

Work in Progress: Project Teams' Structure Impacting Students' Professional Skill Development

Emily Buten, University of Michigan

Emily (she/her) is a Ph.D. student in the Engineering Education Research program at the University of Michigan and received her B.S. in Mechanical Engineering from University of Dayton. Her research focuses on individuals' development from students to professional engineers. She is particularly interested in studying co-op/internship programs, professional skills development, and diverse student experiences in experiential learning settings.

Jack Boomer Perry, University of Michigan

Boomer is a graduate student completing his master's degree in aerospace engineering at the University of Michigan. His focus in engineering education research has been towards bridging the gap between the undergraduate engineering curriculum and engineering industry practice.

Cindy Wheaton, University of Michigan

Dr. Aaron W. Johnson, University of Michigan

Aaron W. Johnson (he/him) is an Assistant Professor in the Aerospace Engineering Department and a Core Faculty member of the Engineering Education Research Program at the University of Michigan. His lab's design-based research focuses on how to re-contextualize engineering science engineering courses to better reflect and prepare students for the reality of ill-defined, sociotechnical engineering practice. Their current projects include studying and designing classroom interventions around macroethical issues in aerospace engineering and the productive beginnings of engineering judgment as students create and use mathematical models. Aaron holds a B.S. in Aerospace Engineering from U-M, and a Ph.D. in Aeronautics and Astronautics from the Massachusetts Institute of Technology. Prior to re-joining U-M, he was an instructor in Aerospace Engineering Sciences at the University of Colorado Boulder.

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Abstract

This work-in-progress paper investigates what elements of project teams assist students in developing professional skills. We define professional skills as the non-discipline-specific skills that support students' work (i.e. communication, time management, etc.) and student project teams as co-curricular, student-run activities that complete an engineering task, whether for a national competition or for accomplishing their self-set goals. Project teams are often cited as activities where students can learn technical and professional skills; however, it's unclear which structures or mechanisms on project teams assist or prompt students' professional skill development.

To address this topic, two focus groups were conducted with a total of eight students from different project teams. The focus group structure was inspired by Group Level Assessment and follows the stages of generating, appreciating, reflecting, and understanding. During the generating, appreciating, and reflecting stages the students created a graphical representation of their project teams based on activity systems from Cultural-Historical Activity Theory (CHAT). Activity systems are used to represent a system, such as project teams holistically and are composed of six categories: the members, the tools used, the rules, the surrounding community, the way work is divided, and the goal of the activity. Then students completed another iteration with their diagrams by adding the skills that they have learned from their project team experience based on the Student Involvement Framework. The Student Involvement Framework contains a list of professional skills associated with project teams that were available to students to reference during the focus group. For the understanding stage, the students were asked to discuss their experiences on project teams and how they learned professional skills as members.

The diagrams were analyzed using activity system categories as a priori codes to investigate if professional skills are connected with specific activity system categories. All skills listed in the Student Involvement Framework were written on at least one diagram. While there were not clear connections between activity systems and the majority of the professional skills, some skills were repeatedly connected to specific project team elements or requirements.

Introduction

The benefits of experiential education are documented throughout engineering education literature. Experiential learning is connected to building professional skills that students need post-graduation [1]. Professional skills, which we are defining as the non-disciplinary specific skills that are needed to do engineering work such as communication and teamwork, are important for engineering students post-graduation according to industry [2], [3]. Professional skills complement engineers' technical expertise and increase their ability to work effectively in the workforce. While experiential learning can be integrated into traditional engineering courses through interventions such as project-based learning, adding more content into an already full engineering curriculum is difficult. Also, instructors, who are typically hired because of their technical knowledge, may not feel comfortable or qualified to teach professional skills in their classes. Therefore, experiential learning in extra- and co-curricular settings operates as another way for students to access the benefits that it provides.

Project teams are engineering extracurricular activities that take place outside of classrooms. The goal of project teams are to design, build, and optimize a device or structure to perform a specific task. Typically, but not always, the teams compete against other universities at local and national competitions that are organized by engineering societies or organizations such as the Society of Automotive Engineers (SAE) Baja and American Society of Civil Engineers' (ASCE) Concrete Canoe Competition. Project teams have

been noted in the literature as opportunities for students to learn both professional skills and disciplinary knowledge [1], [4], [5], [6].

It's important to understand how experiential settings are building professional skills because not every student has access to these opportunities. Studies have shown that student's background, such as first-generation, gender, and race, impact their ability or interest in participating in out-of-classroom activities [7], [8], [9], [10]. For project teams specifically, minoritized students often face an entry barrier to participation [11]. Therefore, if we know the most beneficial aspects of project teams, we could work to incorporate some of those in the classroom, giving all students access.

As previously established, elements of co-curricular activities impact what students are getting out of them [12], [13]. This work-in-progress paper seeks to understand if there are specific elements of project teams that promote the development of professional skills by asking the research question: *What aspects of project teams do students associate with utilizing and developing professional skills?*

Methods

The research team conducted three focus groups at two different universities. University A and University B are both large, historically and predominately white, public universities in different regions of the country. A focus group occurred during Spring of 2023 at University A and University B and a second focus group at University A occurred during Fall 2023. Participants were selected from those who responded to an email that was sent to all public email addresses associated with project teams at the two universities. Students interested in participating signed consent forms that collected their contact information, project team name, and their role on their team. Only one student from each project team was invited to participate in each focus group. In the event that two students from the same project team completed the form, the first student to sign up was contacted first to participate in the focus group. A total of 15 members of project teams participated and represented 13 different project teams. 6 participants identified as women and 9 identified as men. The focus group was organized in two parts, with the first half centered around the structure of the project teams and how they operate and the second half focused on connecting these structures with professional skills.

The Group Level Assessment (GLA) methodology [14] was used to structure the focus group following the stages of climate setting, generating, appreciating, reflecting, and understanding. The participants introduced themselves and their team, generated a written diagram of the structure of their team, viewed and commented on others' diagrams, reflected and edited their own diagrams, and compared the inner workings of their teams in more detail with the group. The generating, appreciating, and reflecting stages were conducted on paper by students writing on their diagrams. These diagrams were then collected and analyzed for this study. The climate setting and understanding stages were conducted verbally by students talking with the focus group facilitator and each other. These conversations were recorded, transcribed, and will be analyzed in future research. Two iterations of the GLA structure were performed to correspond to the two parts of the focus group. The first iteration of GLA focused on the structure of the project teams and how they operate and the second iteration focused on connecting project team structures with professional skills.

The diagrams were designed based on activity systems from the Cultural Historical Activity Theory (CHAT) [15]. Activity systems were used to focus on the system being studied, specifically the project team's structure to represent the different aspects of project teams that students associate with professional skills. Activity systems describe a structure using six categories: tools, members, rules, community, work division, and objectives [16]. These categories were used as the starting points for the diagram and the participants were asked to write those aspects of their project team on their diagram. During this phase of the focus group, a projected list of the six categories was shown to the participants

with two examples for each category. The participants were told that they did not have to use the examples as it was not an exhaustive list. After examining the data from the focus groups in Spring 2023, descriptions of the categories were added for the Fall 2023 focus group to add more clarifications for the categories.

The second half of the focus group was focused on professional skills. To begin, students were asked to place professional skills on their diagram of their team in places where they see those professional skills being used or developed. This way, students directly connected professional skills with certain activity systems of their project team. The students repeated the same process as before by adding concepts to their diagrams, viewing others' diagrams, reflecting on their diagrams, and comparing their experiences with professional skills to other participants. During this phase, a list of professional skills was projected in the room. The participants were informed that they could use the list of professional skills but were explicitly told that they did not have to use it and were free to include any skills they deemed appropriate. The projected list was based on the Student Involvement Framework [17]. The Student Involvement Framework contains a list of professional skills that correspond to different types of extra- and co-curricular activities. This framework was selected because it includes a list of skills that students on project teams and other activities believed to be developing and/or learning through their participation. To create this list, researchers conducted a content analysis of 436 registered student activity groups at one university and compiled a list of 20 skills that were mentioned by the organizations. Therefore, the list is based on students' self-perceptions of what they are learning, which matches the goal of the study to understand what professional skills students believe they are developing from their participation on project teams. Also, there is a difference between student, institution, and industry beliefs in terms of what skills are important [18], [19] and what skills students have developed [20]. Using a framework that prioritized students' perceptions was important so the framework aligns with students' experiences. All 20 skills in the framework were projected during the first two focus groups that took place during the Spring 2023 semester. During the Spring 2023 focus groups, the students repeatedly steered the conversation to center around one skill in particular: disciplinary knowledge. However, disciplinary knowledge was the only skill on the list that was not considered to be a professional skill by our research team because it did not fit our definition of non-disciplinary-specific skills. Therefore, disciplinary knowledge was removed from the projected list for the Fall 2023 focus group to encourage students to discuss other skills.

Every diagram was coded by two researchers for the skills participants put on their diagrams and what section of the activity system they placed them under. After coding the diagram separately, all discrepancies were discussed and resolved. The specific skills that were coded either came directly from the projected list of skills or were related to a skill on the list. The skills that were not on the projected list were initially coded verbatim and then we discussed how those skills fit with the Student Involvement Framework. The majority of these skills were synonymous with skills listed in the framework and therefore were re-coded as terms used in the framework. Only two skills, communication and leadership skills, were kept as codes that were not initially included in the framework. While interpersonal and written communication are listed in the Student Involvement Framework, if the type of communication that students were referring to was not clear it was kept as a separate code under communication rather than coded as interpersonal or written communication. Also, students would occasionally include the term professional or "soft" skills to refer to all of the skills. These instances were coded as "General."

Findings

Participants contributed a myriad of professional skills to each activity system category. The objective category contained the most skills at 18, followed by work division (14), team members (11), tools (10), rules (9), and community (6) as shown in Table I. The numbers in the table represent the number of diagrams where students had written the skill in connection with a specific activity system category. The

numbers are only used to represent that some skills were more commonly associated with specific activity systems across different project teams, not for quantitative analysis.

TABLE I
PROFESSIONAL SKILLS PLACED IN THE ACTIVITY SYSTEM

Category	Professional Skill
Community	Networking (11), Teamwork (5), Interpersonal Communication (2), Communication, Cross-Cultural Skills, Public Speaking
Objective	Strategy (6), Creativity (5), Global Awareness (3), Problem Solving (3), Public Speaking (3), Teamwork (3), Written Communication (3), Interpersonal Communication (2), Critical Thinking, Cross-Cultural Skills, Ethics, General**, Humanitarianism, Leadership, Organizational Management, Self-Driven, Time Management
Rules	Public Speaking (4), Self-Direction (4), Time Management (4), Problem Solving (2), Written Communication (2), Creativity, Communication, Interpersonal Communication, Teamwork
Team Members	Interpersonal Communication (5), Teamwork (5), Self-Direction (3), Leadership (2), Networking (2), Time Management (2), Written Communication (2), Ethics, Organizational Management, Public Speaking, Strategy
Tools	Critical Thinking (3), Organizational Management (3), Communication (2), Creativity (2), Problem Solving (2), Self-Direction (2), General** (2), Memory, Networking, Public Speaking
Work Division	Organizational Management (11), Teamwork (4), Self-Direction (3), Time Management (3), Communication (2), Interpersonal Communication (2), Written Communication (2), Creativity, Ethics, Global Awareness, Leadership, Memory, Problem Solving, Public Speaking
Other*	Ethics (3), Creativity (2), Organizational Management (2), Problem Solving (2), Self-Direction (2), Teamwork (2), Cross-Cultural Skills, Strategy, Time Management

*Students placed a skill on their diagram but did not assign it to a specific category

**Professional skills in general, rather than a specific skill, was written

All 20 professional skills from the Student Involvement Framework appeared at least once in the 15 diagrams. Unsurprisingly, the skills that were not included in the project team subsection of the framework, memory and civic responsibility, only appeared occasionally. Meanwhile, the skills that were mentioned the most often on project team diagrams were teamwork (23 instances), organizational management (18 instances), and networking (15 instances). Also, students frequently emphasized certain skills on their diagrams by circling or underlining words or commenting on others' diagrams by using red ink as represented by Figure 1. The emphasized skills tended to match the most commonly written skills such as teamwork and networking, but communication and public speaking skills were also repeatedly commented on.

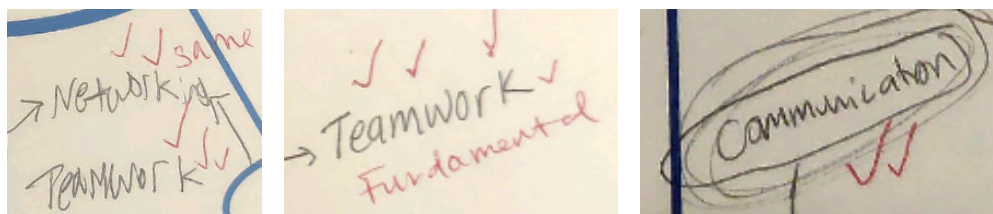


Fig. 1. Emphasized Professional Skills.

Discussion

Overall, there was not a specific category that related to the majority of the skills. Professional skills were sprinkled throughout various students' diagrams so students may not identify professional skills in general with specific aspects of activity systems. For instance, teamwork was written the most number of times and was frequently highlighted on the diagrams. However, it was connected to every single category on activity systems. Two participants even connected teamwork to the center of the diagram rather than placing it within a specific category. Clearly, participants believe it fits in more than one section of the activity system.

However, there were a few professional skills that were connected to specific aspects of project teams. Public speaking was repeatedly connected to presentations that were required either for competition or internal review. Meanwhile, organizational management was connected with organizing subteam work and planning meetings for project team members and networking was connected to working with industry partners and alumni. All of these aspects provide insight into how specific professional skills are being developed on project teams.

Some of the elements of project teams that students connected with developing professional skills are performed in other settings. For example, design reviews or presentations in engineering classes are not uncommon and students in any type of club can organize meetings. However, there are some elements that are unique to project teams that other experiences could adopt to promote the development of professional skills for all students. For instance, students on project teams orchestrate numerous subteams that require them to work with large groups of people. The skills written in the work division category show how navigating and organizing the structure assists in the development of numerous professional skills. Mirroring the project teams' work division in classroom settings could provide more students with another opportunity to develop professional skills that students on project teams currently have.

Conclusion

There was not a clear connection between developing professional skills in general and a specific aspect of activity systems. Other than networking and organizational management skills, most of the professional skills were represented in a variety of categories. More often, skills appeared across numerous activity system categories. However, a couple of skills were repeatedly connected to specific elements of project teams, but the elements were also spread out across categories.

The selected participants and analysis method limit the current study's findings. A possible response bias from the current recruitment model led to all participants in the focus groups having specific roles, such as chief engineer or software lead, on their project team. We recognize that not all members of project teams work have the same responsibilities or are involved to the same extent which can influence what skills students are developing. Also, as previously mentioned, this work-in-progress only reports on the initial analysis of students' diagrams. In future work, we will analyze the transcripts and diagrams using deductive coding to identify if there are specific elements on project teams that are connected with students' development of professional skills. The transcripts can also increase the validation of the study by triangulating the findings that are presented in the current paper.

It is important to figure out which elements on project teams are prompting the development and practice of professional skills on project teams to understand if those elements can be replicated in other settings. Not all students or institutions have the resources or availability to expand or participate in project teams. However, by understanding which structures or elements have been useful for developing professional skills, instructors can introduce similar tactics into classroom settings so more students have opportunities to develop their professional skills.

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