Collaboration Support by Groups Creation in Educational Domain

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Abstract

We propose a method to solve a problem of how to assign students into dynamic short-term study groups with aim to enhance effective collaboration. The method is able to apply many types of students' characteristics as inputs, e.g. interests, knowledge, but also their collaborative characteristics. The design of the proposed method is inspired by the Group Technology approach. Students in created groups are able to communicate and collaborate with several collaborative tools in a collaborative environment which allows us to automatically observe dynamic aspects of the created groups, especially how students collaborate to achieve their goals. The results of this observation provide a feedback to the proposed method.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education—*Collaborative learning*; H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces—*Asynchronous interaction*

Keywords

Groups, Collaboration, Group Technology, Learning

1. Introduction and Related work

Nowadays, we can witness a new trend of collaboration in small groups. Team work is spreading also due to fast development of modern information and communication technologies. On the other hand, this trend causes that users with different social context meet during their mutual collaboration. Users have different characteristics, pursue different goals and engage in different activities to achieve these goals. Therefore, it is important to actively support their collaboration during all phases of a lifecycle of the groups they are assigned to. This task is especially important during a group's creation process which can significantly influence following collaboration.

The problem of group formation is present in many areas where we can influence users' assignment to groups. One of them is domain of Computer-Supported Collaborative Learning (CSCL) where group composition plays important role during collaborative learning. In addition, collaborative software is not applied in this domain as intensively as in other Web 2.0 areas (i.e. social networks or online communities).

Therefore, we propose a method for creating dynamic study groups with aim to support effective collaboration. Additionally, we pay appropriate attention to the design and realization of collaborative environment too.

Recently, several methods and techniques have been applied to group formation, e.g. particle swarm optimization, ontologies, genetic algorithms or agent based methods. These methods usually use only one source of information about students and do not consider actual context, i.e. characteristics of the collaboration. Also they assume that a teacher knows which attributes make collaboration more effective. However, this still poses an open problem.

We have proposed a classification of different approaches to group formation process (see Figure 1) which is based on study of various methods applied to group formation problem. Next, we have defined the requirements for the proposed method which should be fulfilled to solve the identified problems. The proposed method should create the groups automatically and without participation of students. The reason of this decision is that students tend to follow existing social relationships and thus they prohibit the spreading of knowledge in new groups [3]. Our goal is to create short-term dynamic groups so the proposed method should be applied repeatedly. And finally, the method should have a combination of characteristics of different types of methods for creating groups. It should be focused on numerical representation of data as numerical methods are and consider feedback from achieved results during collaboration as

*Master degree study programme in field Software Engineering. Supervisor: Professor Mária Bieliková, Institute of Informatics and Software Engineering, Faculty of Informatics and Information Technologies, STU in Bratislava. Work described in this paper was presented at the 8th Student Research Conference in Informatics and Information Technologies IIT.SRC 2012.

Srba, I. Collaboration Support by Groups Creation in Educational Domain. Information Sciences and Technologies Bulletin of the ACM Slovakia, Special Section on Student Research in Informatics and Information Technologies, Vol. 4, No. 2 (2012) 62-64

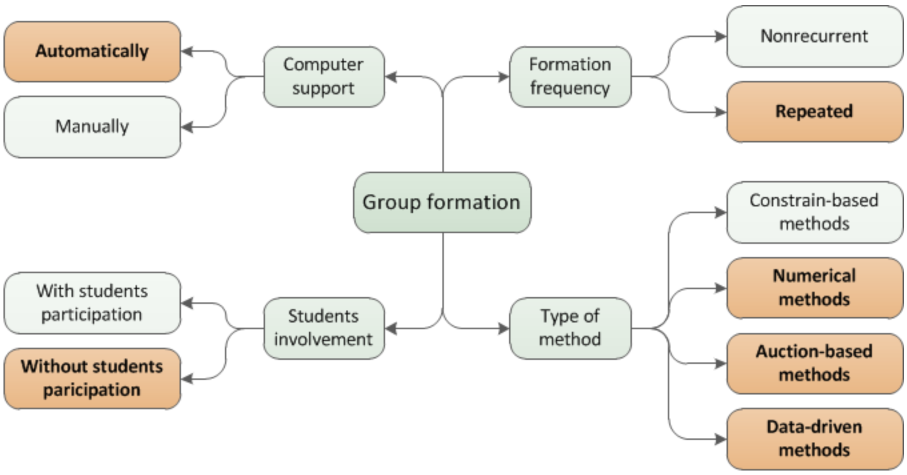

Figure 1: The proposed classification of different approaches to group formation process.

auction-based methods do [6]. In addition, it should not be limited to use only one source of information. Actually, it should be able to use many possible sources of students' information what is typical for data-drive methods.

We drew our inspiration from the Group Technology approach to propose a method that will satisfy all the defined requirements. According to Selim, et al. Group Technology (GT) is an approach to manufacturing and engineering management that helps manage diversity by capitalizing on underlying similarities in products and activities. One application of the GT approach in manufacturing is the so-called Cellular Manufacturing, which is concerned with the design of optimal distribution of machines which cooperate on the production of a set of part families [5]. It is necessary to identify families of similar parts and machines to solve this problem. This process is called cell formation. In other words, groups of machines should be located in close proximity in order to produce a particular family of similar parts and thus minimize production and transfer time [2].

We identified three works employing GT approach in CSCL domain [4, 2, 1]. In contrast to the existing methods for group formation the proposed method considers its iterative application. This approach allows us to take into consideration already achieved students' results and adjust input parameters to encourage better collaboration between students.

2. Method for creating dynamic groups

The context of the method consists of two main processes. *Group Formation* takes different personal or collaborative characteristics as inputs and creates study groups. Personal characteristics can be a student's knowledge, interests, or any other personal characteristics (e.g. age, gender). We can obtain these characteristics from many sources, such as existing user models, social networks or questionnaires. Furthermore, characteristics can be collaborative, such as friendships with other students or a student's collaborative behavior. Characteristic activities performed during collaborative task solving can be obtained automatically by analyzing students' collaborative behavior. *Collaboration* allows students of created groups to participate on task solving via prepared collaborative tools integrated into the common collaborative platform.

Input data to our method are composed of two matrices: a matrix of related characteristics and a matrix of assignments of characteristics to students. We consider two characteristics related if their combination leads to a positive influence on collaboration. These input matrices are used in calculation of clusters of learners and characteristics which is performed in several steps:

1. First of all, three comparison values are defined for each combination of learner and characteristic.
2. Similarity (SC) and relevance coefficient (RC) are defined with these three values.
3. Next, Group Compatibility Matrix (GCM) is created by comparison of calculated similarity and relevance coefficient with their minimal thresholds. Algorithm starts with thresholds set to ones and continuously decreases them until a valid GCM matrix is found. A GCM matrix is valid as soon as each student has at least one assigned characteristic.
4. Finally, it is necessary to perform clustering on a GCM matrix with any array-based clustering algorithm. For our purpose Modified Rank Order Clustering (MODROC) was used.

Output data from our method is a GCM matrix in which the clusters of the students and the characteristics are concentrated along the main diagonal (see Figure 2). Assignment of a student to a cluster of characteristics means that this student has these characteristics or these characteristics should combine with characteristics which are typical for this student. Particular study groups can be created with any combination of students from the same cluster.

We apply our method iteratively which allows us to use several matrices of related characteristics. Each matrix can represent different requirements how to combine characteristics together, i.e. a matrix of complementary characteristics or a dynamic matrix based on achieved results. The dynamic matrix of related characteristics can solve the main problem which is that there is no information about attributes (in our proposal characteristics' combinations) which make collaboration effective and success-

Activity	Student 1	Student 2	Student 3	Student 4	Student 5
Warn of mistake	1	1	0	0	0
Accept warn of mistake	1	1	0	0	0
Write comment	1	0	0	0	0
Write general message	0	0	1	0	0
Ask for explanation	0	0	0	1	1
Give explanation	0	0	0	1	1
Propose action	0	0	0	1	1
Accept action	0	0	0	1	1
Write praise	0	0	0	1	0

Figure 2: An example of clustered GCM matrix acquired in the first phase of evaluation.

ful. After each group finishes task solving, its collaboration and achieved result is evaluated. Afterwards each combination between characteristics which are typical for members of this group will be strengthened according to the achieved evaluation. Equally the dynamic matrix of assignment of characteristics to students can be updated according to the number of performed activities which contribute to these characteristics.

3. Evaluation and Conclusion

Evaluation of our method for group formation cannot be accomplished without a collaborative environment where it can be applied. Therefore we have designed and realized the collaboration platform called PopCorm (Popular Collaborative Platform) which we have integrated with the educational system ALEF [7]. PopCorm consists of four collaborative tools which are suitable for task solving in CSCL: a text editor, a graphical editor, a categorizer, and a semi-structured discussion. The categorizer is a special tool developed for solving different types of tasks the solution of which consists of one or more lists (categories). The semi-structured discussion provides 18 different types of messages (e.g. propose better solution). These different message types allow us to automatically identify student's activities. Recorded activities are used to measure the collaboration by set of seven metrics designed according to studies in psychology which includes the following attributes: argumentation and reaching consensus, task and time management, shared task alignment. In addition, pedagogue can manually add the eighth metric representing the quality of created answer.

We have performed evaluation of our method and the collaboration platform in two phases. Firstly, we carried out a short-term controlled experiment in February 2012. The purpose of this experiment was to evaluate preconditions of the proposed method; namely, the precondition whether activities form natural clusters (behavioral patterns) which influence collaboration in the positive or on the contrary in the negative way. The precondition was confirmed and our method was able to identify three clusters of students and activities at the end of the experiment (see Figure 2).

The second phase consisted of a long-term experiment which we carried out during summer term as a part of education on the course Principles of Software Engineering at the Slovak University of Technology in Bratislava. Students learned new topics and shared information during lectures or during their individual study by means of the adaptive web-based educational system ALEF with integrated PopCorm platform for solving assignments collaboratively.

Table 1: Comparison of achieved results during the second phase of the experiment

Groups created	Avg. evaluation	Feedback
By the proposed method	0.459	4.01
By the reference method	0.392	3.55
Randomly	0.422	3.29

We have comapared the 8-dimensional evaluation of the groups created using our method with a reference method (k-means clustering) and randomly created groups (see Table 1). Groups created by our method achieved the most effective and successful collaboration in comparison with the other two types of groups. We have employed ANOVA statistical model to evaluate significance of achieved results. With the computed p-value 0.0048, the achieved results can be considered as highly significant. Additionally, students have provided a higher explicit feedback in these groups.

Our method based on the Group Technology approach is not limited only to CSCL domain but it can be easily applied in any other domain where dynamic groups should be created according to different user characteristics. We have successfully applied the proposed method during the experiment in collaborative learning by creating dynamic short-term study groups. Big amount of valuable data was acquired and its further analyses seem interesting for group creation research but also for psychological studies of collaborative learning. It would not be possible to acquire these results without the collaborative platform PopCorm which provides students the appropriate environment for effective task solving and automatic identification of their activities.

Acknowledgements. This work was partially supported by the Scientific Grant Agency of Slovak Republic, grant No. VG1/0675/11.

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