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# Work in Progress: Investigating the Effectiveness of an Orchestration Tool on the Nature of Students' Collaborative Interactions During Group Work

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Taylor Tucker graduated from the University of Illinois at Urbana-Champaign with a Bachelor's degree in engineering mechanics. She is now pursuing a master's degree at UIUC through the Digital Environments for Learning, Teaching, and Agency program in the department of Curriculum and Instruction. She is interested in design thinking as it applies to engineering settings and lends her technical background to her research with the Collaborative Learning Lab, exploring ways to to promote collaborative problem solving in engineering education and provide students with team design experiences that mimic authentic work in industry.

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# WIP: Investigating the Effectiveness of an Orchestration Tool on the Nature of Students' Collaborative Interactions During Group Work

## Introduction

This work-in-progress paper focuses on the relationships among orchestration technology, instructor interventions, and student interactions in an undergraduate engineering context. Collaborative problem solving (CPS) has become increasingly common in engineering courses [1], as it more closely mimics work performed by engineers in industry. Complex real-world tasks require practicing engineers to consult and collaborate not only with colleagues of similar discipline but also experts from various other fields [2]; thus, creating effective CPS experiences in engineering curricula is important for effectively preparing new generations of engineers for the demands of the workplace. As collaborative learning engages students at both individual and group levels, implementing CPS practices in the classroom requires instructors to reactively provide guidance for students' conceptual understanding while simultaneously supporting their interactions, rather than solely providing content-focused instruction. This can be done through various means, such as task structures and face-to-face instructor interventions and feedback. However, supporting CPS remains challenging, especially for novice instructors (e.g., teaching assistants; TAs) who often teach introductory engineering courses. Prior research has shown that graduate TAs tend to lack the pedagogical knowledge necessary for monitoring, assessing, and supporting groups' real-time collaborative interactions [3], [4]. The act of managing these pedagogical factors in real time is also known as orchestration [5]. 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. A relatively new practice that addresses this need is the implementation of orchestration technology, which often uses real-time data to facilitate teaching practices while considering various factors within the classroom.

Researchers have developed orchestration tools that help teachers identify crucial learning moments and provide actionable information [6]. Using collaborative orchestration technology requires both technological proficiency and a strong grasp of collaborative pedagogical practices [7]. 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 [3], [4]. Thus, it is necessary to provide TAs with resources that can help them learn about and facilitate collaboration. To better support TAs, who do not always have the resources or training to facilitate CPS, we developed an orchestration tool that provides strategies to strengthen TAs' interventions with groups and support students' collaborative interactions in real time.

We implemented our tool in collaborative discussion sections that were part of a required undergraduate engineering course; these sections were taught by graduate and undergraduate TAs who had little or no experience teaching CPS. These sections required students to work in small groups on ill-structured engineering design tasks [8]. Solving ill-structured tasks collaboratively allows students to engage in higher order thinking and co-construction of knowledge [9]. However, our previous work has shown that support, such as strategic scaffolding, is necessary for fostering meaningful collaborative interactions during these tasks

[10], [11]. The need for support in this context, combined with TAs' known lack of experience in teaching CPS, creates a fitting environment for orchestration technology. In this WIP study, we evaluate the results of implementing our orchestration tool in three discussion sections held over each of two weeks. This paper will explore the following questions:

1) How did TAs interact with the orchestration tool?
2) How did TAs' interactions with the tool inform their interventions with groups?

## Methods

### Design

This study is part of a multi-year design-based implementation research project [12] 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 [13], delivered ill-structured, real-world problems. The orchestration tool, which was co-designed with TAs [14] and provided on an 11" tablet, used machine learning models from previous work [15] to 1) alert to groups' probable need for support that could be confirmed or denied (Figure 1, left), and 2) provide intervention strategies (Figure 1, right). Future work will describe the tool's design in more detail. Additionally, TAs could view students' work in real-time. Video and log file data of students and TAs were collected.

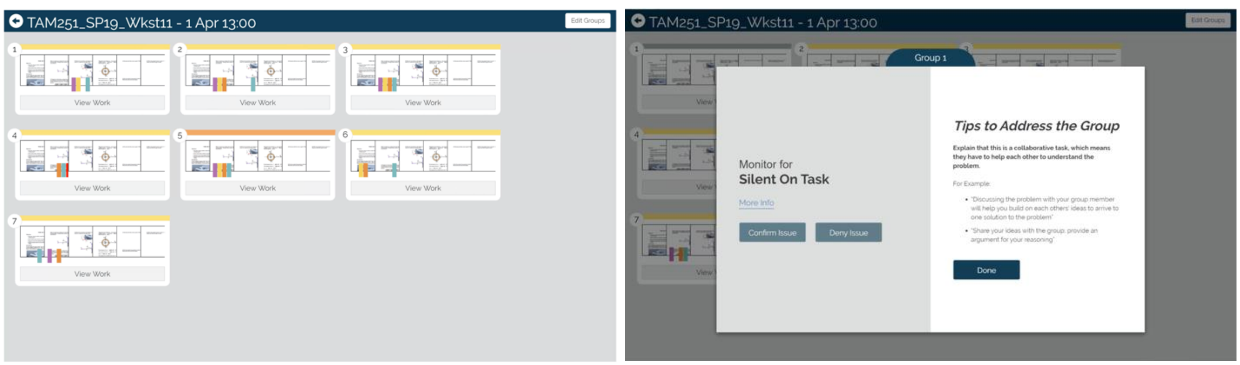


Figure 1. Left image shows the groups presented to TAs, with alerts in orange that flagged groups who may need support; right image shows intervention strategies presented when a TA confirmed a behavior.

### Participants

Participants were 90 undergraduate engineering students (20 female, 70 male) who were registered for a required introductory engineering course. Students were separated by the instructor 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 across the five classes. In this paper, we analyze data from two weeks of 50-minute discussion sessions.

## Results

Of the 377 total tool prompts provided, less than half were opened by TAs (Table 1). Of those that were opened, the majority were denied. Comparable numbers of prompts were both provided and opened for each of the two weeks.

Table 1. Summary of orchestration tool prompts across both weeks

| Semester Week | Total Prompts | Prompts Opened | % Opened | Prompts Confirmed | % Confirmed | Prompts Denied | % Denied |
|---|---|---|---|---|---|---|---|
| 10 | 171 | 78* | | | | | |
| 11 | 206 | 72 | | | | | |
| Total | 377 | 150 | 40 % | 45 | 30 % | 104 | 70 % |

*One prompt was opened and then removed without confirming or denying

Of the total interventions across the two weeks, the TAs intervened while using the tool approximately half the time (Table 2). TAs also monitored the groups prior to intervention for roughly half of their total interventions; however, only 18% of their interventions had the overlap of both monitoring and intervening while using the tool. Prior analysis has shown that the durations of both monitoring and intervention episodes are comparable between interventions where instructors used the tool and those where they did not; furthermore, while the percentage of monitoring was higher for interventions that included the tool, instructors monitored longer when not using the tool [4]. The TAs were able to command the entire group's attention for the majority of interventions and frequently responded to questions or confusion raised by groups, but rarely explicitly prompted group members to converse with one another and infrequently checked groups' understanding at the end of the intervention.

Table 2. Breakdown of orchestration strategies enacted by TAs across both weeks

| 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 group's understanding | 132 (59%) | 22 (56%) | 110 (60%) |
| Instructor explicitly prompted group to talk | 22 (10%) | 3 (8%) | 19 (10%) |
| Instructor commanded entire group's attention | 154 (69%) | 21 (54%) | 133 (72%) |
| Explanations were preceded by a question or confusion from a student | 136 (61%) | 17 (44%) | 119 (65%) |
| Instructor ended by checking group's understanding | 43 (19%) | 3 (8%) | 40 (22%) |

## Discussion

Our first research question seeks to characterize the nature of TAs' interactions with the tool. Initial findings indicate that TAs tended to deny prompts. Previous analysis showed several emergent themes that may have contributed to this behavior, including inaccurate prediction models, a change in the groups' behavior upon monitoring, and distractions in the classroom [4].

Whether or not a prompt was denied, TAs only responded to prompts for less than half of the total provided by the tool. Given that the tool was only intended to supplement TAs' instruction by providing potentially helpful resources, and not to dictate TAs' next steps, this trend is not surprising. Even with an orchestration resource present, TAs are constantly navigating classroom factors and complexities. Although orchestration technology is unable to address the many factors at play in a live classroom environment, it can be employed as a strategic resource to help improve conflicts in real time. The instructors' decisions to use our tool during some of their interventions is promising; ongoing analysis will more deeply investigate their strategies.

Our second question seeks to investigate how TAs' interactions with the tool may have influenced their interventions with groups. Initial findings indicate that when TAs used the tool, they were more likely to monitor a group before intervening and to initiate the intervention themselves, suggesting that the tool effectively directed TAs' attention toward groups. In contrast, without the tool, instructors were more likely to end their intervention by checking the groups' understanding. Future work will examine relationships among these strategies and tool use to determine how to further incorporate constructive use of the tool into TAs' classroom practices.

**Conclusion and Implications**

We implemented an orchestration tool in an undergraduate engineering classroom to support TAs' interventions with groups during collaborative design tasks. Our findings begin to inform strategies that can help novice TAs support CPS in engineering courses, which is significant both for training TAs and for developing technology that supports these strategies. As we continue our investigation, it is important to consider how technology might be intentionally designed to support relevant CPS strategies that are rarely applied by instructors. Our tool's prompting capability has shown that this sort of technology has the capacity to point instructors toward potentially important CPS moments; ongoing analysis will explore those moments' accuracy.

While instructors did use our tool, it was only employed during less than half of their interventions. This trend serves as an important reminder that orchestration tools are only as valuable as the user wants them to be; designs cannot fully account for teachers' individual motivations and values. We already know that TAs' views of collaboration inform their use of supportive resources [3], [4]; these findings can now help outline how technology and CPS approaches can inform classroom practices. Future work will more deeply investigate data from our implementation to better understand the complexities of employing orchestration technology in a CPS environment. Our findings respond to calls to implement CPS in engineering courses by understanding if and how orchestration technology aids TAs in facilitating this form of pedagogy.

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