Adaptive Approach for the Integration of Homogeneous Teams

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Abstract: SPEBC (Sistema Personalizado de Evaluación Basada en Computadora), an adaptive computer-based assessment system will generate personalized assignments adapted to the learner's, knowledge, group and team's characteristics. The present paper proposes the team personalization, which has its basis on the need of dialog among students. This dialogic activity is considered fundamental to construct meanings in science classroom. The team adaptation will be done grouping students with similar characteristics based on their understanding levels. The team personalization will allow teachers to promote the discussion of the students' ideas in order to improve the learners' compression of a given topic.

Introduction

This paper proposes an adaptive approach for the integration of homogeneous teams. This proposal will be useful to adapt questions and answers to the characteristics of a team of learners while they are using SPEBC (Sistema Personalizado de Evaluación Basada en Computadora) (Aguilar, et al., 2006). SPEBC, an adaptive computer-based assessment system, combines an adaptive assessment system with a Classroom Communication System (CCS) (Sharma, M.D., et al., 2005). Teachers by using SPEBC will be able to request the generation of questions and answers and learners will use their voting systems to send the answers in. In this way, teachers will be able to evaluate the learners' understanding levels in real-time (Aguilar, et al., 2007). On other hand, learners will be able to interact with SPEBC at home, through the answering of personalized assignments based on the not understood topics explained in the classroom.

The proposal has its basis on the need of dialog among students in order to improve the learners' comprehension of a given topic. This dialogic activity is considered fundamental to construct meanings in science classroom (Mortimer, E.F., et al., 2003). SPEBC generates questions and it will introduce those questions to the learners grouped in teams. This requires the generation of a dialogic activity and the establishment of agreements to answer those questions. In order to do this, the members of a team have to create a common context that includes not only words but also actions and decisions (Lemke, J., 1990).

The learners' understanding of a given topic will be facilitated by the use of the combination of a classroom communication system and an adaptive assessment system. Furthermore, it will be facilitated with the generation of interactions among learners and between teachers and learners. These interactions can be given as collaborative work among learners when they are working in small teams. Computer Supported Cooperative Learning (CSCL) fosters the interactions among team members. SPEBC supports CSCL, through the use of a computer for the generation of questions and through the use of a voting system as the media to answer those questions. And at this point, we would like to establish a difference between team and group. With a group we mean the whole class. And with team we mean that one group can be divided into small units which include several students.

Previous researches have proved that in order to create a new meaning, students have to propose ideas. Furthermore, they have to argue and contradict to each other (Jimenez, M., et al., 2006). Current assessment systems

adapt questions to the characteristics of each learner. However, a new level of adaptation is required by SPEBC, the adaptation of questions and answers to the team's characteristics. SPEBC requires the team adaptation because we would like to foster collaborative work through the use of SPEBC. Voting systems can be used as a Group Decision Support System (GDSS) and we would like to apply this characteristic in the classrooms. In such a way that the generation of questions and the answer of those questions using a voting system will facilitate collaborative work**.**

Previous works about the inclusion of a student model in an adaptive system have been developed such as those of (Pear, J. J., et al., 2002) and (Alfonseca E., et al., 2005). On other hand, a reference model to support adaptive hypermedia authoring has been previously developed (Wu, H., et al., 1998). Wu proposes the creation of a reference model for the learner, teacher and knowledge. However, we go a step further adapting the student and knowledge models to an adaptive computer-based assessment system (Aguilar, et al., 2007). Furthermore, we propose the creation of the team model.

Figure 1: Students using a voting system in the classroom
(Image taken from: http://www.ambra-solutions.co.uk/product_images/CPS/trinity_remote2_r2_c2.jpg)

There are two types of team integration: Homogeneous and heterogeneous. Homogeneous teams are integrated by members with similar characteristics. And heterogeneous teams are integrated by members with different characteristics. Some of the advantages and disadvantages of working with homogeneous and heterogeneous teams are as follows: Homogeneity may have positive consequences such as team harmony and cohesion, as well as negative consequences like strategic myopia, unfairness in promotion and difficulty of culture change (Berthon, P. R., 1993). On other hand, heterogeneous teams were less satisfied and cohesive and had more conflict than the homogeneous teams, although there were no statistical differences in team performance levels (Staples, D. S. et al., 2006). Heterogeneous teams have a greater variety of information sources than homogeneous teams. If information and preferences can be expressed openly, heterogeneous teams reach better decisions. However, members of heterogeneous teams are more likely to diverge in their preferences with respect to courses of action, which is reflected in lower effort. Team leaders who are likely to be either uninformed or well informed about project payoffs prefer to form homogeneous teams (Mello, A. S. et al., 2006). Some of the advantages that we are expecting from working with homogeneous teams are: The interactions will be done among members with more or less the same characteristics and we think that this will foster the argumentation, justification of those arguments and the decision making. Furthermore, we think that these advantages will foster attitudes such as decision making approved by consensus. Further research will be done in order to determine an approach for the integration of heterogeneous teams.

This paper is organized as follows: Second section presents an approach for the members' integration into homogeneous teams. Third section gives the proposed adaptive approach for homogeneous teams' integration. And at the end of this work, conclusions are given.

Integrating Homogeneous Teams

This section introduces the members' selection process for the integration of homogeneous teams. SPEBC will generate one question, and each team will have to select one answer, introduced using different external representations, and each team will use only one remote control to send the answer in. This implies that the interrelations among the members of a team will take place at the classroom.

The personalization factor to be used as criteria for the selection of the members is the learner's understanding levels. This factor was selected because we designed SPEBC to contain 4 models in order to do the adaptation process, these are: student, knowledge, team and group models. Data to compute the history of each learner will be retrieved from the student model and data to compute the history of each question will be retrieved from the knowledge content model (Aguilar, et al., 2007). The team model will contain the information required to compute the adaptation process for homogeneous and heterogeneous teams. And the group model will contain data to do the adaptation process for heterogeneous groups. In such a way that SPEBC will be able to process three levels of adaptations. The first one, based on each learner, the second one, based on one or more teams. And the third one, based on the group. Some other factors such as: background knowledge, special interests, intelligence types, learning styles, etcetera can be used as personalization factors. However, when more than two personalization factors are used, a combinatorial problem appears.

Learners with similar understanding levels will be saved on the team model and these data will be processed for the selection of the members of a given team. Based on teacher's request, SPEBC will determine automatically, the number of teams and the number of members of a given team, based on the computed number of students with similar characteristics. The sequence of the integration of homogeneous teams will be done as follows: First, learners have to interact with SPEBC in order to update their data in the student and knowledge model. Teams will be constructed based on data saved on these models. Then, the team learning process will be done. Questions will be introduced to the teams in the same way as the next question is introduced to each learner (Aguilar, et al., 2007b). This is because the members of a given team are grouped based on their similar characteristics, so SPEBC adapts and chooses the next best question for teams in the same way as for each student.

Adaptive Approach

This section introduces the personal adaptation required for the team integration. And further adaptations to be done in the team model. Also we identify the problems inherent to team construction and team adaptation, and we propose an alternative to solve those problems.

Personal Adaptation

This section introduces the interactions between student (See Table 1) and knowledge model (See Table 2) required for team adaptation. The student and knowledge models will be updated after learners answer a given question. The team model will access those models to do the team adaptation. And there is no further dynamic adaptations for the team model, because, this model is temporal, that is to say, the team model will be created in a specific time to do a specific activity. When this activity is finished, another team model is generated and requires another access to the updated data saved on the student and knowledge models.

The student model (See Table 1) consists of a set of learners' records which has the following elements: The learner's ID, which will be used as a key of this model, the type of representation (Figure, formula or writing), the type of answer (Right or wrong), the understanding level (1-easy, 2-intermediate, 3-difficult) which means the learner's understanding level about each representation type and the learner's answer time. More factors are included in the given models however, the factors included in Table 1, 2 and 4 are only those factors required for the processing of the team personalization.

Initially, SPEBC will assign to every learner an initial value of 1 for each understanding level. And the student and knowledge models will be initialized with these data. Further dynamic adaptations will be done in order to reach the adequate understanding level for each learner. After SPEBC has been used by a group of learners, the understanding level will be updated dynamically as follows: SPEBC will access the grade of difficulty for each

question saved on the knowledge content model. And based on this value, SPEBC will compare the grade of difficulty with each understanding level. And using the answer time (less or greater than) and depending if the answer was right, SPEBC will assign new values for the learners' understanding levels. We are considering that the learner's understanding level depends on the grade of difficulty of a given question and his or her understanding level of a given external representation type. For this reason, we compare the learner's understanding level with the grade of difficulty of a given question, taking in account the learners' answer time.

Question ID	Type of Representation	Type of Answer	Understanding Level	**Answer time**
	Learner ID: 1005516			
167	Figure	Right	3	5 min
168	Writing	Right	2	3 min
169	Formula	Right	2	3 min
170	Figure	Right	3	5 min
	Learner ID: 1013456			
167	Figure	Right	3	3 min
168	Writing	Right	3	5 min
169	Formula	Wrong	3	4 min
170	Figure	Right	2	2 min
	Learner ID: 1015689			
167	Figure	Right	1	2 min
168	Writing	Right	2	2 min
169	Formula	Right	1	2 min
170	Figure	Wrong	3	4 min
	Learner ID: 1017889			
167	Figure	Wrong	3	4 min
168	Writing	Right	2	3 min
169	Formula	Right	1	2 min
170	Figure	Right	2	2 min

Table 1: An example of an instance of the student model (Adapted from Aguilar et. al, 2007)

For example, consider the following learners: 1005516 and 1015689 and the question 167. Learner 1005516 has an understanding level of 3 and an answer time of 5 min. for the question 167. And learner 1015689 has an understanding level of 1 and an answer time of 2 min. for the same question. SPEBC will compare the grade of difficulty of the question 167 which has a value of 2.5 (See Table 2) and the average answer time for that question which has the value 3.5 min (See Table 2) with their understanding level and their answer time. In the case of the learner 1005516, his or her understanding level and his or her answer time are greater than the question's grade of difficulty and the average of answer times. Therefore, no update will be done in this student. On other hand, the learner 1013456 has a lower understanding level than the average understanding level. An answer time less than the question's average of answer times and his or her answer was right. Therefore, his or her understanding level will be updated with the value 2 and no update will be done in his or her answer time. SPEBC will use this new value to search the next question with a grade of difficulty of ± 0.5 than the updated understanding level.

The knowledge content model (See Table 2) consists of a set of questions' records which has the following elements: The question ID, which is going to be used as key of this table, type of representation, grade of difficulty and the average of answer times. The grade of difficulty is calculated processing the average of understanding levels saved on the student model (See Table 1) for each question and grouped by each representation type.

Question ID	**Type of Representation**	**Grade of Difficulty**	Average of Answer times
167	Figure	2.5	3.5 min
168	Writing	2.25	3.25 min
169	Formula	1.75	2.75 min
170	Figure	2.5	3.25 min

Table 2: An example of an instance of the knowledge content model

Team Adaptation

This section introduces the proposal for team adaptation. The homogeneous team integration requires that students with similar characteristics are grouped in the same team. For this reason, and based on the design of SPEBC, we concluded that the learners' understanding levels can be a good factor to group learners with similar characteristics. The use of this factor in team adaptation introduces the following challenges: The learners' understanding level depends on the grade of difficulty of a given question and their understanding level of a given external representation type. The grade of difficulty and the type of representation for each question is saved on the knowledge model. Moreover, the learners' understanding levels grouped by type of representation and question ID are saved on the student model. So it is necessary to determine an approach in order to establish a relation between these models and the team model. In order to solve this problem we propose the team adaptation approach given below. Previous to the creation of the team model, we need to do a pre-processing of the student model as shown in Table 3.

Representation Type	*Type of Answer*	*Understanding level average*	*Average Answer Time*
Learner ID: 1005516			
Figure	Right	3	5 min
Writing	Right	2	3 min
Formula	Right	2	3 min
Learner ID: 1013456			
Figure	Right	2	2.5 min
Writing	Right	3	5 min
Learner ID: 1015689			
Figure	Right	1	2 min
Writing	Right	2	2 min
Formula	Right	1	2 min
Learner ID: 1017889			
Figure	Right	2	2 min
Writing	Right	2	3 min
Formula	Right	1	2 min

Table 3: Temporal data to be used for the team model

Table 3 consists of a set of learners' records which has the following elements: The learners' ID, which is going to be used as key of this table, representation type, type of answer (Right), the average of understanding levels and the average of answer times. SPEBC will save on Table 3 the learners who answered right a given question for each type of representation. The average of understanding levels and the average of answer times will be calculated by processing the average of understanding levels and average of answer times of each learner for each representation type (See Table 3).

The team model (See Table 4) consists of a set of teams' records which has the following elements: The team number, which is going to be used as key of this model, and the members of a team. The members of a team will be grouped by type of representation. Also the average of understanding levels and the average of answer times will be saved on the team model. SPEBC will process Table 3 to choose the members of the teams. The selection process will be as follows: If the understanding level of each learner is equal, the selection is straightforward. And learners who have an understanding level ± 0.5 will be chosen as members of the same team. For example, in Table 3, there are two learners: 1005516 and 1013456.

These learners are grouped by type of representation: figure, formula and writing. Given the above criteria, the learners 1005516 and 1013456 will integrate the same team (See Table 4). And the learners 1015689 and 1017889 will integrate the second team. The average of understanding levels and the average of answer times will be calculated by processing the averages of the members who integrate a team. And the questions to be introduced to those learners will be given using the grouped external representations (See Table 4). SPEBC will use the average of understanding levels and the average of answer times to choose the next question to be introduced to the teams.

We think that the proposed team adaptation will be effective because students with similar understanding levels will be grouped in the same team. However, sometimes in small teams may not be learners with similar

characteristics. In order to adapt questions and answers to heterogeneous teams and groups, further research is required. Finally, using the proposed adaptation approach, SPEBC will be able to group learners with similar characteristics based on their understanding levels, in a given team.

Learners ID	Type of Representations	Average of understanding levels for each representation	**Average Answer time**
Team Number: 1			
1005516	Figure	2.5	3.75 min
1013456	Figure	2.5	3.75 min
1005516	Writing	2.5	4 min
1013456	Writing	2.5	4 min
Team Number: 2			
1015689	Figure	1.5	2 min
1017889	Figure	1.5	2 min
1015689	Writing	2	2.5 min
1017889	Writing	2	2.5 min
1015689	Formula	1	2 min
1017889	Formula	1	2 min

Table 4: An example of an instance of the team model

Conclusions and Further Research

We will include an automatic integration of homogeneous and heterogeneous teams in SPEBC. This implies the implementation of three levels of adaptation: individual, team (homogeneous and heterogeneous) and group (heterogeneous). Previous works about adaptive assessment systems are focused on each learner's personalization. However, we go a step further adapting questions and answers to a homogeneous team's characteristics, providing a new level of personalization. The inclusion of this approach opens the possibility of the use of a Classroom Communication System (CSS) (Sharma, M.D., et al., 2005) in collaborative learning, under a personalized environment. Further research is required to determine the impact of the team adaptation in the social interrelations among the students. The team personalization will allow teachers to promote the discussion of the students' ideas in order to improve the learners' compression of a given topic.

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