A Novel Group Engagement Score for Virtual Learning Environments

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Abstract—STEM (Science, Technology, Engineering, and Math) education is currently receiving much attention from governments and educational institutions. Our work is based on active learning and video-based learning approaches to support STEM education. Here, we aimed to increase student's engagement through reflective processes that embrace video film-making, and subsequent online discussion and evaluation of those videos. We propose a group engagement score that takes into account both individual activity and similarity of participation, thus allowing corrective actions to be taken when unengaged students or groups are identified. We tested these ideas using our own social learning platform that combines the principal features of Social Networks with tools that facilitate collaborative learning design. This platform stimulates students' learning by means of two main reflective processes: participatory production and peer-review. We evaluated this platform and the learning approach it supports in an Object Oriented Programming course and identified interesting differences between group engagement and video ratings. Our principal conclusion is that greater teacher and student awareness of the ongoing activities and group engagement are needed.

Index Terms—Learning analytics, STEM, video-based learning, atkinson index, gini coefficient, ricci-schutz coefficient, entropy

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1 INTRODUCTION

STEM (Science, Technology, Engineering and Maths) education is currently receiving the attention of governments as a strategic area. In a U.S. Department of Commerce report [57] addressing future jobs, STEM jobs were predicted to increase proportionally over the next 10 years. The interest of the U.S. Government in STEM education can be seen in the allocation of funds for research funds addressing this area [11]. The European Union is also focusing its attention on STEM education, with the European Schoolnet (http://www.eun.org/focus-areas/stem), the educational technologies for Science, Technology and Maths objectives of the Seventh Framework Programme for Research (FP7) and the HORIZON 2020 research programs [29].

Videos have for several decades been used as a teaching resource, showing that they can be a valuable pedagogical resource for STEM [24], [48]. Depending on the student's role, two basic approaches can be considered in video-based learning: with the student as either a consumer or producer. The former approach was adopted early for use in the classroom. Videos were commercially acquired or filmed by the teachers. Videos have been used in well-known approaches, such as blended learning or distance learning with live sessions, but also in more recent approaches, such like "The Flipped Classroom" [34], [45]. Some of the key advantages of a video-based learning approach include: the visual representations are easy

to understand and reduce the instructor's work load [9], videos can include multimedia content that can be effective learning materials [39], students can advance at their own pace [61] and students become engaged with the course through active participation in learning tasks [27].

The student as a producer approach has traditionally demanded greater effort, with video making being costly. As a consequence, students were typically prevented from becoming involved in the recording and editing processes. Despite these difficulties, Tibbs [53] reported a successful experience in which learners made and shared videos, thereby improving the learning process and reinforcing knowledge and interest in the topic. More recently, as video technology and Internet access have become more popular and available, students have had greater opportunity to participate in video making. This allows the application of a more active approach for video-based learning. The active learning approach [6] is based on cognitive activity, "Learning by doing". There are many ways to get students involved in tasks that promote cognitive activity. Here we use the active learning approach with three types of tasks: 1) educational videos created by students; 2) a collaborative approach for the video production process; and 3) peer review of published videos. Here, a new student's role arises: student as a reflective and social actor. Both tasks, video creation and production, require reflective processes. Reflection allows students to build conceptual understanding [19], [40]. Although there are some issues regarding how to use technology to effectively support rather than hinder the reflection process, recent research has shown that videos can support this process and that video editing in particular can enhance the reflective process [35].

Our work is part of an E.U. funded project addressing STEM, active learning and video-based learning. We asked students to create, share and visualize videos on an intranet

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or Internet, and discuss the contents and quality of these videos. This is not a novel approach [31], [42], [48], [51], and the question addressed here is what kind of technology will support these tasks so that they become educationally effective. We are interested in the video production process as a collaborative learning task [20]. Computer Supported Collaborative Learning [47] is based on the Computer Supported Collaborative Work (CSCW) technologies [26], providing users, in our case students and teachers, with new ways of interacting. Currently, social networking [25] is an open research field within the CSCW scope and our work studies the application of social networking within educational environments focused on video-based learning. The impact of the educational use of social networks is unclear [7], [17], [35], [58]. This work takes into account the contribution of the social approach within the framework previously described.

Our aims were to present how group engagement can be measured. Motivation and group engagement depend on the level of participation of group members and the homogeneity of their contributions. Although it is important that a teacher can monitor the individual contributions of each group member, it is more important that group engagement can be characterized from the combination of each group member's contributions. Our approach has two principal benefits. First, the teacher gets access to real-time information about group progress, facilitating early interventions. Teamwork is supported by means of several collaborative tools including chat, forums and shared files. The evolution of the internal activity of each team may provide clues about the quality of the final output. An early sign of disengagement may trigger teacher interventions and prevent team failure before it occurs. Furthermore, the success of video-based learning is based on increasing student engagement through reflective processes. Part of the student's reflection occurs when reviewing peers' work and providing them with feedback. This can be measured during several stages of the video creation and production processes, as there are different intermediate products to be uploaded to the platform: outline, script or storyboard. Second, teachers' reflection is supported throughout and after the learning activity. Thus, teacher's understanding about students' learning and its connection with group engagement is increased. This enables teachers to determine the effects of their teaching practices [16] and to plan better strategies for their learning goals [13]. Therefore, we are presenting a platform for teacher inquiry supported by Learning Analytics.

2 RELATED WORK

The use of the web space as a learning resource has been one of the most developed technologies for enhanced learning in past years. Learners and facilitators have benefited from a wide range of online resources presented in various forms. A first straightforward strategy has been using the webspace as a common repository of teaching materials and learning activities, where facilitators publish their work and share it with others [50]. Several research projects and organizations are oriented around this strategic direction, such as Connections (http://cnx.org/), European Schoolnet's Learning Resource Exchange (http://lreforschools.eun.org), MERLOT (http://

www.merlot.org/) and OER Commons (http://www.oercommons.org). However, reflective learning requires a shift in focus from content-based learning to process-based learning [54] (i.e., the student becomes an active part of the process).

Web 2.0 has become a priority in Technology-Enhanced Learning, as has been shown by Downes [22], Ebner et al. [23] and Rollett et al. [44], among others. In this new scenario, learners and facilitators actively participate in their learning process through online collaborative tools (e.g., blogs, wikis, forums, online office suites, instant messaging and shared calendars). These tools support authoring, promote discussion and help reflection and organize knowledge through different annotation mechanisms.

Our vision of active social learning relies on supporting the design of reflective video-based activities. We take advantage of the principal features of Social Network Systems (SNSs) enhanced with tools that facilitate the collaborative learning design. We propose a social learning platform that stimulates students' learning by means of the production of videos that are subsequently the subject of on-line discussion and evaluation. Students perform two main reflective processes: participatory production and peer review. During the production phase, students use the platform for discussing the script and storyboard, and eventually, the editing process. Final versions of the videos are uploaded to the platform, where students comment and cast votes. The learning design was mainly focused on the group rather than individual level. The teacher gave directions that regulate group behavior, leaving opportunity for internal group organization. Afterward, the teacher took a passive role in favor of the students. Learning is driven by the active participation of the student, reflecting about their own contents and the contents created by other students. At the same time, our approach includes groupware facilities aimed at promoting both inter and intra group discussion. Here the teacher must carefully design the learning activity, as technology by itself is insufficient for supporting a successful learning process. This is especially critical in active learning approaches, where teacher control is more limited once the activity is started. In this sense, it is crucial that teachers have access to precise and easy to interpret metrics that allow them to assess the learning process.

One core concern during the development of our social video-based learning platform was to enable the teacher to monitor student progress. A first key point is that our approach is based on empowering the student active role during the learning process. Thus, the teacher must ensure that students are actively participating in the activity, and that their implication is high. A second challenge lies with teamwork. Videos are created by groups of variable size, with the priority of assessing how team members are contributing to the group progress. In this sense, we have devised a group engagement score that combines student individual engagement and their impact upon the group as a whole.

There is no generally accepted definition of student engagement [4]. The most straightforward definition relates engagement with participation, measured as the time dedicated to learning. In this sense, class attendance has been chosen by many researchers as a simple measure of student engagement [21]. Online learning used similar definitions,

TABLE 1
Interaction Types

Name	Description
Chat	A student (actor) sends a private message to another student through a chat
Blog comment	A student (actor) posts or updates a comment on a discussion thread of a blog entry
Blog entry	A student (actor) creates, deletes or updates the first blog entry
File	A student (actor) adds a new file to the platform
Fivestar	A student (actor) rates a video
Friend	A student (actor) accepts a friend request
Friend request	A student (actor) sends a friend request
Group topic forum	A student (actor) creates, deletes or updates the first post of a discussion thread in a group forum
Group topic post	A student (actor) posts or updates a comment on a discussion thread of the group forum
Images	A student (actor) adds a new image to the platform
Messages	A student (actor) sends a private message to another student through the private message system of the platform
Pdf	A student (actor) adds a PDF file to the platform
Ppt	A student (actor) adds a new PowerPoint presentation to the platform
User	A student (actor) changes her/his personal information
Video	A student (actor) adds a new video to the platform
Word	A student (actor) adds a new Word document to the platform

as in Bulger et al. [8], that defines engagement as the number of internet activities during the lesson or the number of clicks. Other researchers use engagement in a broad sense, incorporating cognitive and behavioral dimensions. A representative exemplar of this approach is a study derived from the PISA report that combined both students' attitudes and their participation [60]. Despite the lack of a clear definition, engagement has been identified as a good predictor of learning and personal development [10], and has been linked to undergraduate academic achievement, student attrition, student retention, student motivation and institutional success [4], [12].

Measuring cognitive and behavioral engagement requires cognitive and performance tests [32] or self-report questionnaires [2], [33]. These surveys report detailed profiles on student engagement, mixing qualitative and quantitative data if necessary. These student questionnaires are a versatile tool that can collect data for multiple dimensions (e.g., background, attitudes, cognitive performance), being highly useful for posteriori analyses. Despite their advantages, the effort required to complete such questionnaires is a major drawback. This can deter students from survey participation or confound the results. In addition, the teacher has to wait for the results of the survey. This absence of

real-time feedback is a fundamental weakness for integrating this approach as a measuring tool during the execution of the activity. Other qualitative data collection methods (e.g., interviews, focus groups and video ethnography) also suffer from the same limitation.

We identified the log data analysis as the most suitable approach for our needs. This approach analyses learners' actions using the digital trace stored in log files. The two main advantages are: 1) it is unobtrusive: learner intervention is unnecessary; 2) its immediacy: learners and teachers can obtain analysis outcomes in near real-time. Log data visualization has been used to monitor learners' activity. Upton and Kay [55] supported learners' self-regulation by producing simple visualizations regarding three learning activities: amount of text contributed to a wiki, amount of code committed to a program and number of group tasks managed. Due to these visualizations, learners identify how their participation in learning activities can be improved. Maldonado et al. [37] provided teachers with more elaborated visualizations regarding learners' behavior in a multi-tabletop environment, which allowed the teachers to visualize the number of active participants, amount and symmetry of tabletop interactions and verbal communication; progress towards the objective and monitoring interactions among learners. The visualization approach delegates to end users the interpretation of the visualized data regarding learners' activities. Here our aim is to provide teachers with an engagement score, removing the need to interpret basic data regarding learners' activities. Most of the log analysis studies published to date have focused on inferring the status of a latent variable representing student's engagement from the e-learning platform interactions. A set of interaction variables were selected according to their feasibility as engagement predictors (Table 1).

This set varies depending on the e-learning functionality. Thus, Cocea and Weibelzahl [14] include the number of reading pages and taking tests. Similarly, Arroyo and Woolf [1] consider problem solving time and number of mistakes, as well as help requests and timing parameters, such as average hints requested or the percentage of all helped problems. Qu and Johnson [43] take into account the current task and the expected time to perform it, as different tasks require different levels of the learner's attention. A computer adaptive test based on Item Response Theory (ITR) combines time on task, the difficulty of the question, and whether the response was correct [3], [28]. These studies report high accuracy results, suggesting that it is feasible to detect motivational-affective levels based solely on computer interactions [18], [41]. There have also been promising results on predicting disengagement [15]. Such approaches might explain the causes of disengagement and recommend more precise interventions to teachers, replacing self-report questionnaires. However, there are several drawbacks to such approaches that affect their practicality: a) Model training and maintenance remains costly as it requires validation by means of self-assessment or expert rating; b) there are concerns about the generalizability of findings gained from single online learning environments [41].

Although predictive models are promising, we advocate a descriptive approach, which should be more easily integrated into current educational practices. We propose a

proxy for group's engagement level that combines group interactions and similarity of participation. This score aims to easily identify groups that required help facilitating early interventions.

3 GROUP ENGAGEMENT PROPOSAL

From our point of view, individual engagement contributes to group engagement in two key ways. First, following the definitions identified in the literature, engagement is highly related to participation [4]. Thus, students should demonstrate a minimum level of activity that is measured in terms of number of interactions (Table 1). This threshold determines if a student is active or not. It is a necessary condition that all group members should be active, otherwise this group will be considered unengaged. Furthermore, the individual contributions are aggregated, obtaining the mean of the interactions per member. Groups with a higher interaction average are more likely to be engaged.

The second key aspect is the balance of participation, which determines if group members have the same engagement level. For example, a group could have a high interaction level but with most of these interactions being performed by just one of the members, so that there are different interaction levels among the group members. This aspect has been considered in other works. From a visual point of view, Maldonado et al. [37] represent symmetry of learners' interactions and verbal communication with polygons. Each learner is represented as a vertex in the polygon. So the more similar in shape to a regular polygon, the more balanced the learners' participation. From a numerical point of view, dispersion indicators can be used to measure this aspect (e.g., the Gini coefficient) [38]. For estimating differences between the group participation level, we have compared four classic inequality measures: Shannon entropy, the Gini coefficient, the Ricci-Schutz coefficient (also named Pietra's measure) and the Atkinson's index [46].

These metrics have three interesting properties: they are normalized between zero and 1, they compare the proportion of participation of each student rather than the absolute contribution and there are standard implementations facilitating their adoption.

We asked four experts for ratings of up to fifty different groups of different sizes and different participation distribution, with the aim of empirically defining what it is understood as similarity of participation. Each group was randomly created by selecting a group size between 2 and 5, and selecting a number of interactions for each member ranging from 1 to 100. Initially, each expert had to classify each group according three levels of participation similarity: low, medium and high. Later, internal validation was assessed using the intraclass correlation coefficient model ICC(2,1) [52]. ICC ranges from 0 (no reliability) to 1 (perfect reliability). Both consistency 0.55 (CI 95 percent 0.42 to 0.69) and absolute agreement 0.55 (CI 95 percent 0.41 to 0.68) were low. We asked raters about this issue and they agreed that there were several groups for which it was difficult to differentiate between the medium and low levels.

We therefore decided to collapse these two levels into one, thereby increasing the inter-rater reliability. The new measures were: consistency 0.766 (CI 95 percent 0.671 < ICC < 0.846) and absolute agreement 0.743 (CI 95 percent 0.632 < ICC < 0.833).

In order to compare the results with raters' evaluations, we created a fictitious rater. This rater is named Golden Judge (GJ) and aggregates the scores of the four experts. The new similarity of participation for each group was computed by choosing from the two levels (high/low) that were most frequently chosen by the four experts. Ties were resolved by choosing the high level. There were 5 ties among the 50 groups.

We evaluated each inequality metric comparing the results using the GJ ratings. Using decision trees, we computed a model that included 60 percent of the responses, and assessed its accuracy using the remaining 40 percent. This assessment was repeated 1,000 times, choosing different sets of ratings each time. The Atkinson index metric performed best, with an accuracy of 38 percent and mean error rate of 3 percent, followed by the Ricci-Schutz coefficient (24 percent) and Gini (23 percent). The worst measure was Shannon entropy, winning just 13 percent of the time.

Based on these findings, we propose the use the Atkinson's index to calculate the similarity of participation. In this case, a value of zero indicates that all members of the group have had the same level of participation, while a value of one indicates a high variety of engagement levels among the group members. We defined two categories of similarity of participation (high and low).

The group engagement level is defined by combining the average number of interactions within the group with the similarity of participation. This combination is necessary because the first factor refers only to global participation as a group, while the second indicates whether the members of the group have an even participation. Thus, using both measures, we can determine whether all members of the group are having good participation.

There are three input parameters:

1. *Number of active users*. This represents the number of users who have made at least one interaction compared to the total number of users of the group.
2. *Interactions average*. It is calculated by dividing the total number of interactions of the group by the number of users of the group. Two categories were defined:
   - Regular. Values greater than or equal to the mean.
   - Small. Values lower than the mean.
3. *Similarity of participation*. This metric corresponds to the Atkinson's index, previously explained.

The group *engagement level* is defined only if the number of active users is greater than one and has been divided into different levels (balanced, uneven and unengaged) depending on the values of the similarity of participation and interactions average. Engagement level was calculated using the following rules, summarized in Table 2.

- The engagement level is BALANCED when all of the members in the group have participated in an even way (the similarity of participation is high) and their interactions average is above or equal to the mean.
- The engagement level is UNEVEN when most of the members in the group have participated in an

TABLE 2
Rules for Engagement Level Definition

Interaction average	Similarity of participation	Engagement Level
Regular	High	Balanced
Regular	Low	Uneven
Small	High/ Low	Unengaged

Fig. 1. System architecture.

uneven way (similarity of participation is low) but their interactions average is greater than or equal to the mean.

- The engagement level is UNENGAGED when, independently of the similarity of participation, the average number of comments is below the mean.

4 VIDEO-BASED SOCIAL PLATFORM

The context of this research is a European project aimed at developing and evaluating a framework for improving STEM students' motivation through creative film making, editing and peer review activities. This framework relies on three principal components: theory space, activity space and web space.

The *theory space* provides pedagogical justifications and models to be used in the design of learning experiences. The *activity space* is allocated in the schools and universities and populated by learners and teachers. Primary activities include virtual and real experiments, simulations and "enactments", which in turn are documented and edited in the form of video clips for further discussion and exchange. Finally, the *Web space* provides STEM related communication through videos and encourages discussions and comments. Video contributions comprise both, artifacts produced in activity spaces, as well as "performances" from external sources. The web space mission is to implement enabled technologies according to theory and activity space requirements. Its goals are as follows:

- *Socializing learner-created content.* Activity space outputs —mainly, but not restricted to, annotated videos— are the input for the Web space. This part of the framework supports uploading, archiving and sharing of learner-created content. Besides, contributions from external sources are also allowed. All of these are accessible through an online repository. These constitute a set of exemplars that provide knowledge about STEM concepts.
- *Social discussion and peer review.* Teachers and students can tag, rate, share or comment on these exemplars or establish real-time discussions around them. Sharing also allows forwarding a video recommendation to particular users. Finally, comments are useful for promoting discussion between students, supporting the interpretation, and clarify the ratings.

In summary, the learning process is based on the student's reflection, following three main steps: collaborative video production, discussion and peer review. The latter two steps are directly supported by the web space, whereas video production is carried out by combining the web space with other pedagogical tools.
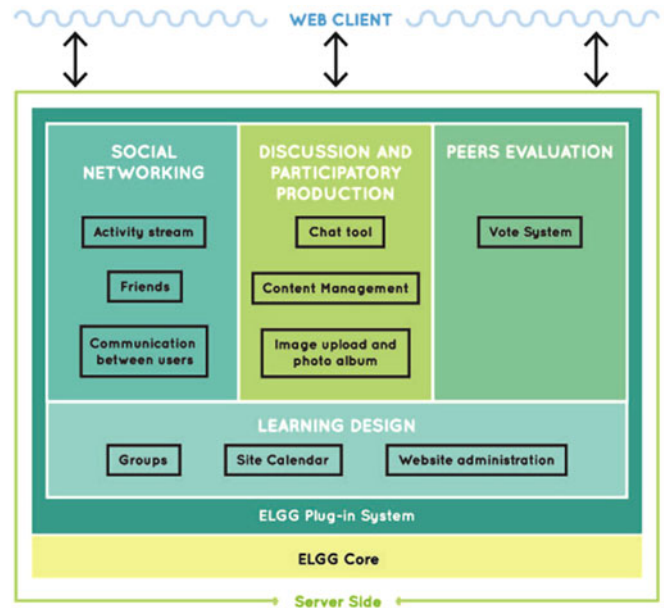
The web space is based on Elgg (http://elgg.org/), an open source social network framework. Elgg allows their users to build and manage social websites, either public or private. In a website developed with Elgg, users can use tools such as blogs, microblogs, file sharing and joining groups of people with similar interests, as well as other functionalities that are typically found in this kind of environments.

Elgg has two principal advantages: 1) it is distributed under the GNU General Public License (version 2); and 2) it has a large community of users and developers. In addition, Elgg powers networks for a wide range of organizations, such as NASA, Oxfam or UNESCO. Usually, Elgg is installed over an Apache web server, although it is possible to install it over another web servers, such as nginx (http://nginx.org/), but this may require additional configuration actions.

As mentioned above, Elgg offers a great variety of general tools for building social networks. Most of these tools are available in the Elgg core, for example management and administration of users and groups, social networking cross-site tagging, access control lists, internationalisation support, templating engine, multiple views, widget framework and plugin API. If other functionalities are required, there are more than 2,000 plugins that have been developed by the Elgg user community. Its modular architecture allows users to configure a social website based on particular needs, using the core distribution, installing additional plugins or even developing new plugins.

In our case, the web space was configured using a number of tools organized into four categories: social networking, discussion and participatory production, peer evaluation and learning design (Fig. 1). Next, we describe each category and the corresponding tools.

4.1 Social Networking

This category comprises the tools that support the social aspects of our platform: activity stream, communication among users and friendships.

The activity stream is an important elements of social networks, allowing users to remain informed about the activities that are underway in the website in real-time. The information that every user receives depends on their friends, groups and channels of interest. When a user logs onto the platform, they receive all of the updates that are of interest to her/him.

For communication between users, the webspace provides messaging systems (private and public), allowing communication among the members of a group and between individual users. Also, the webspace supports video script creation and video commenting activities. These tools allow the user to establish offline communication methods. The webspace also provides a chat tool to facilitate online communication among users. This tool is focused on discussion and participatory production, as shown below.

Finally, the friendship tool allows the user to search for friends inside the social network and to invite friends if they are not yet registered. The system itself can help the user by recommending possible friends.

4.2 Discussion and Participatory Production

The main aim of the tools within this category are to support user participation by means of discussion or content production: chat tool, content management, image upload and photo album creation.

The chat tool supports online synchronous communication among the users of the platform and was installed to meet the need for users of each workgroup to maintain online communications, that seemed necessary for writing the video script.

The content management tool allows users to upload and manage documents and other files types within the platform, so that they can be used by the groups. Moreover, all contents could be tagged and commented. This tool allows the workgroups to store their own files, that can then be used for the video script and video making. Other functions of this tool are to allow the upload of the finished videos to the platform, allowing all of the users to watch and comment on the videos.

The third tool allows the upload of images and the creation of photo albums. This tool has been used frequently in SNSs based learning [49], [59] because it can be used by teachers for uploading slides that will be explained in the classroom, allowing the teacher to explain the contents using the comments associated with every image and allowing students to ask questions using the same comments. For this trial, this tool was added so that it could be used for developing the script of the video if the members of the workgroup decided to produce a storyboard.

4.3 Peers Evaluation

This category provides a voting system supporting the peer evaluation activities. All of the videos created by users should be rated, so it is necessary to include grading tools in the platform. Two different tools were installed, a "Like" button, very similar to the one used in Facebook and other social networks, and a five stars scale rating plugin, allowing the users to rate the videos using a one to five scale (one being the worst opinion and five being the best opinion).

4.4 Learning Design

This category provides three tools that can be used in conjunction with the three previous categories. These tools are: groups, site calendar and website administration.

The group tool is a key feature of our platform: enabling collaboration between the group members for developing the script and the video. That kind of collaboration requires that the platform supports creating and managing workgroups, so communication and file sharing among group members are facilitated. A workgroup in Elgg provides these tools, including a private discussion forum and a file store system for each group.

The site calendar allows the adding of milestones to keep the users and workgroups informed about important dates, for example, due dates for either video upload or video script development. In addition, it is possible to set dates for other activities (e.g., chat meeting).

Finally, the website administration provides a control panel that allows the administrator to configure the interface and tools provided by the platform, to install plugins and access to the system log.

5 EVALUATION

To test our approach and the platform, we conducted an empirical evaluation, which is described in the following section.

5.1 Participants

The subjects were 40 students from an Object Oriented Programming (OOP) course of a Computer Engineering Degree at the Universidad Rey Juan Carlos (Spain). Their participation was incentive with extra credits but without any effect on subject grades.

In the kick-off meeting, the students were gathered in a lab and received the trial instructions. The participation implied that they have to work outside of the class. In the same meeting they organized themselves into 17 teams, eight of them with three members, seven with two members, and two of just one member. Two of the groups abandoned the trial, so only 15 groups finished. The OOP course is taught at two different campuses within our university by the same teacher. The numbers of students belonging to each campus were 11 and 29 respectively. In order to increase the variety of students within groups, we enrolled students from both campuses. These campuses are located in different parts of Madrid, so it is very unlikely that students from different campuses knew each other before the trial. Most of the teams involved students from different campuses.

5.2 Protocol

The trial was organized in three phases: video making, video assessment and user data collection. Video making consisted of four activities: briefing, video script creation, video recording and video publication. The whole trial lasted 18 days (Table 3).

All of the participants in the trial were summoned to a briefing where students received directions about the purpose of the trial, its length and the expected outcomes. Teachers also gave students recommendations on how to

TABLE 3
Trial Calendar

	Trial phase	Activity
1st day	Video making	Briefing
2nd day	Video making	Design of the video script
14th day	Video making	Video recording
15th day	Video making	Video publishing
18th day	Video assessment	Published video assessment
19th day	User data collection	Trial assessment and focus group

make videos. The students had 14 days for making the video script, completing the recording and editing. The video publishing deadline was the 15th day of the evaluation. Once all videos were published, the students had three days to comment and rate the videos published by other groups. Finally, the students' opinions regarding the platform and the trial were collected using a questionnaire and a focus group session. Students' activities followed both approaches, group work and individual work. Although the video making activities were principally group tasks, each group nominated one member that would be in charge of uploading the group's video. Interaction with the platform was mostly an individual work activity, since each student was responsible of her/his own comments and votes. Next, we detail the tasks involved in the video making and video assessment phases.

5.3   Video Making Phase

This phase is made up of four activities: briefing, video script creation, video recording and video publication. Video recording and publishing were collaborative activities, but it was expected that most of the collaborative traffic detected in the platform came from the video script creation activity.

In the briefing, the students were instructed about how to make videos according to the proposed learning approach. The most important instructions dealt with the contents of the videos, which had to address the topic assigned by the teacher. Five different topics were considered:

1. What is inheritance in Object Oriented Programming? (focusing on generalization)
2. What is inheritance in Object Oriented Programming? (focusing on specialization)
3. When does one have to use inheritance?
4. Abstract classes.
5. Java interfaces.

Students were encouraged to be creative (e.g., video formats resembling lecture talks were not allowed) and they were advised to avoid traditional teaching formats, such as slides, instead trying to explain the concept using analogy with the real world, juxtaposing real life objects to abstract concepts. The Video format was free and could include real, stop-motion, cut-out animation, ASCII art, morphing, clay doll filming, computer-generated graphic or clip collage. The video length was capped at a maximum of 5 min. The students also received advise about available software for video editing, programs like windows Live Movie Maker (http://windows.microsoft.com/en-us/windows-live/movie-maker) or Camtasia

(http://www.techsmith.com/camtasia.html) where recommended. Once the video script was recorded, the group were required to publish this using the platform.

5.4   Video Assessment Phase

Teachers gave students some rules about how to complete the assessment process, which consisted of both commenting and rating videos. Thus, each participant should include at least one comment for each video published by the other groups. These comments should highlight positive and negative video features. Students were free to decide the features to comment on and were not given instructions identifying the aspects to be assessed (e.g., how the video address the topic or the video quality). Video authors should answer comments on their videos pointing out if they agree with the comment together with the video improvement, only if the comment was asking for some kind of improvement. Otherwise, they should provide a better alternative. In addition to the comments, each student should individually rate each video using the voting system provided by the platform. Students should take into account the video quality and the potential of the video as an educational resource. Students could also use a like button to rate the video (optional).

5.5   Materials

To support students in completing these tasks, a number of documents were developed. These documents also aimed to gather students' opinion about some parts of the platform used and the trial itself [56]. These documents were:

1. Consent Form. For inclusion in the study, all of the students were required to accept and sign this form.
2. Trial instructions guide. All of the students received a copy of this guide, so that they would know what they should do in the activity.
3. Web platform sign in guide.
4. Web platform user manual.
5. Final questionnaire about the platform.

5.6   Dependent Variables of the Trial

The main variable of this experiment is the students' engagement with the learning approach, as previously explained. The engagement was measured in terms of students' interactions through the platform, and these data were collected during the activities and were available through the platform logging facility. The initial measurements focused on how students interact within their own work groups and with other groups. The next section details these measurements and how they have been used to develop the group engagement score that will be proposed.

6   OUTCOMES

Fourteen videos were uploaded to the platform and included a great diversity of techniques, for example, one video attempted to explain java interfaces using recordings of a video game, while another used various techniques to animate toys. Other examples include role games, professional football images and videos, hand animated cartoons or animated films recorded using the PowerPoint animation recorder.
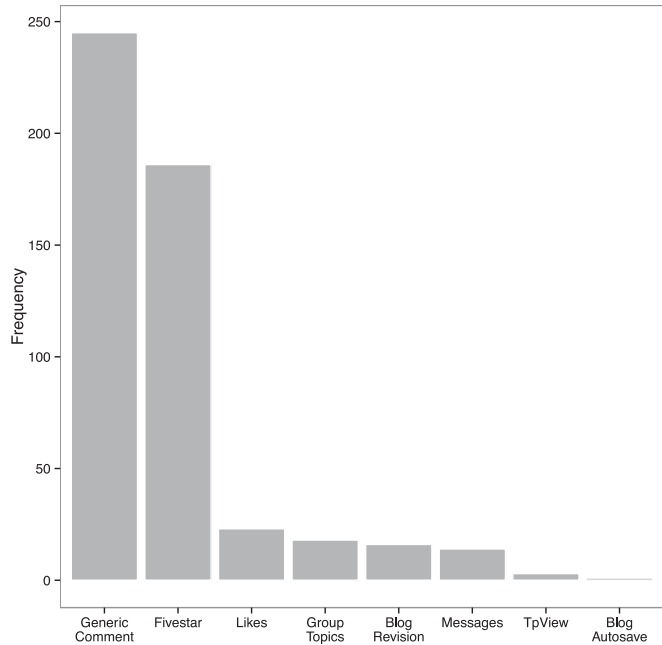
Fig. 2. Interactions frequency in each platform channel.

In this section we analyze the group's and student's engagement levels. Three objectives guided this analysis: (1) to test if groups' engagement was similar among different groups; (2) to test if students' engagement levels were similar among members of the same group; and (3) to test if there was a direct relation between the engagement level and the votes received by each group.

Fig. 2 shows the number of interactions between the users (y-axis) with the platform channels (x-axis).

Fig. 3 shows the number of interactions performed by each workgroup. Each bar included the participation of each group member. The minimum and maximum number of interactions per user were 1 and 21 respectively, with a mean value of 10.5. There was much variability in
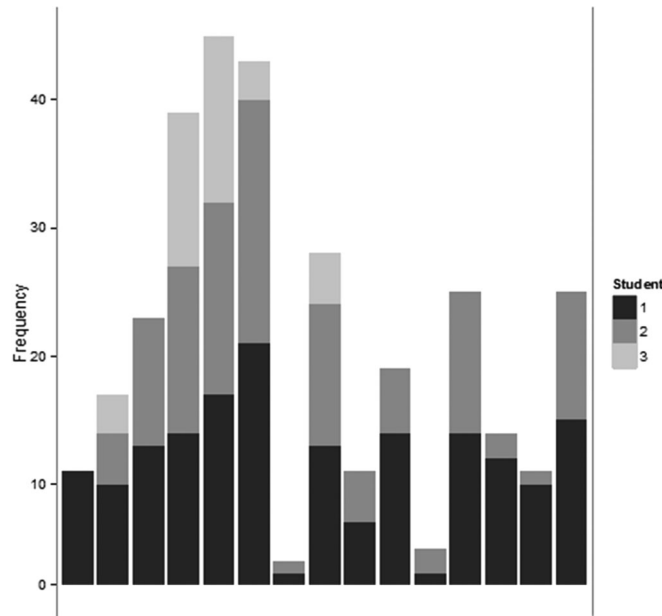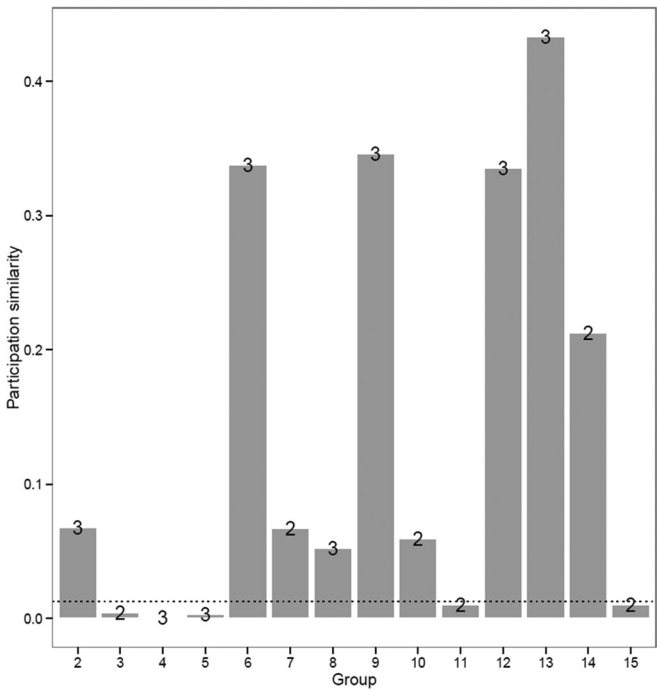

Fig. 4. Similarity of participation for each group. Dotted black line indicates the decision threshold.

the number of interactions performed by each student. The groups performed an average of 19 interactions (min. 4 max. 45).

A threshold of 0.0127 was estimated using the splitting rules of the Atkinson's index decision trees (see section 3). Therefore, the groups were classified into two categories. Those having an Atkinson's index equal or lower than 0.0127 were defined as groups with a high similarity of participation. Those having an Atkinson's index greater than 0.0127 were classified as having a low similarity of participation (Fig. 4 and Table 4).

Table 5 summarizes the engagement level for each group (as defined in section 3) and includes the number of votes cast for each video.

7 DISCUSSION

To discuss the results of the trial, it is important to remember that the instructions of the trial were given to the group, without instructions for how each member of the group should act individually. After analysing the data and the logs of the trial, the main outcomes can be summarized as:

1. Unevenness of group engagement. As seen in Fig. 3, some groups participated much more than others.
2. Unevenness in group member engagement. Within the same group, some users' engagement levels were higher than others.

Fig. 3. Interactions frequency by the users of each group.

TABLE 4
Similarity of Participation of Groups Based on Atkinson's Index

Similarity of participation	Rule	Groups
High	$=< 0.0127$	3, 4, 5, 11, 15
Low	> 0.0127	2, 6, 7, 8, 9, 10, 12, 13, 14

TABLE 5
Discussion Engagement Level

Gr	Act. Use	Int. av. per user	Similarity	Engagement	Votes
5	3/3	REGULAR	HIGH	BALANCED	49
4	3/3	REGULAR	HIGH	BALANCED	34
15	2/2	REGULAR	HIGH	BALANCED	49
3	2/2	REGULAR	HIGH	BALANCED	54
6	3/3	REGULAR	LOW	UNEVEN	35
12	2/3	REGULAR	LOW	UNEVEN	42
10	2/2	SMALL	LOW	UNENGAGED	51
8	3/3	SMALL	LOW	UNENGAGED	49
13	2/3	SMALL	LOW	UNENGAGED	0
2	3/3	SMALL	LOW	UNENGAGED	0
9	2/3	SMALL	LOW	UNENGAGED	55
14	2/2	SMALL	LOW	UNENGAGED	45
11	2/2	SMALL	HIGH	UNENGAGED	0
7	2/2	SMALL	LOW	UNENGAGED	0

Gr. - Group: identifier of the group; Act. use. - Active users: number of active users / group size; Int. av. per user - Interactions average per user: number of average interactions made by group member; Similarity of participation: see Section 3; Engagement level: see Section 3; Votes received: number of votes received by this group.

3. Video rates do not depend on group trial engagement. As can be shown in Table 5, a group with a low engagement level in the experience produced the best rated video. More specifically, this group uploaded the video at the end of the trial and made few comments about the videos of the other groups.

4. Some of the communication channels of the platform were not used. The students only used the communication channels of the platform that were indicated in the trial instructions as mandatory, preferring to use other channels, such as WhatsApp or face-to-face conversation. We hypothesize that if the groups had not been formed by students that had an easy way to meet in person, they would have been more likely to use the tools installed for this purpose in the platform.

Despite the students being satisfied with the trial and platform [56], log analysis (see point I to IV) reflects some key drawbacks. First, we intended the teacher to act as a facilitator of the learning process, rather than a creator and communicator of knowledge. In this sense, the platform provides tools oriented to control the learning design (see Section 4). Teachers set up the collaborative learning activity according to their pedagogical goals, and once the learning activity had started, became passive actors. In the current version, teacher can define the groups and configure the deadline calendar. However, these tools have been demonstrated to provide a weak support for the discussion process. We found no clear relationship between the number of votes obtained and the engagement level of each group (Table 5). Thus, the discussions had no impact on the rate process of the students. We believe that this was because the teachers had no explicit control over this process. Conversely, the whole discussion process configuration was offline, by means of verbal instructions. Another reason for this could be the use of external communication channels, as the students said in the final focus group, allowing them to work without using the platform tools. Thus, a large part of the discussion process (mainly the process which

supports the video making) was done by external channels. As the trial had no tool for measuring external interactions, it is possible that a direct relationship between the number of votes and the engagement level was overlooked because of an underestimation of engagement in those groups opting for external channels.

Additionally, the platform did not provide an explicit means for teacher intervention during the activity. In classrooms, some students are more engaged than others, and this was also the case in our social platform setting. Therefore, although we foster a passive role of teacher, it seems necessary to empower teacher intervention in order to motivate unengaged groups.

Following this line of reasoning, teachers require better methods for gathering evidence of the design process effectiveness. As can be extracted for the learning analytics data, what happened in the trial was very different of what was expected. This raises the need to enhance learning analytics capabilities for easily monitoring the platform, so that teachers can take corrective actions if necessary. In this sense, we propose an engagement level score that informs of the performance level of each group. This score is obtained by combining the similarity and the engagement measures. It is worth noting that this metric should be understood as an early sign of a conflicting group, rather than as an assessment of the activity.

The platform was initially designed for supporting collaborative reflective processes. The platform empowered social interaction between individuals (e.g., social networking tools) and provided inter and intra group communication support (e.g., participatory production and discussion tools). From the tool usage distribution (Fig. 2) it is evident that the groupware tool (group topics and messages) was underused. In our opinion, social learning platforms must integrate private social communication channels. During the trial, the students preferred to use their own private channel (e.g., WhatsApp) or to meeting in person. The use of messaging applications are currently replacing other conversation channel, including e-mail, and therefore should be considered in social learning environments.

8 CONCLUSION

Group engagement should be characterized from the combination of individual member engagement. We propose a score that aggregates the participation level of group members and the similarity of their contributions. Although the limited number of groups included in our study did not allow an analysis of statistical significance, the use of this metric appears promising. We propose that teachers are likely to benefit from this measurement, getting early information about group engagement, as well as increasing the understanding about how engagement is connected with students' learning.

We have implemented a social video-based learning platform that stimulates students' learning by means of participatory production and peer-review. We set up a trial using student groups from an undergraduate OOP course. Videos were uploaded, discussed and assessed by students. We tested our group engagement definition using the trial

outcomes. The log analysis draws out several lessons that suggest the necessity of incorporating real-time engagement metrics, such as the one proposed in this article.

First, teachers require a more flexible toolkit that gives them greater control over the learning design, and allows them to intervene during the learning activity. Platforms should increase their configurability, allowing teachers more fine-grained activity design. Furthermore, the teacher's role is key for encouraging student participation and maintaining group cohesion. Thus, teacher awareness of the on-going activity and groups status should be enhanced, and online specific channels for dynamization purposes should be provided.

Second, the engagement metric should be available not only for the teacher but also for the students. In the ARCS model [30], informative feedback is an example of a technique that increases participant satisfaction, so increasing the students' awareness on their own performance would improve their motivation and engagement. In addition, "choice and control are critical to enhance motivation to work on classroom tasks" [5], therefore, using a metric that gives to students a real-time feedback could also improve their motivation, as it provides them the information needed to make the proper choices about their learning. The proposed score allows students to know if other team members are participating in a balanced way. Furthermore, they could also access other groups' engagement scores, allowing comparison of real-time results. Both teachers and students could take corrective actions when necessary. As stated before, the technology itself is likely to be unable to produce the improvement we expect, although it may be possible to use it to quantify these differences and to carry out correct actions to overcome them.

Lastly, it seems that there is no link between discussion engagement and evaluation outcomes, although this result could be influenced by the lack of an evaluation of the interactions performed outside of the platform tools. In further works, it will be important to define a way of measuring interactions that take place beyond the platform (e.g., face-to-face or private message system like Telegram).

In the case that, using this new measure, no significant changes were detected, we would hypothesize that this link could be improved by structuring the evaluation process. It may be necessary to scaffold peer review so that students can develop links with the ideas that come out during the discussion process. In addition, despite the learning design incorporating strict activity instructions, teams clearly showed different levels of participation. Social learning platform should support mechanisms for encouraging learners' engagement. For instance, students should receive automatic reminders of uncommented and unrated videos. This takes into account that there are some videos which have not received sufficient comments.

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