Team Formation Methods for Increasing Interaction During In-Class Group Work

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ABSTRACT

In contrast to the student teams used for larger and longer group projects, in-class groups are often ephemeral, lasting for only a few minutes or until the end of the period. Because of this, little effort is put into forming these groups, usually letting the students self-select their teams. This paper argues that greater student interaction and learning can take place by using instructor-selected teams. Two group formation techniques for in-class group work, the latent jigsaw method and grouping students by Felder-Silverman learning styles, are presented. Observations from a classroom deployment of these techniques are also described.

Categories and Subject Descriptors

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

General Terms

Human Factors, Performance

Keywords

collaborative learning, active learning, learning styles

1. INTRODUCTION

In computer science education, two forms of group learning are practiced rather universally: large group projects and small, in-class group activities. Modeled from industry, group projects have teams of students working on a large project over several days or the length of the entire term. In-class group work, however, takes place in at most a single class period and often consists of student-to-student discussion. These two methods, as well as other variations on group work, all depend strongly on proper team functioning for success. Thus, it should come at no surprise that educational researchers have developed multiple guidelines for assigning people to groups [8, 10].

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Surprisingly, these team formation methods are often dismissed and unused for in-class group activities under an argument of diminishing returns. The educational gains, if any, of using these methods are perceived to not warrant the time and expense of forming and assigning teams [11]. However, successful group work relies on strong, uniform interaction among the students. Student-selected teams offer no guarantees of participation [11]. Assigning teams, though, provides instructors with a direct means of promoting student-to-student interaction.

This paper aims for computer science instructors to reconsider their use of in-class group work. Arguments are made that assigning groups can improve how group members interact. Two team formation methods for promoting more interaction for in-class group work are also presented. The first is the latent jigsaw method, a new method for assigning groups based on prior student knowledge for the purpose of peer-teaching. The second method shows how forming groups by learning styles can promote participation by creating a comfortable social atmosphere for the members.

2. WHY ASSIGN TEAMS?

This section details the argument for assigning students to groups during in-class group activities. In order to understand how team formation methods can improve group work performance, it is necessary to understand what exactly makes collaboration successful.

2.1 Successful Group Work

To begin, consider the many educational benefits of collaborative learning. First, directly engaging the learner with the subject matter allows for better absorption of the material [12]. The increased socialization and exposure to different student ideas can also improve student retention in the major [5]. Finally, Springer et al. have shown that collaboration leads to an intense level of information processing that encourages cognitive growth [12].

All of these benefits point at a single key concept: student interaction. By analyzing dialogues between students and tutors, Core et al. [3] found that an individual student's learning gains correlated strongly with the number of words and utterances made by that student. Students who passively listened showed significantly weaker learning gains.

These results suggest that encouraging student-to-student interaction is key to successful group work. In the time allotted for the group learning experience, each student should feel both comfortable and motivated enough to engage in multiple conversational exchanges within their group. These exchanges can be nearly anything: questions, comments, etc. Thus, the challenge for us, the instructors, is to find ways of promoting this vital interaction among our students.

2.2 Reasons to Avoid Student-Selected Teams

One aspect of group work controlled by the instructor is how the groups are formed. Group membership clearly affects interaction among the students, thus giving the instructor a direct means of influencing interaction. Typically, the instructor chooses between assigning the groups and letting the students select their own teams.

Focusing just on group projects, Oakley, et al. [11] list several pitfalls of letting students select their own groups. First, students of similar abilities tend to congregate together: strong with strong, weak with weak. This limits interaction by preventing weaker students from learning how stronger students approach problems and robbing the stronger students of the educational values of peer teaching. A second pitfall is that groups will likely form around pre-existing friendships. This decreases the exposure to different ideas, and such groups are more likely to encourage and cover for inappropriate behaviors like non-participation and cheating [11].

Self-selection can also pose a problem for under-represented minorities. When an at-risk student (e.g., a woman in computer science) is isolated in a group, this isolation can contribute to a larger sense of feeling alone. This can then lead to non-participation or purely passive roles such as being the team's secretary [9, 11].

It is a simple observation to see that these arguments against self-selected groups apply just as much to in-class group activities. Students are likely to form groups based on neighbors, which are often friends. At-risk minorities will still stand the risk of isolation. Assigning groups provides us, the instructors, with a means to combat these pitfalls and thereby improve the quality of our in-class collaborative exercises.

2.3 Adjusting for In-Class Group Work

The question now arises as to how we go about assigning teams in order to provide interaction among the students. The methods suggested for group projects provide a starting point, but the shorter duration of in-class activities raises some challenges.

First, consider the educational goals we hope to achieve by using collaboration in the classroom. Generally, a focus is put on students learning and mastering a topic. Projects groups additionally aim to teach students how to collaborate as a preparation for working in industry [13]. If groups for in-class activities are formed with the goal of reducing the time needed for working together, more focus can be put on the learning goals. Thus, teams that promote immediate productivity are desirable for in-class group work.

A second effect of the time constraint involves participation within a group. In project groups, the involvement of members can vary greatly over the course of the project. Some team formation methods design groups so that some members are active at the start while others are more active towards the end [10]. The shorter in-class activities simply do not have this luxury. Teams need to create a group atmosphere that supports and encourages uniform participation by each and every member.

Thus, any team formation method used for group projects might require adjustments in order to benefit interaction for in-class activities. The remainder of this paper describes two methods for team formation that meet these requirements of immediate productivity and uniform participation. Positive experiences and observations from a pilot classroom deployment of these methods are also presented.

3. USING TEAMS IN THE CLASSROOM

Before delving into the methods, though, this section briefly describes the classroom context that both motivated and prototyped the group formation methods.

3.1 Course Description

The work in this paper took place during my two terms as the graduate teaching assistant (TA) for a *Data Structures* (for majors) course at a large, public university. Taken by every CS major, this course introduces students to a variety of advanced data structures and their computational efficiencies. A normal offering consists of 35–50 students attending three 50-minute lectures and a required 50-minute recitation section per week (students are assigned to one of two section times). Support staff usually consists of a graduate and an undergraduate TA.

To balance out the theory-heavy lectures, I chose to spend sections focusing on applications of data structures. To give the students experience in using data structures, I gave the students open-ended questions involving choosing an appropriate data structure for a given scenario. Typically, students would spend 5 to 10 minutes discussing the scenario in groups. Afterwards, the class would come together and discuss the various solutions proposed by each group.

3.2 Classroom Logistics

Overall, implementing the group work exercises was fairly straightforward. The sections that term were fairly small: 22 students in one, 15 in the other. Converting the classroom's layout for group work instead of a more traditional lecture also 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.

Additionally, a fellow graduate student was brought in to act as an independent observer. As I was piloting two new group formation methods for in-class group work, I wanted an unbiased record of how the students interacted in their groups.

4. LATENT JIGSAW METHOD

This section describes a new method designed for forming teams: the *latent jigsaw method*. This method creates a peer-teaching environment that promotes productivity and requires uniform participation by all group members.

4.1 The Original Jigsaw Method

The *latent jigsaw method* is a modification of the original jigsaw method [2]. The original jigsaw method creates a peer-learning situation in which a topic has been split up and each part mastered by a student in a group. Thus, a student is responsible for teaching his or her share to the group and is also dependent on the rest of the group to do the same. The following explains the general procedure:

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 at least one representative from each of the expert groups.
4. Each student teaches their expertise to their new group.

Note that this method is not suited for group projects; it is purely a collaborative learning exercise.

4.2 Adjustments

As an in-class group activity, the jigsaw method already possesses the properties of immediate productivity and uniform participation. During the learning groups stage (steps 3 and 4), each group is given the *agenda* of having *each* member educate the others about the topic they've mastered. However, this mastery is critical. The expert group stage requires enough time and effort to make the students capable of successfully educating their peers.

The latent jigsaw method skips the expert stage by utilizing the students' prior knowledge and opinions. Students are presented with a question that has multiple correct solutions and are asked to choose from a restricted set of answers. Figure 1 shows an example of this using a data structure scenario. Once the answers are collected, the learning groups are formed by grouping together students who chose different answers. Then, like in the original method's learning groups stage, each student explains to the rest of the group why they chose to answer as they did. Formally, the latent jigsaw procedure is as follows:

1. Students read an open-ended question and select one answer among X correct solutions.
2. Students are then placed into groups of size X such that each member chose a different solution.
3. Each student then explains to their group why they chose their particular answer.

Note that the latent jigsaw method's educational goals differ from those of the original method. Instead of having students learn a new topic, this method asks students to engage in critical thinking. The students exercise their current knowledge and the insights of their peers in order to evaluate alternative solutions.

Additionally, the latent jigsaw method possesses several properties for potentially enhancing the interaction among students. For example, during the learning group stage, each student is motivated by the notion that their answer is the most right, thus incurring a personal stake in the education of their peers. Another benefit is that the expert groups differ with every question. The exposure of students to a wider set of different viewpoints and learning approaches can enhance the socialization benefits of group learning.

4.3 Example

To better illustrate how this method works, consider the following example taken from one of my sections. Students were required for homework to complete an online survey of scenarios like the one in Figure 1. The figure also contains the responses for that scenario.

Because some time had occurred between filling out the survey and section, students met briefly in "expert groups" comprised of people who had chosen the same answer. Since 10 students answered Insertion Sort in Figure 1, they were split into two groups of 5 each under the recommendation that smaller groups are more effective [11]. Heap Sort and Quick Sort experts were placed in one group each with each group containing 6 people. The five minutes spent in these expert groups not only helped jog the students' memories but also potentially introduced them to reasons they had not considered when answering the scenario.

> The system you are designing requires a sort routine. 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 | (27%) |
> | b) | Insertion Sort | (46%) |
> | c) | Merge Sort | (0%) |
> | d) | Heap Sort | (27%) |

Figure 1: A restricted scenario used for the latent jigsaw method. Responses are also shown ($n = 22$).

Five learning groups were formed by shuffling the expert groups together so that each group had at least one representative from each expert group. Care was taken to avoid isolating any women or minority students [11]. Each learning group had a representative from each of the Insertion Sort expert groups. Since each expert group had a different review experience, the insights of both experts is valuable to the peer-learning experience. One group had two Quick Sort experts and another had two Heap Sort experts.

After each member of the learning groups had taught the rest of the group about their reasons for their answer, the class came together to discuss the question as a whole.

4.4 Observations

This peer-teaching was successful as well in encouraging interaction. Many expressed excitement at the thought of being a teacher and channeled this excitement into their interactions with their groups. This contagious enthusiasm helped motivate all students to be active participants.

Another interesting effect occurred 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 1 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 and engaged in further critical thinking.

5. GROUPING BY LEARNING STYLES

A common strategy used in business management for forming teams is to use personality types [1]. This section describes how types can be used to form groups that promote participation and productivity by creating a socially comfortable atmosphere. Note that unlike the latent jigsaw method, the teams formed in this section can, if desiredm be reused for other activities.

5.1 Personality Types and Teams

Personality types, or learning styles, are tools designed by psychologists to help classify and describe human behavior. These styles often cover a wide range of attributes: how a person prefers to interact with other people, acquire information, form ideas, and act on ideas [7]. Unsurprisingly, styles have been widely used in improving education [7].

For group projects, Jensen, et al [10] investigated the use of the 6-Hats team formation strategy (6HTFS) for forming teams. The 6HTFS classifies people according to the roles they often take in groups (e.g., brainstormers, devil's advocates, etc.). Students were placed into groups so that each group had at least one member who preferred one of the hats/roles. The idea is that each hat makes a key contribution at some point during the solution process. In practice, this proved to be true and resulted in both higher group satisfaction and higher grades.

5.2 Adjustments

In order to use learning styles to form teams for in-class group work, two major alterations are made. Firstly, Felder-Silverman learning styles (FSLS) [4] are used. Because they were developed to specifically describe the learning behaviors of engineering students, these styles work on a finer granularity than more general purpose inventories like 6HTFS and the Myers-Briggs Type Inventory [7].

Since a complete description of FSLS's five axes is beyond the scope of this paper, only the two axes most relevant to group work will be described. First, the Reflective / Active (R/A) axis describes how an individual approaches a problem. Reflective learners prefer to think silently before offering a solution or starting an experiment. Active learners instead prefer to learn by physically trying out new ideas, as well as brainstorming out loud with a group of people. The second axis, the Sequential / Global (S/G) axis, describes how a person acquires information. Sequential learners typically acquire information in small, ordered chunks to form the big picture. Global learners often first grasp the big picture and then the details.

The second alteration is to make the groups homogenous in terms of the members' styles instead of mixing them like in Jensen et al.'s approach. Consider the effects of mixing reflective and active learners. The reflective learners will prefer to think in silence at first, while the active learners will likely want to brainstorm out loud. Similarly, sequential learners will most likely focus on the details while the global learners prefer to look at the big picture. By making the groups consistent, though, the members are likely to all start with the same approach as well as focus on the same level of details. This sameness produces both immediate productivity and uniform participation as the members discuss the different knowledge and ideas that each brings to the table.

In summary, groups were formed using learning styles by the following criteria:

- Group members should have similar R/A scores.
- Group members should have similar S/G scores.

Additionally, a criterion was added to not isolate any at-risk women or minority students [11].

It is important to realize that these are only guidelines for forming teams. In some cases, it might not be possible to achieve all the criteria. Other times, the instructor's personal experiences with a student might be more important when fitting students into groups. Remember, the goal is to assign teams such that all students within a group generally approach problems with the same style but not necessarily the same ideas.

5.3 Example

At the beginning of the term, students were asked for homework to complete the Index of Learning Styles Questionnaire [6] in order to ascertain their Felder-Silverman learning styles. This online assessment identifies the student's dominant style on each style 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. These results were then used to form groups. Table 1 shows the four groups formed for a section of 15 students, four of whom were women.

In general, the criteria from earlier were followed. Greater emphasis was placed on the Reflective / Active axis as these scores directly address how interaction begins within a group. Unsurprisingly, some exceptions were made when teams were assigned. For example, it proved difficult to form groups with similar scores on the S/G axis.

In a few instances, special cases were made for individual students. For example, even though student D4 has a score of 5-A on the R/A axis, he was placed in a group of reflective students. This was largely due to outside interactions between him and me. D4 is naturally quiet and reserved and tends to think before saying anything. While this is characteristic of a reflective learner, he demonstrated to me in office hours a strong preference for learning by doing examples. This explains his score of being moderately active. However, because of his tendency to think before speaking, he was teamed with moderately reflective individuals.

Another break with the criteria was the isolation of female students A1 and B3. Again, personal experiences with these students allowed me to break with the criteria. Aside from being the only active female, student A1 was quite vocal and assertive in both lecture and section. B3 had demonstrated in office hours a natural impulse to help explain concepts to her peers. I had no concern that isolating them would reduce their participation. As it turned out, both women took on leadership roles that emphasized participation from the rest of the members.

Table 1: Discussion groups from a section ($n = 15$).

	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

5.4 Observations

In a bit of serendipity, technical problems delayed me from forming groups, so on the first day that group work took place, the students were allowed to choose their own groups. Many of the undesirable behaviors from Section 2.2 took place. In particular, many students worked alone or not at all. However, when assigned groups were used the next time, the amount of participation was dramatically different. According to my and the observer's observations, all students were engaged and active in their group's conversations.

Of particular interest were the dramatic differences between the active and reflective groups. Upon receiving the problem scenario, the active groups, (e.g., Group A in Table 1) immediately 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. These behaviors were so distinctive that the independent observer, who did not know the constituency of the groups, was able to correctly identify each group as active, mildly reflective, or strongly reflective. Thus, the pacing of interaction within any group was well in line with the group member's learning styles.

Other signs of greater participation and involvement by the students became evident when the class came together to discuss answers. 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 a group 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. Interestingly, this was a group of highly reflective students who rarely spoke in section.

6. CONCLUSIONS

The educational benefits of group work come from the students interacting with each other. As instructors, our goal is to promote participation among our students. For short, in-class group activities, we can achieve this by assigning students to teams that encourage immediate productivity as well as uniform participation among the group members. This paper presented two methods that meet these goals. The latent jigsaw method assigns groups based on prior student knowledge in order to promote peer-teaching and critical thinking. The other method uses Felder-Silverman learning styles to promote participation by creating familiar a social atmosphere to work in. When implemented, each method created a classroom environment in which the students were actively engaged and participating with the other members in their groups.

By taking the time to form groups, the quality of collaborative learning was radically changed. Additionally, my students' own attitudes towards in-class group work appeared to have changed. At the beginning of the term, a student survey revealed that 53% of the 34 students had negative opinions regarding in-class group work. The end of term course evaluations reflected a different opinion, though. Out of the 27 responses, only one student complained about the group work. The rest of the responses were peppered with positive comments about the group activities, including comments about increased socialization, exposure to new ideas, and better learning.

To repeat, interaction is the key to group learning. This paper presented a strong argument for going the extra mile and assigning teams for in-class group activities in order to promote student participation. It is this author's hope that other instructors will find these arguments and the team formation methods useful in their own teaching practice.

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