# Supporting Collaborative Learning in Small Groups: An Initial Specification for Distance Learning Platforms

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## ABSTRACT
Distance learning (DL) in higher education comes as a blessing to students that are far from the main university centers. In fact, several governments are using DL as a way to socialize education by developing community-based education centers in remote parts of their countries. Unfortunately, the high dropout and retention rates show that the use of DL is still away from the expected results. This reality is motivating several efforts toward the analysis and solutions for this issue. This paper is based on the premise that collaborative learning activities, mainly when carried out in small groups and supported by elements that promote collaboration, have positive effects by increasing the ability of knowledge acquisition of students and improving their learning outcomes. Based on such premise, we formulate five research questions that lead the investigation and experiments associated with the integration of collaborative aspects into a distance learning platform. The final aim is to answer such questions, giving strong evidences to support our findings.

## Categories and Subject Descriptors
K.3.1 [**Computers and Education**]: Computer Users in Education – *collaborative learning, distance learning*.

## General Terms
Design, Experimentation, Theory.

## Keywords
Collaboration, distance learning, Moodle, group formation, intelligent adaptation.

## 1. INTRODUCTION
The Distance Learning (DL) technology has allowed several types of higher education courses be delivered to locations and populations that have historically not been afforded opportunities for involvement in such educational level. Higher education distance learning in Brazil, for example, has become a reality in the country due to both the high investment in the creation of the Brazilian Open University and the new Brazilian legislation which now allows up to 20% of any current syllabus in the Curriculum of traditional courses to be provided in the distance modality.

Distance learning initiatives generally offer an attractive cost-benefit for both learners and institutions, since such institutions are able to attract a larger number of learners at a reasonable cost [17]. In Brazil, several Departments for Distance Learning have been set up and research projects undertaken to form new virtual learning environments. Moreover, with the chance to devote 20% of the curricular schedule to distance learning courses, it seems that e-learning in higher education has really taken off in Brazil. However, from an educational perspective, what seemed to be innovative and radical has turned out to be reactionary and present lots of problems such as lacking in interactivity and failures in stimulating students [22].

To illustrate the real situation of Brazilian DL approach, we could use recent indicators. The bars, in the next graph (Figure 1), show the huge increase in the number (in thousand) of registered students in DL higher education institutes [1]. In 2003 we had about 49.000 students, while this number increased to about 1 million in 2011. The green line connects the percentage of increasing in each year, giving an idea of future trends.

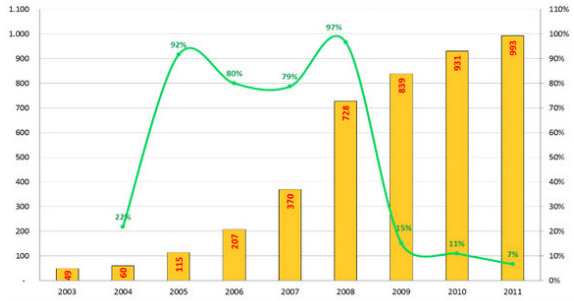


**Figure 1. Number of registered students in higher education institutes and increasing percentage from 2003 to 2011 [3].**

In a cycle of four/five years, the relative rate of students conclusion (output/input) is about 55% in the traditional education. This same rate reaches about 30% in the distance learning modality [17]. Thus, considering the graph about, from 1 million of students registered in 2011, we could say that about 700.000 of these students will not conclude their courses.

A deeper investigation of this data shows that the students' dropout rate is the main reason to this phenomenon. According to consultants in distance learning [2], "several students are not able to adapt themselves to the routine of individual studies that this education modality requires. Thus, they receive low grades during evaluations, loss motivation and dropout their courses". This sequence mainly happens during the first semester of studies, where we found the highest dropout rate.

An interesting hypothesis from the Brazilian studies is: "several students are not able to adapt themselves to the routine of individual studies". This hypothesis is in accordance with educational and psychological studies, which say that interactions

enhance learning. The next two sentences, from the work of Blom and colleagues [2], support this idea:

- "*the peers find support from one another for solving the tasks and furthermore, several students regard the social format as being natural because they are already used to the idea of engaging in study group practices*";
- *"In addition to the effect of verbal interactions, these study groups provide the advantage of social facilitation: it is easier to sustain heavy effort associated with the course material in groups than individually - humans are social animals…".*

Thus, we see that the lack in interaction, communication and collaboration among students may be one of the main problems in the current DL strategies in use. While we are focusing on Brazilian indicators, we see that other countries, such as Greece [27] and Croatia [9], suffer from similar problems, so that the improvement of DL strategies could be considered as a global concern.

We see that much of the current research agree about the dropout problem and several important works have investigated this phenomenon [16,21,19]. The majority of works try to create models to predict the behavior of students that tend to dropout. Our research team has works in this direction [28], since we have a huge database with information of several courses running since 2007. While other studies try to relate the dropout behavior to the students' grades, we are trying to carry out a more ample study, which considers since social conditions of students until basic actions such as access to forums and chats in the virtual platform (Moodle).

This work of data mining is important, however it is mostly used to identify problems and provide information for future actions. A new direction of research of our team intends to implement tools that can be integrated to the platform and support learning methods and theories that may be useful for improve the DL process. Our first effort is associated with the concept of collaborative learning. As discussed above, the current use of the platform does not properly support interaction/collaboration among students, so that students mostly use the educational content in an individual manner. In order, the platform has tools for collaboration, such as the chats and forums. However they are generally used in a very limited or incorrect way. Thus, we are looking for more effective approaches to integrate this important concept - collaboration - in the diary use of the Moodle environment by students.

## 2. COLLABORATION AND LEARNING

It is important to justify the reasons to lead our efforts to the use of collaborative learning concepts as initial solution to our current DL strategies. The intention of this paper is to investigate a special kind of collaboration that occurs in small groups. According to Kearsley [14], online learning is as much a social activity as an individual one. However, the quality and quantity of interactivity can vary dramatically from course to course. In general, courses that provide limited forms of interaction tend to present feeble outcomes and this is probably our case. Analyzing the Moodle logs, we see that participation in forums is limited to about 10% of students and always the same students. The use of chats is almost inexistent. The use of assessment is a common way to force this interaction. However it is not a natural approach and some works show that assessments do not generate a significant difference to learners' participation [3].

In order, educational benefits of collaborative group activities have also been confirmed in several research investigations. Chen and colleagues [4] show that the student engagement in collaborative activities has been positively related to the quality of learning experience. However, learning platforms must include opportunities and resources for students to engage in interactive and collaborative activities with their peers. The work in [3] lists pedagogical benefits, and consequently better learning outcomes, of collaborative learning when it is properly supported for such platforms. Such benefits include: development of critical thinking skills, Co-creation of knowledge and meaning, reflection and transformative learning [20].

We see that the literature present several evidences about the advantages of using collaboration in learning strategies. However we are interested in a particular type of learning that occurs in small groups. In order, the literature also presents several works that recognize collaboration in small groups as both advantageous and appreciated by students. For example, the work of Gayatan and McEwen [12] shows that small groups enable students to identify and correct misconceptions more easily and quickly and to improve understanding of the topics being studied. Finegold and Cooke [8] also support this affirmation and show that small groups are considered as more suitable for group discussions and equal contribution of group members. The study in [24] found that small groups provide students with a better learning experience and ultimately greater academic achievement. The work discussed in [3] reported that students often prefer working in small teams over large study groups.

Besides all these evidences, the use of small groups in distance learning platforms is almost compulsory, since DL learners generally seek for flexibility during their activities and they can see participation in group learning as an impediment to their progress. Consequently, the use of small groups (from 3 to 5 members) is also a strategy to attenuate this perception, since it is easier to arrange a common timetable if the process considers few participants.

There exist initial pragmatic efforts to promote collaboration learning in online small groups using, for example, Evolutionary Game Theory [5]. Similarly, we also intend to promote collaboration in small groups, but using resources that must be integrated to the Moodle platform and answering some questions that are still open in this kind of approach.

## 3. RESEARCH QUESTIONS

Our efforts are aimed at answering the next five research questions:

- **Question 1**: how to support small group collaboration (SGC) in distance learning platforms? This means, how to configure a SGC resource for DL?
- **Question 2:** how should be the specification of a learning object for this type of SGC resource, so that this object motivates collaborative behaviors?
- **Question 3:** considering the complete set of students, how could be the best strategy to create small groups? How to cluster students?

- **Question 4:** Should these groups be dynamic, so that they change in some way to better support collaboration? Groups should adapt themselves to improve the collaborative behavior?
- **Question 5:** How to evaluate the SGC approach applied to DL modality?

In order, our long term project intends to collect evidences to support the next hypothesis: small group collaboration improves the performance of students involved in distance learning platforms. Next section discusses initial research methods and directions to answer these questions.

# 4. RESEARCH METHODS

## 4.1 Question 1

Distance learning platforms have a set of resources that provide different alternatives for present educational contents and activities. For example, Figure 2 shows some of the resources available in the Moodle platform. Thus, one option to integrate a SGC resource, following the Moodle pattern, is to create a new resource called *Collaboration*, which could appear such as the example below.

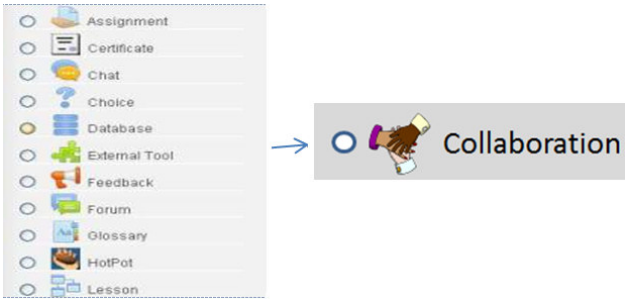


**Figure 2. Integration of a collaboration based resource following the Moodle pattern.**

As any other Moodle resource, this Collaboration resource should have a set of parameters for its configuration. However, the main point that must be defined is what this component should present. To answer this question, consider the scenario described in [4].

> "*Imagine a lecture theatre. A student stands up and interrupts the teacher: "Excuse me sir, could you pause for three minutes, while I discuss with my neighbor what you just said?" What can hardly occur in normal lectures, takes place spontaneously, when watching video recordings of these lectures.*"

This scenario is an interesting way to provide collaboration and, as stressed in [2], easy to be implemented via videos. A SGC resource could implement this approach for a distance learning environment using, for example, the next schema (Figure 3).

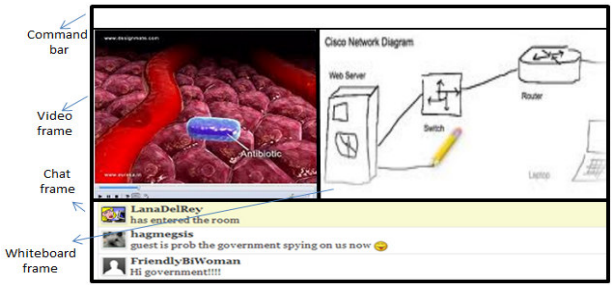


**Figure 3. Schema of an initial proposal for a SGC resource, showing a command bar, video, chat and whiteboard frames**

This initial schema for a SGC resource has three main parts. First, a video frame with the traditional video commands. Each member of the group could pause/resume the video and the resource control should be able to synchronize a single stream to multiple peers (members of the small group). Second, a shared whiteboard[1] to support the students` discussions. Third, a common chat frame. Then, each student could access the resource from you place and participate during a session with a pre-defined video, which must be implemented as a SGC learning object.

## 4.2 Question 2

As discussed above, educational videos are the learning objects of a SGC resource. However, a simple video may not instigate collaboration and students could simply watch the video. According to Dillenbourg and collegues [6], "*Collaborative learning is not always effective; its effects depend on the richness and intensity of interactions engaged in by group members during collaboration*". They relate learning outcomes to the emergence of knowledge-productive interactions such as (1) elaborated explanations, (2) negotiation of meanings, or argumentation, and (3) mutual regulation of cognitive processes.

Dillenbourg and Hong [13] discuss the concept of macro scripts as an approach to configure collaborative learning and promote the emergence of such interactions. The idea is to use scripts to disturb the natural convergence of a team and, consequently, increase the intensity of interactions required between team members for the completion of their collaborative task. Then, the interactions necessary to maintain/restore collaboration produce the desired learning outcomes.

Specifications of SGC learning objects could consider the idea of disturbing the natural convergence of its users via three interactions [13]: argumentation, explanation and mutual regulation. All these interactions could be produced via interactive video lessons[2], which permit the integration of questions along the video stream.

### *4.2.1 Argumentation*

Learning objects that face conflicting positions tend to intensify argumentation hence it is necessary to reach agreements. Interactive-video quiz (in-video quiz) could be used to produce such conflicts. When it is time for an in-video quiz, the lecture

[1] http://www.javaworld.com/article/2077111/core-java/networking-our-whiteboard-with-java-1-1.html

[2] http://www.knewton.com/blog/teacher-tools/how-to-make-an-interactive-lesson-using-youtube/

will pause and students will see a question and answer options on the screen (Figure 4). Each student will choose an option and if there are divergences between the answers, then the students must reach a consensus so that the video can resume its execution.

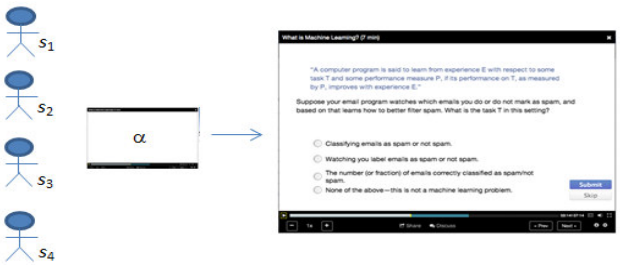


**Figure 4. Example of in-video quiz from the Machine Learning course (by Andrew Ng - Coursera). In this scenario, all students see the same video α, which contains one or more in-video quizzes.**

### *4.2.2 Explanation*

Learning objects that fragment knowledge tend to augment the need for explanation among team members. Consider that the presentation of a subject α is divided in four parts $\alpha_1$...$\alpha_4$, so that the performance of a final activity *x* depends on the understanding of $\alpha_1 \ldots \alpha_4$. If we have a group composed of four students $s_1 \ldots s_4$, then the SGC resource could be configured to send each $\alpha_i$ to $s_i$. Thus, differently of the previous scenario, students will watch different videos. At the end of the videos, the activity *x* is then presented to the group. This schema is illustrated in Figure 5.

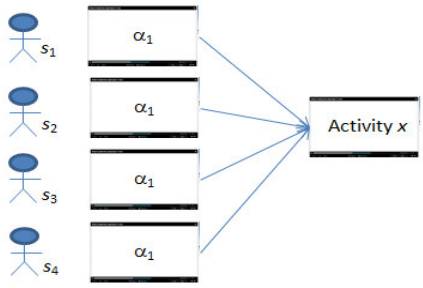


**Figure 5. Schema of knowledge fragmentation using interactive videos.**

### *4.2.3 Mutual Regulation*

Mutual regulation looks at how individuals reciprocally regulate each other's cognitive processes and engage in shared modes of cognitive regulation. Learning objects could enforce mutual regulation, for example, when they create role differences by allocating different responsibilities in solving problems. For example, the WiSim experiment [13] intends to increase collaborative effort via mutual regulation by distributing simulation inputs across different phones and hence requiring students to negotiate values and coordinate their experimental design. Thus, mutual regulation is built in to the use of the roles in conjunction with each other. As questions are asked and answered, or content is clarified and summarised, learning is monitored for accuracy. As predications are made they are evaluated for consistency with new content events. In this way, the whole group monitors their on-going comprehension in a process where learners mutually regulate their joint learning.

Learning objects that enable the jointly creation of solutions by learners mutually building on each other's contributions, in a coordinated interdependent effort, could foster mutual regulation. The next schema (Figure 6) shows a possible scenario that could be configured in the SGC resource using its whiteboard. After the educational video α, an (or several) in-video quiz is active and students are lead to construct the solution of this activity in the whiteboard Each student of the group has a pre-defined time *t* (turn) to contribute to the solution, while other students observer such construction. After *t*, the construction is paused and the turn passes to the next student. All students must keep the attention on the group resolution, since each of them will resume the construction from the point where it was paused. This approach also instigate student to think ahead, in accordance with the ongoing line of resolution, so that they can better perform in his/her turn.

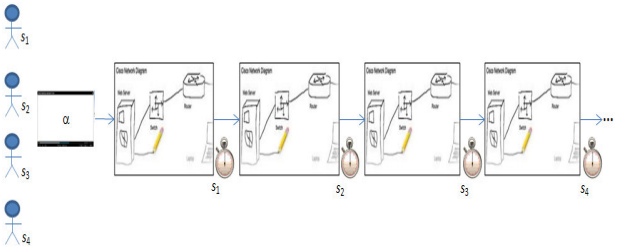


**Figure 6. Schema of mutual regulation using interactive videos.**

Along his/her turn, a student can diverge and "regulate" the resolution flow, changing the current reasoning, or just continue the resolution adding more steps. The adjustment of *t* is an important aspect of this approach. The shorter is *t*, the more interactive is the process. However, *t* must have a minimum limit value, otherwise a student will not be able to develop so much is reasoning for subparts of the problem during his/her turn.

## 4.3 Question 3

The work of Juwah [13] has found that allowing learners to form their own groups and select their own topics facilitates socializing within groups and positive group dynamics. However, other works say [18] that complete power should not be given to students to assure that groups have an appropriate mix of higher and lower skilled students. In fact, to allow students to form their own group is just one option to assign groups. Randomly assign the groups, or assign them using some criterion to increase the effectiveness of the group are other approaches.

As discussed in [10], frequently instructors need to consider additional context-specific criteria and preferences which force them to figure out the assignment of the students by hand. However, if the number of features to be considered is high, then this task is very time-consuming and may produce groups that are not prone to collaborate and, consequently, learning. This fact has motivated the development of several approaches [23,26,11] for automatic groups formation.

The automation of small group formation is more complex inside the SGF resource framework because, while traditional education generally has more homogenous classes (classes composed of similar students), this reality is completely different in DL classes.

There is a huge diversity for features such as usual time of study, age, social conditions, technological resources in use, previous knowledge, cognitive facilities and so on. In addition, other aspects should also be considered. For example, researchers have found that good students perform better in homogenous groups, whereas weaker students tend to perform better in heterogeneous groups [25,15].

We can abstract the assignment of small groups in two stages. First, the selection of features. Second, the prioritization of a selection strategy. Two examples of strategies are:

- Maximally diverse groups: focused on creating maximally diverse groups where the sum of pairwise differences of some characteristics is maximized;
- Evenly skilled groups: focused on maximizing the minimal skill for each group.

Our intention is to use the Cluster Analysis, an unsupervised machine learning technique, to group set of students in such a way that students in the same group are more similar to each other than to those in other groups (clusters). K-means is a particular, efficient and simple algorithm for Cluster Analysis. In this algorithm, we are given a training set $x^{(1)},...,x^{(m)}$, and want to group the data into a few cohesive "clusters". Here, we are given feature vectors (list of the students features) for each data point $x^{(i)} \in R^n$ as usual. Our goal is to predict $k$ centroids and a label $c^{(i)}$ for each data point. In order, $k$ is the number of groups of a classroom. If the classroom has 40 students and we want to create 4-students small groups, then $k = 10$. More details of this application can be seen in [29].

## 4.4 Question 4

Consider a small group $\Omega$, where students $[s_1, s_2, s_3, s_4] \in \Omega$, and a function $f(x,t)$ that qualifies the level of collaboration in a small group $x$ in a time moment $t$, returning a value inside the interval [0..100]. Then, if $f(\Omega,1) = 90$, we interpret that $\Omega$ has a high level of collaboration at the beginning of the group formation. However, over the time, this value could decrease. This means that $\Omega$ is losing its sense of collaboration.

It is important to detect that collaboration is losing its strengths in a group, or that collaboration is becoming useless for it, because the system can try some strategy to identify and fix the problem. One possible strategy is to adapt or rearrange the group to a new situation. For example, if one of the students is not able to follow the evolution of the group, he/she can lose its motivation and does not properly collaborate. Obviously, absences from small groups have a more profound impact than absences from the general conferences. Thus, a new organization of the group may be required.

An answer to *Question 4* first requires to measure collaboration. This means, to specify $f$. The work of Dillenbourg [7] is a proper start point hence he clarifies the notion of collaboration via dimensions of learning. We highlight three of these aspects:

- Situation: a situation can be termed 'collaborative' if peers are more or less at the same level, can perform the same actions, have a common goal and work together [7]. For example, collaboration may become harder if students have very different basic levels about a subject in study;
- Interaction: collaboration requires interaction. However, the degree of interactivity among peers should not be defined by the frequency of interactions, but by the extent to which these interactions influence the peers' cognitive processes [7];
- Mechanisms: collaboration can be seen from the perspective of the used learning mechanisms. If some mechanism is 'more collaborative' than others, then we should identify a more frequent use of these mechanisms in collaborative contexts.

Thus, if we are able to understand and measure these three dimensions for a given scenario, then we could act on it and favor the collaborative/learning process via adaptation of groups. In order, this is just the initial part of the work to answer the question 4. The measure of collaboration assists the identification of possible problems. If we are able to identify the problem, then we may relate this problem to the group arrangement and suggest a new group formation.

## 4.5 Question 5

The validation of our efforts intends to choose a specific discipline that has a high rate of dropout and retention and use the SGC resource along the configuration of this discipline in the Moodle platform that will run to new students. The final results of the performance of new students may be compared to the historical results of this discipline, so that we could analyze the outcomes and detect improvements. We intend to carry out three sets of experiments:

- Experiments using SGC resource without automatic group configuration. In this case, the assignment of groups will be carried out by the own learners;
- Experiments using SGC resource with automatic group configuration;
- Experiments using SGC resource with automatic and adaptive group configuration.

The formalization of these experiments is part of the future activities of this project.

# 5. CONCLUSION

This paper presented the main research questions that should be investigated regarding the development of resources to support small groups' collaboration in distance learning environments, such as Moodle. Our current work is focused on the three first questions. The application illustrated in Figure 3 is in a final stage of development and it will be a practical example of SGC resource for DL. We intend to carry out three different types of evaluation on this resource: (1) ability to improve collaboration, (2) ability to improve the learning process of students, and (3) usability.

Regarding *Question 2*, learning objects to support the three collaborative strategies were already specified via the *IEEE LTSC Learning Object Metadata* (LOM) pattern, which defines a set of properties that enables the management, location and evaluation of such objects. The next step is to instantiate such specifications with real content.

Finally, regarding *Question 3*, we are describing mathematical equations that represent similarities and dissimilarities among several students' attributes, such as location, age, participation frequency, traces of personality and others; so that we can apply clustering techniques and create learning groups in a more flexible way [29]. The conclusion and integration of these works are part

of our efforts to provide a SGC resource to the Moodle environment.

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