

Can a Simulated Student Detect Problems in Collaborative Learning Environments?

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Abstract

Learning in collaboration has well-known advantages. However, situations may arise that hamper collaboration or learning in a group. This paper focuses on three concrete negative situations that decrease the benefits of learning collaboratively: off-topic conversations, passive students and problems related to students' learning.

A Simulated Student has been designed to detect and avoid the three negative situations dealt with in this work. The Simulated Student was added to a collaborative system, Habipro, with the goal of testing its efficiency in controlling the negative situations. The data from the experimentation showed that in most cases the Simulated Student detected when these circumstances arose and helped students to overcome them.

1. Introduction

Computer Supported Collaborative Learning offers students many advantages. Learners may work with other students, exchange ideas and reflect upon other points of view [3, 6]. However, when students work in a group certain circumstances may occur that hamper collaboration or learning. In this section we describe three concrete situations that often arise in collaborative environments, which prevent the benefits of learning in collaboration from taking place. The first situation occurs when one or more students do not collaborate with the other students. We call this type of students "passive students". The second situation is related to students' learning. Sometimes students do not understand concepts and in consequence do not know how to solve problems. The last situation, which we call "off-topic conversation", occurs when students start to talk about other topics that are not related to the topic to be learnt.

This paper is organized as following: In subsequent paragraphs the reasons why the previous situations might decrease advantages of working in a group are described. The second section describes HabiPro, a system utilised to test the Simulated Student. The third section presents

how the Simulated Student (SS) acts to detect and avoid the three negative situations. The last section describes the results obtained from an experiment performed to validate the SS's efficiency.

1.1. Passive Students

Studies of efficient groups shows that the benefits of collaborative learning are achieved by active teams [7]. Unfortunately, members of groups are not always active. A group may contain students with little motivation, or the opposite may even occur. That is to say, a hyperactive student does not give other students the opportunity to participate. Both situations are negative because they do not allow all students to improve their skills or knowledge through their experimentation and participation.

There may be various reasons why a learner does not take part in solving exercises. For instance, the student does not have the appropriate knowledge to deal with the problem, or the student does not have enough selfconfidence to propose ideas. Depending on the reasons why the student does not participate, the SS that we have implemented will use different strategies to invite passive student to participate.

1.2. Dissoriented Students

The following negative situation is related to the learning process. On some occasions groups waste a lot of time trying to solve a problem in the wrong way. The fact that students try different ways is a good pedagogical technique because students learn from their experiences. A central part of the learning process occurs when students attempt to apply the instructional material to solve problems for themselves [1]. Important learning progress may occur when students encounter obstacles, work around them, and explain to themselves what worked and what did not [2, 4]. However, this type of learning has potential cognitive and motivational pitfalls. Students trying to solve problems sometimes expend much time and effort pursuing blind alleys because of errors or poor strategies. Of course, in some cases students may learn something valuable while searching

for a solution. In many cases, however, such episodes leave students confused and frustrated. So if a group does not obtain feedback after spending a lot of time working on a task, members may lose motivation, even abandon the activity or begin to talk about other topics causing some group members to feel that they are wasting their time.

1.3. Off-topic conversations

In order to test how students work with a collaborative system, an experiment was carried out [9]. Students were divided into groups of different sizes and were asked to solve the same set of exercises. Each group member used a computer and could communicate with his/her peers via chat. The chat conversations were recorded. Upon analysing the conversations it was observed that in many cases students talked about topics that were not related to the exercises; for instance they talked about the football match that they had seen the day before. When this type of conversation was brief, it presented no problem. In fact, it could even be advantageous on some occasions because it helped to relax the environment and made students more comfortable within the group. But if these interactions continued for a long time they could be prejudicial to the learning process. As [5] claim, more interaction among participants in a collaborative learning group would be beneficial for learning. However one exception is if the discourse is mostly off-topic and detracts from the time and effort devoted to learning

2. Habipro, a collaborative system

Having described the negative consequences that these three situations may bring, we are going to present Habipro, a system to which the SS was added.

Habipro, which was designed to help students to develop good programming habits, is a collaborative, distributed, synchronous learning system that enables students to work cooperatively even though they are in different geographical places.

The interface of Habipro provides different workspaces. One of them is an unstructured chat window that permits communication among students. The SS also uses this chat window to communicate with the real students.

A bigger window displays the problems to be solved. Below this problem area, the answer windows are, one per student even for the SS (which is always considered as one student more). In these windows each student writes the solution that he proposes. Having one answer window per student permits the learners and the system to know who has proposed each solution. Students use the chat window to decide which solution they think is the

correct one, and when they reach an agreement they can check whether the solution is really correct.

3. The Simulated Student's roles

This section describes the behaviour of the SS when it detects a negative situation. In order to check the students' learning and collaboration, the SS monitors the student models and the group model. Both models are now briefly described.

The student models contains three entities:

Frequency and type of interaction: In order to monitor each student's participation the system stores the frequency with which each student intervenes and what type of intervention is performing. There are two possible types of interaction, writing in the chat window or proposing a solution in the answer window. These parameters are important to determinate the passivity of a particular student.

Density of interaction: This is the number of letters written by a student in an intervention. When students write in the chat window the system calculates the density of the interaction. If the system passes to the following exercise a new density of interaction counter is created, thus the system knows the density of interaction per exercise. This avoids the situation of a student who has passive behaviour not being considered passive because s/he had a high density of interaction, for instance, in the first exercise. Two more indicators can be calculated from the density of interaction. The total density of the student's work is obtained by adding up all the densities stored, and the average density is calculated by dividing the total density by the number of exercises. The three indicators are very useful in detecting passivity.

Level of knowledge: Having one answer window per student enables the system to deduce the level of knowledge and mistakes of each student. By comparing the individual proposal to the real solution the system can suppose each student's knowledge. The group model is formed of four entities:

Group interaction: This indicates the global participation of the group. It is calculated by adding all the individual frequencies of interactions. The Group interaction is useful in order to compare the degree of participation of each student with respect to the group as a whole. This information is also helpful for comparing the results of different groups and for calculating statistics.

Group density: This is the sum of the students' density of interaction. The group density helps us to compare roles within the group. For instance, if a group has a group density of 100, student A has a density of 75 and student B's density is 25, this suggests that student A is probably playing the role of leader, or at least, this student makes more comments and proposals than student B. So student

B has more possibility of being considered passive than student A.

Group knowledge: Group knowledge is generally inferred from the group's actions. In order to infer the students' knowledge, HabiPro uses the information from the answer windows. Each student may propose solutions in the answer window, and through the chat discuss their proposals and choose which solution to check. This agreement is considered as an indicator of the group's knowledge.

Group preferences: The type of exercises where students have more success, and the kind of help that they often ask for, are also factors to be taken into account. This information helps the system to adapt to the users.

3.1. Detecting passive students

In order to detect passive behaviour the SS uses a module called Detector of Passivity to check the frequency with which each student intervenes by proposing solutions in the answer window. If this parameter is inferior to a established threshold, the SS suspects that a student might be passive.

However, a low frequency of intervention in the answer window is not a clear indicator of passivity. For this reason, the SS also checks the frequency and density of participation in the chat window and the students' level of knowledge. These indicators help to detect:

Whether the student's participation is also poor in the chat window. In this case, if student's participation density is also low, the student is considered passive.

Whether, although the learner participates little in writing in the answer window, when s/he does participate in proposing ideas, his/her density of interaction must be equal to or higher than the average of the group density. In this case, the student would not be considered passive, perhaps the student needs more time to reflect than the rest.

Whether the student participates in the chat window with only sentences such as: yes, no, maybe (low density of interaction). In this case the student would be considered passive.

When the Detector of Passivity, after studying all the indicators, considers that the learner is passive, a second module called Selector of Passivity has to investigate what type of passivity is taking place. This sub-module checks the number of solutions that have been proposed by the student and the index of mistakes and successes obtained. The study of these parameters in conjunction with the comparison of the specific (features of the student) and global (features of the group) parameters such as density, frequency of interventions or knowledge helps the SS to conclude why the passivity might have occurred.

The SS has different types of intervention, depending on the kind of passivity detected. In the case of the learner not having enough knowledge the SS focuses its interventions on helping the student to gain knowledge. The types of interventions are:

1. Asking for feedback: The goal of this intervention is to look for feedback about the passive student's behaviour. In this way the SS tries to make the students realise that there is one student who is participating less, in order for them to help him/her. The SS may ask questions related to the passive student's knowledge or refer directly to his/her behaviour, for example: "Tom, didn't you understand the previous exercise? You seem confused".
2. Asking the other students for justification: The SS tries to make the passive student acquire knowledge from the other students' explanations. For this reason the SS asks the other students with more knowledge to explain the solution. Example: "Peter, do you mind explaining your solution to us, Tom and I don't understand it".
3. Checking knowledge: The SS checks whether the passive student's knowledge is improving. Example: "Tom, this time you propose a solution in the answer window, ok?"

When the Selector of Passivity determines that the passive student's knowledge is adequate, the role of the SS centres on increasing the student's self-confidence, and encouraging the learner to participate and to share his/her knowledge. These types of interventions are briefly described below:

Invitation to participate: The SS tries to encourage the supposedly "shy student" to participate. Example: " Ann, you are very quiet, what do you propose?" Asking for feedback: The SS asks the passive student's opinion. Example: "what do you think about my proposal, Ann?".

Asking for an explanation: The SS tries to get the passive student's attention by asking him/her about his/her behaviour. This is an indirect way of telling the other students that there is a student who is not taking part as much as the rest. Example: "Ann, you aren't joining in much, are you tired?".

Asking about preferences: The SS solicits the passive student's interaction using indirect means. For instance, it asks about his/her preferences. Example: "Don't you like this kind of exercises?"

The case of hyperactive students has not been directly dealt with in HabiPro. However it is dealt with in an indirect way, since if in a collaborative environment there is a student whose participation is excessive, the SS would detect that the other students have an inferior degree of participation. So, the SS would act by inviting them to participate more in solving the exercises. In this way the effect of the hyperactive student could be

decreased.

3.2. Detecting learning problems

The SS monitors the students' learning in order to check whether learning is taking place or to detect learning problems.

The SS controls both the individual student's knowledge and the group's knowledge through the solutions that they write down in the answer windows. The module called the Learning Controller checks how many times students try a solution and whether it is close to the correct one or not. When the Learning Controller detects that students do not have enough knowledge or they do not understand the problem since they cannot find the solution after an adequate number of attempts, the Learning Controller invites the SS to act. Normally the interventions of the SS consist of giving a clue that helps the student to delimit the question or to reflect on the problem.

The number of trials that the Learning Controller considers adequate per exercise depends on the difficulty of the exercise and on the students' level of knowledge.

When a problem is detected the SS gives hints as a human student might do, using words that students would use and sometimes does not show much confidence in its proposal. So, students reflect upon these ideas and reject them if they disagree. If the clue was given in the manner of a teacher using technical language and with more authority, perhaps the advantage of working with a SS would disappear.

In the case of students not understanding the clue proposed by the SS and continuing to try incorrect answers, the SS generally suggests the solution and an explanation of it, with the goal of students understanding the solution.

Besides helping students to find the solution to the problem, the SS also makes other types of interventions related to motivating students' learning or checking that learning has taken place. For instance, when students find the solution at their first attempt, the SS congratulates them with the aim of maintaining their motivation. This is positive reinforcement.

One disadvantage of working collaboratively in a group might be that a student who knows the solution writes it in the answer window without explaining to her groupmates why the solution works. In this way perhaps the groupmates do not learn why the solution is correct. The SS tries to avoid this situation by checking whether students understand their solutions. For instance, the SS asks why a solution was proposed and why it is better than the others. In this way it can also verify whether students found the solution by chance.

3.3. Detecting off-topic conversations in HabiPro

In order to detect whether off-topic conversations are taking place, the SS uses the Conversation Processor which contains different databases. One is a general database, which contains words related to problem solving in programming. Another is a specific database that possesses words related to the specific exercises, one database per exercise. The final database, called the playful database, contains words related to conversations that young students might have in their free time (football, women, men...). Of course, this database can be modified depending on the environment where HabiPro is used.

When students write a sentence in the chat window, the Conversation Processor checks whether the conversation contains keywords stored in the specific database. If no keyword is found, the second step is to check if the student's conversation contains words belonging to the general database. In the case of none of the words in the conversation matching one or more words of the specific and general database, the SS supposes that students are talking about other topics. If this situation occurs once or twice the SS does not intervene because a short off-topic conversation usually helps students feel more comfortable in the group or to relax briefly. On the other hand, if the conversation lasts a while it might be negative, so this is when the SS acts. The Situation Controller module is in charge of deciding whether the SS does or does not have to intervene. The Situation Controller tests the duration of the off-topic conversation, the group's knowledge and the group's preferences in order to determine whether an off-topic conversation is taking place and whether the SS should act.

The goal of having a playful database is that the SS can know what students are talking about. It can then finish that conversation with a sentence related to the off-topic conversation, with the objective of appearing to understand said conversation. An example of intervention is "I don't like football. Let's finish this exercise". In the case of it not being possible to know what students are talking about because none of the words in the conversation match the words in the playful database, the SS tries to draw the students' attention back towards the exercise by suggesting a possible solution. We performed an experiment with teachers imitating the role of a SS. The experiment showed that the most efficient interventions to close off-topic conversations were those that did not give an option to continue the dialogue, but only proposed a possible solution to the problem and ignored the students' comments about other topics [8]. One example of the SS's interventions could be: "I think the solution is 13, don't you?"

4. Evaluation and conclusions

In order to evaluate the efficiency of the SS in detecting and avoiding the three negative situations an experiment was carried out.

Forty-four students, divided into pairs (twenty-two pairs) utilised HabiPro. Each pair has to solve nineteen exercises using the system. Students thought that they were collaborating with two students. They did not know that the third student was a SS. Thus, the situation of students considering the SS's proposal more was avoided.

Students communicated with each other by using the chat window. All interventions were recorded.

To analyse the efficiency of the SS the following aspects were studied for each situation:

- How many times did the problem arise? (the problem could be having a passive student, off-topic conversations, or problems related to learning)
- How many times did the SS detect it?
- How many times did the SS solve the problem?
- How many interventions by the SS were necessary to solve the problem?
- Did the SS act when it was not necessary? (This means that the SS thought that there was, for instance, a passive student, but the student was not passive in reality).

4.1. Did the SS detect passive students?

Eight cases of passive students occurred. The logs analysed showed that the SS detected the eight cases. On all occasions its intervention caused the passive student to take part in solving the exercises. In fact, from the logs we observed that after the SS's intervention the passive student usually proposed a solution to the problem. However, once one student repeated his passive behaviour, so two interventions were necessary to encourage that student to participate. Usually just one intervention was sufficient.

The SS acted unnecessarily once when it supposed that one student was passive but in reality the student was working as he should have been doing.

4.2. Did the SS detect learning problems?

Students often had problems in solving the exercises. Concretely, students tried three or more solutions in 65 times. The logs showed that the SS always intervened when students had problems in solving the exercises. The logs indicated that when students proposed a wrong solution the SS acted by suggesting a solution or asking a question related to the solution. The intervention of the SS helped students to solve the problem in 93.8% of the

cases, (61 times out of 65). However, students ignored the SS's advice 4 times. Hence in these cases the SS's intervention was not effective. One intervention from the SS was enough to help the students to solve the problems. The SS intervened unnecessarily once considering that students needed help when they did not need it.

4.3. Did the SS detect off-topic conversations?

Fourteen off-topic conversations took place. The SS detected twelve of these situations and avoided them in eleven cases. Its interventions were successful in 91% of the cases. One intervention was enough to stop the offtopic conversations in each case. There was one unnecessary intervention.

Data showed that in most cases the SS acted successfully in detecting and avoiding the three negative situations. The cases where the SS acted unnecessarily are being studied with the finality of detecting why this happened and thus avoiding the occurrence in further sessions.

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