Examining the factors that impact group work effectiveness in studio physics

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Studio physics, or SCALE-UP, has been found to improve outcomes such as conceptual understanding, problem-solving skills, and student attitudes when compared to traditional instruction. Such an active-learning environment relies heavily on group work. However, little is known about how best to structure groups and train students to work together effectively. In order to understand the factors that affect group productivity, we must first determine a measure for group effectiveness. We conducted a pilot study on group dynamics in the introductory calculus-based physics sequence at Texas A&M University-Commerce. Video analyses were of students working tutorials. Two coding schemes were piloted: behavioral clusters indicating students’ epistemological framing and student engagement. Roles assumed by students were also noted. While coding for behavioral clusters and student engagement represented some aspects of group work well, these schemes did not provide sufficient detail to determine group effectiveness.

Students’ problem solutions can be examined or the exam scores of the individual students in each group can be investigated. Alternatively, the effectiveness of the group can be determined through observations. Scherr and Hammer found through observation that behavioral clusters of the group indicated the epistemological framing of the students. Students’ behaviors can indicate whether they see group activities as simply a task they need to complete or as an opportunity to learn [6].

There are several types of groups, and they vary in their productivity. In a traditional group, the members work together because they have been assigned to, but they are not invested in helping each other. They interact mainly to clarify and confirm. In an effective group, the members are invested in helping each other and believe that by doing so, they will all be more successful. A traditional group is typically only as productive as the individual members, but an effective group is more productive than any individual member [3]. In this work, we focus on determining group effectiveness through observation. While evaluating student work provides some insight, this method does now show whether all group members were actively involved. Similarly, group effectiveness may not accurately be reflected in exam grades due to the many factors that affect exam performance. We conducted a pilot application of two coding schemes to video observations of studio classes at Texas A&M University-Commerce (A&M-Commerce). We used the coding scheme developed by Scherr and Hammer [6] to provide insight into students’ epistemological framing, and we also coded for student engagement to identify whether all students benefited from group work. We evaluated whether these coding schemes accurately represented group effectiveness. Additionally, the roles taken on by students were noted.

II. COURSES

At A&M-Commerce, we converted our introductory calculus-based physics sequence to studio mode in Fall 2015. This sequence includes one semester of Mechanics and one semester of Electricity & Magnetism. Classes meet 3 times
per week for 2 hours each day. Activities include the University of Washington Tutorials in Introductory Physics, University of Minnesota Context-Rich Problems, PhET simulations, and traditional labs. Typical class size is 30 students. Two sections of Mechanics and 1-2 sections of Electricity & Magnetism are offered each semester. Each course section is taught by a different instructor. One of the authors (RML) teaches a section of Mechanics, and one of the authors (WGN) teaches a section of Electricity & Magnetism each semester. One graduate teaching assistant and two learning assistants (LAs) work in each section alongside the professor. Students in these courses are typically science and engineering majors. The percentage of female students in each class typically varies between 10% and 20%.

Students are assigned to work in groups of 3 or 4. They change groups twice during the semester. Groups are mixed ability, so each group has a member from the top-, middle-, and bottom-third of the class based on pre-testing and exam performance. In addition to these criteria, instructors and LAs work together to structure groups based on student personalities, in particular to avoid problems with one student being dominant.

Several methods are used to promote effective group work. During the first week of class, instructors provide information to the students about expectations for group work, and the students begin working together on an icebreaker activity. In-class assignments are always turned in as a group. For each group assignment, students rate each other for teamwork and bottom-third of the class based on pre-testing and exam performance. During the 2015-2016 academic year, students were randomly assigned roles at the beginning of each class: Manager, skeptic, or recorder. How-
FIG. 1. Time lines of behavioral cluster codes for each group. Colors indicate code. Blue: Completing worksheet, Red: Listening to instructor, Green: Engaged in discussion, Yellow: Joking, Grey: Other. Each segment represents 1 minute.

Mechanics Group B consisted of one white female (Tracy), two Hispanic males (Mark and Russ), and one white male (Sam). Tracy and Mark sat next to each other and across from Sam and Russ. Sam read all of the questions aloud and kept the group moving forward. He often made comments about needing to leave early. Mark spent a lot of time fidgeting and leaning over the table. Tracy engaged in discussion with Sam the most of all the group members, and while she understood the material well, she did not take the lead. Russ was quiet for the majority of the time and only occasionally asked questions. Hence, Sam was the manager, and Tracy occasionally acted as skeptic, while the other two group members did not assume any meaningful role. As shown in Figure 2, this group spent more time joking and less time engaged in discussion compared to Group A.

Electricity & Magnetism Group A consisted of one Asian female (Evelyn), one Asian male (Ben), and one Hispanic male (John). Evelyn and Ben sat next to each other and across from John. Evelyn read aloud all of the questions and stated her ideas for the answers. While the other two students appeared to be actively listening based on eye contact and straight posture, they rarely contributed to the conversation. Ben would occasionally correct Evelyn. John sometimes asked a question or became more involved when there was an opportunity to manipulate equipment. Evelyn was the clear manager, and only very rarely did either of the other group members act as skeptic. Figure 3 shows that during the majority of the time all of the group members were involved, but this does not show that involvement, for Evelyn, meant speaking and, for Ben and John, meant active listening. The lack of conversation is also reflected in the small percentage of time devoted to joking.

Electricity & Magnetism Group B consisted of four white males (Josh, Matt, Phil, and Brian). Matt and Josh sat at opposite corners of the table. Though all group members contributed to the conversation, Josh and Matt did the majority of the talking. Matt stated his ideas confidently, leading the group as manager, while Josh often took on the role of skeptic. Phil and Brian both contributed occasionally. This group spent more time joking with each other than Group A did. They also discussed topics only tangentially related to the tutorial as represented by Other in Figure 2. The involvement of all group members is reflected in Figure 3, but this does not show which group members spoke the most.

V. DISCUSSION

An effective group should be more productive than any individual in the group and should benefit all of its members. A group is most effective when the students frame the activity as an opportunity to learn rather than only as a task they have to complete. We sought to determine if the two coding schemes applied reflected group effectiveness by these criteria. In the Mechanics course, Group A appears to be more effective than Group B. They spend more time engaged in meaningful discussion as shown in Fig. 2 indicating that they are trying to learn. Additionally, Group A keeps more of its members involved than Group B does as reflected in the much smaller percentage of time Group A spent working separately as shown in Fig. 3, so more of its members benefit from group work. Group A is still not ideal though as the group splits and one...
student is on his own for much of the time. The determination of the coding scheme agrees with the instructor’s views of the groups. In Electricity & Magnetism, the distinction between the two groups is less clear. Group A spends a larger percentage of time involved in discussion as shown in Fig. 2, while Group B involves all of its group members for a slightly larger percentage of the time as reflected by the smaller percentage of time spent working separately shown in Fig. 3. Based on these coding schemes, Group A would be more effective in terms of spending their time in active discussions, and Group B would be more effective in terms of involving all group members. However, discussion appears very different in Groups A and B. In Group A, discussion is one student doing most of the talking (Evelyn) with infrequent input from the other students. In Group B, discussion is one student leading (Matt), one student challenging this leader (Josh) indicating his interest in learning, and two other students occasionally providing their input. The coding scheme used for student engagement does not provide this information. The instructor believed Group B to be more effective.

The roles assumed by the students may impact the effectiveness of the groups largely through affecting the nature of discussion. In mature groups, members will take on roles naturally and rotate as needed [3]. As noted earlier, the instructors did not assign roles during this semester. All students were expected to record during tutorials regardless. Students took on their preferred roles of manager or skeptic naturally, while some students were more passive. Every group had a manager, but managers varied in their abilities to keep the entire group on task. The most notable difference between groups is the extent to which they had a true skeptic. Clark in Mechanics Group A and Josh in Electricity & Magnetism Group B spent large portions of class time acting as skeptics which led to more animated and meaningful discussion because they prevented the group from settling on answers without conversation. Tracy in Mechanics Group B only occasionally acted as skeptic, and Ben and John in Electricity & Magnetism Group A also only very rarely acted as skeptics. Discussion in these groups was less animated and less meaningful. However, the coding schemes applied do not reveal this information.

VI. CONCLUSION

We pilot tested two coding schemes to determine group work effectiveness in studio physics by observing groups working on tutorials in the two-semester calculus-based introductory sequence. Group work was coded for behavioral clusters and involvement of group members. In addition, the roles taken on by each student were noted. More time spent in the engaged in discussion cluster was used as an indicator of group effectiveness along with the percentage of the group members actively involved. While the coding schemes agreed with the instructor’s views in Mechanics, the determination of most effective group in Electricity & Magnetism was less clear cut. In particular, coding for behavioral clusters does not reveal the nature of the discussion, such as whether students acted as skeptics or more frequently readily agreed with each other. Additionally, the percentage of group members involved leaves out crucial information such as how frequently each person speaks and who is listening. Due to the complex nature of group dynamics, the coding schemes will need to be revised to better reflect more aspects of group work that indicate group effectiveness. In the future, we will extend our analysis to video from two additional semesters, including problem-solving and lab activities, and analyze student interviews.