.1007/978-3-540-32827-8
- Evans, C. (2013). Making sense of assessment feedback in Higher Education. *Review of Educational Research*, 83(1), 70-120. doi:10.3102/0034654312474350
- Falk, R. F., & Miller, N. B. (1992). *A primer for soft modeling*. Akron, Ohio: The University of Akron Press.
- Fischer, G., Rohde, M., & Wulf, V. (2007). Community-based learning: The core competency of residential, research-based universities. *International Journal of Computer-Supported Collaborative Learning (IJCSSL)*, 2, 9-40. doi:10.1007/s11412-007-9009-1

- Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39-50. doi:10.1177/002224378101800104
- García-Valcárcel, A., Basilotta, V. y López, C. (2014). Las TIC en el aprendizaje colaborativo en el aula de Primaria y Secundaria. *Comunicar*, 42(21), 65-74.
- Garrison, D.R. (2006). Online Collaboration Principles. *Journal of Asynchronous Learning Networks*, 10(1), 25-34.
- Garrison, D.R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education*, 2(2-3), 87-105. doi:10.1016/S1096-7516(00)00016-6
- Garrison, D. R., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: interaction is not enough. *American Journal of Distance Education*, 19(3), 133-148. doi:10.1207/s15389286ajde1903\_2
- Garrison, D. R., Cleveland-Innes, M., & Fung, T. S. (2010). Exploring causal relationships among teaching, cognitive and social presence: Student perceptions of the community of inquiry framework. *Internet and Higher Education*, 13(1), 31–36. doi:10.1016/j.iheduc.2009.10.002
- Garrison, D.R. & Shale, D. (Eds.). (1990). *Education at a distance: From issues to practice*. Melbourne, FL: Krieger. doi:10.1080/08923649009526713
- Gikandi, J.W., Morrow, D., & Davis, N.E. (2011). Online formative assessment in higher education: A review of the literature. *Computers & Education*, 57(4), 2333-2351. doi:10.1016/j.compedu.2011.06.004
- Grieve, R., Padgett, C. R., & Moffitt, R. (2016). Assignments 2.0: The role of social presence and computer attitudes in student preferences for online versus offline marking. *Internet and Higher Education*, 28, 8-16. doi:10.1016/j.iheduc.2015.08.002
- Haake, J. M., & Pfister, H.-R. (2010). Scripting a distance-learning university course: Do students benefit from net-based scripted collaboration? *International Journal of Computer-Supported Collaborative Learning*, 5(2), 191-210.
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Thousand Oaks, CA: Sage.
- Hair, J. F., Sarstedt, M., Hopkins, L., & Kuppelwieser, V. G. (2014). Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *European Business Review*, 26(2), 106–121. doi:10.1108/EBR-10-2013-0128
- Hair, J., Ringle, C., & Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *The Journal of Marketing Theory and Practice*, 19(2), 139-152. doi:10.2753/MTP1069-6679190202
- Hamid, S., Waycott, J., Kurnia, S., & Chang, S. (2015). Understanding students' perceptions of the benefits of online social networking use for teaching and learning. *Internet and Higher Education*, 26, 1–9. doi:10.1016/j.iheduc.2015.02.004
- Henseler, J., & Chin, W. W. (2010). A comparison of approaches for the analysis of interaction effects between latent variables using partial least squares path modeling. *Structural Equation Modeling: A Multidisciplinary Journal*, 17(1), 82–109. doi:10.1080/10705510903439003
- Henseler, J., Hubona, G., & Ray, A. R. (2016). Using PLS path modeling in new technology research: updated guidelines. *Industrial Management & Data Systems*, 116(1), 2-20. doi:10.1108/IMDS-09-2015-0382
- Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. In Sinkovics, R. R. & Ghauri, P. N. (Eds.), *Advances in International Marketing* (pp. 277-319). Bingley: Emerald. doi:10.1108/S1474-7979(2009)0000020014
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43(1), 115-135. doi:10.1007/s11747-014-0403-8
- Hew, K., & Cheung, W. (2008). Attracting student participation in asynchronous online discussions: A case study of peer facilitation. *Computers & Education*, 51(3), 1111–1124. doi:10.1016/j.compedu.2007.11.002
- Hillman, D. C., Willis, D. J., & Gunawardena, C. N. (1994). Learner–interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *American Journal of Distance Education*, 8(2), 30–42. doi:10.1080/08923649409526853
- Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural equation modelling: guidelines for determining model fit. *Electronic Journal of Business Research Methods*, 6(1), 53-60.
- Hostetter, C., & Busch, M. (2013). Community matters: Social presence and learning outcomes. *Journal of the Scholarship of Teaching and Learning*, 13(1), 77–86.

- Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1-55. doi:10.1080/10705519909540118
- Isotani, S., Inaba, A., Ikeda, M., & Mizoguchi, R. (2009). An Ontology Engineering Approach to the Realization of Theory-Driven Group Formation. *International Journal of Computer Supported Collaborative Learning*, 4(4), 445-478. doi:10.1007/s11412-009-9072-x
- Johnson, D. W., & Johnson, R. T. (2004). Cooperation and the use of technology. En D. H. Johanssen. (2nd ed.), *Handbook of research on educational communications and technology*, 785-811. Mahwah, NJ: Lawrence Erlbaum Associates.
- Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). *Cooperative learning methods: A meta-analysis*. Minneapolis, MN: University of Minnesota.
- Kerlinger, F., & Lee, H. (2002). *Investigación del comportamiento. Métodos de investigación en las ciencias sociales*. México: McGraw-Hill.
- King, A. (2007). Scripting collaborative learning processes: a cognitive perspective. In Fischer, F., Kollar, I., Mandl, H., Haake, J.M. (Eds.), *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives* (pp.13-37). New York: Springer. doi:10.1007/978-0-387-36949-5\_2
- Kirschner, P. A. (2002). *Three worlds of CSCL. Can we support CSCL*. Heerlen: Open University of the Netherlands.
- Kozlowski, S. W. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest*, 7(3), 77-124. doi:10.1111/j.1529-1006.2006.00030.x
- Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior* 19, 335–353. doi:10.1016/S0747-5632(02)00057-2
- Ku, H.-Y., Tseng, H. W., & Akarasriworn, C. (2013). Collaboration factors, teamwork satisfaction, and student attitudes toward online collaborative learning. *Computers in Human Behavior*, 29, 922-929. doi:10.1016/j.chb.2012.12.019
- Kuo, Y.-C., Walker, A. E., Schroder, K. E. E., & Belland, B. R. (2014). Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education course. *Internet and Higher Education*, 20, 35–50. doi:10.1016/j.iheduc.2013.10.001
- Kwon, K., Liu, Y., & Johnson, L. (2014). Group regulation and social-emotional interactions observed in computer supported collaborative Learning: Comparison between good vs. poor collaborators. *Computers & Education*, 78, 185–200. doi:10.1016/j.compedu.2014.06.004
- Lee, E., Chan, C., & van Aalst, J. (2006) Students assessing their own collaborative knowledge building. *International Journal of Computer-Supported Collaborative Learning*, 1(1), 57-87. doi:10.1007/s11412-006-6844-4
- Lee, S. J., Srinivasan, S., Trail, T., Lewis, D., & Lopez, S. (2011). Examining the relationship among student perception of support, course satisfaction, and learning outcomes in online learning. *Internet and Higher Education*, 14, 158–163. doi:10.1016/j.iheduc.2011.04.001
- Lu, J., Lajoie, S.P., & Wiseman, J. (2010) Scaffolding Problem-Based Learning with CSCL Tools in *International Journal of Computer-Supported Collaborative Learning*, 5(3), 283-298. doi:10.1007/s11412-010-9092-6
- Macdonald, J. (2003). Assessing online collaborative learning: process and product. *Computers & Education*, 40(4), 377-391. doi:10.1016/S0360-1315(02)00168-9
- Manca, S., & Ranieri, M. (2016). Is Facebook still a suitable technology-enhanced learning environment? An updated critical review of the literature from 2012 to 2015. *Journal of Computer Assisted Learning*, 32(6), 503–528. doi:10.1111/jcal.12154
- Marcoulides, G. A., & Chin, W. W. (2013). You write, but others read: Common methodological misunderstandings in PLS and related methods. In H. Abdi, W. W. Chin, V. Esposito, G. Russolillo, & L. Trinchera (Eds.), *New perspectives in Partial Least Squares and related methods* (pp. 31-64). New York: Springer. doi:10.1007/978-1-4614-8283-3\_2
- Martin, D. P., & Rimm-Kaufman, S. E. (2015). Do student self-efficacy and teacher-student interaction quality contribute to emotional and social engagement in fifth grade math? *Journal of School Psychology*, 53, 359-373. doi:10.1016/j.jsp.2015.07.001
- McMillan, J., & Schumacher, S. (2010). *Research in Education: Evidence-Based Inquiry*. Harlow: Pearson Addison Wesley.
- Medina, R., & Suthers, D. (2008). Bringing representational practice from log to light. *Proceedings of the 8th international conference on International conference for the learning sciences*, 59-66.

- Molinillo, S., Aguilar-Illescas, R., Anaya-Sánchez, R., & Vallespín-Arán M. (2018). Exploring the impacts of interactions, social presence and emotional engagement on active collaborative learning in a social web-based environment. *Computers & Education*, 123, 41–52. doi:10.1016/j.compedu.2018.04.012
- Molenaar, I., Roda, C., Van Boxtel, C., & Sleegers, P. (2012). Dynamic scaffolding of socially regulated learning in a computer-based learning environment. *Computers & Education*, 59(2), 515-523. doi:10.1016/j.compedu.2011.12.006
- Moore, M.G. (1989). Editorial: Three types of interaction. *American Journal of Distance Education*, 3(2), 1–7. doi:10.1080/08923649309526818
- Näykki, P., Isohäätä, J., Järvelä, S., Pöysä-Tarhonen, J., & Häkkinen, P. (2017). (2017) Facilitating socio-cognitive and socio-emotional monitoring in collaborative learning with a regulation macro script – an exploratory study. *IJCSCL*, 12 (3), 251-279.
- O'Dwyer, L. y Bernauer, J. (2014). *Quantitative research for the qualitative researcher*. California: Sage. doi:10.4135/9781506335674
- Oakley, B. Felder, R.M., Brent, R., & Elhajj, I. (2004). Turning Student Groups into Effective Teams. *Journal of Student Centered Learning*, 2(1), 9–34.
- Onrubia, J., & Engel, A. (2012). The role of teacher assistance on the effects of a macro-script in collaborative writing tasks. *International Journal of Computer-Supported Collaborative Learning*, 7(1), 161-186. doi:10.1007/s11412-011-9125-9
- Pachler, N., Daly, C., Mor, Y., & Mellar, H. (2010). Formative e-assessment: practitioner cases. *Computers & Education*, 54(3), 715-21. doi:10.1016/j.compedu.2009.09.032
- Packham, G., Brychan, P., & Miller, C. (2006). Student and tutor perspectives of on-line moderation. *Education + Training*, 48(4), 241-251. doi:10.1108/00400910610671915
- Paswan K.A., & Young J.A. (2002). Student evaluation of instructor: a nomological investigation using structural equation modeling. *Journal of Marketing Education*, 24(3),193–202. doi:10.1177/0273475302238042
- Pérez-Mateo, M., & Guitert, M. (2012). Which Social Elements are Visible in Virtual Groups? Addressing the Categorization of Social Expressions. *Computers & Education*, 58, 1.234-1.246. doi:10.1016/j.compedu.2011.12.014
- Prichard, J.S, Bizo, L. & Stratford, R.J. (2006). The educational impact of team-skills training: Preparing students to work in groups. *The British Psychological Society*, 76, 119-140. doi:10.1348/000709904X24564
- Prichard, J.S., Bizo, L. & Stratford, R.J. (2010). Evaluating the effects of team-skills training on subjective workload. *Learning and Instruction*, 21, 429-440. doi:10.1016/j.learninstruc.2010.06.003
- Prinsen, F.R., Terwel, J., Volman, M.L.L., & Fakkert, M. (2008). Feedback and reflection to promote student participation in computer supported collaborative learning. In A. Ashman, R. Gillies, & J. Terwel (Eds.), *The teacher's role in implementing cooperative learning in the classroom*, (pp. 132-162). Berlin: Springer. doi:10.1007/978-0-387-70892-8\_7
- Puntambekar, S. (2006). Analyzing collaborative interactions: divergence, shared understanding and construction of knowledge. *Computers & Education*, 47(3), 332-351. doi:10.1016/j.compedu.2004.10.012
- Reyes, M. R., Brackett, M. A., Rivers, S. E., White, M., & Salovey, P. (2012). Classroom emotional climate, student engagement, and academic achievement. *Journal of Educational Psychology*, 104, 700–712. doi:10.1037/a0027268
- Sims, R. (2003). Promises of Interactivity: Aligning learner perceptions and expectations with strategies for flexible and online learning. *Distance Education*, 24(1), 87–103. doi:10.1080/01587910303050
- Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences*, 3(3), 265-283. doi:10.1207/s15327809jls0303\_3
- Sobreira, P., & Tchounikine, P. (2012). A model for flexibly editing CSCL scripts. *International Journal of Computer-Supported Collaborative Learning*, 7(4), 567-592. doi:10.1007/s11412-012-9157-9
- Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of CSCL. In J.-W. Strijbos, P. Kirschner & R. Martens (Eds.), *What we know about CSCL: And implementing in higher education* (pp. 53-86). Boston, MA: Kluwer. doi:10.1007/1-4020-7921-4\_3
- Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge: MIT Press. doi:10.7551/mitpress/3372.001.0001

- Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer, (Ed.), *Cambridge handbook of the learning sciences* (pp. 409-426). Cambridge, UK: Cambridge University Press.
- Strijbos, J., Martens, R., & Jochems, W. (2004). Designing for Interaction: Six Steps to Designing Computer-Supported Group-based Learning. *Computers & Education*, 42, 403-424. doi:10.1016/j.compedu.2003.10.004
- Tenenhaus, M.; Vinzi, V; Chatelin, Y.M., & Lauro, C. (2005). PLS path modelling. *Computacional Statistics & Data Analysis*, 48(1), 159-205. doi:10.1016/j.csda.2004.03.005
- Tseng, H. W., & Yeh, H. T. (2013). Team members' perceptions of online teamwork learning experiences and building teamwork trust: a qualitative study. *Computers & Education*, 63, 1-9. doi:10.1016/j.compedu.2012.11.013
- Vuopala, E., Hyvönen, P., & Järvelä, S. (2016). Interaction forms in successful collaborative learning in virtual learning environments. *Active Learning in Higher Education*, 17(1), 25-38. doi:10.1177/1469787415616730
- Williams, K., Morgan K., & Cameron, B. (2011). How do students define their roles and responsibilities in online learning group projects? *Distance Education*, 32(1), 49-62. doi:10.1080/01587919.2011.565498
- Zhan, H. (2008). *The effectiveness of instructional models with collaborative learning approaches in undergraduate online courses*. Arizona: ProQuest, UMI Dissertation Publishing. Northern Arizona University.

**Computer-Supported Collaborative Learning: An analysis of the relationship between interaction, emotional support and online collaborative tools.****Highlights**

- Analysis of the key elements in Computer Supported Collaborative Learning.
- Intra-group emotional support is the element with the greatest impact in Collaborative learning.
- Student interaction in work groups plays a key role as a mediating factor.
- Online collaborative tools have a positive influence in intragroup interaction as well as on emotional support.
- Teacher-student interaction influences student interaction in work groups.