2013 IEEE 13th International Conference on Advanced Learning Technologies

An Exploratory Study on Group Formation Based on Learning Styles

Shuangyan Liu, Mike Joy and Nathan Griffiths
Department of Computer Science, University of Warwick
Coventry, United Kingdom
jenny@dcs.warwick.ac.uk, M.S.Joy@warwick.ac.uk, Nathan.Griffiths@warwick.ac.uk

Abstract— **Recent work has highlighted how consideration of learning styles in the process of group formation for collaborative learning can have a positive impact. This paper investigates the performance of similar learning style groups and diverse learning style groups in group work, and explores how a grouping algorithm based on students' learning styles affects students' learning achievements and processes. An empirical study with current undergraduate students in the UK has been conducted. The participating students were invited to accomplish two group discussion tasks. Each student performed the two activities, in a separate group each time, once in a group consisting of students with similar learning styles, once in a group with diverse learning styles. No volunteer shared both groups with any individual student. This paper focuses on analysing the learning achievements and collaboration processes for the two types of groups, particularly with respect to the quality of group interactions. A significant difference was found between the percentages of time spent on meaningful interactions by the two types of groups, revealing that diverse learning style groups tend to spend significantly more time on meaningful interactions than similar learning style groups. In addition, the diverse learning style groups had demonstrated significantly less negative social-emotional reactions in showing disagreements.**

Keywords- learning styles, group formation, collaborative learning, grouping algorithm, group work

I. INTRODUCTION

The composition of groups is one of the factors that determine the effectiveness of collaborative learning, and is affected by several variables as noted by [1], including the demographics of the group members such as age, gender and race, the size of the group, and other differences between participants. Wang *et al.* [2] suggested that for a group to function effectively in a given learning environment, teachers should identify specific student characteristics and the group type (homogeneous or heterogeneous) which they understand to be appropriate for the learning activity.

In traditional class mode educational settings, teachers typically either let students self-select their group partners or manually assign them to different groups. However, there are limitations for these methods, and student self created groups are usually formed based on friendship rather than for educational reasons [3], in this case, students tend to avoid heterogeneous groups because they prefer to choose group partners who are like them in ethnicity, student status, gender, knowledge or competence. This can prevent one of the benefits of collaborative learning, that is, learning from other students with different strengths and backgrounds. Manually assigned groups can increase the likelihood of heterogeneous groupings, but this does not ensure that the groups work effectively together. Moreover, constraints such as large class size and time limitation may prohibit teachers from forming groups efficiently.

Compared with such chosen grouping methods, grouping methods where students are randomly assigned to groups increase the efficiency of the group formation process and the likelihood of heterogeneous groupings, but do not guarantee that students satisfy their individual needs. Chapman *et al.* [4] suggest that self selected student groups tend to work better than those groups selected by random assignment. Their study indicated that students in randomly assigned groups generally had more concerns about working in their groups, and had slightly less positive group attitudes and lower group outcome measures.

Recent work on incorporating psychological features of students into the group formation process has focused on learning styles including those carried out by Sandmire & Boyce [5], Robertson [6], Alfonseca *et al.*[7], Grigoriadou *et al.* [8] and Papanikolaou *et al.* [9]. In the previous study [10], we have proposed a grouping approach (namely Intelligent Grouping based on Learning Styles—"iGLS") that can form groups with diverse types of learning style (e.g. active and reflective learning styles). iGLS has suggested several system components for supporting group formation tasks in a web-based collaborative learning environment (CLE). The core part of the iGLS approach is a grouping algorithm for forming groups based on learners' learning styles. The algorithm takes as inputs learning style scores and other grouping parameters, and generates a set of groups through the processes of sorting, segmenting, and assigning. A detailed description of the algorithm can be found in [10]. The iGLS grouping algorithm was implemented as one of the components for supporting grouping in a contemporary CLE. It can also be developed as part of a stand-alone software tool for group formation in face-to-face or blended learning settings. Although the feasibility of implementing the iGLS grouping algorithm as a software tool for group formation has been demonstrated, the potential impact of the grouping algorithm on students' group work has not yet been examined.

978-0-7695-5009-1/13 $26.00 © 2013 IEEE
DOI 10.1109/ICALT.2013.32

The research reported in this paper is an empirical investigation of how the iGLS grouping algorithm works for group formation. Using a cohort of university students studying science related subjects in the UK, an experiment was conducted in which both diverse and similar learning style groups were formed, using the iGLS grouping algorithm and a comparison grouping algorithm (form similar learning style groups manually). In this paper, various aspects of the group collaboration are examined and the two types of groups are compared quantitatively and qualitatively, in order to explore the following research questions.

(1) Do groups with diverse learning styles perform more effectively and efficiently than groups with similar learning styles?

(2) Does the iGLS grouping algorithm lead to different outcomes for the diverse learning style groups formed?

II. Impact of Learning Styles on Group Collaboration

An increasing number of studies such as those by Wang *et al.* [2] and Caropreso & Chen [11] have explored the relationships between psychological attributes of students and group collaboration development, and many of these studies reveal that such attributes (including learning styles) affect how students engage with group collaboration. Several case studies have shown that taking account of learning styles positively influences the effective formation of groups including Alfonseca *et al.* [7], Papanikolaou *et al.* [9], Grigoriadou *et al.* [8] and Nielsen *et al.* [12].

A case study by Alfonseca *et al.* [7], involving data gathered from 166 Computer Science students who had solved programming exercises in pairs, suggested that learning styles affect the performance of students when working in groups. In particular, pairs worked more effectively when the students' learning styles in the active/reflective dimension were dissimilar and pairs which were allocated by considering the active/reflective dimension obtained a higher mean score than those allocated by considering the other dimensions of the Felder and Silverman Learning Style Model (FSLSM) [13].

An empirical study by Papanikolaou *et al.* [9] investigated the impact of learning styles on group formation for collaborative concept mapping activities. The findings suggested that the ideal group consists of students with a mixture of learning styles but without extreme differences (rather than students with a wide range of styles or students whose styles are similar).

From the existing case studies, it is believed that mixed learning style groups without extreme differences work better than other types of groups, and that the active/reflective tends to be the most influential of the dimensions of FSLSM that impacts on group work by undergraduate students.

The FSLSM is used for categorising learning styles in the process of forming groups in this paper. This is because FSLSM includes a dimension of active/reflective learning styles which most other learning style models do not, and it provides a sliding scale supporting a richer classification of students' styles and a shorter learning style questionnaire than the instruments used by most other models that contain the active/reflective styles.

III. Research Methods

A. Research Design

In this study, a cohort of first year university students (aged 18+) were invited to complete two group discussion tasks relating to professional skills development. The first task was focused on the topic of "making a good scientific poster", and the second task was titled "creating an effective PowerPoint Presentation". The participants were expected to discuss in groups the issues that they thought important on the given topics and noted their ideas on sheets of paper. The participating students were assigned into Similar Learning Style (SLS) groups manually for the first task while they were assigned into Diverse Learning Style (DLS) groups using the iGLS grouping algorithm for the second task. Details of the grouping algorithm can be found in the study of [name deleted to maintain the integrity of the review process]. Lowry *et al.* [14] indicated that small groups of size three, compared with larger groups, can establish and maintain higher levels of communication quality. Therefore for both the group tasks, groups of three were formed.

B. Participants

Volunteers were drawn from four science departments at the authors' university—Mathematics, Physics, Chemistry and Statistics. They were requested to complete an on-line pre-study questionnaire in order to determine their learning styles before the experiment. 26 students completed the questionnaire and 20 of them subsequently completed the experiment. Based on the information collected from the pre-study questionnaire, the participants were categorised into three types based on their learning style scores for the active/reflective dimension of FSLSM: 'active' (from -11 to -5), 'neutral' (from -3 to 3), and 'reflective' (from 5 to 11) (the score values on the dimensions of FSLSM increasing by 2 in every step). Since the participants had all the types of learning styles on the active/reflection dimension ('active', 'neutral' and 'reflective'), the sample was considered to be suitable for conducting the experiment.

C. Procedure

The participants were given a brief introduction to the two discussion topics before being allocated into groups. Seven collaborative groups were formed for each task. Each group completed the task under the guidance of a tutor who was responsible for coordinating the group—keeping the audio recorder, delivering and collecting data forms, and controlling the timing of the task. The tutors were trained to engage in (as far as is possible) an identical way with each group, and they were not expected to explain the topics of the tasks to the students during the

group discuss processes. A single task was to be completed within a 30-minute period (a group could end the task before the time limit).

A group record form was used for recording the issues that the group members thought important on the given topics, the proposers of the ideas, and the total time used to complete the task. A total of 14 group record forms and 14 audio recordings of the entire group discussion process were collected for further data analysis.

An expert questionnaire was created via aggregating the items proposed by the participants. The expert questionnaire was used to assess the importance levels of the issues identified in the group record forms, which was completed by tutors from the English department in the authors' university who were teaching modules on professional skills to science students and had good knowledge of how to make and evaluate scientific professional presentations (e.g. posters and PowerPoint presentations). The questionnaire used a 5-point Likert Scale for assessing the importance level: 1—Not at all important; 2—Low importance; 3—Medium importance; 4—High importance; and 5—Essential. Two experts returned their responses to the expert questionnaire and the average scale scores were adopted for assessing the individual and group achievements.

D. Data Analysis

In order to measure group and individual student achievements, group scores (GS) and single student scores (SSS) were calculated, using the following definitions.

$$GS = \sum_{i=1}^{t} L_i \tag{1}$$

$$SSS = \sum_{j=1}^{m} L_j + \sum_{k=1}^{n} L_k / N_k \tag{2}$$

In the above formulae, *t, m, n* represent respectively the number of items proposed by a group, the number of items proposed solely by an individual student, and the number of items proposed by this student and his/her group members together; L_i, L_j, L_k represent the levels of importance of the proposed items *i, j, k*; and N_k represents the number of people who proposed item *k* together.

The time spent on meaningful interactions (MIs) (T_{mful}) is equal to the total time (T) that a group completed a group task minus the time that a group spent on meaningless interactions (T_{mless}). That is, $T_{mful} = T - T_{mless}$. Examples of meaningless interactions include silence without posing anything at the end, long discussion without any concrete result, and "off-topic" discussion.

Furthermore, a content analysis of the transcriptions of the audio recordings of the group discussion was carried out. The content analysis adopted in the study was based on Bales' Interaction Process Analysis (IPA) framework [15], which was selected since it addresses a methodology of identifying the nature of interactions among small face-to-face group members. The framework describes group behaviors in 12 categories from the perspectives of social-emotional and task-oriented functions of groups.

Independent samples t-tests were used for identifying the differences between the SLS and DLS groups in (i) the group scores, (ii) the percentage of time spent on MIs, (iii) the total number of units of group interactions (a 'unit' refers to a single simple sentence in a discussion transcription), and (iv) the number of units of group interactions under each category of Bales' IPA framework [15]. For the t-tests, the data belonging to the SLS and the DLS groups were compared. The two sets of data are independent since the groups belonging to the first set are distinct from the groups in the second (no volunteer shared both groups with any individual student). A related-samples t-test was used to demonstrate the differences in individual student achievements between students belonging to the SLS and DLS groups.

IV. Results

A. Group Achievements

Group scores were calculated according to formula (1) presented above for the SLS and DLS groups. Fig. 1 illustrates the group scores obtained. In the scatter diagrams, the triangle points represent the SLS group scores and the square points the DLS group scores. The two dashed lines represent the average group scores. The 'orphan' groups (Group 7, 14) actually consisted of students of diverse (5, -3) and similar (-1, 1) learning styles respectively. Since this does not satisfy the objective of comparing SLS and DLS groups, the two 'orphan' groups are not included in the comparison.

For group task 1, the group scores ranged from 33 to 73, with a mean of 51 (SD = 13.25). Both the highest and the lowest groups are 'neutral' groups. For task 2, the scores ranged between 49 and 65 with a mean of 56 (SD = 5.49). The difference between the highest and lowest scores is smaller than that of the SLS groups.

The DLS groups gained a higher average group score than the SLS groups, but the higher SD of the latter reflects the larger spread of values for the SLS groups. An independent samples t-test was conducted to compare the

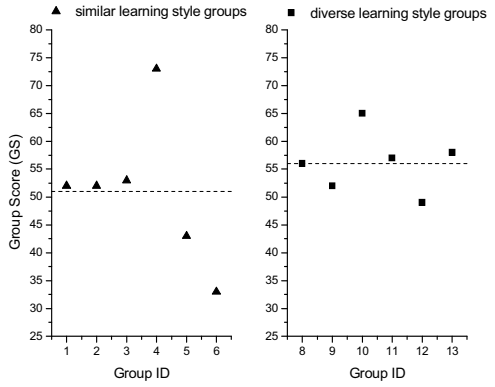

Figure1. The group scores by similar learning style groups and diverse learning styles groups.

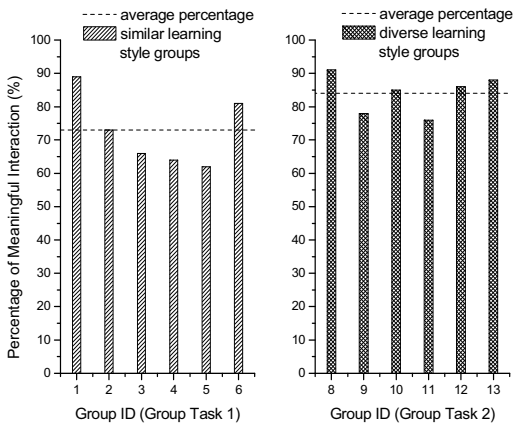

Figure 2. Percentage of meaningful interactions by similar learning style groups and diverse learning style groups.

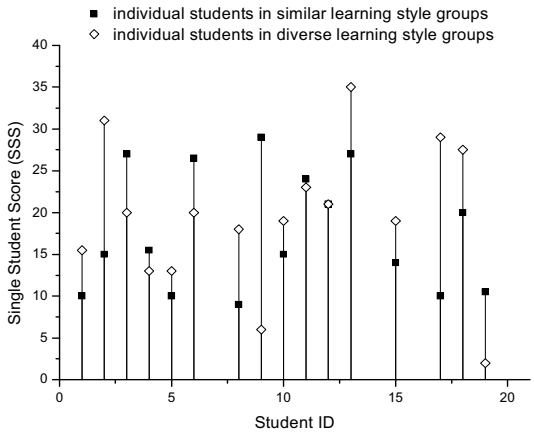

Figure 3. The single student scores of each participant in the similar learning style groups and diverse learning style groups.

two sets of groups, but revealed no significant difference between the scores: $t(10) = -0.882$, $p = 0.398 > 0.05$.

Besides the group scores, the percentage of time spent on MIs by the SLS groups and DLS groups was also analysed. This is illustrated in Fig. 2, in which the two horizontal dashed lines are the mean values.

For the first group task, the percentage of time spent on MIs ranged from 62% to 89%, with a mean of 73% (SD = 10.67%). Group 1, which spent most time on MIs is an 'active' group, whereas the 'reflective' group (Group 2) spent the same as the average value and the 'neutral' groups (3–5) spent less than average on MIs. This supports the claim that 'active' students tend to engage more with group work. It is also interesting to see that although reflective students may prefer to work alone, they were not the worst performing group in terms of MIs when grouped together.

For the second group task, the percentage of time ranged from 76% to 91% with a mean of 84% (SD = 5.83 %), with only two of the groups below the mean value. The higher mean value obtained by the DLS groups indicates they tend to be keener to discuss the topic than the SLS groups. Moreover, the smaller SD that the DLS groups demonstrated reveals that their values are more close to the mean.

An independent samples t-test shows significant difference between the percentages of time on MIs by the SLS and DLS groups: $t(10) = -2.316$, $p = 0.043 < 0.05$. This suggests that DLS groups tend to spend significantly more time on MIs.

B. Individual Student Achievements

Single student scores for the two types of groups were obtained from formula (2) (Fig. 3). In this vertical drop line diagram, the 'square' symbols represent the single student scores for group task 1 and the 'diamond' symbols represent the single student scores for group task 2. The distance between the two symbols in a vertical line shows the difference between the student scores of a single student for the two group tasks.

As illustrated in Fig. 3, 9 students (56%, N=16) gained higher student scores from the DLS groups than they obtained in the SLS groups, and 66.7% of 'active' students, 60% of 'neutral' students and 33.3% of 'reflective' students gained higher individual scores in the DLS groups. This finding suggests that students with all three types of learning style ('active', 'neutral' and 'reflective') have the potential to achieve higher individual results in DLS groups.

Scores for the SLS groups ranged from 9 to 29 (M = 17.72, SD = 7.18), and for the DLS groups from 2 to 35 (M = 19.5, SD = 8.69). A related-samples t-test showed no statistically significant difference in single student scores between the two groups: $t(15) = -0.701$, $p = 0.494 > 0.05$.

C. Patterns of Group Interactions

The content analysis identified the categories and the number of units of group interactions for each group (Table 1). According to the Bales' IPA framework [15], group interactions can be divided into 12 categories. Categories 1–3 represent positive social-emotional interactions for showing solidarity, tension release, and agreeing; categories 4–6 correspond to task-oriented interactions attempting to give suggestion, opinion and orientation for the solution individually; categories 7–9 indicate task-oriented interactions asking for orientation, opinion and suggestion; and categories 10–12 represent negative social-emotional interactions for showing disagreement, tension and antagonism.

Most of the group interactions, regardless of which group, fall under categories 3–6, indicating that both groups concentrated on giving suggestions, opinions, orientations and agreements. Neither type of group had a contribution under category 11 or 12, so there were no negative social-emotional reactions. On average, SLS groups interacted much more under categories 8 ('asking for opinions') and 10 ('showing disagreement'), and less under categories 1 ('showing solidarity') and 2 ('showing tension release') than the DLS groups.

Two 'neutral' groups (6, 5) had the largest and the least number of units of interactions respectively for task 1. The average numbers of units of interaction by the SLS and DLS groups are 218 and 197 respectively. A possible reason for this difference is that the SLS groups spent

TABLE I. UNITS OF INTERACTIONS CATEGORISED UNDER CATEGORIES 1-12 OF THE BALES' IPA FRAMEWORK

Category [15]	Group ID (SLS Groups)							Group ID (DLS Groups)						
	1	2	3	4	5	6	Mean	8	9	10	11	12	13	Mean
1	1	1	0	4	0	4	1.67	3	2	6	5	4	1	3.5
2	0	6	0	0	0	5	1.83	4	1	0	3	0	19	4.5
3	44	77	43	47	34	48	48.83	68	16	33	22	59	51	41.5
4	31	38	15	28	15	21	24.67	23	13	15	19	23	23	19.33
5	73	39	46	53	31	79	53.5	85	21	38	32	76	68	53.33
6	77	67	59	51	50	85	64.83	82	30	23	54	82	67	56.33
7	6	7	6	8	17	10	9	2	6	0	30	4	20	10.33
8	2	8	1	4	7	8	5	4	5	3	3	2	4	3.5
9	4	6	0	2	3	4	3.17	0	2	0	2	2	7	2.17
10	5	11	6	4	6	4	6	8	3	0	0	2	0	2.17
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	243	260	176	201	163	268		279	99	118	170	254	260	

longer completing the group task on average and thus produced more units. No significant difference was found between the total number of units by the SLS and DLS groups: $t(10) = 0.594$, $p = 0.565 > 0.05$.

Moreover, independent samples t-tests were carried out to compare the numbers of units of interactions of by category for the SLS and DLS (Table 1). There is a significant difference between the number of units of interactions under category 10 ('showing disagreements') by the SLS and DLS groups: $t(10) = 2.307$, $p = 0.044 < 0.05$, but for the other categories there are no significant differences (and since no interactions were identified, no statistics were calculated for categories 11 and 12).

V. CONCLUSION

In this paper, the authors investigated the performance of similar learning style groups and diverse learning style groups in a collaborative learning. The learning achievements and group member interactions were analysed and compared. It was found that the diverse learning style groups tend to spend significantly more time on MIs than similar learning style groups. In addition, the DLS groups tend to demonstrate less times of showing disagreements for the group collaboration processes. It would be interesting future work to examine the subgroup differences that may with larger numbers of subgroups (i.e. 'active', 'neutral' and 'reflective' subgroups).

REFERENCES

[1] P. Dillenbourg and D. Schneider, "Collaborative learning and the Internet", *Proceedings of the International Conference Computer Assisted Instruction*, Hsinchu, Taiwan, pp. 6-13, 1995.

[2] D.-Y. Wang, S. S. J. Lin and C.-T. Sun, "DIANA: A computer-supported heterogeneous grouping system for teachers to conduct successful small learning groups", *Computers in Human Behavior*, 23(4), 2007, pp. 1997-2010.

[3] M. A. Redmond, "A computer program to aid assignment of student project groups", *Proceedings of SIGCSE'01*, pp. 134-138, 2001.

[4] K. J. Chapman, M. Meuter, D. Toy and L. Wright, "Can't We Pick our Own Groups? The Influence of Group Selection Method on Group Dynamics and Outcomes", *Journal of Management Education*, 30(4), 2006, pp. 557-569.

[5] D. A. Sandmire and P. F. Boyce, "Pairing of Opposite Learning Styles Among Allied Health Students: Effects on Collaborative Performance", *Journal of Allied Health*, 33(2), 2004, pp. 156-163.

[6] E. J. Robertson, The effects of learning styles on group development in an online learning environment, Master of Science Thesis, University of North Carolina Wilmington, 2005.

[7] E. Alfonseca, R. M. Carro, E. Martín, A. Ortigosa and P. Paredes, "The Impact of Learning Styles on Student Grouping for Collaborative Learning: a Case Study", *User Modeling and User-Adapted Interaction*, 16(3-4), 2006, pp. 377-401.

[8] M. Grigoriadou, K. Papanikolaou and E. Gouli, "Investigating how to group students based on their learning styles", *Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies*, Kerkrade, The Netherlands, pp. 1139-1140, 2006.

[9] K. Papanikolaou, E. Gouli and M. Grigoriadou, "Accommodating individual differences in group formation for collaborative concept mapping", *Proceedings of the 2nd International Conference on Concept Mapping*, Costa Rica, pp. 16-23, 2006.

[10] S. Liu, M. Joy and N. Griffiths, "iGLS: Intelligent Grouping for Online Collaborative Learning", *Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies (ICALT 2009)*, Riga, Latvia, pp. 364-368, 2009.

[11] E. Caropreso and S.-J. Chen, "The impact of personality on collaborative online learning", *Proceedings of the International Conference Society for Information Technology & Teacher Education*, Albuquerque, New Mexico, USA, pp. 2371-2375, 2003.

[12] T. Nielsen, A. E. Hvas and A. Kjaergaard, "Student team formation based on learning styles at university start: Does it make a difference to the students?", *Reflecting Education*, 5(2), 2009, pp. 85-103.

[13] R. M. Felder and L. K. Silverman, "Learning Styles and Teaching Styles in Engineering Education", *Engineering Education*, 78(7), 1988, pp. 674-681.

[14] P. Lowry, T. Roberts, N. Romano, P. Cheney and R. Hightower, "The impact of group size and social presence on small-group communication", *Small Group Research*, 37(6), 2006, pp. 631-661.

[15] R. F. Bales, "A set of categories for the analysis of small group interaction", *American Sociological Review*, 15(2), 1950, pp. 257-263.