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Work in Progress: Dialogue Videos Foster Interaction Between Homework Partners

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Introduction

Interaction between students enhances learning gains when these interactions involve constructive inferences and each student participates by making constructive inferences [1]. When students are outside of the classroom, achieving that quality of interaction is challenging, but doing so would greatly enhance the students' preparation for class or follow-through after class. In this study we seek to use dialogue videos to foster interactions between pairs of students outside of the classroom while working on homework in a flipped bio-transport class (fluid dynamics, heat transport, and mass transport). Thus, our research question is: Do dialogue videos enhance learning and foster interaction between students?

In each dialogue video, a student/tutee works an example problem while the instructor/tutor assists the tutee and ensures that the tutee thinks out loud. Monologue videos, instructor only, were also recorded for some of the examples – keeping as much of the content the same as possible with the corresponding dialogue video. The homework problems assigned to students share deep features with the example shown in the video, but differ in surface features so that students cannot simply copy the work done in the example video and instead need to construct new knowledge (their homework answers) not shown exactly in the video. The pair (two homework partners) turn in one collaborative homework solution; thus, the method encourages collaboration between the homework partners.

Methods

Students in a bio-transport class were assigned into pairs (dyads). We did not include a control in which students work alone because that has been extensively compared with students working interactively, and interactive learning has been shown repeatedly to lead to enhanced attainment of learning objectives [2]. Each week, the following sequence was conducted. (1) Each student took a pre-quiz consisting of 4 questions. (2) Dyads worked collaboratively on a homework assignment that shared deep features (but differed in surface features) with an example video that the dyad watched while working together on their homework. Dyads video recorded themselves during this process. (3) Student teams submitted their completed homework and video file on the due-date of the homework. (4) Each student took a post-quiz consisting of 4 questions closely related to the questions asked on the pre-quiz.

Pre and post quizzes were scored on a 5-point rubric yielding total scores between 0 and 16 for each. Cohen's d (effect size) was calculated ([3]: $(\mu_1-\mu_2)/s$), and average post-quiz scores were compared by paired t-test or repeated-measures ANOVA. Students' self-recorded videos were coded for the quality of their interactions as described by [1].

Two factors were varied: (1) the scaffolding (instructions) given to the students and (2) whether students watched a dialogue video or monologue video. Statistical analyses of the number of interactive episodes for each group are performed (by coding interactions observed in the students' self-recorded videos) to test the hypothesis that students watching dialogue videos have more interactive episodes and higher learning gains than students watching monologue videos and students receiving feedback in their scaffolding have more interactive episodes and higher learning gains than students who did not receive feedback in their scaffolding.

Survey data (Intrinsic Motivation Instrument [4]) was collected asking students several questions relating to student perception of value, cost, and efficacy of using these videos to learn transport phenomena. These surveys also asked for students to state their preference for particular scaffolding methods and dialogue vs. monologue video format.

Results

Five trials (different homework assignments) were conducted in which students took a pre-quiz, watched a short online lecture about a topic, worked in dyads on a collaborative homework assignment while watching an example similar to their homework problem, and then took a post-quiz. This was all accomplished prior to any in-class instruction on the topic covered in the homework. Post-quiz scores on all five trials (shown in Table 1) averaged 68.4% vs. an average of 23.8% on pre-quiz scores (normalized learning gain of 58.5% on average).

Table 1. Pre-quiz and post-quiz scores on assessments for all 5 trials conducted to-date.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Pre (n=)	35.2% (87)	32.7% (80)	11.9% (86)	29.7% (74)	8.8% (74)
Post (n=)	73.2% (88)	64.0% (87)	72.2% (85)	65.0% (84)	67.1% (82)

There are two commonly used metrics that we can use to compare this with other standard teaching methods: Cohen's d (effect size) and absolute scores on post-quizzes. Walberg [5] and Bloom [6] presented effect sizes for several standard educational methods including assigned homework (d=0.30), graded homework (d=0.80), and one-on-one tutoring with a teacher (d=2.00). These indicate that 62% (small effect), 79% (large effect), and 98% (huge effect) of students participating in these interventions had greater learning gains than students who did not participate in these interventions. The effect size for our method of collaborative homework while watching a dialogue example video is d=2.54 (categorized as a "huge" effect), indicating that 99% of students doing homework this way exhibited greater learning gains than students prior to this learning. This is much better than standard graded homework, and it even compares favorably to one-on-one tutoring.

Absolute learning as demonstrated by a post-quiz is very good, mean of 68.4%, but this is not quite as good as one-on-one tutoring by a teacher can achieve (approximately 80% according to Van Lehn et. al [7]). However, the students have not even set foot in the classroom by the time they have achieved 68.4% of these learning gains. This process takes place in the context of a flipped class, so in-class learning can begin at this point to help students better achieve the learning objectives. In particular, students in a flipped calculus III class better achieved learning objectives related to conceptual understanding [8], and additional gains beyond 68.4% are likely to have been achieved through in-class instruction subsequent to this collaborative homework with dialogue video process. The seeming disparity between our Cohen's d being greater than tutoring yet our post-quiz scores being less than tutoring is most likely due to larger variance (S) for the tutoring studies reported by Bloom and Walberg.

Among the 5 trials, the first three included variations in the instructions given to students. One particular set of instructions, that included task-oriented feedback half-way through the process, resulted in a statistically significant increase in student learning gains. To do this, the instructor created a Word document including information and/or questions that led students to check their work at each critical step in the process of solving the homework problem. Students were instructed to talk with their homework partner about this information and, if they decided they had not done the homework correctly, to try those parts of their homework again.

The last two trials varied whether the video was a dialogue video (tutee doing the problem under guidance of the instructor) or a monologue video (same example worked by the instructor alone). The mean post-quiz results for students watching dialogue videos (67.1%) were 2.1% greater than the mean post-quiz results for students watching monologue videos (65.0%), p=0.13 in paired t-test of each student in each condition (mean pre-quiz scores were identical between the two groups, 19.3% for both monologue and dialogue). Although this result does not meet our pre-established $p<0.10$ criterion for statistical significance, this result is suggestive of a small effect size ($d=0.2$) showing that dialogue videos are slightly better than monologue videos for eliciting learning in this format.

However more students prefer monologue videos (46%) than prefer dialogue videos (28%). The most common reasons given were that the monologue videos were quicker to watch and the instructor made fewer mistakes so students weren't confused about whether a demonstrated method might be incorrect. Students who preferred the dialogue videos stated that they could identify with the tutees' questions, and they got to see more details of how and why they were supposed to take certain steps in the solution of their homework problems.

Table 2. Intrinsic Motivation Instrument survey. (1 = not true at all, 7 = very true)

	Mean (1 to 7)	Standard Deviation (1-7)
Value/Usefulness of videos	3.7	1.8 (n=83)
Value/Usefulness of homework format	2.9	1.8 (n=83)
Effort/Importance of homework format	4.6	1.8 (n=83)
Perceived Competence in homework format	4.5	1.5 (n=83)
Effort/Importance of transport phenomena	6.3	0.9 (n=21)
Value/Usefulness of transport phenomena	5.8	1.1 (n=21)

Finally, we surveyed the students using the Intrinsic Motivation Instrument [4] to assess their intrinsic motivation to learn transport phenomena in general and their motivation to use this video format for learning problem solving specifically. We hypothesized (1) that students would be more motivated learning from a student tutee in a dialogue video than from the instructor in the monologue videos and (2) that working examples and homeworks based on real-world biomedical problems would enhance the students' intrinsic motivation to learn transport and/or apply transport to real-world problems. The scores of 6.3 out of 7 and 5.8 out of 7 for the effort/importance of transport phenomena and the value/usefulness of transport phenomena indicate that students do see the real-world significance of the content they are learning. However, students generally disagreed that the homework format had value / was useful (2.9 out of 7). Thus, there is an apparent mismatch between the learning gains demonstrated in this method with the value the students perceive in this method of learning.

Discussion

The method shown here, in which students work collaboratively with a homework partner to complete an assignment similar to an example shown in a video dialogue between a student tutee and the instructor, has great potential for online learning of engineering topics. In this case, the class was a flipped class that met in-person on a traditional university campus. So, in this case, use of these videos allowed one instructor with a large class (~100 students) to teach complex problem-solving skills to that number of students effectively. Providing a document with information allowing students to double-check their work (task feedback) somewhat enhanced learning. And dialogue videos were likely better than monologue instructor-led examples in achieving learning gains. Although this method ($d=2.5$, post-quiz 68.4%) is not quite as good as the educational gold standard of one-on-one tutoring ($d=2.0$, post-quiz ~80%), this method can be scaled to large numbers of students working asynchronously from the instructor.

One challenge to overcome is the students' resistance to this homework format. The biggest complaint expressed by students was the need to work with a homework partner. Since interacting with a partner is an integral reason why this method likely works as well as it does, students' aversion to completing homework with a partner is a challenge to implementation. A 2017 study by Pociask and co-workers [9] indicates that over half of students prefer to self-select their teammates, and many others would prefer to work alone. Anecdotal discussions with students indicate that students' desire to work alone is mostly due to busy schedules incentivizing working quickly (which students perceive can best be done working alone) and to a desire to not be dependent on teammates who may not pull their weight. Thus the problem could partly be solved by allowing students to choose their own teammate, but this may have adverse effects on the learning of students who do not enter the class knowing a study partner.

In ongoing work, we plan to study (a) the quality of interactivity of students conducting homework this way, (b) the possible benefits to students who enter the course with lower prior knowledge, and (c) conduct repeated measures using the same homework assignments but with a new cohort of students.

As a part of this study, we have asked students to record themselves doing the homework together so that we can assess the quality of their interactions. Although we tried to avoid bias by making it clear to students that their self-recorded video would have no influence on their grade, it is possible (or even likely) that students choosing to participate in the study by self-recording themselves were more likely to be interactive because they were self-recording than would other students who did not choose to participate in the self-recording. With that caveat, we will analyze the students' self-recorded videos by coding those for interactive episodes. These can be quantified and correlated with student attainment of learning objectives (assessment scores). We expect that this will provide information about whether students actually work interactively on these homework assignments, whether one student does the preponderance of the work, or whether students merely take turns doing the work (but not interacting while the other takes a turn).

One interesting result that is not yet fully analyzed is the possible disproportionate benefit to students who enter the course with lower prior knowledge. Freeman and co-workers [10] found a likely benefit of active learning for under-represented minorities, so this result would not be unexpected. We did not explicitly study the ethnic status of our students, but we did categorize students into "higher" prior knowledge and "lower" prior knowledge based on their pre-assessment scores for each assignment. Although it is not statistically significant at this time, our approach is trending toward having greater benefit for dyads of two lower prior knowledge students than for mixed dyads (one higher and one lower prior knowledge) or for dyads of higher prior knowledge students. Additional data and better control for this variable may allow us to make this conclusion in a future publication.

Finally, we continue to collect data to increase our sample size as well as determine variability when offering the same homework assignments to a second cohort of students. This will allow us to determine whether some effects may have been due to the relative difficulty of some assignments vs. others or whether these effects are really due to the causes we mention above. Added sample size may also lead to greater confidence in our conclusions as well as possibly adding statistical significance to observed trends that are not currently showing statistical significance.

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