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Work in Progress: Teaching Effective Teamwork Skills in Biomedical Engineering Laboratory Courses

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Introduction

In order to effectively solve the complex problems of today, engineers are often required to work in teams [1]. ABET accredited programs are therefore required to equip students with "an ability to function effectively on a team […] [2]. Although there are many opportunities throughout the undergraduate engineering curriculum to incorporate team work (i.e. group assignments and presentations, lab courses, design projects, etc.), students do not typically receive formal guidance on how to be an effective teammate. This can limit students' opportunities to conscientiously practice and improve upon their team-working skills.

Students placed in teams without additional guidance on effective teamwork techniques can struggle, and the team may merely divide work without collaborating with one [3, 4]. Using a peer evaluation process has shown to increase accountability of team members as well as increase students' self-awareness [5], [6]. Yet, Jassawalla et al. found that the peer evaluations cannot help students who do not believe they have ineffective team skills [7]. Additionally, peer evaluations can also be inflated if students are required to justify their ratings, and may therefore not properly capture team dysfunction [8], [9].

We are ultimately aiming to develop activities that promote early metacognition and effective team-working behaviors in undergraduate biomedical engineering laboratory courses. This work-in-progress discusses the early stages of our studies, in which we seek to understand whether the simple act of implementing a collaborative cloud-based lab notebook keeping process impacts student performance in lab courses, compared to individualized student lab notebook keeping. Additionally, we summarize student perceptions of good collaborative habits through the evaluation of open-ended post-course peer evaluation surveys. We plan to use these findings to inform our approach for introducing metacognitive pre-course teamwork surveys into our lab courses, thereby helping students to practice and improve team-working skills.

Methods

Course Structure

Our curriculum requires biomedical engineering majors to complete three separate, identically structured upper-level laboratory courses in which students work in pairs to design and conduct experiments, analyze data, and document findings in a laboratory notebook. In 2016-2017, we implemented a cloud-based electronic lab notebook platform (LabArchives Classroom Edition), and measured significant student improvement in communication, documentation, and presentation skills compared to paper-based notebook keeping [10]. Students were required to complete the notebooks individually, even though they were collaborating in lab on their experiment.

In autumn 2017, we transitioned the electronic lab notebook from an individual to a team assignment in order to provide a more collaborative student learning opportunity. Participants in the study were either a junior or senior level undergraduate student enrolled the biomechanics

laboratory course, and engaged with the lab course and electronic notebook keeping as previously described [9]. At the end of the course, students submitted their team notebook for summative assessment. Additionally, each student completed a self- and peer-evaluation survey asking to rank contribution of themselves and their partner on a Likert-scale and provide comments to justify the rankings.

Team Performance Evaluation

All twelve team notebook submissions from the autumn 2017 Biomechanics laboratory course were analyzed for performance in communication, documentation, presentation and overall quality using the rubric and methods previously described [10] . These results were compared to the same analyses performed on individually completed lab notebook submissions (n=40) from the autumn 2016 Biomechanics lab offering [10].A t-test analysis was performed between the two groups using JMP Statistical Software to identify whether team-based notebook keeping impacted student performance.

Peer and Self-Evaluation Analysis

Both quantitative (Likert-scale ranking) and qualitative open-ended response data were collected via survey from each student enrolled in either the autumn 2017 or the spring 2018 lab course (n=52). The open-ended responses from the post-course peer evaluation surveys (n=52) were scored by totaling the number of instances that positive or negative behaviors characterized were mentioned [9], [11].

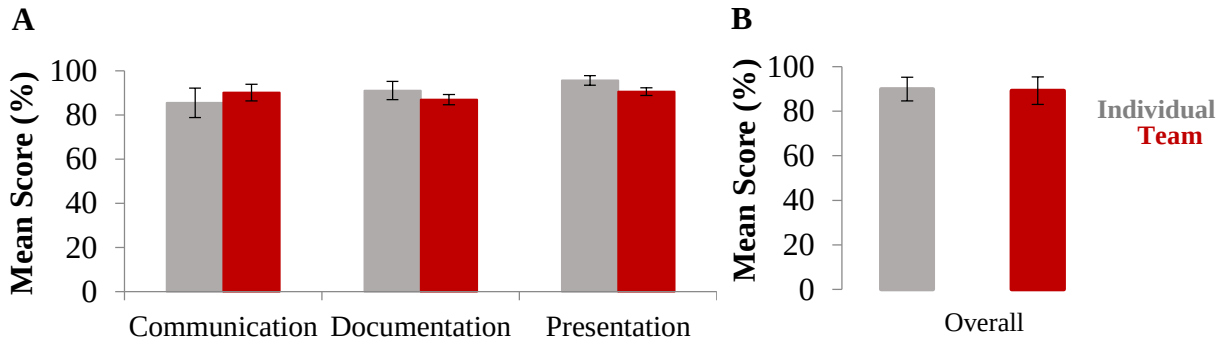

Figure 1: Average laboratory notebook scores completed as an individual (grey, autumn 2016) and as a team (red, Autumn 2017). There were no significant differences between team and individually completed notebooks in either **A)** each of the three rubric categories (communication, documentation and presentation), or **B)** the overall mean notebook scores. Rubric scores are presented as percentages. $\alpha = 0.05$.

Results and Discussion

We found no statistical difference in submission quality between lab notebooks completed individually versus those completed as a team (**Figure 1A**). The overall mean score in each category was also not significantly different ($p < 0.05$) between individual and team electronic laboratory notebooks (**Figure 1B**). In a previous study, we compared individually completed electronic to paper-based lab notebook submissions against the same rubric, which were designed to measure how well the lab notebook met the assessment criteria areas of communication, documentation, and presentation [10].The results showed students who submitted lab notebooks electronically had significantly higher overall mean and category-

specific scores than students who submitted lab notebooks on paper ($p < 0.05$). However, the results in this current study suggest that the quality of electronic notebook submissions is not impacted by whether the notebooks were completed individually vs. as a team. The average grade on the individual electronic notebooks was above 85%, and thus seeing improvements of statistical significance would be difficult. Therefore, these results indicate that team collaboration should be examined by a different method.

All students enrolled in the autumn 2017 and spring 2018 Biomechanics lab were required to complete a peer- and self-evaluation survey at the conclusion of the course. Students were asked to rate themselves and their partner on contribution and engagement in the lab, as well as provide comments to support their rating. It was found that nearly every student scored themselves and their partners with a 5/5 score. In the open-ended comments, students collectively mentioned 119 behaviors about their partner and 92 behaviors about themselves. Out of 119 behaviors mentioned in the peer evaluation, 113 were positive behaviors. Similarly, 88 out of 92 behaviors were positive in self-evaluation. The positive behaviors mentioned most often were being dependable, cooperating and communicating with each other, as well as putting forth effort. However, students mostly discussed these behaviors in terms of accomplishing work, which may mean that some teams are merely dividing up work and not truly collaborating with one another. Additionally, since the surveys were conducted at the end of the course, teammates were not given an opportunity to reflect upon their behaviors.

Ongoing Work

For the reasons discussed above, students may need guidance on how to be an effective team member prior to the start of lab. The aforementioned results from the peer- and self-evaluations will aid in informing an intervention to promote effective team-working skills. We propose a metacognitive approach using the reference of behaviors characterize by Baker and Miller [9], [11] in which students will participate in a more directed self- and team-reflection on incorporating effective team-working behaviors in the lab. This intervention will be delivered at the beginning of the course in half of the labs offered in autumn 2018. We anticipate this technique will allow students to develop self- and team-awareness, accountability, and goals specific to meeting the course objectives. The impact of our intervention will be measured using a post-lab self- and team- evaluation for all autumn 2018 lab sections, to compare whether the pre-lab metacognitive intervention impacted students' approach to teamwork. We will also re-measure team notebook submission quality to understand whether metacognitive approaches to teamwork can impact the quality of student work.

Conclusions

The mere implementation of collaborative cloud-based lab notebooks did not impact the quality of work in comparison to the individual cloud-based lab notebooks. These results suggest that additional activities should be considered to promote and measure effective teamwork. Ongoing work includes the development of pre-course student surveys that aim to improve student self-awareness, self-motivation and other behaviors that contribute to effective teamwork.

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