Evaluating Learning Style-based Grouping Strategies in Real-world Collaborative Learning Environment

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Abstract. Collaborative learning is defined as situations where multiple learners participate in solving common problems. Collaborative learning provides a way of building knowledge through activities of collaboration with others. Group work is a representative form of collaborative learning and has been used in higher education. In group work, however, one of the widely discussed issues is group composition. Students have different attributes including learning styles, background knowledges, gender, and so on. Typical group formations are homogeneous and heterogeneous compositions. Numerous work addressed the problem and evaluated how learning outcome varies between different group formations both in online and physical environments. In this study, we focus on the group formation for real-world collaboration. We introduce different types of grouping into a class of a theme-based course and discuss the effects of different learning styles in collaborative learning environment. Students are characterized according to Kolb's learning style inventory and then grouped by homogeneous, heterogeneous, and random strategies. We investigate how intra-group interactions varies with different types of composition; we monitor the activity levels of every group and have students peer-review each other for quantitative evaluation of contributions. We find typical patterns of activities and contributions, and discuss their association to grouping strategies.

Keywords: collaborative learning, group work, group formation, learning style

1 Introduction

There are many chances to learn something new and to work in collaboration anytime and anywhere through one's life. Outside school, there are variety of possible collaborators of different generations with different backgrounds. Especially in super-aging society, life-long learning is more important for us, and we are rquired to learn collaboratively in the growing diversity. Thus, it is crucial for us to take into account such various contexts of individuals for better learning experience and better outcome in collaborative learning.

Collaborative learning is a situation in which two or more people learn or attempt to learn something together [6], and group work is a representative form of collaborative learning widely used in higher education. Some researches have proved that there is a tendency that better learning is realized when students are actively involved in collaborative activities [9,15]. In terms of the class quality and the performance, students are more satisfied with the activities that fulfilled in the collaborative learning environment [4,6].

One of the widely discussed issues of group work is group composition. Webster and Sudweeks described that the roles and interactions of group members are very important for a group's productivity [20]. Johnson and Johnson have observed that there are a lot of factors which influence a successful collaborative learning, such as positive interdependence, meaningful interaction, individual accountability, collaborative skills training, and appropriate rewards [17]. Therefore, it is important to look for appropriate group formation approach considering group interactions to solve many problems of collaborative learning.

Learners have many attributes that could be considered for group composition, such as background knowledges, gender, psychological factors, and so on. Adán-Coello et al. reported that homogeneous group outperformed the other non-homogeneous grouping for students to collaboratively learn a programming language [2]. The reason is that students with the same learning style can avoid undesirable conflict and can easily achieve a consensus solution.

Learning style is one of the classification schemes of learning activities of learners from the cognitive and psychological viewpoints. It can have a beneficial impact on the process of collaborative learning. It has shown that psychological factors, especially learning styles generate different perspectives on effective strategies for building the dynamic group interactions. Thus learning styles can be a significant traits of individuals to take into account, but there are a limited number of researches to investigate the effect of learning styles in real-world collaborative learning environment.

In this study, we focus on the group formation for real-world collaboration. We introduce different types of grouping methods into a class of a theme-based course and discuss the effects of different learning styles in collaborative learning environment. We employ Kolb's learning style theory [11] to characterize students, and then group them by homogeneous, heterogeneous, and random grouping strategies. We investigate how intra-group interactions varies with different types of composition; we observe the change of group activeness during a class, and have students peer-review each other for quantitative evaluation of their contribution to group work. Finally, we extract and discuss on patterns of group activity levels and the distribution of contributions.

2 Related Work

Regarding the pattern of the group, different grouping methods also be discussed in the literature. According to De Bello [5], homogeneous groups (considering the abilities, interests and experiences of students) tend to be better when spe-

cific aims are need to be refined. In majority of research, heterogeneous grouping method performed better than other methods, but, at the same time, heterogeneous groups encounter the problem that a common agreement is difficult to reach due to its diversity. However, it is the merit of this type of groups. Both method have their own advantages and disadvantages.

A variety of contextual factors (like the type of the work itself) may shape the effects of diversity observed across studies [10]. There is a trend to apply diversity of learning inclination in group work. Research on group formation has begun to investigate the form of diversity that is based on psychological features of team members and includes individual differences involving personality traits and values, as well as attitudes, preferences, and beliefs [7].

In Computer Supported Collaborative Learning systems, group formation can be performed either by the teacher or automatically by the system. Many algorithms have been proposed for quick and automatic group formation that is well-balanced [18] or satisfies requirements [12,14,19]. However, they did not consider the group interaction and group performance as a result in a real world collaborative learning environment.

Learning styles were also considered in work [3,8,13] together with personality types as a tool for building computer supported grouping system. However, pedagogical fundamentals of collaborative learning have not been considered. Therefore, it is important to investigate how intra-group activities changes when learning styles are taken into account for group composition.

3 Method

3.1 Identification of Learning Styles

Firstly, we identify the learning style of every students. As shown in Fig. 1, Kolb's model [11] categorizes learners into four groups: divergers, assimilators, convergers, and accommodators. A diverger is a person who prefers to view concrete situations from many different viewpoints and to approach problems through observation rather than action. An assimilator is the person who has strengths in understanding a broad range of information and put it into concise and logical form. A converger is the person who is good at finding real usage of ideas and theories. They also has abilities of problem solving and decision making by solving questions or problems. An accommodator is the person who can learn from their own concrete experiences. They are likely to rely on people to accomplish tasks.

The Kolb Learning Style Inventory (KLSI) is a tool for extracting students' learning styles based on the underlying his experiential learning theory. The theory proposes an experiential learning cycle consists of four modes of Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). KLSI quantify a specific preference of a learner among the four modes of the learning cycle.

The Learning Style Inventory (LSI) is a self-reporting questionnaire forcing a learner to rank four words in each item. The original version of the Learning

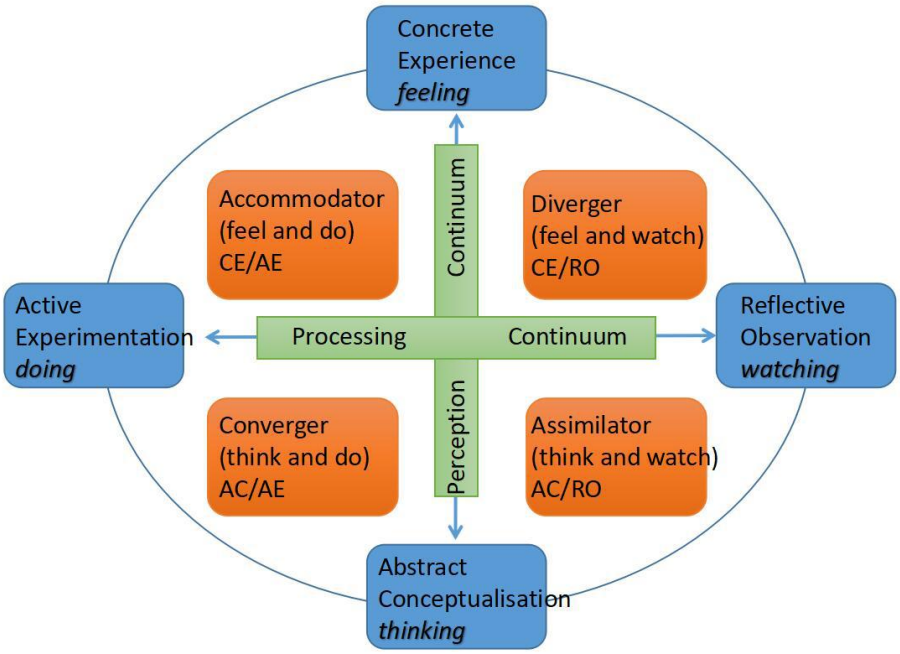


Fig. 1: Kolb's learning styles. Outer blue rectangles represent learning modes in the learning cycle. The horizontal and vertical axes are called processing continuum and perception continuum, respectively. Four learning styles are located in the quadrants.

Style Inventory consists of nine items as described in [16]. We use a version of LSI found in [1] in this research, which is composed of ten items. Table 1 shows the list of the items. In fact, we use a Japanese version of this questionnaire translated by one of the authors. Four words in each item correspond to four learning modes of CE, RO, AC, and AE, in this order.

Table 1: The version of Learning Style Inventory we used in thin research. There are ten items of questionnaire, and a respondent is required to rank four words in each item without ties. Four words in an item correspond to four learning modes of CE, RO, AC, and AE, in this order.

#	CE	RO	AC	AE
1	involved	tentative	discriminating	practical
2	receptive	impartial	analytical	relevant
3	feeling	watching	thinking	doing
4	accepting	aware	evaluating	risk-taker
5	intuitive	questioning	logical	productive
6	concrete	observing	abstract	active
7	present-oriented	reflecting	future oriented	practical
8	open to new experiences	perceptive	intelligent	competent
9	experience	observation	conceptualization	experimentation
10	intense	reserve	rational	responsible

A respondent is required to rank four words in each item without ties. Specifically, it is done by assigning scores to words; 4 to the word best characterizing his or her learning style, 3 to the next best, 2 to the next least characterizing word, 1 to the least.

From the result of a questionnaire, the summation of scores of the ten words are computed for each modes. Figure 2 shows an example of identification of one's learning style from the result of Learning Style Inventory questionnaire. In the picture, summation scores of four learning modes are represented as points on axes. They are connected by lines and form a triangle on each quadrant. We identify respondent's learning style by the quadrant on which the largest triangle is located. In this example, we consider the respondent is a "accomodator".

3.2 Group Formation based on Learning Styles

Figure 3 shows the overview of the three grouping methods. We make homogeneous groups (Grouping Method I), heterogeneous groups (Grouping Method II), and random groups (Grouping Method III) according to students' learning styles. All the students in a homogeneous group have the same learning styles. A heterogeneous group consists of students of all the four learning styles. The people assigned to neither homogeneous groups nor heterogeneous groups form random

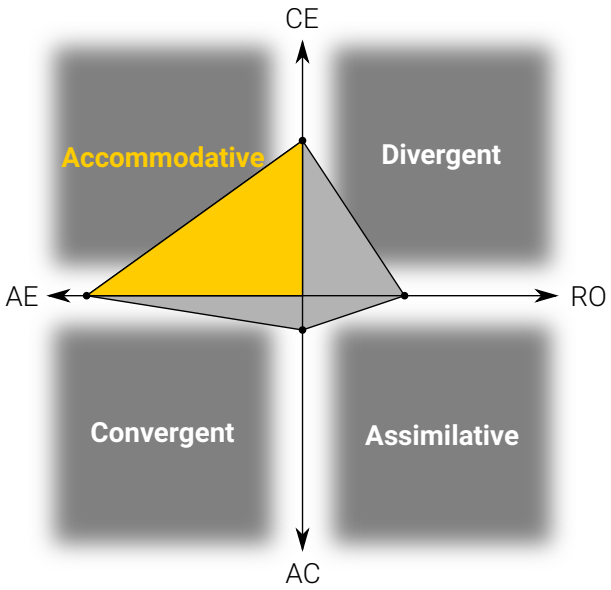


Fig. 2: An example of identification of one's learning style from the result of Learning Style Inventory questionnaire. In the picture, total scores of four learning modes are represented as points on axes, and they are connected by lines. The preference of respondent's learning style is identified by the quadrant which have the largest triangle enclosed with a line and axes. In this example, the largest triangle is located on the upper left quadrant, and the learning style is identified as "Accommodative".

groups. Such people also include students whose learning style is unknown because of some invalid answers of the questionnaire, i.e. forbidden ties, or the absence in a week when learning style questionnaire is conducted. Therefore, note that a random group may or may not be homogeneous or heterogeneous.

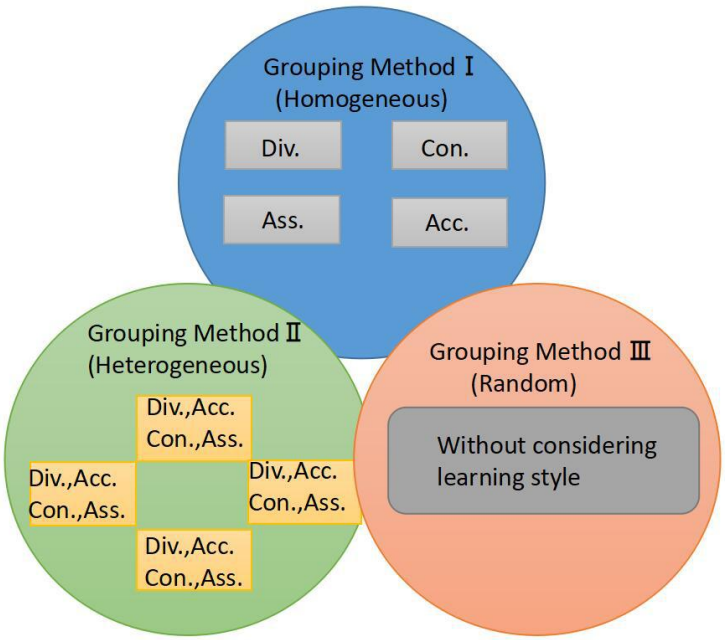


Fig. 3: Three grouping methods. A homogeneous group is composed of students of the same learning styles. A heterogeneous group consists of students of all the four learning styles. A random group is formed from the rest of students including people whose learning styles are not identified.

Though learning styles are the primary concern for arranging groups, we also take into account other three attributes of students. We consider genders, disciplines, and past groups including ones in other rounds. Every groups are made so that these attributes are well distributed. For example, we assigned at least one female students to every group.

3.3 Observation of Group Activeness

To investigate how group activities changes group by group, we monitor the level of their activity during group work. In this research, we subjectively evaluate each group every ten minutes using seven-level scale shown in Table 2.

Table 2: The scale of group activeness level. We employ seven-level scale of group activity. The level of activeness is assess subjectively according to the description shown below.

Level	Description of the degree of group activity
3	Not only one to one discussions are conducted, but one to many and many to many discussions appear frequently.
2	All group members participate in discussions.
1	One to one and one to many discussions occasionally appear.
0	Average. Discussions are being carried out among group members, but lack of involvement is observed.
-1	One to one discussion appears occasionally, but still some members are doing their personal stuff.
-2	Better than -3 but still lack of interaction.
-3	No discussion in a group, or most of the members are doing things not related to the class, e.g. sleeping, playing phone etc.

3.4 Measurement of Contribution

We have students do peer review after every group work. Students are required to evaluate group members, including him- or herself, from the view point of their contribution in group work. Every student has the same budget of 100 points, and he or she can give others any points from the points. As a result, one receives from 0 to 400 points (or 500 points in the case of 5 people group) from other members.

We records the total points that students acquired, and analyze the distribution of points within a group. From the distribution, we expect to find some patterns that suggest the relationships between students' activeness in a group and their learning styles.

4 Experiment

4.1 The Target Course

All freshman students in Kyushu University from different departments participate in the collaborative learning courses in the autumn semester 2017. In the courses, teacher-led collaborative learnings were conducted. We targeted one of the courses, in which one of the authors and two other teachers taught three sub-classes alternately and in parallel from their own perspectives.

In depth, 104 male students and 47 female students took the course, and we had the students split equally into three sub-classes, i.e. 50 or 51 students per resulting subclass. The course is composed of three rounds in a semester; in every round, students of a subclass were taught by different teachers. In this research, we consider only the teaching by one of authors.

The pedagogy in this collaborative learning course included lectures, student individual works, collaborative activities, and final presentation. Teachers

introduced the knowledge in their field that related to the theme (lecture). Students then apply the knowledge in their individual work or in the collaborative learning (collaborative activities). At the end of each round, each group give a presentation as a learning output. Specifically, the process of a single round is structured as shown in Fig. 4 and as follows.

1. Teachers introduce the class theme and the related knowledge for the whole round.
2. Students have to come up with one topic individually on the theme after teacher's instruction in the first week.
3. Based on the individual work, each group is required to decide one topic for the collaborative activities in the next three weeks through a group work.
4. In the second and third week, students mainly focus on collaborative activities.
5. In the fourth week, all the group are required to give a presentation as the final outcome for their collaborative learning.
6. In the second, third and fourth week, peer reviews are conducted for evaluating each group member's performance and contribution within the group.

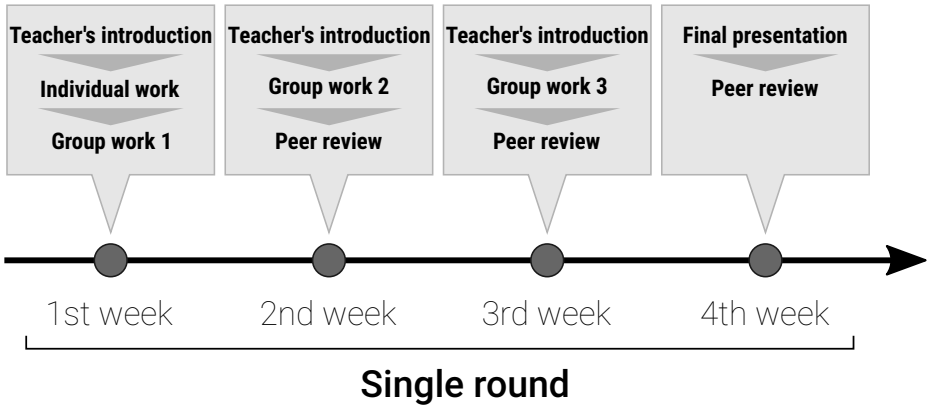


Fig. 4: The process of a single round of the course. A single round is composed of four weeks.

4.2 Distribution of Learning Styles

Among all the 151 participants of the three rounds of the course, no data is available for 6 students who were absent when learning style questionnaire was conducted. Furthermore, we found answers from 41 students were invalid because of not permitted ties. As a result, we successfully identified the learning styles of 104 individuals (about 69%) while the rest of them remained unknown. Figure 5

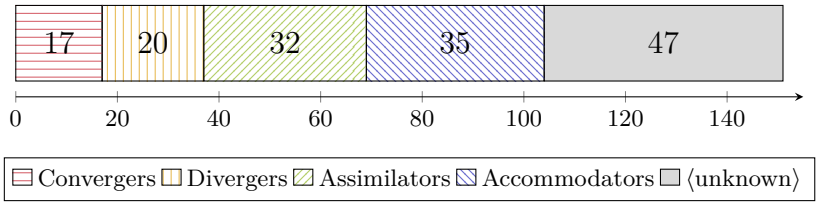


Fig. 5: The distribution of learning styles. Among the all 151 participants, learning styles of 104 students were successfully identified.

shows the resultant distribution of learning styles. The largest type is a group of accomodators, followed by that of assimilators.

We then grouped students considering the learning styles There are 50 or 51 students in a subclass, and we make four homogeneous groups and four heterogeneous groups first. These groups consist of exactly four students. We then make four random groups. In random groups, there are four or five students.

4.3 Group Activeness

Group activities were monitored by one of the authors in the third week of second and third rounds. Figure 6 shows an example of the time series of the activeness of a homogeneous group. Students in this group started their activity sharply, and they were talking heatedly during the class.

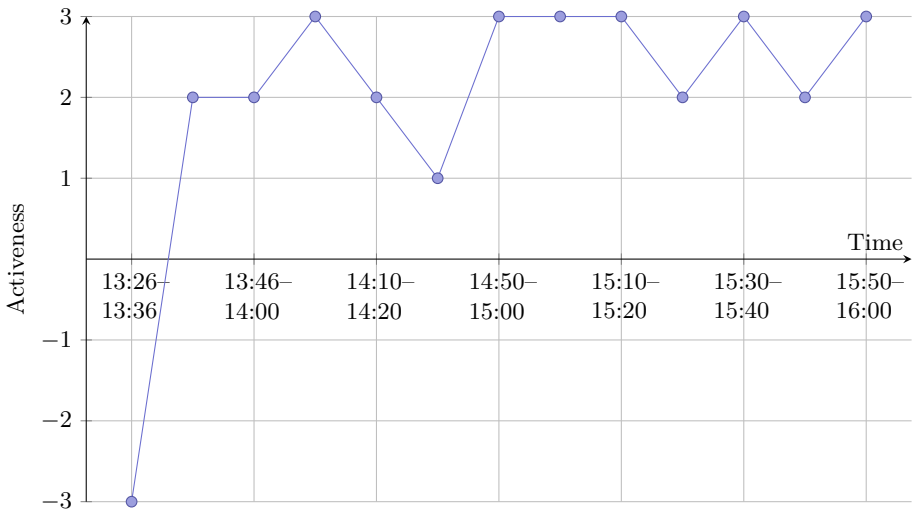


Fig. 6: An example plot of activeness level change of a group. This type of activeness change is categorized as *Sharply-increased* according to Table 3.

The author also extracted subjectively based patterns from the observations. Table 3 shows the eight patterns of group activeness found in the course. For instance, the group of the previous example belongs to the *Sharply-increased* pattern.

Table 3: Observed patterns of group activeness change. Eight types are found among plots like Fig. 6.

#	Pattern Name	Description
1	Waving-low	Discussions appear occasionally, process then stop in a low degree.
2	Waving-high	Discussions appear occasionally, process then stop in a high degree.
3	Low-tension	Discussions hard to appear, members' motivation in low tension.
4	High-tension	Discussions easy to appear, members' motivation in low tension.
5	Sharply-decreased	High activeness in group sharply turn into low activeness.
6	Sharply-increased	Low activeness in group sharply turn into high activeness.
7	Gradually-decreased	High activeness in group gradually turn into low activeness.
8	Gradually-increased	Low activeness in group gradually turn into high activeness.

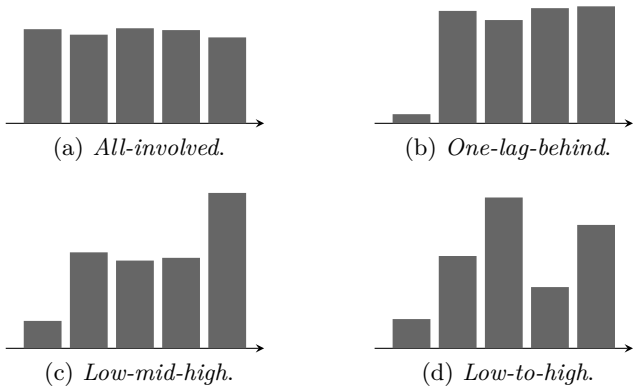
According to the results from the two rounds of the course, we obtained the following observations: (1) all members involved in the final presentation, (2) activeness patterns 2, 4, and 6 frequently appeared in heterogeneous groups, (3) activeness patterns 3 and 5 can be found in the group that members were occasionally absent in group work, and (4) it seems that heterogeneous group members more likely get involved in group activities.

4.4 Distribution of Contributions

We had students peer-review each other within every group. Since every student have the same amount of points to give to members of the group, including themself, only the distribution of total assigned points matters.

From our observation, as shown in Fig. 7, we found four typical patterns of the distributions. In the distributions of the *all-involved* pattern (Fig. 7(a)), points are almost equally distributed, which indicates that all the members contributed to the group work. The *one-lag-behind* pattern (Fig. 7(b)) is for the distributions where all the members got nearly the same scores except for one person. In such a group, there is an inactive or absent person. The *low-mid-high* pattern (Fig. 7(c)) represents the distributions consisting of three divided ranges of scores. Different from the previous patterns, this pattern suggests the existence of a leader in a group as well as average people and a low-contributing person. The *low-to-high* pattern (Fig. 7(d)) indicates that scores ranges from low to high. In this case, contributions greatly varies from person to person.

The *low-mid-high* pattern was found in the group that leadership appeared. The *all-involved* pattern was frequently appeared in heterogeneous groups and occasionally appeared in the other two types of groups. Heterogeneous group members more likely to get involved in group work. The *one-lag-behind* pattern was rarely found in the course. The *Low-to-high* pattern was generally found in homogeneous groups but not occasionally.



(a) *All-involved.* (b) *One-lag-behind.*

(c) *Low-mid-high.* (d) *Low-to-high.*

Fig. 7: Four representative patterns of the distributions of peer-review scores; (a) points are almost equally distributed, (b) all the members got high scores except for one person, (c) scores are split into three divided ranges, and (d) scores ranges from low to high.

5 Conclusion

We reported how learning style-based group composition affects group activities in real-world collaboration. Based on Kolb's experiential learning theory, we employed his Learning Style Inventory to identify learning styles of learners. Three types of strategies to form homogeneous, heterogeneous, and random groups were examined in a collaborative learning course of Kyushu University. We monitored the group activity level of every group during the course. From the results, we found eight kinds of representative patterns of group activeness changes. We had student to peer review each other within a group, which results in the distributions of members' relative contributions. The distributions varied group by group, and we discovered four types of the contribution distributions. We also showed relationships between group formation strategies and those patterns of activeness and contributions. In the future work, we intend to look further into the impact of grouping methods with a larger number of groups and observers.

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