Engaging Industry in the Classroom to Enhance Teaching of Heavy Civil Construction

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Even though every construction project requires a civil portion to be completed, civil work is one of the most challenging areas to understand and estimate by students. Knowledge areas such as earthwork and processes like determining activities' duration, resources, methods, and costs must be integrated into each project. This integration requires students to have a "how to build" mindset. Unfortunately, students barely began building this mindset in the final years of their undergraduate degrees. Aiming to scaffold students' "how to build" mindset, the Construction Management Department at Fresno State has engaged heavy civil industry members in improving and developing courses within the construction management bachelor curriculum. Starting in Fall 2020, a heavy civil committee representing five heavy civil companies and public entities have worked on (1) identifying civil knowledge gaps found in early-career students and proposing ideas to fill those gaps, and (2) collaborating in the classroom activities like guest speakers, expert panels, judges, and coaches. Twenty-three (23) industry-classroom interaction events have been held between 2020-2022, including ten (10) different companies and entities in four sophomore and senior levels courses. This article reflects on (1) the industry-faculty interaction's outcomes through the heavy civil committee and (2) the impact of different in-classroom activities on student's perception of their learning of civil aspects.

Keywords: Heavy Civil, Industry engagement, Industry advisory board, Teaching

1. Introduction

Even though every construction project requires a civil portion to be completed, civil work is one of the most challenging areas to understand and estimate by students. Knowledge areas such as earthwork and processes like determining activities' duration, resources, methods, and costs must be integrated into each project. This integration requires students to have a "how to build" mindset. Unfortunately, students barely began building this mindset in the final years of their undergraduate degrees.

According to Lamancusa (2008), industrial participation in the classroom enriches the learning process. Thus, promoting industry-faculty students' activities might help to enhance the teaching and learning of civil aspects. Previous studies analyzed the effect of industry engagement activities across

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different universities (Genheimer & Shehab, 2009; McKinnis et al., 2001). However, few studies focused on how the industry engagement with faculty and students was articulated. This article describes and analyzes the case of the Fresno State Construction Management Department, where a heavy civil committee was created to promote the involvement of heavy civil industry in curriculum improvement and students learning of civil aspects of construction. This article reflects on (1) the industry-faculty interactions through the heavy civil committee and (2) the industry-students interaction through the 23 industry-classroom activities.

2. Background

Usually, a gap exists between what is "taught and tested in formal schooling and the competencies required to be good at work" (Billett et al., 2010). The Learning Factory is an example that, in 1994, aimed to address this gap. This concept was created based on three core beliefs: lectures alone are insufficient, interactive, hands-on experiences benefit students, and faculty and industrial participation enrich the learning process (Lamancusa et al., 2008).

Industrial participation in the classroom might be articulated with a focus on industry-faculty interaction, industry-students interaction, or both. Regarding the first case, a study evaluating nineteen US university-based industry outreach programs found that the most highly rated benefit of being involved with industry partners was the update of faculty's practical skills (McKinnis et al., 2001). In the case of industry-students interaction, Genheirmer & Shehab (2009) surveyed 90 engineering school directors and advisory board members to characterize the operation, makeup, and effectiveness of advisory boards. These authors found that one of the industry advisory board activities that most correlated with the effectiveness of these advisory boards was to "promote engagement of board members with students in activities such as panels and forums, interviews, design projects, and social events.

Activities such as guest speakers' lectures, industry members acting as judges in students' presentations, panels, or industry coaches provide different types of interaction between industry members and students. This interaction primarily relates to how communication among participants is developed. A description of three main types of communication models may help identify the primary type of communication associated with the previously mentioned activities.

In the transmission model of communication, Richard Ellis and Ann McClintock (1990) described communication as a linear, one-way process

Figure 1. The transmission model of communication.

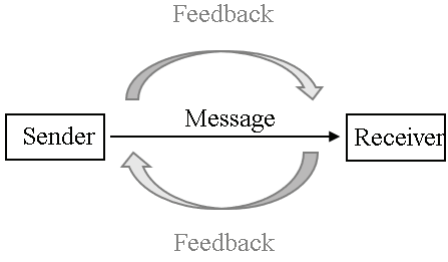

Figure 2. The interaction model of communication.

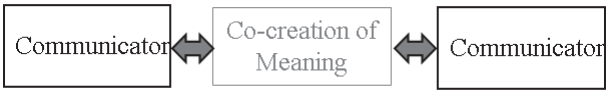

Figure 3. The transaction model of communication.

where the sender transmits a message to the receiver. In this model, the sender is the focus, and the receiver is viewed as the target (Fig. 1).

In the interaction model, on the other hand, Wilbur Schram (1997) considered communication a process where participants take alternate positions as sender or receiver. The meaning is generated by sending a message and receiving feedback (Fig. 2). In this case, the focus is not on the sender or the receiver but on the interaction itself.

Finally, in the transaction communication model, Dean C. Barnlund (1970) defined communication as a process where participants create social realities within social, relational, and cultural contexts. In this case, communication not only occurs to exchange messages but to create relationships, alliances, or even communities (Fig. 3).

These models represent a spectrum from simpler to more complex communication, which revolves around more interaction and engagement between participants (Fig. 4).

This article uses the framework of communication models to characterize the in-classroom activities under the lens of the communication established between industry members and students.

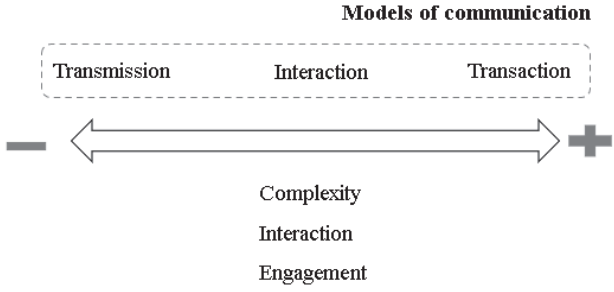

Figure 4. Communication models' spectrum.

3. Fresno State Case: Heavy Civil Committee and Impact on Learning of Different Types of In-Classroom Activities

Aiming to scaffold students' "how to build" mindset, the Construction Management Department at Fresno State has engaged heavy civil industry members in improving and developing courses within the construction management bachelor curriculum. Starting in Fall 2020, a heavy civil committee representing five heavy civil companies and public entities have worked on (1) identifying civil knowledge gaps found in early-career students and proposing ideas to fill those gaps, and (2) collaborating in the classroom activities like guest speakers, expert panels, judges, and coaches.

3.1. *Industry-faculty interaction: heavy civil committee*

Online monthly meetings were held between the faculty leader and the heavy civil committee. These meetings aimed to be a space to hear and discuss ideas and concerns of heavy civil construction companies with the ultimate goal of improving the construction management curriculum so that it meets / exceeds heavy civil industry requirements and needs.

The approach taken in these two years is twofold. On the one hand, the committee focused on identifying and addressing knowledge gaps in entry-level students working for heavy civil companies. On the other hand, the monthly meetings served to coordinate in-classroom activities.

In order to identify and address the knowledge gaps, the committee followed a four-step approach.

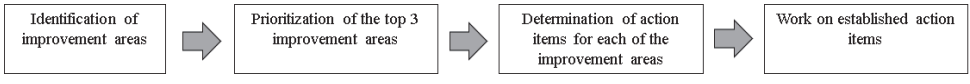

Figure 5. Heavy Civil Committee. Methodology to address knowledge gaps

3.2. *Industry-students interaction: in-classroom activities*

In-classroom activities were proposed, discussed, and coordinated in the monthly committee meetings. During the two years analyzed, four types of activities were conducted: guest speakers' lectures, industry members as judges in students' final presentations, industry panel discussions, and industry coaches.

- Guess Speakers' lectures. The industry member comes to class and lectures the students about a topic. Once the lecture is finished, usually there is time for questions and answers where students ask questions and the industry member answer those questions.
- Judges. In project-based courses, students work during the semester on a project, and at the end, they present their results to the class. Usually, these projects focus on analyzing an actual project and creating a schedule and a cost estimate. In the final presentations, industry members come to class, listen to the presentations, and function as judges that ask questions to the presenters, evaluate the work and provide feedback. Students and industry members interact at the end of the course through the final project.
- Industry Panel Discussion. In project-based courses, students work during the semester on a project and have the opportunity of discussing and share their progress with industry members via interim presentations. These presentations do not show the final result but the progress and the thought process that led students to that point. In these interim presentations with an industry panel, students have the opportunity not to be evaluated but to gather feedback from industry members about the process and criteria they are taking. This feedback is helpful for the next steps in the project.
- Industry Coaches. One course at Fresno State Construction Management Department focuses on coaching a team to participate in the ASC Competition. In this course, students have a faculty coach, and industry members are invited to participate in this class and collaborate as industry coaches.

Table 1 shows all the in-classroom activities developed:

Aiming to explore whether communication differences across in-classroom activities impact students' perception of their learning, a survey was conducted on students who have attended one or several of the courses where heavy civil industry members were invited to participate as (1) guest speakers, (2) judges, (3) industry panel members, and / or (4) industry coaches. The survey asked them to rate the impact that each of the four

Table 1. 2020-2022. Industry-Classroom Activities

#	Academic Year	Date		Course	Company	Topic	Activity
1	2020-2021	9/30/2020	CM 20	Construction Documents	Walsh	Project Delivery Methods. Progressive Design-Build	Guest Speaker
2		10/8/2020	CM 127	Construction Soils & Foundations	Kiewit	Mud Mountain Dam Project. Project Presentation	Guest Speaker
3		11/28/2020	CM 20	Construction Documents	Kiewit	Change management	Guest Speaker
4		12/15/2020	CM 127	Construction Soils & Foundations	Kiewit	Mud Mountain Dam Project.	Final presentations judges.
5		2/8/2021	CM 151	Heavy Civil Construction	High-Speed Railway Authority	Sustainability in Infrastructure Projects. Envision Award	Guest Speaker
6		3/17/2021	CM 20	Construction Documents	Walsh	Project Delivery Methods in Federal Projects	Guest Speaker
7		4/17/2021	CM 151	Heavy Civil Construction	Caltrans	Claims and Challenges in highway construction	Guest Speaker
8		4/21/2021	CM 151	Heavy Civil Construction	Army Corps of Engineers	Structures construction. Challenges, Risks & Special Considerations	Guest Speaker
9		5/5/2021	CM 151	Heavy Civil Construction	Teichert, Army Corps of Engineers	Heavy Civil Projects presentations	Final presentations judges.

Table 1. 2020-2022. Industry-Classroom Activities

#	Academic Year	Date	Course	Company	Topic	Activity
10		9/24/2021	CM 98 Heavy Civil Competition	Kiewit, DeSilva Gates, Teichert, Independent Consultant	ASC Competition Simulation. Project 1. Presentation	Final presentations judges/ Industry coach
11		10/7/2021	CM 127 Construction Soils	Army Corps of Engineers	Site investigations	Guest Speaker
12	2021-2022	10/14/2021	CM 127 Construction Soils	Kiewit	Mud Mountain Dam Project. Project Presentation	Guest Speaker
13		10/20/2021	CM 144 Site Development	Teichert, DeSilva Gates	Site development design. Layout description presentation	Civil Industry Panel
14		10/20/2021	CM 20 Construction Documents	Army Corps of Engineers	Contracts in Federal Sector	Guest Speaker
15		10/29/2021	CM 98 Heavy Civil Competition	Kiewit, DeSilva Gates, Teichert, Independent Consultant, Heavy Road & Rail Inc	ASC Competition Simulation. Project 2. Presentation	Final presentations judges/Industry coach
16		11/5/2021	CM 98 Heavy Civil Competition	Granite	Estimating Earthwork	Guest Speaker/ Industry Coach
17		11/10/2021	CM 20 Construction Documents	Kiewit	Quantity takeoff. Civil	Guest Speaker

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#	Academic Year	Date	Course	Company	Topic	Activity
18		12/1/2021	CM 144 Site Development	Teichert/DeSilva	Site Development. Logistic Plan, Schedule, Estimate	Civil Industry Panel
19		12/3/2021	CM 98 HC Competition	Kiewit, DeSilva Gates, Teichert, Independent Consultant, Heavy Road & Rail Inc	ASC Competition Simulation. Project 3. Presentation	Final presentations judges/Industry coach
20		12/8/2021	CM 127 Construction Soils	Kiewit	Soils report, Quality understanding	Group project presentations judges
21		02/14/2021	CM 151 Heavy Civil Construction	High-Speed Railway Authority	Sustainability in Construction	Guest Speaker
22		02/23/2021	CM 151 Heavy Civil Construction	Army Corps of Engineers	Project lifecycle	Guest Speaker
23		05/09/2022	CM 151 Heavy Civil Construction	Kiewit, DeSilva Gates, Teichert, Independent Consultant, Heavy Road & Rail Inc	Heavy Civil Projects presentations	Industry Panel

previous activities had on their learning of heavy civil aspects. The rating varied from 1, meaning "no impact," to 5, meaning "it highly impacted my learning of heavy civil aspects." Twenty-seven (27) students answered the survey.

To consider the communication difference across in-classroom activities, a communication level was assigned to each activity based on its similarity to the communication models of transmission, interaction, or transaction (Fig. 6).

- Guess Speaker's lecture. The author assigned this activity a communication level of 1, corresponding to the transmission communication model because this model represents communication as a linear and one-way process. In a guest speaker lecture, the message goes from the presenter to the students most of the time.
- Judge in final presentations. The author assigned a communication level of 2, corresponding to the interaction communication model because this model considers that participants take alternate positions as sender or receiver in the communication process, and the meaning is generated by sending messages and receiving feedback. In the final presentations, industry members acting as judges provide feedback to the students who have presented their work.
- Industry Panel Discussion. The author assigned a communication level of 3, corresponding to the interaction communication model because the industry panel discussion establishes an interactive discussion about the work in process. Students could share their thought processes and gather feedback from industry members. Given that the work is not finished yet, the feedback might be richer and more impactful in students' final outcomes. As in the previous activity, there is a feedback loop between industry members and students. The difference between being a judge in final presentations and participating in a panel discussion is the frequency of the feedback loop, which is higher in panel discussions than in final presentation judges.
- Industry Coaches. The author assigned a communication level of 4, corresponding to the transaction communication model because this communication model occurs not only to exchange messages but also to create relationships, alliances, or even communities. Industry members acting as coaches establish a personal relationship with students having the opportunity to interact one-on-one in different stages of the competition training.

The survey also included an open-ended question where students were asked to write about some of the benefits of inviting heavy civil industry

members into the classroom (Open-ended prompt included in the survey: *Please, write some of the benefits of inviting heavy civil industry members into the classroom*). The affinity diagrams technique was used to establish group codes (Carnevalli & Miguel, 2008). The affinity diagrams sort qualitative data based on the underlying relationships in the resulting groups (Andersen & Fagerhaug, 2006).

4. Findings and discussion

The following sections include the main findings related to (1) the industry-faculty interaction's outcomes through the heavy civil committee and (2) the impact of different in-classroom activities on student's perception of their learning of civil aspects.

4.1. *Industry-faculty interaction: monthly meetings*

One of the objectives of the heavy civil monthly meetings was to address and identify knowledge gaps to be addressed in the Construction Management curriculum. The committee identified ten areas to strengthen: specifications, quality assurance, quality control, advanced scheduling, contract language, quantity takeoff, letter writing, grading improvement plans, document control, Environmental rules and regulations, and OSHA certification.

The committee prioritized the top three by independently raking them and selecting the three whose ranks achieved the highest level of agreement among them. The topics prioritized were (1) specifications, (2) quality assurance and quality control (QA / QC), and (3) advance scheduling. During the subsequent meetings, discussion and action items were defined to enhance these topics within the CM curriculum.

4.2. *Industry-students interaction: in-classroom activities*

Results from the survey indicated that 100% of students agreed that all industry-engagement activities impacted their learning (Fig. 6, detail A). Further, for each activity, more than 54% of the students thought that these activities highly impacted their learning of heavy civil concepts. In the case of panel discussions and industry coaches, the percentage of agreement in this assessment rose to 71% (Figure 6, detail B).

These results suggest that students perceive activities with a communication level of 3 (panel discussion) and 4 (coaches) provide more value in terms of impact on their learning than the ones where the communication level was 2 (judges) or 1 (lectures). Thus, activities with a more frequent feedback loop and activities that enable a more direct relationship between industry

Table 2. Areas to strengthen and Actions developed

Topics	**Area of focus**	**Actions developed.**
Specifications	• Payment: Including (1) Unit price and lump-sum, (2) Units of measurement, and (3) Conditions leading to withholding payments. • Time Including (1) Timeline for different tasks, (2) Submittals, (3) Time restrictions • Conflicts between documents Understand what governs what	These concepts were included and reinforced in the course "Construction Documents."
QA / QC	• Including QA / QC concepts in the curriculum • Evaluating the option of creating a QA / QC complementary to the CM curriculum	Four sessions of QA / QC concepts were aggregated in the course "*Construction Soils and Foundations.*" Focus on Caltrans and USACE Quality criteria were considered. Creating a QA / QC certification is currently under evaluation.
Advance Scheduling	Including the scheduling software Primavera P6 in the CM curriculum	Coordination with the software company was performed, and Primavera Cloud will be available for students starting Fall 2022.

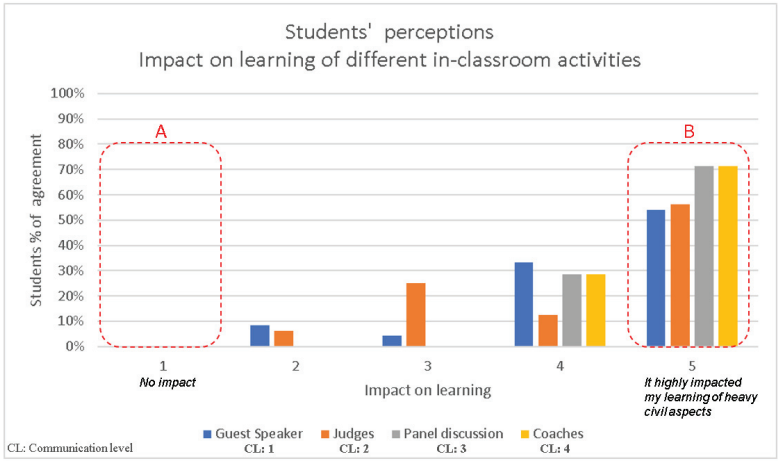

Figure 6. Different in-classroom activities. Impact on learning

members and students were considered by more than 70% of the students to have a high impact on their learning of heavy civil aspects.

Furthermore, the analysis of the open-ended question focused on the benefits of inviting industry members into the classroom showed a response rate of 70.4%. The analysis found three main benefits behind the students' comments: 31.5% of students considered inviting heavy civil industry members opened their minds to the heavy civil industry. Thirty-seven percent (36.8%) of students emphasized the benefit of having practical advice in the classroom. Finally, the remaining 31.5% of students pointed out the additional value that industry engagement provided to the regular class. Students' responses are included in this article's appendix.

5. Conclusions

In the Fresno State case, the industry-faculty interaction through the heavy civil committee helped (1) create rapport between industry members and the faculty, facilitating initiative, motivation, a sense of progress, and engagement. (2) Improve curriculum but also coordinate class activities. (3) Gather feedback from in-classroom activities. (4) Understand the gaps that industry members see in entry-level students. (5) Promote continuous communication, and (6) gather real-world projects to be used in the classroom.

Industry-students interaction through in-classroom activities was considered highly beneficial by students. More than 70% of the students surveyed agreed that activities such as industry panels or industry coaches that allow for a more frequent feedback loop and a more direct relationship between industry members and students greatly impacted their learning of

heavy civil aspects. Furthermore, they reported that having industry in the classroom (1) opened their minds to the heavy civil industry, (2) provided practical advice that helped them to be more prepared for the future, and (3) provided additional value to the classes with real-world examples and experiences.

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