Investigating the Impact of an Online Collaboration Course on Students' Attitudes and Learning

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Abstract: Collaboration and teamwork are critical skills in today's workplace, but teaching them effectively remains a challenge. Collaborative U, an online instructional resource that students complete at the start of a major group project, was designed to address this issue. We present results from a randomized controlled trial comparing Collaborative U to a control condition equated on format and duration. Students in the Collaborative U condition maintained their initial high positive attitudes towards collaboration from pre to post, whereas students in the control condition showed a decline. Furthermore, students who completed Collaborative U learned more from pre to post and also rated team process and final products significantly higher than those in the control condition on a variety of attributes. Our findings offer encouraging evidence for the efficacy of a short, online intervention in supporting teamwork skills, and have important implications for integrating team-based activities into classrooms.

Keywords: collaboration, teamwork, higher education, open learning, online learning

Introduction

The benefits of learning with one or more peers have been documented extensively in the learning sciences and educational literature (Johnson, Johnson, & Smith, 1987; Roschelle & Teasley, 1999). Learning collaboratively has been shown to benefit students of various age groups, and institutions of higher learning have been increasingly integrating collaboration into their classrooms as a way to increase active learning (e.g., Barkley, Cross, & Major, 2014). Engaging in team projects during college years also helps students develop important skills for today's workplace, where most will be required to work in teams, as emphasized by several frameworks that outline key 21st century skills (AAC&U, 2015; Dede, 2006).

Despite the myriad cognitive and motivational benefits of collaboration, it does not always yield positive outcomes. For example, teams may fall prey to the effects of social loafing (Karau & Williams, 1993), fear of evaluation (Paulus & Dzindolet, 1993), or production-blocking (Diehl & Strobe, 1987), which may hinder a team's productivity. Students sometimes report dissatisfaction with project teams (Barfield, 2009), and worry about the fairness of their individual grades (Comer, 1995), and instructors may grow weary of troubleshooting collaborative activities in the classroom (Panitz & Panitz, 1998).

In this research, we report results from an online intervention designed to provide students with the tools to effectively engage in face-to-face collaborative interactions, such as working together on a team project. The goals of the intervention were to improve the quality of students' collaboration by helping them engage in productive team skills and contribute evenly to a common goal. We describe results from a large-scale randomized controlled trial, in which first-year college students were assigned by section to an intervention group that participated in online instruction focused on improving collaboration skills, or to a control group that received an online instruction of similar format and duration but not related to collaboration. We investigated the effects of the intervention on students' performance, attitudes, and learning.

Background and literature review

The term 'collaborative learning' refers to the practice of assigning students to work in teams of two or more to produce or create something (Dillenbourg, 1999). It is incorporated into college classrooms in a variety of ways, including but not limited to group projects, think-pair-share activities, and peer reviews, among others. However, the degree to which groups are successful differs. Many studies in higher education have found collaboration to be better than individual learning (see Lou, Abrami, & d'Apollonia, 2001; Springer, Stanne, & Donovan, 1999 for meta-analyses), but others have found no difference (e.g., Crooks, Klein, Savenye, & Leader, 1998), and a handful have found collaboration to be worse than individual learning (see Kirschner, Paas, & Kirschner, 2009 for a review).

Several studies have found that when students receive collaboration support, it improves their collaboration, and leads to better outcomes compared to when they collaborate in the absence of support (Weinberger, Stegmann, & Fischer, 2010). Collaboration support may take the form of collaboration scripts (Rummel & Spada, 2005), prompts (Xie & Bradshaw, 2008), guided activities, collaborative argumentation (Asterhan & Schwartz, 2009), workshops, or readings that address collaboration. Some of these strategies are strongly supported by evidence (e.g., Rummel and Spada, 2005), whereas others have not received strong support (e.g., Rau, Kennedy, Oxtoby, Bollom, & Moore, 2017). In the present work, we took a cognitive task analysis approach (see Crandall and Hoffman, 2013 for a review) to identify, instruct, and provide practice on several key skills that team members need. The idea was to promote learning of key skills in the online resource in a variety of contexts, some designed to be fairly realistic, and immersive experiences, so that students would be able to transfer these key skills to their real-world teams.

Learning interventions tested in controlled laboratory settings often show promising results, but when applied at scale in larger classroom environments, the effects are frequently not sustained (Elmore, 1996). It is also difficult to assess the efficacy of such interventions at scale, because implementing randomized controlled trials in educational settings presents numerous challenges (Cook, 2002). As a result, evidence on efficacy of learning interventions often falls short of the "gold standard" of randomized controlled trials (Whitehurst, 2003). In this research, we aimed to apply findings from basic research and test our intervention at scale, in the context of a "gold standard" randomized controlled trial.

Present study

We created an online instructional module that teaches collaboration skills as a form of collaboration support. We tested its effectiveness thoroughly by delivering it within a randomized controlled experiment, such that one group of students received our intervention, and the other received a control module of similar duration and format. Students applied those skills in a face-to-face collaborative project that they completed as part of a general education seminar taken by all first-year math and science students at Carnegie Mellon University.

Method

Course description

EUREKA! is a seminar-based course that is taken by all first-year students in the Mellon College of Science and is a requirement for graduation. During the seminar, students are exposed to campus resources that promote academic and personal success, and they participate in recurring self-assessments that promote personal well-being, academic improvement, and ethical decision making. Most pertinent to the current study, students also work on team projects focused on a scientific research topic of their own choosing. Students work over much of the semester in teams of 3-5 to produce a short video on a research topic of their choosing, and lead an in-class discussion/activity as a group. All students took an individual pretest before the online intervention, to assess their personal attitudes towards collaboration and their knowledge of good collaboration practices. An identical immediate posttest followed the intervention (also completed individually). At two points during the group projects, students rated their peers as well as themselves on contributions to the team. Finally, students were evaluated on their final products by both their instructors and their peers (see Figure 1 for timeline).

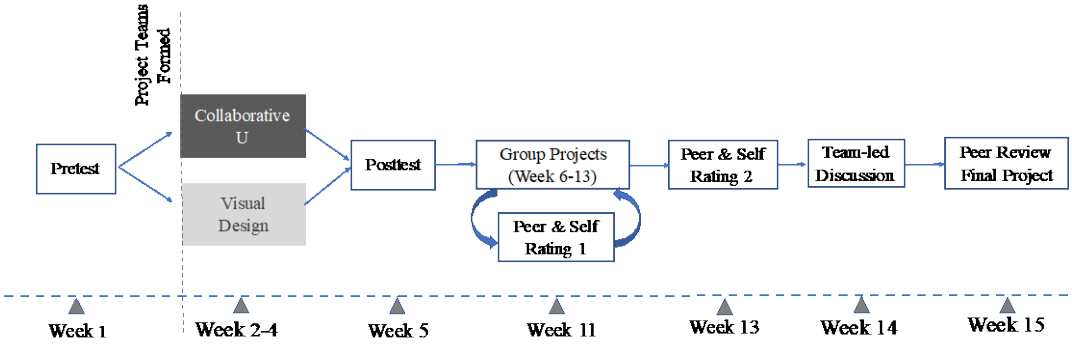

Figure 1. Timeline of Activities.

Developing the intervention: Collaborative U

In 2015, Carnegie Mellon University made acquiring collaboration and teamwork skills a critical priority for all students and a goal of its strategic plan. An interdisciplinary team was assembled around a proposal to build

evidence-based, scalable, faculty-friendly basic training for students involved in group projects. The resulting prototype, Collaborative U, is a 3-hour online instructional module informed by rigorous research and practical experience on structuring effective collaborative teams. For example, Woolley and colleagues have shown that social sensitivity and equal participation among members are some of the key factors that improve effectiveness of teams (Woolley, Aggarwal & Malone, 2015). We also leveraged interactive training methods developed and refined over a decade of training student project teams in traditional face-to-face workshops by collaboration and conflict skills trainers.

Figure 2. Screenshot showing one of the "learning by doing" activities in Collaborative U.

Collaborative U combines online modules that students work through individually with face-to-face practice activities performed as teams. Instructors assigned Collaborative U as part of EUREKA! at the start of the team projects. Students completed two hour-long units individually online, covering basic diversity communication and conflict resolution skills. After each unit, students completed a 20-minute activity in their project teams, discussing members' strengths and differences and practicing skills for navigating conflicts constructively. The online modules involved an extended video-based interactive scenario for skill demonstration and practice, and a variety of other realistic practice environments, such as texting and video chats (see Figures 2 and 3 for examples).

Collaborative U was deployed using the Open Learning Initiative (OLI) platform. OLI is an open educational resources project at Carnegie Mellon University that allows instructors to develop online courses consisting of interactive activities and diverse multimedia content. OLI courses are sometimes delivered asynchronously without an instructor; in other cases, they are used by instructors to support and complement face-to-face classroom instruction. Studies that compared student learning in a blended (face-to-face plus OLI) course on introductory statistics to a traditional, face-to-face version of the same course showed that students learned better and in half the time in the blended-OLI format (Lovett, Meyer, & Thille, 2008; 2010).

Figure 3: Example of an immersive, real-world activity in Collaborative U.

Control condition

Like Collaborative U, the control condition was a set of OLI modules, with a similar format but focused on a different topic. The control modules addressed visual design, so there was a reasonable mapping of that instruction to help students make better team products. The in-class activities that teams worked through after the individual unit work were focused on visual design for all students in the control group.

Study design

We investigated the impact of Collaborative U on actual team function in a course assignment. The EUREKA! course had thirteen recitation sections, seven of which were randomly assigned to receive the Collaborative U OLI modules, and the remaining six to receive a control OLI resource targeting visual design. Students from both conditions completed pre/post-tests on teamwork. The time on task was roughly equivalent across groups. Two 20-minute face-to-face team activities and discussions were completed in class (focused on either teamwork or visual design, respectively) so that students could apply what they learned in the OLI modules.

Participants

Participants were first-year students enrolled in the EUREKA! seminar at Carnegie Mellon University. 120 students completed the Collaborative U module, and 106 completed the control module. The gender distribution across both conditions was 50-50.

Research questions

We assessed the impact of collaborative support in the form of an online instructional module, Collaborative U, relative to a control module of equal duration on students' team process, learning, and performance. Specifically, we asked the following questions:

1. How does Collaborative U impact students' attitudes towards collaboration, and their knowledge of good collaboration practices from pre to post, compared to control?
2. How does Collaborative U impact student's self-ratings and ratings of their collaborative peers in terms of team process, relative to control?
3. How does Collaborative U impact the final team product, in this case, a project video and in-class discussion, compared to control?

Measures

Pre and post tests

Before and after the intervention, students responded to two five-item questionnaires, on which each item was rated on a five-point scale, with 1 corresponding to "Strongly Disagree" and 5 corresponding to "Strongly Agree". These scales measured students' attitudes towards collaboration and their knowledge of what makes a good team. They also took a conceptual knowledge test on collaboration before and after completing the intervention on which they could score between 0 and 4 points.

Students' self ratings and peer ratings of team process

Students rated themselves and their teammates at two time points on the following attributes: promptness and attendance at team meetings, preparedness at meetings, effort level, attitude, helpfulness, content knowledge, effectiveness toward project goals, flexibility, and desirability as a team member. The ratings were on a scale of 1-4, with 1 indicating *never/ rarely*, and 4 corresponding to *always*. The first peer rating was completed at week 11, about 5 weeks into the team project, immediately after the video was due, and the second peer rating was completed at week 13, after the teams led in-class discussions.

Peer reviews of final project videos

Each student used a rubric to grade videos produced by every other team. They rated the videos on a scale of 1-10 on the following attributes – objective, summarization, clarity, time distribution, interest, audio quality, video quality, group dynamics, and relevance, and assigned an overall score.

Results

In this section, we will first present results from pre and post assessments for the *Attitudes towards Collaboration* and *Charactersitics of good team* scales, as well as the content knowledge test. We will then describe results from students' self-ratings and peer ratings of team processes. Finally, we will present results from peer reviews of final project videos.

Pre and post tests

Overall, on students' mean rating on the *Personal attitudes towards collaboration* scale, there was a marginal effect of test time, such that both conditions changed significantly from pretest to posttest, $F(1, 208) = 2.81$, $p = .09$. Students in both Collaborative U and control conditions showed a marginal decline in their mean scores from pre to post. However, this decline was driven primarily by the control condition (see Figure 4a). Analyses of simple effects indicated that the decline from pre to post was marginally significant for the control condition, $F(1,208) = 3.68$, $p = .056$.

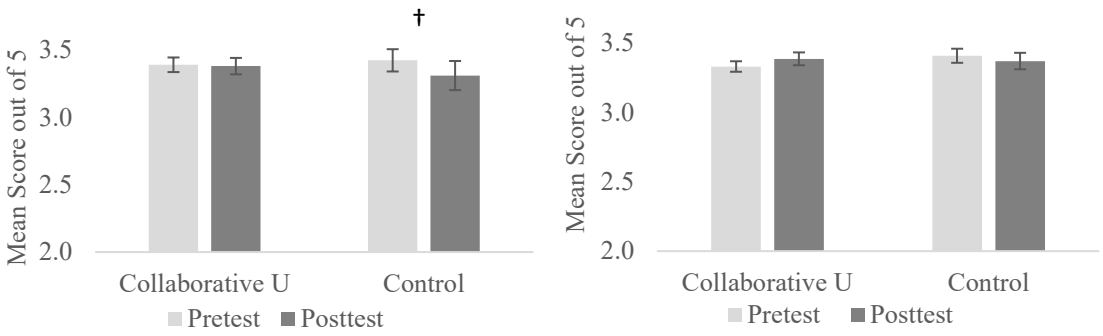

Figure 4. (a) Personal attitudes towards collaboration and (b) Characteristics of good teams.

On the *Characteristics of good teams* scale (see Figure 4b), there was no main effect of test -time, $F(1, 208) = 0.39$, *ns, i*ndicating that overall, there was no change from pre to post . The interaction between test-time and condition was not significant $F(1,208) = 1.14$, *ns* . Examination of means suggests that students in Collaborative U showed a slight improvement, and those in the control condition showed a slight decline, however, since the main effects and interaction did not reach significance, follow up tests were not conducted.

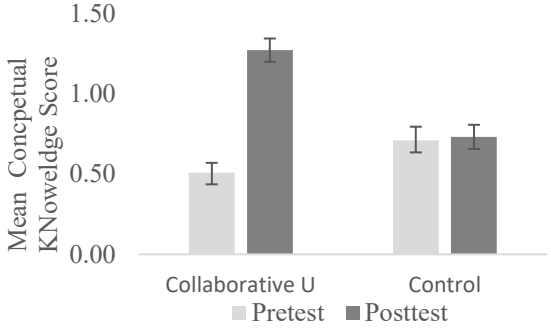

Figure 5. Performance on content knowledge test.

Students also took a conceptual knowledge test on collaboration before and after completing the intervention, on which they could score between 0 and 4 points. Figure 5 shows the mean pretest and posttest scores for each condition. A repeated measures ANOVA was significant for test-time, $F(1,209) = 36.47$, $p = 0.00$, indicating that all students improved from pre to post. The main effect for condition was also significant, indicating that the means for the Collaborative U and control conditions were significantly different, $F(1, 209) = 4.08$, $p = 0.04$. A test-time by condition interaction was also significant, $F(1,209) = 32.58$, $p = 0.00$. Follow up tests indicate that the difference between pretest and posttest was significant for the Collaborative U condition, $F(1,209) = 78.26$, $p = 0.00$, but not for the control condition, $F(1,209) = 0.049$, *ns*.

First peer review and self review

On the first peer review that took place in week 11, students in the Collaborative U condition rated their peers higher than those in the control condition on a variety of attributes (see Figure 6). For effort level $t(536) = 3.099$, $p = .002$, attitude ($t(533) = 2.765$, $p = .006$), helpfulness $t(536) = 2.182$, $p = .029$, flexibility $t(536)= 3.65$, $p = .0002$, and desirability as a team member ($t(536)= 2.91$, $p = .003$), ratings by students in Collaborative U condition were significantly higher compared to those in the control condition. The overall rating for team members was also significantly higher in Collaborative U compared to the control condition $t(536) = 2.03$, $p = .04$. On content knowledge $t(536) = 1.66$, $p = .09$, and effectiveness towards project goals ($t(536) = 1.73$, $p = .08$), they were

marginally higher. On two other measures — attendance and preparedness at meetings, the two conditions were not significantly different. Interestingly, on self-ratings, students in Collaborative U and control were not significantly different on any of the attributes.

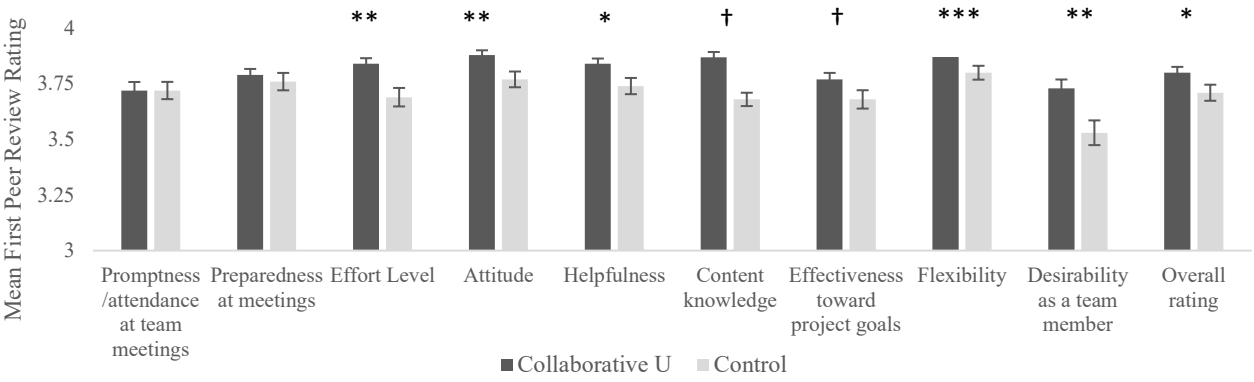

Figure 6. First Peer Rating.

Second peer review and self review

On the second peer review that took place in week 14, students in Collaborative U continued to rate their peers higher compared to those in the control condition on several measures. For attitude ($t(475) = 1.67$, $p = .09$), content knowledge $t(476) = 1.90$, $p = .058$), and flexibility the difference in rating was marginally significant $t(477) = 1.85$, $p = .06$), favoring Collaborative U. On 'desirability as a team member' the difference was significant $t(475) = 3.17$, $p = .001$, again favoring Collaborative U (see Figure 7). On preparedness at meetings, effort level, helpfulness, effectiveness towards project goals, as well as overall rating, the differences were not significant. Just as on the first round of ratings, students in Collaborative U and control did not differ significantly on self-ratings for any of the attributes.

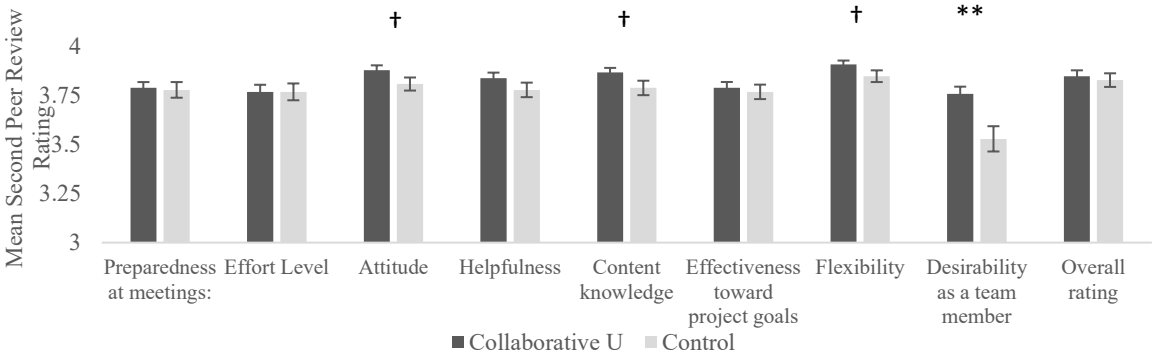

Figure 7. Second Peer Rating.

Peer Reviews of Team Products

On ratings of team products demonstrated via team-led, in-class discussions, students in Collaborative U received higher ratings compared to those in the control condition on several measures. On objective ($t(842) = 2.05$, $p = .04$), summarization ($t(784) = 2.30$, $p = .02$), clarity ($t(785) = 2.86$, $p = .004$), time distribution ($t(783) = 3.40$, $p = .0007$), group dynamics ($t(784) = 3.68$, $p = .0002$), relevance ($t(762) = 2.49$, $p = .01$), and overall score $t(843) = 2.41$, $p = 0.016$, the differences were significant, favoring Collaborative U (See Figure 8). On interest ($t(784) = 1.68$, $p = .09$), the difference was marginal. Finally, and of note, on audio quality and video quality — attributes not directly related to collaboration, the two conditions were not significantly different.

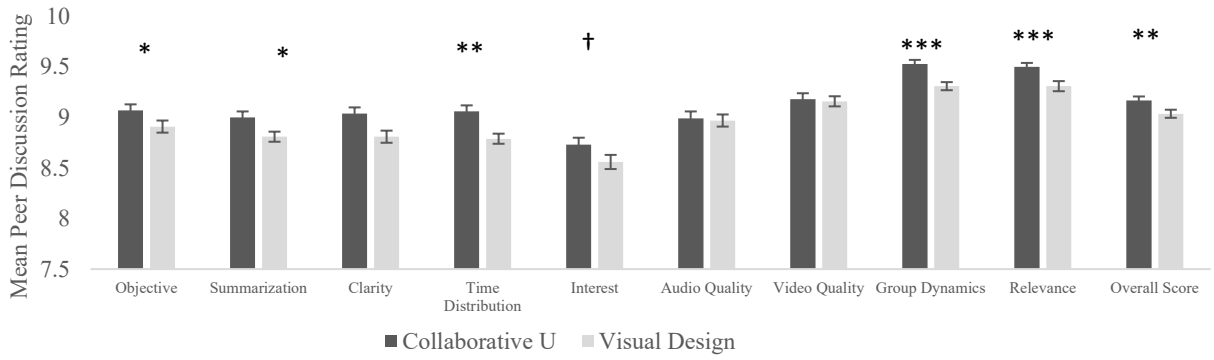

Figure 8: Peer review ratings of in-class discussions.

Discussion

In this paper, we describe results from a randomized controlled trial comparing a short online instructional module for collaboration support with a control condition equated on format and duration. We found compelling evidence that completing our instructional intervention had significant impacts on students' team processes and products. On personal attitudes towards collaboration, students in Collaborative U maintained their initial high scores from pre to post, whereas the control condition showed a significant decline. This result suggests that engaging with the Collaborative U modules provided an inoculation effect that buffered against the decline experienced by students in the control condition. Students in Collaborative U also learned more content knowledge from pre to post. Further, when compared with a control condition, students in Collaborative U rated their peers higher on several attributes critical to good team participation. Students in Collaborative U also generated better final products as a result of the team activity, as measured by peer review ratings of various attributes.

While our findings are encouraging, we note a few caveats. First, our study was done within the context of a highly selective private university. In order to be more generalizable, our study needs to be replicated across different settings, such as public universities and community colleges. Second, we used peer reviews to rate teammates' contributions to teams. However, more objective measures of quality of collaboration are available, such as the Collective Intelligence Battery (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010) which would be useful in corroborating the results of peer reviews and project grades. Third, while our study showed an advantage for the Collaborative U condition on immediate assessments, we need to understand how Collaborative U affects student attitudes and perceptions of collaboration in the long term, and whether it helps prepare them for future collaboration opportunities. We are currently pursuing these questions by longitudinally following up a subset of the students who participated in the present study. These robust measures of learning will further solidify the evidence that online collaboration support can lead to better learning and collaborative performance.

Despite the limitations discussed above, our findings show strong evidence that collaboration support in the form of an instructional module can improve students' team performance and their knowledge and attitudes toward collaboration. By comparing it against a time-equated, relevant control condition, we showed that it was not simply additional instructional time that explains the superior outcomes for the Collaborative U group. Given the increased use of collaboration as a form of active learning in higher education, we believe that our findings have wide applicability. Delivering the intervention through an online platform makes it easier to implement at scale.

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Acknowledgments

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