An evaluation of students' motivation in computer-supported collaborative learning of programming concepts

Luis Miguel Serrano-Cámara, Maximiliano Paredes-Velasco, Carlos-María Alcover, J. Ángel Velazquez-Iturbide

Universidad Rey Juan Carlos, C/Tulipán, S/N, Móstoles, 28933 Madrid, Spain

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Motivation is a very important factor for successful instruction. This factor is especially relevant in collaborative learning contexts, where social interaction plays an important role. In this paper we present an evaluation of motivation in 139 students who were instructed under four pedagogical approaches: traditional lecture, collaborative learning, collaborative learning guided by CIF (an instructional framework for collaborative learning), and collaborative learning guided by CIF and supported by MoCAS (a collaborative learning tool). We considered the four dimensions of motivation according to self-determination theory. The statistical results show that, in global terms, students were more motivated by jointly using the collaborative instructional approach CIF and the MoCAS tool than by using a collaborative approach. Detailed analysis of the different kinds of motivation yields mixed results. Students who were instructed with CIF and especially those students instructed with CIF and MoCAS exhibited higher intrinsic motivation. Furthermore, students instructed with CIF and MoCAS were the most extrinsically motivated via identified regulation. With respect to extrinsic motivation via external regulation, students instructed in a traditional, individual way were more motivated than students instructed collaboratively. Finally, high levels of amotivation were also associated to instruction using CIF and MoCAS. In summary, our results suggest that CIF and MoCAS are associated with high levels of intrinsic and extrinsic motivation, a finding that can aid in improving the learning processes, but they are also, unexpectedly, associated with amotivation, suggesting an overall increase in activation in the students who show mixed motivators.

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1. Introduction

The European Higher Education Area (EHEA) promotes the use of instructional models where students play a more active role than in traditional instruction. There are different pedagogical approaches that encourage an active role of the student, such as problem-based learning (Dochy, Segers, & Van den Bossche, 2003; Ellis et al., 1998), project-oriented learning (Jones, Rasmussen, & Moffitt, 1997) or case-based learning (Harvard Business School, 2013). These approaches can be combined with collaborative learning if several students work together to achieve a common goal (Dillenbourg, 1999). The computer supported collaborative learning (CSCL) field gives computer support to these approaches.

In a previous work (Serrano-Cámara, Paredes-Velasco & Velázquez-Iturbide, 2011), we proposed an instructional framework aimed at designing and developing collaborative learning activities based on educational objectives, called CIF (Collaborative Instructional Framework). In short, CIF combines CSCL activities (Bonwell & Eison, 1991; Koschmann, 1996) and learning goals, stated in terms of Bloom’s taxonomy (Anderson et al., 2001; Bloom, Englehart, Furst, Hill, & Krathwohl, 1956). CIF is supported by the system MoCAS (Mobile Collaborative Argument Support), which was designed to cope with a range of different screen sizes, from PCs to mobile phones.

The CIF framework has been used with students enrolled in a course on introduction to computer programming (usually known in the computing community as CS1). The learning outcomes of several instructional methods were compared (Serrano-Cámara, Paredes-Velasco & Velázquez-Iturbide, 2012). We obtained a statistically significant improvement in the learning outcomes of students jointly using the CIF framework and the MoCAS system. We also obtained anecdotal evidence of the higher motivation of these students. Given the importance of motivation for learning, we considered important to have more founded knowledge on the influence of CSCL on students’ motivation.

The aim of this study is to evaluate students’ motivation using CIF and MoCAS as CSCL materials. In order to obtain as much information as possible, we compared the same four instructional methods as...
used in the previous evaluation of learning outcomes (Serrano-Cámara et al., 2012). The joint use of CIF and MoCAS is the experimental group and the three control groups instructed students: in a traditional form, in a collaborative form, and collaboratively with CIF (but without the support given by MoCAS). To conduct the evaluation, we measured self-determination and the four dimensions of motivational by means of the Situational Motivation Scale (SIMS) developed by Guay, Vallerand, and Blanchard (2000), in its Spanish adaptation and validation (EMSI, see Martín-Albo, Núñez, & Navarro, 2009).

The article is structured into several sections. Section 2 contains a description of the state of the art on motivation and CSCL in education, mainly in computer programming education. Section 3 describes previous concepts related to our research, namely the CIF framework, the MoCAS platform, and EMSI motivational scale. Sections 4 and 5 describe the experiment design and method, and the results, respectively. Finally, in Section 6 we present a brief discussion and our conclusions.

2. Background

2.1. Motivation in education

Motivation has been a central issue in the study of human behavior, since it is at the core of biological, cognitive, and social regulation processes. In the real world or in a practical sense, motivation is highly valued because of its consequences: motivation helps produce positive results (Ryan & Deci, 2000a). Motivation is a core factor in the learning–teaching process to improve active learning (Pintrich, 2003), because motivation concerns energy, direction, persistence and equifinality – all aspects of activation and intention (Ryan & Deci, 2000a). The literature shows a high diversity in terms and approaches about motivation (Murphy & Alexander, 2000). From these different conceptual models, the self-determination theory can be a theoretical framework very useful to understand motivation within the educational and academic contexts (Deci, Vallerand, Pelletier, & Ryan, 1991; Vanssteenkiste, Lens, & Deci, 2006). Self-determination theory (Deci & Ryan, 1985) emphasizes the importance of the development of internal human resources for personal development and self-regulation of behavior. Self-determination is based in intrinsic motivation, or prototypical manifestation of the human tendency toward learning and creativity, and in self-regulation, which is concerned with how the people assume social values and extrinsic contingencies and progressively transform these into personal values and self-motivation (Ryan & Deci, 2000a).

There are several dimensions of motivation depending on the level of self-determination, ranging through a continuum from more to less self-determination:

1. Intrinsic motivation refers to doing something because it is inherently interesting or enjoyable; intrinsic motivation is an important phenomenon for educators because it is a natural wellspring of learning and achievement that can be systematically catalyzed or undermined by instructor practices, and because intrinsic motivation produces results in high-quality learning and creativity (Ryan & Deci, 2000b).

2. Extrinsic motivation via identified regulation – a more self-determined or somewhat internal regulation – implies an option as it occurs when the behavior is considered important for the subject’s goals and values.

3. Extrinsic motivation via external regulation – a less self-determined or more external regulation – refers to doing something because it leads to a separable outcome – to obtain a reward or to avoid a punishment.

4. Amotivation, the least self-determined dimension, implies non-regulation and occurs when individuals do not perceive the contingencies between the behavior and its consequences, and behavior has not intrinsic or extrinsic motivators (Ryan & Deci, 2000a).

These authors note that each type of motivation leads to different consequences. Previous research carried on from this model has shown that the most self-determined forms of motivation (i.e., intrinsic motivation and identified regulation) are more closely associated with positive consequences such as the natural propensities for growth and integration, as well as personal well-being and constructive social development. On the other hand, the most negative consequences, for instance, a low self-esteem and avoidance behaviors, are linked to lower levels of self-determination, such as amotivation and external regulation.

Moreover, self-determination theory postulates that social and environmental factors affect motivation, facilitating or inhibiting intrinsic motivation and its potential positive consequences. These factors are present in educational contexts, especially in collaborative learning and group active learning where social interaction, sensemaking processes and collective processes in distributing, sharing and interpreting information and knowledge play a central role (Alcover, Gil, & Barrasa, 2004). Research results point out that, rather than focusing on rewards for motivating students’ learning, it is important to focus more on how to facilitate intrinsic motivation (Deci, Kostner, & Ryan, 2001). One of the environmental factors that may be more relevant in educational settings to enhance motivation refers to the learning strategies and teaching methodologies used (Schunk, Pintrich, & Meece, 2008). Therefore, to research the educational methodologies and group and collaborative learning from an intrinsic motivation view is very interesting and relevant in the EHEA context.

2.2. Collaborative learning and CSCL

There is a large body of documented experience about active learning from collaborative approaches (Keser, Uzunboylu, & Ozdamli, 2011). Collaborative learning refers to a situation where two or more people learn or attempt to learn something together: knowledge, skills, competencies and so on. Specifically, it is defined by a set of processes which help people interact together in order to accomplish a specific goal or to develop an end product which is usually content specific. In summary, following the conclusions of Dillenbourg (1999), the words “collaborative learning” describe a situation in which particular forms of interaction among learners are expected to occur, which would trigger collective learning mechanisms, but there is no guarantee that the expected interactions will actually occur. Hence, a general concern is to develop ways to increase the probability that some types of interaction occur, and to facilitate the achievement of the learning goals.

The crucial issue in collaborative learning is what may be called “practices of meaning-making in the context of joint activity”, intersubjective learning (Suthers, 2005) or group cognition (Stahl, 2006). This learning is not merely accomplished in a group context or interactionally, but it is actually constituted of the interactions between participants (Stahl, Koschmann, & Suthers, 2006). In collaborative learning some factors are particularly important, such as group composition and functional roles of team members (Wang & Lin, 2007), team and task regulation processes (Saab, van Joolingen, & van Hout-Wolters, 2012), levels of interdependence and trust processes (Rico, Alcover, Gil, & Sánchez-Manzanares, 2009), or team and task awareness (Frisner, Kirschner, & Erkens, 2011). They are factors that turn influence on motivation.
and collective efficacy, communication behaviors, coordination processes and, in sum, on performance, efficacy and outcomes obtained in a wide range of tasks (Johnson & Johnson, 1998). Research has confirmed that collaborative learning encourages the use of high-level cognitive strategies, critical thinking, deep learning, deep understanding, and positive attitudes towards learning and groupmates, and also provides learners with more open and flexible means of working collaboratively with their peers (Wang & Lin, 2007). Therefore, we believe that collaborative learning is a building block of the teaching–learning process advocated in the EHEA.

Moreover, computer-supported collaborative learning (CSCL) is one of the most dynamic branches of the learning sciences concerned with studying how people can learn together with the assistance of computers. It proposes the design and development of new software and applications to build collaborative environments that facilitate social knowledge construction and that bring learners together and so that can offer creative activities of intellectual exploration and social interaction (Gress, Fior, Hadwin, & Winn, 2010; Stahl et al., 2006). Previous research has analyzed various motivational factors in collaborative learning (Jarvela, Volet, & Jarvenoja, 2010) and, specifically, in CSCL, such as goal orientations, expectancy and value components (e.g. Schoor & Bannert, 2011), intrinsic and extrinsic peer motivation (e.g. Kong, Kwok, & Fang, 2012), group composition and self-efficacy (Wang & Lin, 2007), co-regulation of learning (e.g. Chan, 2012) or academic motivation (e.g. Rienties, Tempelaar, Van den Bossche, Gijselaers, & Segers, 2009). From this previous research derives the need to know more deeply the motivational aspects implied in the use of collaborative learning and CSCL, such as the effects of different teaching methodologies used in learning processes.

2.3. CSCL in computer programming

There are many tools aimed at collaboratively supporting programming education. Some systems are not specific of computer programming but they are used with this purpose. CSCL in computer programming is based on combining social interaction functions with software development and debugging functions. One important design issue is how to build CSCL tools that put together those functions. One approach is to extend CSCL tools by incorporating some typical features of IDEs (Integrated Development Environments) that support programming work, as in SICODE (Pérez, Paule, & Cueva, 2006) and COLLEGE (Duque & Bravo, 2008). These systems support decision-making utilities for specific functions such as program compiling and running, allowing the coordination of group members through chat or messaging. However, this approach has the important limitation that the resulting systems do not support utilities for decision making on the program design activity.

Another approach is to integrate CSCL features into professional IDEs. This is the case of some Eclipse or NetBeans plug-in tools (Gartner and da Silva Pinto, 2012; Cheng et al., 2003). COALA (Jurado et al., 2009) extends the Eclipse IDE to support distributed delivery of problems and solutions, and instructors’ hand-written annotations on students’ solutions. The Cole-Programming system (Jurado, Molina, Redondo, & Ortega, 2012) extends the COALA plug-in to support collaborative interaction using chat and forum tools. Sometimes, the tools are the result of integrating several plug-ins. For instance, Jazz Samgan (Vijay et al., 2008) combines two plug-ins: Samgan (Ho, Raha, Gehringer, & Williams, 2004), that supports distributed pair programming, and Jazz (2013), that supports communication and coordination to develop software in group. In this approach, tools are similar to repositories, where students connect to a server, they download an Eclipse project (including a plug-in template) and, finally, they may develop source code without guidelines or assistance. Therefore, these systems neither support the management of student groups or problem statements, nor collaborative edition of source code. Sometimes, students have to perform individually the programming task and later send the source code they developed to the teacher (Jurado et al., 2009, 2012). Properly speaking, it is cooperative learning rather than collaborative learning.

An important class of CSCL systems supports the interpretation of source code and the simultaneous animation of its visualization. Thus, the CAROUSEL system (Hübshner-Younger & Narayanan, 2003) was designed to support users in the tasks of sharing with the community, peer evaluation, and asynchronous discussion. Sometimes, these systems are the result of connecting several tools. For instance, the SICAS–COL system (Rebelo, Mendes, Marcelino, & Redondo, 2005) is the result of two tools: PlanEdit (Redondo, Bravo, Ortega, & Verdejo, 2002) and SICAS (Gomes & Mendes, 2001; Marcelino, Mihaylov, & Mendes, 2008). The JeCo system (Moreno, Myller, & Sutinen, 2004a) is the result of connecting Jeliot 3 (that supports code animation and visualization, see Moreno, Myller, & Sutinen, 2004b) and Woven Stories (that supports collaborative writing, see Nuutinen, Sutinen, Botha, & Kommers, 2010). These tools have the limitation that discussion and argumentation dialog utilities (e.g. chat) are not likened to the code developed by the users.

An important issue in CSCL for computer programming is what concepts they support. For instance, in the imperative programming paradigm, important concepts are: scope of identifiers, loops, procedures, etc. One tool aimed at making easier these basic concepts is SCALE (Gogoulou et al., 2007). HabiProt (Vizcaíno, Contreras, Favela, & Prieto, 2000) is a system developed with a different purpose, namely assisting students in the acquisition of general programming skills. These tools are collaborative repositories to ease the programming task to the students, but they do not structure or connect the students’ code blocks.

The systems described in the literature report different kinds of evaluation. Most of them report on their use and often provide anecdotal evidence on their use. In general, evaluation of these systems focuses on collecting feedback from students using questionnaires and only some systems have been evaluated with respect to educational achievement of students. Up to our knowledge, there are no motivation evaluations of CSCL systems for programming education.

3. Preliminaries

In this section we introduce the CIF framework and the MoCAS system, as well as the EMSI scale used to measure motivation.

3.1. Collaborative Instruction Framework (CIF)

The Collaborative Instruction Framework (CIF) is oriented to the analysis level of Bloom’s taxonomy (Bloom et al., 1956). The analysis level was selected because it is especially appropriate for argumentation and discussion and ultimately for collaborative learning. In the original formulation by Bloom, the analysis level was divided into sixteen educational objectives. For each educational objective, CIF defines a Domain Card (DC) that gives the instructor a guideline about how to achieve it. A DC consists of three sections:

1. A problem statement aimed at achieving the corresponding educational objective.
2. Detailed instruction on how to work collaboratively to achieve the educational objective.
3. An assessment of learning achievements.

For the experiment reported in this paper, the instructors applied CIF to the domain of scope of identifiers in a structured programming language. We used a DC corresponding to the first objective of the analysis level of Bloom's taxonomy (namely “the ability to recognize unstated assumptions”). The problem statement asked students to build a table identifying the scope of all the identifiers occurring in a given program. The session was scheduled as the following sequence of activities:

1. Form different groups.
2. Deliver an instance of the problem (i.e. two pieces of program code) to all the groups.
3. Each group has to solve the problem (i.e. to determine the scope of the identifiers contained in the program).
4. Each group submits their solution, which is assessed by the system.
5. The answers given by the different groups are clustered and displayed.
6. A presentation of the answers of each group is made by its members.
7. A debate about disagreements among the groups is moderated by the instructor to promote dialog and discussion.
8. Doubts, mistakes or missing elements are clarified by the instructor.

More details about the CIF methodology are given by Serrano-Cámara et al. (2011, 2012).

3.2. MoCAS

The Mobile Collaborative Argument Support (MoCAS) learning platform is aimed at supporting collaborative activities defined using CIF. The platform supports interaction in devices with different screen sizes, from smaller (e.g. smartphones) to larger ones (e.g. PCs).

MoCAS supports the instruction of a representative topic of analysis tasks, namely scope of identifiers in procedural programming. In its current state of implementation, MoCAS supports the programming languages Pascal, C and Java.

MoCAS completely supports in-class instruction, thus it supports all the activities identified in the CIF framework, which vary for the different kinds of users. On the one hand, MoCAS supports activities intended for instructors about group management, control of the class dynamics, and support for assessment. In particular, MoCAS allows merging the groups’ solutions into a single table to foster discussion and automatically creates a solution to any problem statement, which may be compared with group and class solutions. On the other hand, students can operate with the system and collaboratively interact. In particular, they may collaboratively build a table of scopes, agree/disagree about proposals, and communicate via chat.

Fig. 1 shows the PC user interface of MoCAS. The left-hand side contains the problem source code. The central and right parts of the screen contain two tables of scopes. The top table is the result of merging the solutions contributed by several student groups. Each row of the table raw contains the list of identifiers of a specific function or procedure. For each identifier, the name and line number are displayed in brackets. Identifiers are colored with a code representing intergroup agreement (black: 75–100% of agreement; green: 50–74% of agreement; red: 0–49% of agreement). In addition, blue denotes missing proposals (i.e. identifiers that are a part of the solution but have not been proposed), black denotes right proposals contributed by all the groups, and crossed items represent identifiers which are wrongly associated to the scope. The bottom table contains the automatic solution generated by MoCAS and used to check the solutions proposed by the groups.

3.3. Situational Motivation Scale (EMSI)

In order to assess situational motivation, Guay et al. (2000) proposed the Situational Motivation Scale (SIMS for short). SIMS has 16 items that allow assessing the four dimensions of motivation according to self-determination theory: intrinsic motivation, identified regulation, external regulation and amotivation. The authors of SIMS proved that the scale was adequate to measure the diverse types of motivation in educational contexts, both in the laboratory and in field studies, with satisfactory levels of internal consistency in all the subscales of motivation. Therefore, SIMS is a satisfactory instrument to assess situational motivation in educational contexts.

Martín-Albo et al. (2009) recently proposed a Spanish version of SIMS, called “Escala de Motivación Situacional” (EMSI). The authors evaluated the EMSI scale in an educational context (an experiment with undergraduate students) to evaluate its psychometric characteristics. As a consequence, the authors proposed to eliminate items 10 and 11 of the original SIMS scale (corresponding to identified regulation and external regulation, respectively) in order to improve the internal consistency of subscales.

The resulting EMSI scale has 14 items grouped into the four subscales or dimensions of motivation. Each item responds differently to the question: “Why are you performing this task/activity at this time?” and is rated on a Likert-type scale, ranging from 1 (does not correspond at all) to 7 (corresponds exactly). With an intermediate score of 4 (corresponds moderately). The remaining items are related to each dimension as follows:

- **Intrinsic motivation**: items 1, 5, 9 and 11. A sample item is: “Because I think it is an interesting activity”.
- **Extrinsic motivation via identified regulation**: items 2, 6 and 12. Sample items included: “Because I am doing it for my own good” and “It is my own decision”.
- **Extrinsic motivation via external regulation**: items 3, 7 and 13. A sample item is: “Because I am supposed to do it”.
- **Amotivation**: items 4, 8, 10 and 14. Sample items included: “I do this activity but I am not sure if it is worth” and “There may be good reasons to do this activity, but I don't personally appreciate anyone”.

4. Experimental design

In this section we explain the experimental design. We first describe the hypothesis, variables and measurement instrument, then the population participating in the experiment and finally the treatment given to each group and the protocol used for the evaluation.

4.1. Hypothesis, variables and measurement instrument

As explained in the introduction, we want to evaluate students’ motivation when the topic under study is instructed according to CIF and supported with MoCAS. Therefore, our hypothesis can be stated as “the CIF collaborative framework supported with the MoCAS tool motivates students more than other learning methods”.

Obviously, the independent variable is the pedagogical approach adopted. Four pedagogical approaches were considered:

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1. For interpretation of color in Fig. 1, the reader is referred to the web version of this article.
traditional instruction based on lectures, collaborative instruction, collaborative instruction guided by CIF, and collaborative instruction guided by CIF and supported by MoCAS.

The dependent variable was students’ motivation. As explained in Section 3.C, the instrument used to measure motivation was the EMSI scale. This scale has 14 items corresponding to the four dimensions of motivation. The value associated to each dimension is computed as the mean of the values obtained for the corresponding items in the scale. A global value also is computed as the mean value of the 14 items.

We must take into account that some items are negative and the others are positive. For example, item 4 (“Perhaps there are good reasons to perform this activity, but I cannot imagine anyone”) is negative because a high score in this item denotes lack of motivation. Therefore, scores of negative items are inverted in order to compute statistics measures.

4.2. Participants

The participants were students enrolled in a CS1 course at our university in the academic year 2011–2012. Four different enrollment groups were used for the experiment: Degree in Computer Science (two groups from two campuses), Degree in Software Engineering and Degree in Computer Engineering. Each group was instructed in the topic using a different pedagogical methodology. The three control groups were: E1-Ind (traditional instruction), E2-Col (collaborative instruction) and E3-CIF (collaborative instruction guided by CIF). The experimental group was E4-CIF-M (collaborative instruction guided by CIF and supported by MoCAS).

A total of 139 freshmen students participated, distributed in the four enrollment groups as Table 1 shows. The groups had similar socioeconomic characteristics.

Three instructors participated in the experiment: one instructor in experiments E1-Ind and E2-Col, one instructor in experiment E3-CIF, and one instructor in E4-CIF-M. In addition, the latter instructor was aided by an assistant to solve any technical problem with the infrastructure and to assist students in learning MoCAS. The instructors had a long experience in teaching the subject. Additionally, the instructors of groups E3-CIF and E4-CIF-M had used the CIF framework and the MoCAS tool for other topics in past years.

4.3. Protocol

The evaluation was conducted in a 2 h session. For groups E1-Ind, E2-Col and E3-CIF, the session was held at the classroom, as no equipment was required, but the session for group E4-CIF-M was held at a computer laboratory. Participation was mandatory (as attendance to the course activities in general). However, they were informed that participation would be rewarded with 0.15 points in the final grade of the course (over a scale of 10 points).

Students had to fill in a pre-test at the beginning of the session and a post-test at the end. These tests were intended to measure the educational gains of students, which is not the focus of the article, thus we do not refer to them until the conclusions section. Notice the participation of different instructors in the different groups, thus we could wonder whether the each instructor had different influence in his/her corresponding groups with respect to motivation. We did not have the opportunity to have the same instructor for all the groups, but our rationale is that the instructor has an influence on the global student motivation in the course. However, we measured the students’ increase in motivation in a single session and this is more closely related to the activity itself than to the instructor.

The session had several elements in common for all the groups. At the beginning of the session, the instructor explained the theory contents using PowerPoint and a projector. Students were given
the EMSI motivation questionnaire at the end of the session. Fig. 2 summarizes the evaluation procedure.

For the central part of the session, the procedure varies in the different groups:

- **E1-Ind.** The instructor illustrated the theory concepts with five examples on the blackboard. Students individually solved two problems posed by the instructor. The results were assessed by the instructor on the blackboard and discussed.

- **E2-Col.** Students were organized into groups of four students each (with some groups of five students). The assignment of students to groups was random, depending on where they were seated. The instructor delivered a piece of source code and the problem statement on paper. Groups worked collaboratively on the problems trying to figure out the scope of each identifier. Finally, a voluntary group wrote their solution on the blackboard, and the rest of students and the instructor discussed its correctness.

- **E3-CIF.** The phase of group formation was similar to E2-Col. In addition to delivering the problem statement and the source code on paper, the instructor made visible the source code using the projector. Each group worked independently and built a table of scopes. In this process, students used paper and they discussed face to face. The instructor did not participate and only answered students’ questions about the problem statement. Some groups wrote their respective tables of scopes on the blackboard, and students and the instructor discussed those proposals. Finally, the instructor explained the mistakes committed and made comments on different arisen issues.

- **E4-CIF-M.** The initial part of the session was similar to the previous group. Groups were formed assisted by MoCAS, and students in each group were given the validation information necessary to start a MoCAS session on their PCs. The instructor demonstrated how to use MoCAS over the projector, displayed the problem statement and the source code using MoCAS, and explained the problem statement and the material available through MoCAS. Then, students used MoCAS to build their table of scopes, make proposals, and arguing and achieving consensus about the table of scopes (one table per group). They were allowed to switch from interacting with MoCAS to arguing and achieving face-to-face agreements in the classroom, all of this as a very dynamic process. When the students ended collaboratively elaborating their groups’ tables of scopes, the tables were projected by MoCAS on the blackboard through the projector. The automatic solution generated by MoCAS, was also displayed, as well as error marking of wrong and missing proposals in the groups’ solutions. The instructor discussed those proposals. Finally, the instructor explained the mistakes committed and made comments on different arisen issues.

### 5. Results

In this section we present the results obtained. We first present the global results and then the results obtained at the four motivational dimensions.

#### 5.1. Global results

The results of the descriptive analysis are shown in Table 2. Notice that the group who used the CIF+MoCAS approach obtained the highest mean (4.94).

Standard error is 5% ($p = 0.05$). We first examined the means by applying Shapiro–Wilk to E2-Col, E3-CIF and E4-CIF-M (population samples smaller than 50) and Kolmogorov–Smirnov to E1-Ind (population samples equal to or greater than 50). Table 3 shows the results. We can note in the Shapiro–Wilk test that $sig > 0.05$ in the
5.2. Results in the four dimensions of motivation

We also wanted to know the results in the four dimensions of motivation. We first checked the normality of data obtained for each of these dimensions and we obtained that it was not satisfied for any dimension. The groups that do not have normal distributions in any of the dimensions ($\sigma < 0.05$) follow:

- Intrinsic motivation: control group E2-Col ($\sigma = 0.013$).
- Extrinsic motivation via identified regulation: control groups E1-Ind ($\sigma = 0.037$) and E3-CIF ($\sigma = 0.023$).
- Extrinsic motivation via external regulation: control group E3-CIF ($\sigma = 0.08$).
- Amotivation: control groups E1-Ind ($\sigma = 0.00$) and E2-Col ($\sigma = 0.018$), and experimental group E4-CIF-M ($\sigma = 0.002$).

The non-normality in the dimensions of the EMSI test for our population samples prevents us from using a hypothesis contrast based on ANOVA. Consequently, we did a hypothesis contrast that does not require normality in the samples, namely hypothesis contrast by means of confidence intervals. This contrast allows us to identify the group with the highest mean if it satisfies the following conditions: (a) if its mean is higher, and (b) if it does not intersect with the confidence intervals it is compared to. The confidence intervals for the four dimensions in the four groups can be found in Tables 7–10.

Table 7 shows the results for intrinsic motivation. The control group E3-CIF and the experimental group E4-CIF-M exhibit more intrinsic motivation than the control groups E1-Ind and E2-Col, given that their confidence intervals are longer and they do not intersect with either E1-Ind or E2-Col. Furthermore, the distance of the confidence intervals from group E4-CIF-M to groups E1-Ind and E2-Col is even longer. As a consequence, students find more “interesting and pleasant” an instruction based on the CIF approach, being this perception even greater when the CSCL MoCAS tool is used.

Table 8 shows the results for extrinsic motivation via identified regulation. The confidence intervals of the experimental group E4-CIF-M do not intersect with the remaining groups. Therefore, we may claim that E4-CIF-M has a statistically higher mean. This allows us claiming the positive relationship that exists between the joint use of CIF and MoCAS and students’ extrinsic motivation via identified regulation. In other words, students consider that it is important to achieve the learning goals of the course.

Table 9 shows the results for extrinsic motivation via external regulation. The confidence intervals of all the groups intersect, thus the differences in means are not statistically significant. Control approach with the others, without taking the order into account.

Using the new value of $p$ in the post hoc Scheffé test, we only find an intersection of two experiments with $\sigma < 0.0083$: E2-Col (collaborative approach) and E4-CIF-M (CIF+MoCAS approach). Therefore, we conclude that the CIF+MoCAS approach motivates more to students than the collaborative approach without CIF.
group E1-Ind is the only one that does not intersect with the control group E2-Col, therefore its higher mean is proved statistically. This analysis suggests that the students do not perceive collaboration as a rewarding approach. However, this conclusion cannot be claimed with respect to the instructional approaches based on CIF (E1-Ind intersects with E3-CIF and with E4-CIF-M).

Table 10 shows the results for amotivation. The experimental group E4-CIF-M does not intersect with control groups E2-Col and E3-CIF, therefore we may claim that a collaborative activity based on MoCAS is also related to amotivation.

6. Discussion and conclusions

We have presented an evaluation of collaborative learning involving 139 college students. Our purpose was to evaluate the students’ levels of motivation with respect to four pedagogical methodologies with and without computer support: traditional lectures, collaborative learning, collaborative learning guided by the CIF framework, and collaborative learning guided by the CIF framework and supported by the MoCAS tool.

The results obtained allow us to claim that CIF and especially CIF combined with MoCAS are the pedagogical methodologies that the most intrinsic motivation produced in students. Furthermore, students instructed with CIF and MoCAS exhibit higher extrinsic motivation via identified regulation. With respect to extrinsic motivation via external regulation, students instructed in a traditional, individual way were more motivated than students instructed collaboratively without the use of CIF. Finally, high levels of amotivation were also related with the joint use of CIF and MoCAS. In sum, our results suggest that CIF and MoCAS are associated with high levels of intrinsic and extrinsic motivation, which can improve the learning processes, but also, unexpectedly, with amotivation, suggesting an overall increase in activation in the students who show mixed motivators in their learning activities. We feel unable to give an explanation without having available more founded data, thus it is an open issue for the future.

Prior research shows a direct relationship between intrinsic motivation and positive consequences, whereas the less self-determined kinds of motivation (amotivation and external regulation) lead to more negative consequences (Martín-Albo et al., 2009; Vallierand, 1997). These relations indicate that students who feel pleasure and satisfaction when performing an academic task may have higher levels of persistence to continue to carry out the task in the future, and vice versa. Future research should explore whether different motivational orientations based on a learning methodology (especially in collaborative learning strategies like those used in our study) are related to students’ behaviors and their subsequent academic outcomes.

One relatively minor concern for the adoption of CIF and MoCAS is that some extra time is required for students to get familiarized
with the MoCAS system. In our evaluation, this drawback was alleviated by the aid provided by an assistant. In real settings, it would be more realistic to schedule a short session to let groups of students practice and become familiarized with the system.

In retrospective, we have conducted two evaluations of CIF and MoCAS with respect to other three instructional approaches; one evaluation was of educational effectiveness, and the evaluation reported here was of motivation. In both cases, the joint use of CIF and MoCAS proved to yield higher results. We consider that this was of motivation. In both cases, the joint use of CIF and MoCAS proved to yield higher results. We consider that this was of motivation.

As explained in Section 3.C, students also filled in a pre-test and a post-test, so the joint evaluation of all the tests can be even further illuminating about the effects of CSCL on students.

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