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Examining the Influence of Instructor Interventions on Group Collaboration

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Abstract: Collaborative problem solving is often used in STEM higher education courses to support conceptual knowledge and teamwork. However, course teaching assistants (TAs) often lack the collaborative pedagogical knowledge necessary to orchestrate this form of learning. In this paper, we examine TAs' orchestration strategies and technology used to understand how these factors influence groups' collaboration. Contributions from this paper describe the interplay among technology, strategies, and groups' collaboration toward understanding how to support collaboration in these courses.

Introduction

Collaborative problem-solving has become a common pedagogy in postsecondary STEM courses (e.g., Freeman et al., 2014). However, instructors often lack the skills needed to facilitate effective collaboration (Greiffenhagen, 2012). Efforts to increase the use of collaborative learning in engineering courses have been driven by research indicating that this form of pedagogy allows students to both deepen their conceptual knowledge and develop better team skills (e.g., Barron & Darling-Hamond, 2008). Prior research has shown that graduate teaching assistants (TAs), who frequently teach core engineering courses, often lack the pedagogical knowledge to monitor, assess, and support groups' real-time collaborative interactions (Shehab, 2019; Lawrence, 2020). There is an ongoing need to support TAs in identifying groups' progress and orchestrating collaborative interactions; thus, it is necessary to present TAs with actionable information and recommendations to help them navigate groups who may need collaborative support. In this paper, we describe a study that investigates TAs' orchestration strategies with groups while using a real-time, supportive orchestration tool and examines how these strategies affected groups' interactions.

Perspectives

Orchestration technology has been shown to support teachers' monitoring and awareness of student behaviors and needs in real-time (Holstein, Aleven, & McClaren, 2018; Martinez-Maldanado et al., 2017). Using collaborative orchestration technology requires both technical proficiency and a strong grasp of collaborative pedagogical practices (Dimitridas, 2012). While engineering TAs are often equipped with sufficient knowledge for general technology use in the classroom, they have a wide range of views and experiences with collaborative learning that impacts how they interact in classrooms that embed both (Lawrence, 2020). In light of this range, it is necessary to provide TAs with resources that can help them learn about and facilitate collaboration.

To support small-group collaboration, research suggests that TAs should use monitoring strategies to observe and identify the nature of groups' interactions and, when necessary, follow up with interventions that prompt groups to talk (Hoffmann & Mercer, 2016; Kaendler et al., 2016; Shehab, 2019). However, research indicates that, without training, implementation of these strategies does not occur naturally (Kaendler et al., 2016). This instruction gap creates the opportunity for orchestration technology that embeds features to alert and advise TAs of instances that may require a collaborative intervention (van Leeuwen, Rummel, & van Gog, 2017). We hypothesize that, with resources to help identify and support collaborative interactions, instructors' interventions can support change in students' collaboration. In this paper, we study TA-student interactions to understand the interplay among teacher's orchestration strategies, technology, and groups' collaboration. We will explore these interactions to answer the following research questions:

1. How did TAs interact with the orchestration tool and groups of students during discussion sections?
2. How did the TAs' interventions and tool use affect groups' collaborative interactions?

Methods

Design

This study is part of a multi-year design-based implementation research project (Penuel, Fishman, Cheng, & Sabelli, 2011) that focuses on supporting collaborative problem-solving in undergraduate engineering discussion

sections. In these courses, students worked in groups of two to four on tasks presented through synchronized drawing software on 11" tablets, which allowed group members to view and modify each other's work. The tasks, which were designed using a literature-based framework (Shehab et al., 2017), delivered ill-structured, real-world problems. The orchestration tool, which was co-design with TAs (Lawrence & Mercier, 2019), used machine learning models (Paquette et al., 2018) to 1) provide alerts of groups' probable need for support that could be confirmed or denied, and 2) provide strategies for intervention (Figure 1). Additionally, TAs could join groups to view students' work in real-time. Video and log file data of students and TAs were collected; two weeks of data are analyzed in this paper.

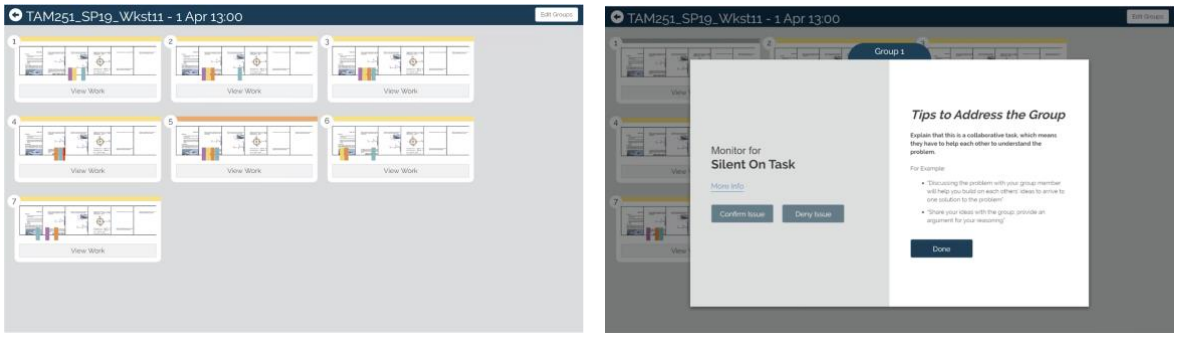

Figure 1. The image on the left shows the orchestration tool interface visualizing seven groups. The image on the right shows an alert that was selected and confirmed by an instructor and strategies to address the group.

Participants

Participants were 90 undergraduate engineering students (20 females, 70 males) who were registered for a required introductory engineering course. Students were separated into 26 groups across five discussion sections. Groups remained consistent throughout the entire semester. Each discussion section had three TAs consisting of one graduate student and two undergraduate students. In total, eight TAs (two graduate and six undergraduate students) taught the five classes.

Analysis

To understand how TAs' interventions affected groups' interactions, interventions were identified in the video data and transcribed in playscript form (Sullivan & Forrester, 2018). Each transcribed intervention was framed by 20 seconds of student dialogue before and 30 seconds after, building on prior monitoring and intervention analysis (Shehab, 2019; Lawrence, 2020). Log file data were reviewed to identify tool use during interventions. Each intervention was coded for the presence of orchestration strategies that were derived from literature and past research (Table 2; percent agreement ranged from 89% to 99%; Cohen's Kappa ranged from 0.25 to 0.96). Students' behaviors before and after the intervention were coded for talking or silent, engaged (e.g. nodding, making eye contact with the speaker) or not, and on-task or off-task (IRR = 0.91). Using these codes, each group was categorized as collaborative or non-collaborative. A collaborative group was identified when the majority of students were engaged and talking on task; a non-collaborative group was identified when the majority of students were silent, talking off task, or split across codes, indicating a lack of cohesion.

Results

Across the two weeks, the TAs engaged in 223 interventions with groups (Table 1). The machine learning models presented 678 alerts; 374 were opened by an instructor. Of those 374, 80 were confirmed–meaning the instructor confirmed that they perceived the detected behavior as correct. An instructor viewed a group's work 79 times. Thirty-nine instances of tool use led to an intervention with students, including 38 alerts and one "view work."

To understand how TAs interacted with groups, each intervention was coded for the presence of orchestration strategies. Table 1 illustrates the frequency of each strategy across all types of interventions. During the majority of interventions, the instructors initiated by probing for the groups' understanding, held the whole group's attention, and chose to explain content after students asked questions or expressed confusion (as compared to explaining without prompting). Interventions, where the TA used the tool, were less likely to explain content without students asking questions or expressing confusion. These interventions were also more likely to be initiated by the instructor. Several orchestration strategies were infrequently enacted by TAs across all interventions, including monitoring a group before intervening, prompting group members to talk to each other, and ending the intervention by checking for students' understanding.

Table 1. Instructors' orchestration strategies across all interventions, those that had tool use and those that did not.

Orchestration Strategies	Frequency (%)		
	All Interventions	Interventions with Tool Use	Interventions without Tool Use
Total interventions	223 (100%)	39 (100%)	184 (100%)
Instructor monitored the group	58 (26%)	14 (36%)	44 (24%)
Instructor initiated intervention	111 (50%)	27 (69%)	84 (46%)
Instructor initiated intervention by probing for the groups' understanding	132 (59%)	22 (56%)	110 (60%)
Instructor explicitly prompted the group to talk	22 (10%)	3 (8%)	19 (10%)
Instructor had the whole group's attention	154 (69%)	21 (54%)	133 (72%)
Explanations were preceded by question or confusion from a student	136 (61%)	17 (44%)	119 (65%)
Instructor ended by checking for the group's understanding	43 (19%)	3 (8%)	40 (22%)

We coded before and after each intervention to understand if the instructors' intervention and tool use affected students' collaborative interactions. Across all groups, 56% (N = 134) were in a collaborative state (e.g., talking on task and engaged) before an intervention started. After an intervention occurred, 60% (N = 89) of groups were in a non-collaborative state. Of the groups that were in a collaborative state before the TA engaged in an intervention, half remained in a collaborative state and half transitioned into a non-collaborative state (Table 2). The majority (73%) of groups that were in a non-collaborative state pre-intervention transitioned into a collaborative state post-intervention.

We also compared groups' collaborative states pre- and post-intervention specifically for those in which the TA used the tool. Most groups (60%) that were in a collaborative state before such an intervention transitioned into a non-collaborative state once the TA left. Of groups that were in a non-collaborative state before a tool-based intervention, 57% transitioned into a collaborative state post-intervention while 43% remained in a non-collaborative state.

Table 2. Groups' collaborative states pre- and post-intervention for all interventions and for those where the instructor used the orchestration tool.

Status Before an Intervention	Status After an Intervention	Frequency (%) of all Interventions	Frequency (%) with the Tool
Collaborative	Collaborative	62 (50%)	10 (40%)
	Non-collaborative	62 (50%)	15 (60%)
Non-Collaborative	Collaborative	72 (73%)	8 (57%)
	Non-collaborative	27 (27%)	6 (43%)

Conclusions and Implications

The goal of this study was to understand how instructors' orchestration strategies and tool use during interventions affected groups' collaboration. Several orchestration strategies, including monitoring and checking for understanding, have been shown to be beneficial for collaborative activities (Hoffmann & Mercer, 2016; Kaendler et al., 2016; Shehab, 2019). Prior research shows that these strategies do not occur spontaneously and require support for successful enactment (Kaendler et al., 2016). Our findings indicate that the orchestration tool prompted the TAs to enact some orchestration strategies more frequently as compared to interventions without the tool.

Findings from the groups' interactions show that groups who were in a non-collaborative state before an intervention benefited from interventions with and without the orchestration tool, meaning that they transitioned

into a collaborative state after the TA engaged in an intervention. While some tool-based interventions helped move students toward collaboration, our initial findings have not revealed a concrete difference in benefits between the two types of interventions. Future work will examine the relationship between individual orchestration strategies and groups' changes in collaboration to further understand what strategies were most useful in supporting groups' collaborative states. Further analysis will be used to inform how and what strategies are presented through the orchestration tool to support instructors. This work has important implications regarding the interplay among technology, orchestration strategies, and groups collaboration, and sheds light on the need to understand how to support novice instructors (Greiffenhagen, 2012) as they facilitate collaboration in higher-education engineering courses.

References

Barron, B., & Darling-Hammond, L. (2008). *Teaching for Meaningful Learning: A Review of Research on Inquiry-Based and Cooperative Learning*. Book Excerpt. George Lucas Educational Foundation.

Dimitriadis, Y. A. (2012). Supporting teachers in orchestrating CSCL classrooms. In Research on E-Learning and ICT in Education (pp. 71-82). Springer, New York, NY.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415.

Greiffenhagen, C. (2012). Making rounds: The routine work of the teacher during collaborative learning with computers. *International Journal of Computer-Supported Collaborative Learning*, *7*(1), 11-42.

Hofmann, R., & Mercer, N. (2016). Teacher interventions in small group work in secondary mathematics and science lessons. *Language and Education*, *30*(5), 400-416.

Holstein, K., McLaren, B. M., & Aleven, V. (2018). Informing the design of teacher awareness tools through causal alignment analysis. *International Society of the Learning Sciences, Inc.* [ISLS].

Kaendler, C., Wiedmann, M., Rummel, N., & Spada, H. (2015). Teacher competencies for the implementation of collaborative learning in the classroom: a framework and research review. *Educational Psychology Review*, *27*(3), 505-536.

Lawrence, L. & Mercier, E. (2019). Co-design of an orchestration tool: Supporting engineering teaching assistants as they facilitate collaborative learning. *Interaction Design and Architecture(s) Journal*, (42), 111- 130.

Lawrence, L. (2020). The design process of a collaborative orchestration tool and its implications for instructor uptake. (Doctoral dissertation, University of Illinois at Urbana–Champaign). ProQuest Dissertations Publishing.

Martinez-Maldonado, R., Yacef, K., Dos Santos, A. D. P., Shum, S. B., Echeverria, V., Santos, O. C., & Pechenizkiy, M. (2017, July). Towards proximity tracking and sensemaking for supporting teamwork and learning. In *IEEE 17th International Conference on Advanced Learning Technologies* (ICALT) (pp. 89-91). IEEE.

Paquette, L., Bosch, N., Mercier, E., Jung, J., Shehab, S., & Tong, Y. (2018). Matching data-driven models of group interactions to video analysis of collaborative problem solving on tablet computers. *International Society of the Learning Sciences, Inc.* [ISLS].

Penuel, W. R., Fishman, B. J., Cheng, B., & Sabelli, N. (2011). Developing the area of design-based implementation research. *Menlo Park, CA: SRI International*.

Shehab, S., Mercier, E., Kersh, M., Juarez, G., & Zhao, H. (2017). Designing Engineering Tasks for Collaborative Problem Solving. In *Making a Difference—Prioritizing Equity and Access in CSCL: The 12th International Conference on Computer Supported Collaborative Learning*. Philadelphia: The International Society of the Learning Sciences.

Shehab, S. S. (2019). Collaborative problem solving in higher education classrooms: Exploring student interactions, group progress, and the role of the teacher (Doctoral dissertation, University of Illinois at Urbana-Champaign).

Sullivan, C., & Forrester, M. A. (Eds.). (2018). *Doing qualitative research in psychology: A practical guide*. Sage.

van Leeuwen, A., Rummel, N., & van Gog (2017). Teacher regulation of collaborative learning: research directions for learning analytics dashboards. In *Making a Difference: Prioritizing Equity and Access in CSCL*, *2*(805-806), 1939-1382.

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