Shih, J. L. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education.
Taiwan: Asia-Pacific Society for Computers in Education

Supporting Teachers in Group Work Formation and Analytics for In-class Group Activities

Liang Changhao[a*], Ivica Botički[b] & Hiroaki Ogata[a]
[a] *Kyoto University, Japan*
[b] *Faculty of Electrical Engineering and Computing, Zagreb, Croatia*
*liang.changhao.84c@st.kyoto-u.ac.jp

Abstract: This paper introduces a system for collaborative learning which is designed to assist teachers in forming and grading groups for in-class group activities. The system is implemented as an extension of a learning analytics dashboard system and uses log data from a learning management system for operation. It consists of a group formation parameter console and the results console where formed groups are visualized and can be graded. The system supports teachers by using algorithms based on reliable learning evidence thereby simplifying the group formation process. All the group formation and grading data is logged thereby cyclically providing an infrastructure for subsequent collaborative learning activities.

Keywords: Collaborative Learning, Group Formation, Learning Analytics, CSCL

1. Introduction

In collaborative learning students work in groups on a task towards a goal (Dillenbourg, 1999). Collaboration is not only important for learning about content, but also for acquiring negotiation skills, learning to provide good arguments to support own ideas and nurturing social sense of belonging to the team (Stahl, Koschmann, & Suthers, 2006). With the advancement of ICT, new tools that include constructivist and collaborative learning are starting to emerge (Paredes & Martin, 2004). In this paper we examine the notion of collaborative learning based on the data in LMS platforms and existing learning analytics services.

According to Vygotsky's Zone of Proximal Development (ZPD), collaboration leverages peer and group resources so that individuals develop their potential and extend their knowledge (Vygotsky, 1978). To achieve this, imbalance between group members and their resources is sometimes designed for in group activities. On other occasions, friendship amongst students can be considered, making the groups homogeneous. For successful in-class collaborative learning, teachers need to envision the lesson, enable collaboration, encourage students, ensure learning, and evaluate achievements (Urhahne, Schanze, Bell, Mansfield, & Holmes, 2010). Amongst these tasks, group formation is the fundamental component since it determines quality of group work (Wessner & Pfister, 2001). When undertaken by the teachers, the task of forming heterogeneous or homogeneous groups is by any means no trivial and teachers might often feel confused since they do not always have an immediate access to the background information and data about the students.

The system presented in this paper builds on an existing learning analytics platform and provides features to support teachers in group work formation and analytics. It also contributes to the learning analytics platform by supplying group work performance data to other learning analytics-based services. By using its visualization support teachers can compare students' performance in group work and make more informed group formation decisions in their subsequent learning designs.

2. Theoretical Background

Since the 1960s, there has been considerable effort invested in research of cooperative learning and small group dynamics (Gillies & Ashman, 2003). Cooperative learning is done by individuals, who then contribute with their individual results to the group and present the collection of individual results as

their group product (Dillenbourg, 1999). In collaborative learning the interaction among group members is stressed and learning occurs socially as collaborative construction of knowledge (Roschelle & Teasley, 1995). Computer-supported collaborative learning (CSCL) is an emerging branch of learning sciences concerned with studying how people learn together with the help of computers (Stahl et al., 2006). In CSCL, teachers are often overwhelmed with the amount of work when setting up and implementing collaborative learning activities. To make in-class group work successful, teachers should direct their energy on orchestrating classroom activities, rather than spending time on technical things like group work set-up and technology adjustments (Austin, Smyth, Rickard, Quirk-Bolt, & Metcalfe, 2010).

Today's online learning platforms provide massive log data that can be used for learning analytics possibly leading to improved learning designs and outcomes (Siemens, 2013). There exists an abundance of research evidence on how these logs can be used to improve e-book contents and the quality of learning and education (Arnold et al., 2012; Fujimura K; Ogata, H; Okubo, F; Shimada, A; Yamada, M; Yin, C;, 2014; Lu, Huang, Huang, & Yang, 2017). Our study is contextualized around a learning analytics platform connected to a Moodle-based learning management system (LMS) designed in Japan (Flanagan & Ogata, 2018), which is being used at several international locations.

In this paper we examine a variety group formation algorithms (Hoic-Bozic, Mornar, & Boticki, 2008). These algorithms are used in conjunction with user modelling (Boticki, Akçapınar, & Ogata, 2019), where the most common way is to rank students according to the data in the user model variables (one example for such a variable are Moodle quiz scores) and organize them into groups.

3. A Model for Group Formation and Scoring in a Learning Analytics Platform

The group formation module introduced in this paper is an extension of a learning analytics system and its dashboard application which is a central component for visualizing learning evidence (Ogata, Majumdar, Akçapinar, Hasnine, & Flanagan, 2018). As illustrated in Figure 1, learning log data is collected from educational applications such as the BookRoll system (Flanagan & Ogata, 2018), organized into student model variables which characterize students' features (Brusilovsky et al., 2016) and stored into the analysis database. The group formation module makes use of the user model data and grouping algorithms to generate groups. Once groups are formed and their performance is graded, these data are used to update the student model for further learning analytics use.

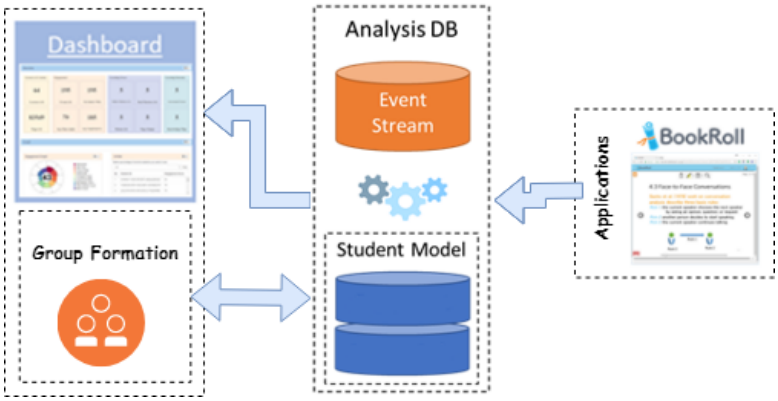

Figure 1. The main learning analytics components including the group formation module.

Figure 2 shows the workflow of group work activities. In the beginning, teachers need to decide which course and students are to be used as part of collaborative work. Following that, the teachers decide on the group formation parameters that best suit the concrete learning activity. During and after group work, teachers grade the performance of group work and give feedback to the students. Using performances obtained from the previous application cyclically, teachers get more informed for the next group formation processes. The group score user model gets more reliable as group activities and grading get frequent.

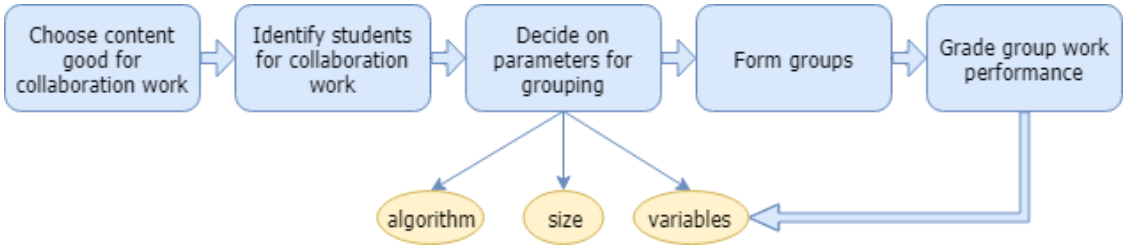

Figure 2. The process of group formation.

The process described in Figure 2 are supported by the group formation module which gets input containing course and student data from the Moodle LMS platform. Teachers can modify the data by excluding inactive students from group formation and use the parameters feature to decide on an adequate algorithm and user model variable (Table 1 and Table 2). Alternatively, the teacher can select automatic grouping and leave the parameter selection to the system (default settings being heterogeneous algorithm, the group score user model variable, and the group size of four). Teachers can view the formed groups and evaluate their group performance in three indicators (Table 3), which are then recorded as group score user model variables.

Table 1

Algorithms used in the group formation process

Algorithm	Algorithm Operation Description
Homogenous	The algorithm groups students with similar values of a variable.
Heterogenous	The algorithm groups students with differing values of variables.
Friendship	The algorithm groups students who are friends as identified by the teacher.
Random	The algorithm groups students randomly.

Table 2

Variables used in the group formation process

Variable	Variable Explanation
Engagement	The variable records the time student spent on using the learning platform.
Reading style	The variable models two reading styles: receptive reading and responsive reading (Pugh, 1979). The former refers to the style of reading page after page sequentially and the latter deals with students engaging in more interaction with the digital material (taking notes and posting comments).
Concept	The variable describes the mastery of each key concept found in academic materials of a course.
Score	The variable records previous assessment scores.
Group score	The variable models students' previous performance of in group, gathered as part of group grading.

Table 3

Metrics of group performance evaluation

Indicator	Metrics for evaluation
Collaboration quality	Interaction and communication occurring during group work, participation of members and rational division of labor
Speed / efficiency	Whether each subtask is finished on time and reasonable time management
Final output	The quality of final outputs and artefacts of group work

4. Teachers' Use of the Group Formation Module

This section will demonstrate two examples of group formation: the heterogeneous group formation based on course grades and group formation using the Friendship algorithm. In a group lesson, teachers may want students with different course grades to work together and learn from each other. In that case, teachers can select heterogeneous algorithm and choose score as the user model group formation variable via the parameters feature shown in Figure 3.

In some learning activity designs teachers may want to group students with good mutual relationships together. After setting mutual relationships between the students and getting an overview of the whole class (Figure 4), the teachers use the Friendship algorithm to form the groups of friends.

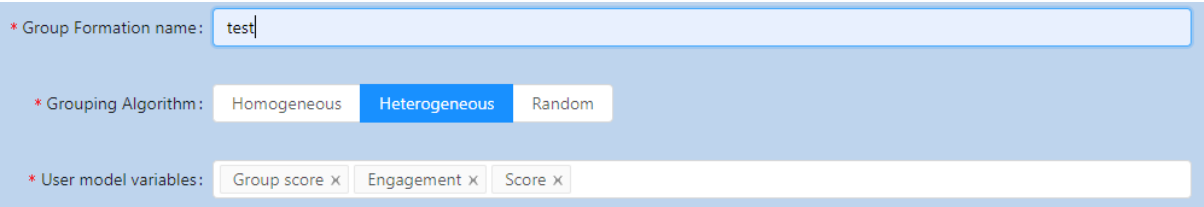

Figure 3. Parameter feature of the group formation module.

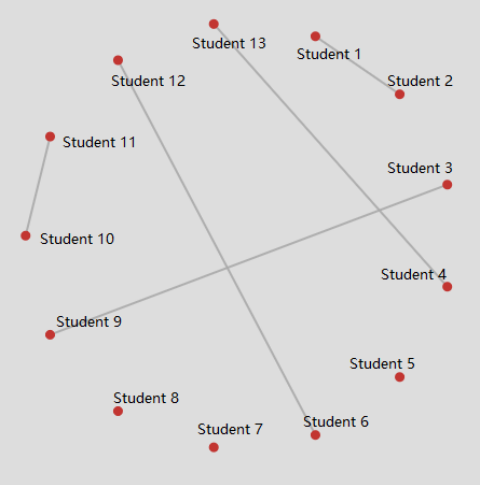

Figure 4. Student relationship graph used by the Friendship group formation algorithm.

Figures 5 and 6 depict the results of the heterogenous and Friendship grouping algorithms operation, respectively. Traffic-light colors are used to give indication of previous group work performance to the teachers who guide the group formation process (green, yellow and red color denote good, average and low previous group work performance, respectively). Group performance indication is shown both at the group level and at an individual student level. Teachers score the group performance for each indicator and the scores in all three indicators are stored as part of the group user model giving an overall estimation of students' collaboration performance.

Figure 5. Groups formed (3 groups of 4 students) using the heterogeneous grouping algorithm and the color indication of individual and group collaboration performance.

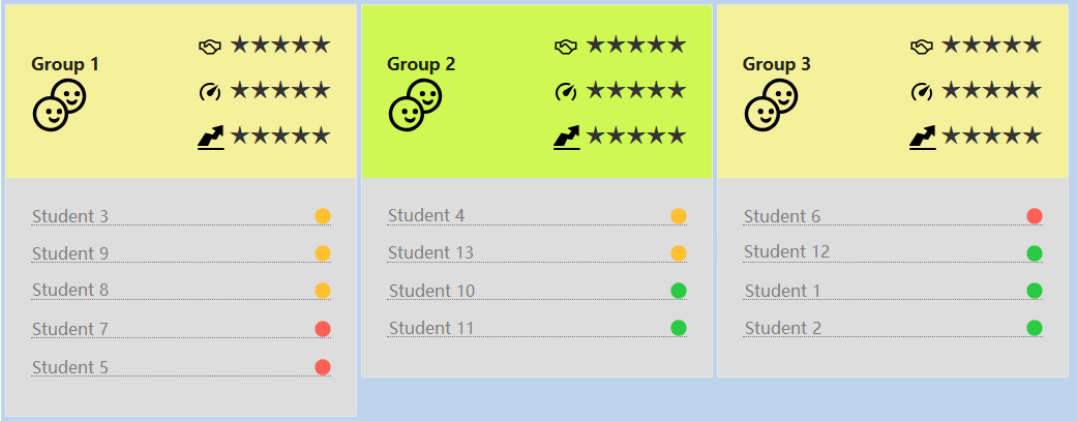

Figure 6. Groups formed (one group of 5 and two groups of 4 students) using the Friendship algorithm and color indication of the individual and group collaboration performance.

5. Conclusions and Future Work

Teachers might get overwhelmed when using CSCL in their teaching activities and need support to be able to execute and manage such activities in a timely and informed manner. The group formation system provides group formation assistance with visuals to the teachers and enriches group work experience with the help of the learning analytics platform. In the system presented in this paper, teachers have an option of choosing an automatic group formation feature which favors imbalance between members of a single group. This is grounded in the research in the area of the Zone of Proximal Development (ZPD) and potentially promotes construction of knowledge and an elevated level of mutual understanding of a topic (Nyikos, 1997).

In terms of group performance, the system allows real time rating of groups by the teachers in the three main indicators. The performance rating component is available directly on the group results panel, for the teachers to take an immediate record of group performance and adjust the grade in real time. Such a feature facilitates the adequate timing of teachers' interventions, which proved to be of importance for in-class collaborative learning (Coll, Rochera, & De Gispert, 2014). Meanwhile, not only summative but also formative indicators such as collaboration quality are stressed in the system (Strijbos, 2011).

The group work module presented in this paper was developed as an extension of an existing learning analytics platform and allows teachers to conduct group formation based on the existing user data (user models) in their in-class activities. Future work will examine the ways of using the system in in-class group activities with a focus on evaluating group performance in realistic collaborative environments with social loafing and free-riding, as the most challenging problems in today's collaborative learning. In parallel, empirical research is necessary to verify whether and to what extent group formation algorithms help teachers with groupwork and in fulfilling the collaboration goals of a lesson. This will lead, as part of the planned future work, to automatized suggestions of group formation algorithms to the teacher, depending on the identified group formation purpose.

Acknowledgements

This research was supported by JSPS KAKENHI Grant-in-Aid for Scientific Research (S) Grant Number 16H06304 and NEDO Special Innovation Program on AI and Big Data 18102059-0.

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