Facilitating Group Discussions Through Learning Styles and Prior Student Knowledge

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ABSTRACT

During in-class group work, student participation is often imbalanced. Some students are naturally more vocal and dominate conversations, while others remain quiet and uninvolved. This paper describes two new group formation methods that aim to improve overall student participation. The first uses Felder-Silverman Learning Styles [5] to form groups that students are comfortable participating in. The second, new method, the *latent jigsaw*, extends the original jigsaw method [2] by assigning groups based on prior student knowledge to promote peer-teaching. Classroom experience in implementing both methods is also described.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education—*Collaborative learning*

General Terms

Human Factors, Performance

Keywords

group work, learning styles, jigsaw method, latent jigsaw method, collaborative learning

1. INTRODUCTION

Research has shown that in-class group work has many positive effects on student learning. By being directly involved with the subject matter, group work enables active learning to occur and allows for better retention of the material [1, 3, 9]. The increased socialization and exposure to different student ideas can also improve student retention in the major [6]. Since individual participation within a group can vary, these benefits are unfortunately not guaranteed to occur for all students.

Social dynamics plays a strong role. When a female student is isolated (an all too common occurrence in computer science classes), she is likely to assume the role of secretary or not participate at all [8]. Considering people in general, some are naturally more vocal, while others are more quiet. In a group with quiet people, a vocal person will either dominate or be uncomfortable due to the lack of active, vocal interaction within the group. Similarly, a quiet person might not interact at all with a group of vocal people.

How to form groups is another concern. Although there exist guides and suggestions for what makes a good group [3, 4], there is no perfect solution. Random assignments help mix up the class but do not directly address the problems caused by social dynamics. Student-formed groups almost guarantee that a person will be comfortable with their group, but such groups are often based on friendships and thus do not promote socialization within the classroom community.

This paper introduces two new methods for group formation that improve student participation. The first method uses Felder-Silverman Learning Styles [5] as the criteria for assigning groups. The central idea to this method is that group members who share similar learning styles should be more comfortable interacting with each other. The second method, the *latent jigsaw method*, extends the original jigsaw method [2] by using students' prior knowledge to partition them into specific, peer-teaching roles. The experience of using both techniques in the classroom is also described.

The next section gives background on the class in which both methods were deployed. Section 3 describes using learning styles to form effective groups, and an example of its use is detailed in Section 4. The theory and application of the latent jigsaw method is covered in Section 5. Student feedback responses to the group work experiments is detailed in Section 6. Finally, Section 7 concludes the paper and suggests future work and study with these new methods.

2. BACKGROUND

The group work experiments in this paper took place in the quiz sections of both the winter and spring offerings of the *Data Structures* (for majors) course at a large, state university. During this time, I served as the graduate teaching assistant for the course and led quiz section each week.

2.1 Course Description

Taken by every major, this course introduces students to a variety of advanced data structures and their computa-

Scenario:
You need a data structure with the following functionality. Items are inserted, looked up, and removed on a fairly frequent basis. Every hour, in order to save space, you remove the least used data (usage to be defined by you) from the structure.

Figure 1: An example of a data structure scenarios.

tional efficiencies. A normal offering consists of 35–50 students attending three 50–minute lectures and one 50–minute quiz section per week (two quiz section times are usually offered). Support staff usually consists of both a graduate and undergraduate TA.

2.2 Winter Quarter: Student-Created Groups

As the graduate TA for the course, I wanted to balance the theory-heavy lectures by spending time in quiz section discussing applications of data structures. Of particular interest were problems in which any one of several data structures would suffice. In such *scenarios*, students would weigh the pros and cons of using one data structure or algorithm over the others. Figure 1 shows an example.

During the winter offering of the course, students discussed scenarios in groups formed on the basis of where they sat. Afterwards, the class would come together to hear the various solutions proposed by each group. As expected, though, the groups consisted mostly of friends. Participation was mixed; the more talkative students dominated both their groups and the class discussion at the end. Some individuals even avoided talking with anyone and instead worked independently.

2.3 Spring Quarter: Assigned Groups

Many students enjoyed the scenarios and listed them in the course evaluations as contributing greatly to their learning. Several even mentioned this directly to me at the end of the quarter. Given these responses, I decided to continue using scenarios in the spring offering of the course. As one motivation for the students, involvement with group work contributed to their class participation grade (5% of their final grade).

Additionally and more importantly, to improve overall participation and better the overall group work process, I decided to assign the groups and developed two methods to do so. Groups formed by the learning style method in Section 3 were reused throughout the term. However, the groups formed by the latent jigsaw method in Section 4 were for one-time use only for specific scenario discussions.

Converting the classroom's layout for group work instead of a more traditional lecture did not pose any significant problems. For example, there were only ten minutes to prepare the room for the afternoon section, but this was more than sufficient. Using a map to direct students to sit in specific locations with their groups at the beginning of class prevented confusion and saved time.

3. GROUPING BY LEARNING STYLES

The first technique I developed for forming groups is the *learning style method* described in this section. This section describes the Felder-Silverman learning styles and shows how they can be used to form groups.

Table 1: Learning style survey results.

	Strong	Weak	Weak	Strong	
Reflective	49%	27%	12%	12%	Active
Visual	46%	30%	18%	6%	Verbal
Sensing	12%	33%	24%	30%	Intuitive
Sequential	21%	27%	36%	15%	Global

33 Responses, 4 Non-responses

3.1 Theory of Learning Styles

Although there are many breakdowns of learning styles available, the Felder-Silverman Learning Styles [5] were designed specifically for students in the sciences. These styles break learning into four distinct axes:

- *Reflective / Active:* Reflective learners prefer to think silently before offering a solution or starting an experiment. Active learners instead learn by physically trying new ideas, as well as brainstorming out loud with a group of people.

- *Visual / Verbal:* Visual learners learn best when pictures, graphs, etc. are used. Verbal learners acquire knowledge better if it is written or spoken.

- *Sensing / Intuitive:* Sensing learners prefer information that comes immediately from their own senses. Intuitive learners favor knowledge that comes from remembered and imagined experiences.

- *Sequential / Global:* Sequential learners acquire information in small, ordered chunks to form the big picture. Global learners grasp general ideas first and then master the smaller specifics.

3.2 Group Formation Criteria

To ascertain the students' learning styles, students were given an assignment to complete an online assessment [7]. These results identify the student's dominant style on each axis and returns a score from 1–11 (odd values only) to indicate the relative strength of this learning style. A score of 3 or less indicates that the subject is well-balanced on the axis and only slightly prefers one style over the other. Throughout this paper, we will refer to such a score as being *weak* and higher scores as *strong*. Table 1 displays the results of the survey. These results and other advice on group work [4] led to the following criteria for group formation:

1. Groups should contain 3–5 people.

2. No isolated females.
   When isolated in a group, women tend not to participate or merely play the role of secretary [8]. The number of women in the course was 9 out of 37 students (5 in the morning section, 4 in the afternoon).

3. Place people together who score similarly on the Reflective / Active axis.
   The Reflective / Active axis is extremely influential on a student's comfort level when engaged in collaborative learning. As can be expected, group work comes more naturally to an active learner but only if there are other people in the group to actively exchange ideas

with. A strongly reflective learner might be comfortable with group work if he or she has time to think silently before contributing. In a group with active learners, however, such an individual will feel pressure to contribute to the vocal brainstorming. By using the Reflective / Active axis to place people in groups, we increase the chance that the group environment will be more conducive to each student's brainstorming style.

4. Mix sequential and global learners together.

   Most students had scored on both the Sequential / Global and Sensing / Intuitive axes, making either a viable criterion for forming groups. The former was chosen since sequential and global learners naturally compensate each other. By approaching a problem in two directions, group members may be exposed to insights they would likely not have otherwise considered.

4. AN IMPLEMENTATION OF THE LEARNING STYLE METHOD

This section describes the details of deploying the learning style method in my two quiz sections. The guidelines from Section 3.2 did require some adjustment, but students participated more fully as compared to my experiences with the winter offering.

4.1 Tuning the Groups

On the first day that group work was supposed to occur, technical issues delayed forming the group assignments. In the morning section, students were allowed to form their own groups, resulting in poor, uneven participation as in the previous quarter. The group assignments for the afternoon section, however, were prepared just in time for class. A greater percentage of the students participated than in the morning section, but there were exceptions. These two dry runs gave insights into how to improve the groups and deal with the problems of incomplete data and the limitations of the learning style model. Table 2 shows the refined groups that were formed for the afternoon quiz section. Due to space constraints, the morning groups are not shown. Notice that the group formation criteria are not fully followed.

Students A2 and D2 did not complete the online assessment, thus making it difficult to place them. By recalling their typical, past behavior in the classroom, in office hours, etc., I estimated where they fell on the Reflective / Active axis. For example, A2 often thought out loud in office hours when trying to understand a problem or solution, hence his assignment as an active learner.

Previous experiences also helped correct a major limitation of the criteria. How a person works in a group is only one factor involved in a person's score on the Reflective / Active axis. A person's socialization style might not agree with group work, even though they prefer working hands-on with an idea. For example, during the dry run, student D4 rarely interacted with the active group to which he was originally assigned. Although naturally quiet and reserved, he preferred to learn by doing examples in office hours, hence his score of mildly preferring active learning.

One final break with the criteria was the isolation of female students A1 and B3. Both women were natural facilitators. In their groups, each took on a leadership role that, while not dominating the others, encouraged forward progress. Thus, there was no concern that isolating them would not reduce their participation.

Table 2: Afternoon section discussion groups

	Sex	Reflective/Active	Sequential/Global
A1	F	3–A	3–G
A2	M	?	?
A3	M	7–A	1–G
A4	M	1–R	1–G
B1	M	1–R	7–S
B2	M	9–R	3–S
B3	F	11–R	5–G
B4	M	11–R	3–S
C1	M	9–R	3–S
C2	M	7–R	1–G
C3	M	5–R	1–G
D1	M	1–R	1–G
D2	F	?	?
D3	F	9–R	7–S
D4	M	5–A	3–G

4.2 Observations

During group work, several behavioral patterns emerged that showed positive effects of grouping students by learning styles. The strongest, in fact, was the difference between the active and reflective groups. Due to the small number of active learners in the classroom, each section had only one active group. Upon receiving the problem scenario, the active group, (e.g., Group A in Table 2) instantly started thinking out loud and bouncing around ideas. Meanwhile, the reflective groups sat silent as each member processed the problem. After a period of time ranging from 30 seconds to 2 minutes, each reflective group would begin discussing the problem together.

Groups also differed by the roles the members played In some groups, one individual consistently acted as leader and guided the discussion. In both the morning and afternoon active groups, however, leadership rotated among the different members as they discussed different scenarios, This rotation allowed each student the opportunity to strongly influence and participate. In Group C, however, no student ever took on a leadership role. All decisions and actions were instead handled by consensus, which again shows strong participation by all the group members.

The leadership style of student B3 was also very interesting. Often by speaking first, she tended to take on the role of facilitating the discussion. In this role, she made sure every group member participated and expressed their own ideas. Over time, it appeared that her group members grew more spontaneous in making comments, but B3 always held the role of group facilitator.

Not all groups designated a secretary, either. Student D3 would often take notes and draw out her ideas, but not those of her group members. She would then use these notes to explain her ideas to her group. Often, her group mates would then interact with these notes. Some groups, particularly

active groups, used a shared piece of paper to record their ideas. Both the morning and active groups would tightly huddle together and write on top of each other's sketches. From my viewpoint as the instructor, these notes were illegible scratchwork. However, students used them to focus their discussion. They also used these notes when presenting their ideas to the rest of the class.

During these class discussions, there were signs of greater participation and involvement by the students. After the students had worked on a scenario for several minutes, I would randomly call on students to explain what their group had come up with. Without fail, students responded clearly and confidently, regardless of their typical classroom persona. In particular, if a member of their group had come up with a really good idea, they gave credit to that person and would sometimes offer for him or her to explain the idea in better detail. A favorite example is when Group B was describing their solution to a scenario involving sorting. Together, they had developed a unique list data structure that achieved significant speedups. When describing it, the entire group got excited and started finishing each other's sentences.

In summary, these observations show that students participated more fully within their groups and were more comfortable working with each other. Still, one unexpected result is worth mentioning. Despite the comfort and increased socialization with their classmates, the assigned groups in section did not seem to affect the voluntary formation of groups outside of class for working on the programming projects. This is not all that surprising. First, these groups could consist of students from either section. Secondly, by the time students take this course, they have likely already formed friends within the major. Both factors likely explain why there was no effect on programming groups.

5. LATENT JIGSAW METHOD

After the success with the previous approach, I explored other approaches to forming groups to add variety to the group work. In this section, I describe another effective method, the *latent jigsaw method*, for encouraging group participation.

5.1 Methodology

The latent jigsaw method is a collaborative learning exercise derived from the original jigsaw method [2]. The basic idea of the jigsaw method is to create a peer-learning environment within a group by making each student responsible for teaching the others about a specific topic. The general procedure is as follows:

1. Split the class into X *expert groups*.
2. Each expert group learns and masters a separate topic.
3. Reshuffle the expert groups to form *learning groups* of size X such that each group has one representative from each of the expert groups.
4. Each student teaches their expertise to their new group.

The latent jigsaw method adjusts the first two steps by using the students' prio knowledge. Outside of class, students were asked to complete an online survey of multiple-choice questions like the one in Figure 2. The questions were

Scenario:
The system you are designing requires a sort routine. Unfortunately, memory usage is at such a high cost on this machine (say it is a small, embedded device) that you cannot afford to have much (if any) overhead in your sorting algorithm.

Which sorting routine would you choose?

a) Quick Sort (29%)
b) Insertion Sort (41%)
c) Merge Sort (0%)
d) Heap Sort (29%)

Figure 2: A multiple-choice question used for the latent jigsaw method. Response data also shown.

data structure scenarios as in Figure 1, but with answers restricted to only a few choices. For each individual question, the latent jigsaw method was implemented as follows:

1. Form expert groups of students who selected the same answer for the survey question to be discussed.
   Because nearly half of the 37 students answered Insertion Sort in Figure 2, it was necessary to break these experts up into smaller groups. To do this, the technique in Sections 3 and 4 was used.

2. Expert group members discuss and reflect on why they chose their particular answer.
   Because some time had occurred between filling out the survey and quiz section, it helped for students to reflect on why they chose to answer as they did. This peer review potentially also introduced students to reasons they had not considered.

3. Shuffle the students into learning groups such that each new group has at least one representative from each expert group.
   In the case of multiple expert groups, each group had a different review experience. Thus, there was value in having each learning group include a representative from each and every expert group. Again, to help guarantee the good interaction within the learning groups, the learning style technique was used.

4. Each member of the group explains why they chose their particular answer.

5.2 Observations

Overall, creating both the expert and learning groups from the survey results was a simple task. The only real challenge came from dealing with the uneven distribution of answers. Inevitably, some learning groups had multiple or no representatives from a particular expert group. However, each learning group always had at least one representative for each response.

As before, the students' overall group work participation was largely positive. A strong factor in this was likely the use of the learning style method to form the expert and learning groups. The interactions within both expert and learning groups were like those described in Section 4.2.

This peer-teaching was successful as well in encouraging participation. Many expressed excitement at the thought of

Table 3: Student opinion at the start of the term on the effectiveness of in-class group work.

Hurtful	·····	Neutral	·····	Helpful
3%	50%	3%	11%	33%

being a teacher and channelled this excitement into their interactions with their groups. Also, after the learning groups had completed their tasks, I asked students to explain to the class the merits of each answer. Since I knew who had answered what in the survey, I purposely asked a student to explain an answer different from their own. For example, I would ask a student who answered Insertion Sort for Figure 2 to explain the merits of choosing Quick Sort. The students responded with what they had learned. Interestingly enough, many gave meta-answers in which they also mentioned the positives and negatives associated with all the choices. A few even admitted that their opinion on which answer was best had changed. This shows that students paid attention to the discussions within their learning groups.

6. STUDENT FEEDBACK

From the instructor's viewpoint, both collaborative learning exercises achieved strong participation while exercising the students' abilities to work with data structures. Student opinion was ultimately mostly positive as well.

When students submitted their Felder-Silverman learning styles, they also answered an opinion poll on the value of in-class group work. The results are shown in Table 3. Although one third of the class found group work to be helpful, over half of the students expressed negative opinions of group work.

Throughout the term, though, student opinion on group work shifted to a more positive outlook. On the first day of working in assigned groups, there was some grumbling about being told where to sit, but these disappeared by the next section. Only one student ever actively defied participating in group work by refusing to change seats. This problem was quickly remedied by just relocating his group to where he was sitting.

For the course evaluations, students were not prompted to mention group work in their comments. However, out of the twenty-seven responses, only one student said group work detracted from their learning while ten students specifically mentioned group work as contributing to the course. While the single negative comment had no explanation, the positive comments went into rich detail about increased socialization and better understanding of the material. Letting them speak for themselves, here are a few comments from my students that quarter:

> I thought the group activities were a good chance to get to know other students and their opinions.
>
> The group work and problem solving was excellent. This is a much better way to learn than just looking at slides.
>
> Group work was useful for understanding certain aspects like tradeoffs between data structures...

7. CONCLUSIONS AND FUTURE WORK

The methods presented in this paper provide two means of improving overall student participation in in-class group work. Both techniques utilize characteristics already possessed by the students to form groups. The learning style method uses how students prefert to think and interact. The latent jigsaw method uses their prior knowledge and opinions. After the successful implementation of both methods in my quiz sections, I and my students feel that these methods are useful additions to the teacher's toolkit.

For future work, I would like to see both techniques deployed in other classes by different instructors. In particular, it would be interesting to apply the learning style method in an introductory class where students are unlikely to know each other. Finally, developing software to aid instructors in forming groups is another avenue I am considering.

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