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Experience is Not Mastery: Unexpected Interactions Between Project Task Choice and Measures of Academic Confidence and Self-Efficacy in First-Year Engineering Students*

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Engineering confidence and self-efficacy are key contributors to persistence in engineering. Hands-on, team-based engineering design projects can increase students' engineering self-efficacy, by providing mastery experiences. However, not all students benefit similarly from project-based learning in teams; students can take on different tasks and as a result, experience different changes in confidence or self-efficacy. In this study, we investigated the relationships between time spent on various project tasks and students' initial levels of and changes in confidence or self-efficacy. This study used a mixed-methods approach to data collection and analysis, focusing on 97 students between 2012–2015 enrolled in two different project-based learning contexts: at a small private engineering college and at a large public university. We found that engineering confidence and self-efficacy did not increase monotonically over the project experience for both contexts. Although there were no relationships between project tasks and related measures in confidence (for example, students who spent more time on building did not have a higher increase in tinkering self-efficacy), there were negative correlations between time spent on writing tasks and students' initial confidence/self-efficacy and changes in confidence/self-efficacy. Our findings indicate that time spent on task may not be a proxy for mastery experiences, and that changing self-efficacy or confidence may be highly individual and contextual. However, some recurring patterns suggest approaches for intervention that may better support a wide range of students.

Keywords: first-year engineering; project-based learning; self-efficacy; confidence

1. Introduction

Engineering project courses are important components of first-year curricula [1]. Contextualized engineering work at the beginning of the curriculum introduces students to important concepts and principles, preparing students to become practitioners while they acquire and learn to apply engineering knowledge [2]. Hands-on design projects, in particular, increase student enjoyment, allow students to practice "real world" engineering tasks, and provide mastery experiences for engineering students [3].

These mastery experiences allow students to experience what they will be doing as "masters" or practitioners, thus allowing students to actively develop the skills that they will use in their career. Mastery experiences are also a primary contributor to self-efficacy, an individual's belief in his or her ability to succeed [4]. Engineering confidence and self-efficacy influences how students spend their time and make decisions in their engineering classes [5, 6], and have been found to be among the most significant factors in student motivation, persistence, and retention [7, 8].

However, it is not clear if the project experiences that are typically offered as part of first-year courses function as mastery experiences in the context of self-efficacy, or if they function similarly for all students. A prior study demonstrated that an increase in engineering-related self-efficacy has been observed for male students after a hands-on, team-based engineering project, while no change was observed for female students [9]. This may be a result of students doing different types of tasks throughout the project, and thus having different opportunities for mastery experiences [10]. While the reasons that students take on (or are assigned) different tasks can vary—they can be based on the gender stereotypes associated with the project tasks [11], motivation [12], team dynamics [13], status [14], personality [15], etc.—this study focuses on how changes in self-efficacy and incoming self-efficacy relate to time spent on project tasks.

As projects can influence students' engineering self-efficacy, students' incoming self-efficacy may also have an impact on how they approach a project experience. Self-efficacy greatly influences students' decisions [4, 16], and thus students may be more inclined to take on tasks based on their initial levels

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of confidence or self-efficacy. This is particularly relevant in first-year courses, as the prior experiences of students may vary widely: this can include differences in academic background based on opportunity (for example, courses in computer programming that may not be offered at all high schools), or differences due to participation in extracurricular activities, such as involvement in robotics teams. This range of experiences can result in students having varying levels of comfort with different tasks, and thus varying levels of engineering self-efficacy, which can in turn impact how students divide tasks between team members in first-year group projects. A student who participated in an engineering student team in high school—and has relatively high engineering self-efficacy—may end up doing the majority of the technical work for their team, working in CAD or doing hands-on fabrication, and thus may not gain confidence with other aspects of the project, such as communication. Other students may undertake (or be tasked with) non-technical tasks, like writing reports or coordinating meetings, and thus may feel more confident in their writing or project management abilities, but may not have increased self-efficacy related to hands-on work. Previous studies have found that women, in particular, take on less technical tasks [10] and present less technical material and answer fewer questions than their male counterparts [17]. The concern is that this behavior may lead to a "pernicious cycle": students with lower self-efficacy may engage in fewer mastery experiences and thus experience little or no increase in self-efficacy. If this behavior repeats in subsequent team-based engineering project courses, they may find themselves falling successively further behind peers with higher self-efficacy, who engage in tasks that lead to increases in mastery and self-efficacy in course after course.

For this study, the self-reported time spent on different tasks was considered to be a proxy for mastery experiences. This allowed for a focus on the division of *types* of task, as something that previous studies suggested would be affected by demographic factors [17]. The amount of time spent on each task can be considered to be *task choice in a continuing situation*: not merely a checklist of tasks carried out, but as an ongoing decision to work on those activities as part of the team project. Although it is possible to spend a significant amount of time on a task without a sense of increasing mastery, this design does involve making the assumption that spending time on a task is at least somewhat correlated with it being a mastery experience: not doing it at all is clearly not a mastery experience, and spending more time on it is likely to improve one's abilities and confidence more.

The aim of the research study presented here was to investigate the relationship between self-efficacy and tasks undertaken by first-year students in hands-on, team-based engineering design projects. More specifically, the goal was to discover how the engineering confidence and self-efficacy of first-year students at the start of a project may relate to the tasks that they subsequently take on as part of a team, and conversely, how students' task choice over the course of a project may have an impact on their self-confidence and self-efficacy at the end of the project. This work is guided by the following research questions:

1. How does first-year students' engineering confidence and self-efficacy change over the course of a hands-on team-based design project course?
2. What are the relationships between incoming engineering confidence or self-efficacy and the tasks undertaken as part of an engineering design project?
3. Which project tasks relate to changes in engineering confidence and self-efficacy?

With an understanding of how students' self-efficacy impacts and is affected by the tasks that they take on, engineering educators can structure and scaffold these types of projects to improve both academic outcomes (skill development) and affective outcomes (increases in self-efficacy or self-confidence).

2. Background

2.1 Confidence and self-efficacy

Confidence and self-efficacy are two different but related constructs. Both have been found to play a significant part in the academic experiences of engineering students.

Confidence, or the strength of one's belief in one's ability [18], strongly influences student persistence in their major, even more than other factors like ability or achievement. Female students, in particular, often cite a lack of confidence as a reason for leaving STEM majors [19, 20] and also perceive themselves as less capable than their male peers despite having similar or higher abilities [21–25]. Confidence in math and science, specifically, has frequently been found to predict persistence in engineering [7, 8, 26].

While similar, self-efficacy is more context- and domain-specific than confidence, and relates to student perception of expected performance [4, 27]. Self-efficacy influences many choices that students make throughout their studies, beginning with their choice of major or career path [16]; if they do not feel they can succeed as an engineer, they are unlikely to choose it as a field of study. Similarly, self-efficacy is a key determinant of tenacity, persistence and retention within a major [18, 28–30]. Self-efficacy also impacts the tasks that students take on, and how they perceive the work they do. Students may choose to do tasks at which they feel competent, and avoid those that they have less experience doing [4, 5]. Students view obstacles differently based on their level of self-efficacy: students with low self-efficacy will view an obstacle as a "threat" while students who are more confident view it as a "challenge" [5, 31, 32]. As a consequence of this, students who have higher self-efficacy may expend more effort on activities, because they have a stronger belief that they can succeed [33].

Beyond mastery experiences, there are three other main contributors to self-efficacy: vicarious experiences (role modeling), social persuasion, and physiological states [27]. Of the four contributors, mastery experiences have been found to have the strongest influence on self-efficacy [4, 18, 34]. When students have a mastery experience, they feel encouraged that they can succeed as an engineer, increasing their engineering self-efficacy. To help students develop self-efficacy in engineering, therefore, it is important for them to have mastery experiences that map directly onto engineering practice. Hands-on project-based courses are widely used to provide these types of experiences.

2.2 Project-based learning

Projects typically require students to work in teams to integrate and apply disciplinary knowledge to solve a "real world," open-ended problem [35]. Requiring students to apply technical concepts and skills improves conceptual learning and problem-solving skills [35, 36]. In general, projects are intended to be authentic with regards to the case or problem, the workload, the criteria and the demands on the students as practicing engineers [36]. An authentic problem will often be ill-structured, with the open-ended nature of the problem allowing the students more autonomy, responsibility and authority over their work. Within the situated environment, students are able to develop important abilities like teamwork, communication, project management, and information-seeking skills [35–37]. Engaging in projects has been shown to increase student interest in and motivation to study engineering [35, 38] and to result in increased persistence in the major [39–42]. Also, providing students with the opportunity to independently apply their skills in this context allows them to engage in mastery experiences, which can then contribute to development of their engineering self-efficacy.

While capstone design projects have long been a mainstay of the final year of engineering curricula—in the United States, they are an ABET accreditation requirement (ABET 2016)—first-year hands-on design projects have become increasingly popular [1, 2, 39, 44–47]. Engineering education curricula have been criticized on the grounds that students do not have enough opportunities to put their technical knowledge into practice, they do not gain enough design experience, and they do not have sufficient opportunities to practice professional skills like teamwork or communication or to consider social, environmental or economic issues [35, 48–50]. These criticisms can be addressed by incorporating projects throughout the curriculum, starting in the early years. Students can therefore be introduced to engineering thinking and practice sooner and can also be oriented to the profession [38, 51].

First-year design projects that incorporate a hands-on component also serve to increase student motivation and interest and improve students' engineering skills. Hands-on work is perceived to be related to many important engineering skills, such as mechanical understanding, troubleshooting, adaptability, and especially design [3]. As a key source of mastery experiences for engineering students, hands-on work gives students the chance to develop the engineering skills that they will use as practitioners [3] as well as the engineering self-confidence and self-efficacy needed to persist in their program and in the field. However, the benefits of hands-on team design projects do not necessarily accrue evenly to all students. Students who are assigned a lower status—who are perceived to be less capable—may be delegated by their team to take on less challenging tasks [14], and thus may not have the opportunity to work on the skills the course was designed to develop. Difficulties with team dynamics can negatively impact students' engagement, interest or persistence [17]. Thus, motivated by the finding that students participating in the same hands-on team project may not display similar increases in engineering self-efficacy, or may not experience an increase at all [9], the focus of this work is how different students benefit from projects in terms of the impact on their engineering confidence or self-efficacy and how their confidence level relates to the mastery experiences that they complete.

3. Methods

3.1 Participants and setting

The analyses presented here encompass data from two institutions, gathered over three academic years, from 2012–2015 (Table 1). At each institution, students self-selected into the study after all

Table 1. Research study participants

	Small Private College (SPC)				Large Public University (LPU)			
	Female Students	**Male Students**	**Did Not Disclose Gender**	**Total**	**Female Students**	**Male Students**	**Did Not Disclose Gender**	**Total**
2012	17	16	1	34	4	5	0	9
2013	9	8	0	17	2	4	1	7
2014	3	3	0	6	1	1	0	2
2015	0	0	0	0	9	13	0	22
Total	29	27	1	57	16	23	1	40

students in targeted classes were invited to participate.

The datasets were not combined both because statistically significant differences were observed between the incoming levels of self-efficacy and confidence in students in each setting, and also because the project courses in the two settings were structured differently.

One set contains data from students enrolled in a multidisciplinary program in a small, private engineering college (denoted SPC in this paper) located in the northeastern United States. The students participated in the study while in a required first-year design course. The design course consisted of two phases: in the first half of the semester, students completed an individual hands-on project that was intended to help students develop design and fabrication skills. The second half of the semester was a project in which teams of approximately five students designed and built a prototype of a toy, which generally included both electrical and mechanical elements. This course was taught by the same instructors each year of the study.

The second set contains data from students enrolled in the engineering college at a large public university (denoted LPU in this paper) located in the Midwest. Although all incoming engineering students take the first-year design course, for this study, specific sections were targeted that incorporated a substantial hands-on component. As at the SPC, the first part of the design course involved individual projects to develop students' skills before they assembled into teams for a larger-scale hands-on team project. Each section assigned a different team project, all of which were hands-on and employed the "design, build, test" model. The project may involve creating an underwater remote-operated vehicle (ROV) that had to complete a variety of timed tasks; a solar-powered model car; or a product for use in the "real world," in which many students focused on opportunities on campus, such as improving the laundry facilities in dorms. The course time was evenly split between engineering topics and technical communication, both written and oral. Each course section was taught by a different instructor, but the overall course structure was the same.

3.2 Data collection

The study presented in this paper involved a mixed-methods concurrent nested approach to data collection and analysis [52], in which the focus is on the quantitative data, which was collected first, while the qualitative data, collected afterwards, plays a supporting role.

3.2.1 Pre- and post-course survey

The pre-course survey included questions about demographics, Big Five personality traits [53], and prior engineering experience and exposure. Both pre- and post-course surveys consisted of items that made up seven constructs of engineering confidence and self-efficacy, drawn from previously-developed instruments to investigate aspects.

3.2.1.1 Persistence in Engineering (PIE) instrument

The Persistence in Engineering instrument (Eris et al., 2005, 2010) was created to investigate the relationship between persistence in engineering and academic self-confidence, as defined by three constructs: academic self-confidence in math and science, in open-ended problem solving, and in professional and interpersonal skills. This instrument was validated and has been used to demonstrate gender differences among engineering students. The instrument was used here to provide more broad-based insight into academic self-confidence and persistence, and the ability to contextualize results by reference to this previous study.

Five measures from the Persistence in Engineering (PIE) instrument [7, 54] were used here. First, students self-rated their Commitment to Completing an Engineering Degree as well as their Confidence in Completing an Engineering Degree. These two items were on a Likert scale from 1–5, where 1 was "strongly disagree" and 5 was "strongly agree."

The next three measures from the PIE survey

Table 2. Confidence items

Solving Open-Ended Problems	Creative thinking Solving problems that can have multiple solutions Critical thinking skills Ability to apply math and science principles in solving real world problems*
Math and Science Skills	Math ability Science ability Ability to apply math and science principles in solving real world problems*
Professional and Interpersonal Skills	Self-confidence (social) Leadership ability Public speaking ability Communications skills Business ability Ability to perform in teams

* Note that one survey item was included in two constructs.

focused on three constructs: Solving Open-Ended Problems (section 3c), Math and Science Skills (section 3a), and Professional and Interpersonal Skills (section 3b). Students were asked to rate their confidence in a variety of items for each construct (Table 2). These items were rated on a Likert scale from 1–7, where 1 was "strongly disagree", 2 was "disagree", 3 was "somewhat disagree", etc.

The Persistence in Engineering instrument was previously tested for internal consistency by calculating Cronbach's alpha values for each construct. It was determined that the three constructs (Confidence in Solving Open-Ended Problems, Math and Science Skills, and Professional and Interpersonal Skills) were reliable, with Cronbach's alpha values of $\alpha = 0.69$, $\alpha = 0.83$, and $\alpha = 0.84$, respectively (Eris et al., 2007).

3.2.1.2 Engineering and tinkering self-efficacy instruments

Because of the potential relationship between task choice in hands-on engineering design projects and gender, and between gender and engineering self-efficacy, we also used a pair of instruments that had been recently developed at the time of administration, focused on Engineering Self-Efficacy and Tinkering Self-Efficacy [56]. These two instruments are both much more narrowly focused (hence, self-efficacy rather than self-confidence). The Tinkering Self-Efficacy instrument was intended to specifically capture hands-on project work, as previous studies suggested that this might be an area where student experiences differed.

Students rated their agreement with approximately 30 statements for each instrument, describing engineering and hands-on (tinkering) tasks. A

Table 3. A subset of items from the Engineering and Tinkering Self-Efficacy instruments

Engineering Self-Efficacy	I can statistically model a process I can apply theoretical concepts to real-world problems. I have written and oral communication skills. I understand the relationship of theory to application. I am a logical thinker. I know different ways to create a design. I have engineering experience. I have a broad technical knowledge base. I can summarize the key points of a technical problem with simple language. I understand the theory behind how something works. I understand and can apply mathematical concepts to a problem.
Tinkering Self-Efficacy	I have the knowledge and technical skills to create mechanisms or devices. I have spatial sense. I am inquisitive. I work well with my hands. I try to understand how things work in order to fix problems. I have a passion to create. I can troubleshoot technical problems. I like to take things apart to find out how they work. I want to know how things work and how to make them better. I am curious. I like to build with my hands. I have creative abilities. I have experience using a range of tools.

representative subset of these statements is shown in Table 3.

The Self-Efficacy instruments were not previously tested for reliability, and thus internal consistency was tested. After the first round of data collection, Cronbach's alphas were calculated to determine internal consistency of both the Engineering Self-Efficacy and Tinkering Self-Efficacy constructs. Both the Engineering (30 items, α = 0.941) and Tinkering Self-Efficacy (30 items, α = 0.935) instruments were found to be highly reliable.

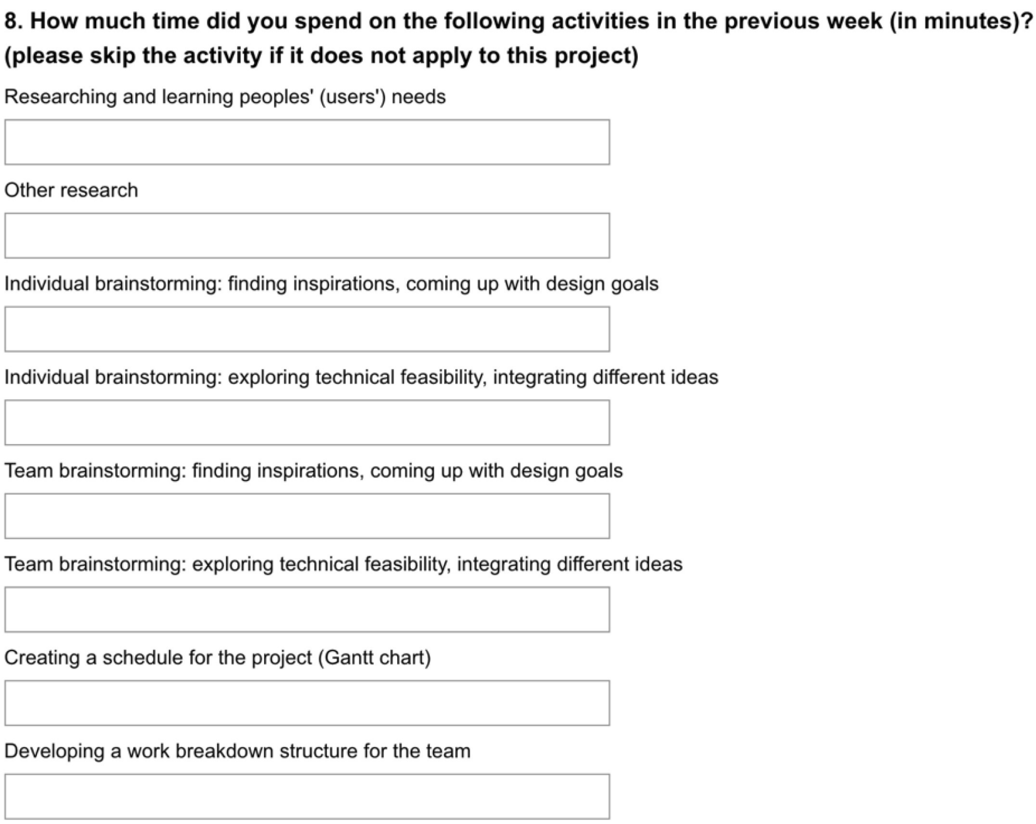
3.2.2 Weekly activity logs

Weekly activity logs were utilized to determine how students were spending their time in the course in total, and in specific design project tasks. Students were presented with a list of tasks and asked to record how much time they spent on each task in the preceding week. They also had the opportunity to write in activities that did not appear on the list; and to reflect briefly on their experiences that week. Weekly logs were used because they have a relatively short retrospective period (striking a balance between the labor-intensiveness of a daily diary of activities, or the inaccuracies inherent in asking students to reflect on their activities at the end of term) and because it maps onto the regular weekly rhythm of classes. The initial list of tasks was generated by pilot work done at the SPC prior to the start of data collection: student researchers enrolled in the first-year design course recorded the tasks they carried out. The list of tasks then were written to be generalizable to any hands-on engineering project, were ordered to match a typical engineering design process [57], and were intended to be reasonably comprehensive. As students at the LPU never took the opportunity to write in additional tasks, this suggests that their experiences were also well captured. A portion of the weekly log survey, in which students report the minutes devoted to different tasks, is shown in Fig. 1.

For analysis, the 40 tasks were clustered in two different ways: by mastery and by activity.

To create "mastery clusters", tasks were mapped to one of the five Confidence or Self-Efficacy measures, collectively comprising mastery experiences. Tasks were mapped to a cluster if it matched an item from that construct. For example, the task "preparing written materials to present or submit" mapped to the Confidence in Professional and Interpersonal Skills item "communications skills" and to the Engineering Self-Efficacy item "I have written and oral communication skills." This also means that tasks could be mapped to more than one cluster.

In the "activity clusters", similar tasks were grouped together into one of twelve broader areas:


8. How much time did you spend on the following activities in the previous week (in minutes)? (please skip the activity if it does not apply to this project)

Researching and learning peoples' (users') needs

Other research

Individual brainstorming: finding inspirations, coming up with design goals

Individual brainstorming: exploring technical feasibility, integrating different ideas

Team brainstorming: finding inspirations, coming up with design goals

Team brainstorming: exploring technical feasibility, integrating different ideas

Creating a schedule for the project (Gantt chart)

Developing a work breakdown structure for the team

Fig. 1. Screenshot of an excerpt from the weekly log in which students report time spent on tasks.

Table 4. Mapping of the log tasks to mastery and activity clusters

	Mastery Clusters					
	Solving Open-Ended Problems	**Math and Science**	**Professional and Interpersonal**	**Engineering**	**Tinkering**	**Activity Clusters**
Individual brainstorming: finding inspirations, coming up with design goals	X			X		Brainstorming
Individual brainstorming: exploring technical feasibility, integrating different ideas	X			X		
Team brainstorming: finding inspirations, coming up with design goals	X			X		
Team brainstorming: exploring technical feasibility, integrating different ideas	X			X		
Performing calculations related to the project		X		X		Calculations
Communicating with people outside your team			X	X		Communication
Communicating with team members about the project			X	X		
Documenting your process			X			Documentation
Taking notes during team meetings			X			
Working with a mechanical system (eg motors)		X		X	X	Hands-On Work
Working with electrical components (eg batteries)		X		X	X	
Using a machine shop (either training or building)				X	X	
Assembling a physical prototype					X	
Improving aesthetics of a prototype					X	
Testing an experimental prototype	X				X	
Troubleshooting an experimental prototype	X				X	
Using CAD (modeling, assembling, dynamic simulation, etc.)	X			X	X	Modeling
Preparing written materials to present or submit			X	X		Oral Presentation
Preparing visual materials to present or submit			X	X		
Preparing the spoken component of a design review or presentation			X	X		
Preparing audiovisual materials to present or submit			X	X		
Creating a schedule for the project (Gantt chart)			X			Project Management
Participating in a design/midterm review	X		X			
Managing a project budget		X	X			
Purchasing materials or supplies			x			
Managing supplies			X			
Other project management			X			
Cleaning/ organizing workspace			X			
Researching and learning peoples' (users') needs	X		X			Research
Other research	X			X		
Reverse engineering (learning from professional or prior projects)	X			X		
Sketching ideas in 2D	X				X	Sketching
Building 3D sketch models	X				X	
Developing a work breakdown structure for the team			X			Teamwork
Motivating other team members			X			
Helping other students			X			
Collaborating with other teams			X			
Working individually on a written report			X	X		Written Report
Working collaboratively on a written report			X	X		
Compiling or editing a written report			X	X		

brainstorming/ideation, calculations, communication, documentation, hands-on work, modeling, oral presentations, project management, research, sketching, teamwork and written communication. Each task was part of only one activity cluster.

Table 4 presents each of the 40 tasks, showing how they are mapped to mastery and activity clusters.

3.2.3 Semi-structured interviews

After the conclusion of the project course, a subset of students completed semi-structured interviews, in which they discussed their background in general, their team, and their individual experience in the engineering project. Students who completed both the pre- and post-course survey and more than 50% of the activity logs were invited to participate in an interview. The interview questions were chosen to delve deeper into factors that were expected to affect engineering self-efficacy, including mastery experiences and the social aspects of their teaming experience, and to investigate how students felt about the roles and tasks they took on during the project. Table 5 presents the phases of the interview and a subset of questions for each.

3.3 Data analysis

3.3.1 Quantitative data analysis

The Likert-scale responses to each construct were quantified into a single measure for statistical analysis by averaging each of the items within the construct. Thus, for each student on the pre- and post-course surveys, there was one number representing each of the seven constructs. From the times reported in the weekly logs, the proportion of total time spent on each task was calculated. Proportion of time was utilized (rather than absolute time) because students responded to varying numbers of activity logs.

Statistical analysis was performed using SigmaPlot v13 (Systat Software Inc.). The statistical design included paired t-tests to compare the students' pre- and post-course confidence and self-efficacy measures, t-tests to compare the data between the two settings, and Pearson's correlations to determine relationships between the time spent on project tasks and the pre- or post-course confidence or self-efficacy of students. SigmaPlot automatically checks for normality in data; if the distribution was non-normal, the corresponding non-parametric test was used (Mann-Whitney was used in place of t-tests). Since tests were always comparing exactly two groups of students (male students compared to female students, SPC compared to LPU students, etc.), ANOVA was not used. Regression was not used due to the relatively small number of data points.

3.3.2 Qualitative data analysis

As part of the larger mixed-methods research study, interview transcripts were coded using NVivo using emergent coding, with a lens focusing on students' descriptions of time spent on tasks on or mentions of self-confidence or self-efficacy. Emergent coding was used to avoid being biased by previously-found results. Activity codes were divided between "time on technical tasks" and "time on non-technical tasks;" "no time on technical tasks" or "no time on non-technical tasks." Confidence or self-efficacy codes were "positive confidence/self-efficacy" or "negative confidence/self-efficacy." As this paper focuses primarily on quantitative findings, the full qualitative analysis is *not* presented here and be will a focus of a future publication. However, we have included some quotes from interviews here, to illustrate and illuminate the quantitative findings.

4. Results

The project experience at each university setting differed in terms of the tasks that students engaged

Table 5. Sample questions from the semi-structured interview protocol

Background	How did you decide to study engineering? Is this engineering program what you expected? If so or if not, in what ways? What did you like best/least about the course?
Team	Can you describe your teammates? For each of your teammates, assign 1–3 roles that they played on the team. Can you describe how your team usually made decisions? Did you feel that your team trusted you with certain tasks? How did you know?
Individual Experiences	What role did you play on your team? How did you feel about that role? What kind of activities did you work on for the project? What was your favorite activity on the project? What were your goals for the course? To what extent did you achieve those goals? Was there anything for the project that you wish you did more of? Why do you think you didn't do more of it? Was there anything for the project that you did more of than you wanted to? Why do you think you did more of it?

in for the project, as well as the overall educational experience. Therefore, perhaps unsurprisingly, there were markedly different patterns observed in the changes of engineering confidence and self-efficacy in students from the two institutions. The observed statistical correlations suggest that there are more complex relationships between measures of self-confidence or self-efficacy and task choice than was implicit in our hypothesis.

4.1 Time devoted to tasks

The students' activity log data provides insights into how students are allocating their time between the mastery clusters and activity clusters throughout the project (Figs. 2 and 3).

At the SPC, students spent the majority of their time on Hands-On Work, Brainstorming and Modeling (Fig. 2). They spent very little time on Research, Written Report, Calculations and Documentation. In terms of the mastery clusters, students spent the most time on Engineering Tasks (tasks that mapped to the Engineering Self-Efficacy instrument) and little time on Math and Science tasks (tasks that mapped to the Confidence in Math and Science Skills instrument). This division of tasks aligns well with the structure of the project course: the primary focus is hands-on design and fabrication; the design process is scaffolded with specific assignments to address difference aspects of the design process, such as ideation; and students present their work in design reviews, rather than in written deliverables.

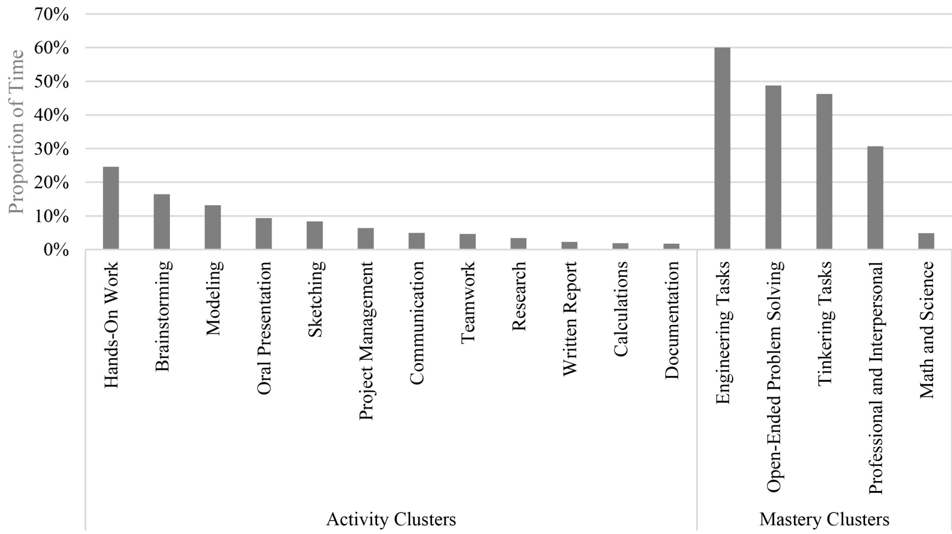


Fig. 2. Proportion of time devoted to tasks at the small private college.

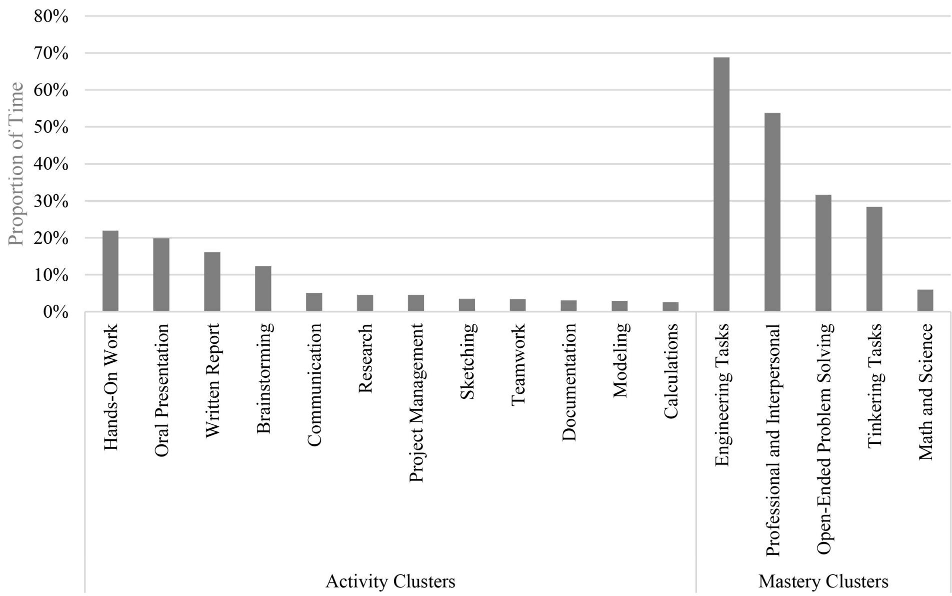


Fig. 3. Proportion of time devoted to tasks at the large public university.

At the LPU, students also spent the majority of their time on Hands-On Work; after this, they spent the most time on the Oral Presentation, the Written Report, and Brainstorming (Fig. 3). None of the other individual tasks accounted for more than 5% of their time. Students devoted the majority of their time to Engineering Tasks and to Professional and Interpersonal Tasks. As with the SPC above, the amount of time the students reported spending on tasks aligned closely with the structure of the course, which is evenly divided between engineering topics and technical communication.

4.2 *Changes in engineering confidence and self-efficacy*

In general, students at the LPU experienced an increase in engineering confidence and self-efficacy, while students at the SPC experienced no change or a decrease.

At the SPC, the only significant change between the start and the end of the semester was in Confidence in Math and Science Skills, which were observed to decrease ($p = 0.046$) (Table 6).

One student specifically discussed their math and science abilities in the interview, expressing why they may have lost confidence in their math and science skills:

> "It's kind of hard because I was like, math and science were very strong suits of mine in high school, but I still feel behind a lot of the people around here. . . [T]here's a lot of growing that I need to do before I'm completely comfortable with all of it."

Another student discussed their changes in confidence throughout the course and how their confidence level did not increase monotonically:

> "I think one thing that I probably should add is that I came in with sort of an nth confidence level, and it sort of, at some point had sort of a spike, and it sort of dropped, and I think now it sort of averaged out higher. . . I think in some ways I was artificial—me feeling like I sort of knew what I was doing, and I think that that's sort of why there was a crash afterwards. . .interesting team dynamics and also outside of [the class], there were interesting things going on. And so that sort of made it fall, and it just sort of depends on what the circumstances are. . . And I'm hoping at some point, I can get that to stable out a little bit more in sort of the healthy range of 'I'm competent. I know what I'm doing, but I don't think that I'm a person who has all the right ideas and I'm the only one who's right.' "

At the large public university, there were significant increases in Confidence in Solving Open-Ended Problems ($p = 0.002$), Confidence in Professional and Interpersonal Skills ($p < 0.001$) and in both measures of Self-Efficacy: Engineering ($p = 0.003$) and Tinkering ($p = 0.029$) (Table 7).

4.3 *Correlations between incoming engineering confidence and self-efficacy and time on task*

To investigate how students choose tasks, Pearson's correlation testing was performed between students' initial levels of engineering confidence and self-efficacy, and the proportion of time devoted to each task cluster. Given the large number of factors included in the correlation testing, the full results are not presented here; however, all of the statistically significant relationships are discussed.

At the SPC, there were no significant positive correlations between an engineering confidence or self-efficacy measure and the corresponding Mastery Cluster (for example, students with high Tinkering Self-Efficacy did not report spending more time on Tinkering Tasks or students with low Confidence in Professional and Interpersonal Skills did not spend less time on the Written Report) (Table 8). There was a significant *negative* correlation between incoming Confidence in Professional and Interpersonal Skills and the time spent on tasks in the Professional and Interpersonal mastery cluster. There were significant positive correlations between three incoming confidence measures (Confidence in Solving Open-Ended Problems, Engineering Self-Efficacy, Tinkering Self-Efficacy) and

Table 6. Changes in engineering confidence and self-efficacy at the SPC

		Incoming		**Outgoing**		**Change**	
		M	***SD***	***M***	***SD***	***M***	***SD***
	Commitment to Completing a Degree	4.58	0.61	4.56	0.95	0.13	0.62
	Confidence in Completing a Degree	4.42	0.87	4.42	1.06	0.23	0.86
Self-Efficacy	Engineering	3.82	0.47	3.82	0.61	0.13	0.42
	Tinkering	3.81	0.52	3.78	0.73	0.12	0.34
Confidence	Solving Open-Ended Problems	5.74	0.75	5.74	1.35	0.17	0.87
	Math and Science Skills	5.82*	0.77	5.36*	1.31	–0.27*	0.91
	Professional and Interpersonal Skills	5.58	0.94	5.62	1.30	0.08	0.68

* Denotes a significant change from incoming to outgoing at $p < 0.05$.
Confidence measures were ranked on a Likert scale 1–7. All other measures were on a Likert scale 1–5.

Table 7. Changes in engineering confidence and self-efficacy at the LPU

		Incoming		Outgoing		Change	
		M	*SD*	*M*	*SD*	*M*	*SD*
	Commitment to Completing a Degree	4.58	0.65	4.55	0.90	0.03	0.85
	Confidence in Completing a Degree	4.47	0.84	4.53	0.92	0.07	0.65
Self-Efficacy	Engineering	3.66*	0.56	4.04*	0.46	0.36*	0.57
	Tinkering	3.65*	0.53	3.84*	0.43	0.18*	0.42
Confidence	Solving Open-Ended Problems	5.64*	0.84	6.03*	0.61	0.34*	0.56
	Math and Science Skills	5.77	1.16	5.99	0.66	0.18	0.68
	Professional and Interpersonal Skills	5.22*	0.91	5.82*	0.88	0.52*	0.64

* Denotes a significant change from incoming to outgoing at $p < 0.05$.
Academic Self-Confidence measures were ranked on a Likert scale 1–7. All other measures were on a Likert scale 1–5.

Table 8. Significant correlations between incoming engineering confidence or self-efficacy and proportion of time devoted to task clusters at the small private engineering college

		Task Cluster	Correlation Coefficient
Confidence	Solving Open-Ended Problems	Math and Science Tasks	0.34
	Professional and Interpersonal Skills	Professional and Interpersonal Tasks	–0.32
		Tinkering Tasks	0.35
		Written Report	–0.52
Self-Efficacy	Engineering	Math and Science Tasks	0.44
		Written Report	0-0.29
	Tinkering	Math and Science Tasks	0.33

Significance level of $p < 0.05$.

time spent on tasks in the Math and Science mastery cluster. Finally, there was a significant negative correlation between two incoming confidence measures, Confidence in Professional and Interpersonal Skills and Engineering Self-Efficacy, and the time spent on the Written Report activity cluster. It should be noted that students at the SPC, in general, did not report spending much time in either the Math and Science cluster or Written Report cluster (Fig. 2).

Although there were no statistically significant positive correlations between a measure and the corresponding tasks, in interviews, students did often report opting out of certain tasks due to lack of experience or confidence in that area. This may have been because of concern that their performance on the task would negatively affect the team:

> "So I know one of my biggest hang-ups learning in engineering classes was that I was not afraid of the tools but I was afraid of messing up as a learner. . . [this course] invites those mess-ups to happen. When you're in the group situation, you don't want to mess up because you don't want to be that person on a team and I think that really limited a lot of folks in their attacking and participation in group projects like that."

Another student mentioned that a larger reason for opting out of tasks was due to dislike for the unfamiliar:

> "Right now I don't like CADing because it's something that I don't know how to do well . . . Anything that I don't know how to do well, I usually don't like it. Like circuits, I don't know how to build circuits well. Don't like to do circuits."

At the LPU, there was one direct positive correlation between an engineering confidence or self-efficacy measure and the proportion of time devoted to the corresponding mastery cluster: the time students spent on Solving Open-Ended Problems was correlated to initial Confidence in Solving Open-Ended Problems. The time spent in this mastery cluster also positively correlated with initial Confidence in Math and Science (Table 9). Several negative correlations were also observed: students with higher levels of engineering confidence or self-efficacy were *less* likely to devote a large proportion of their time to Professional and Interpersonal Tasks, the Written Report, and Oral Presentation.

4.4 Correlations between changes in engineering confidence and self-efficacy and time on task

Pearson's correlations were also calculated between the *change* in engineering self-confidence or self-efficacy of students (calculated as the outgoing measure minus the incoming measure) and the proportion of time devoted to different classes of tasks.

Table 9. Significant correlations between incoming engineering confidence or self-efficacy and proportion of time devoted to task clusters at the large public university

		Task Cluster	Correlation Coefficient
Confidence in Completing an Engineering Degree		Professional and Interpersonal Skills	–0.36
Confidence	Solving Open-Ended Problems	Solving Open-Ended Problems	0.38
		Professional and Interpersonal Tasks	–0.39
		Documentation	0.34
		Written Report	–0.41
	Math and Science Skills	Solving Open-Ended Problems	0.36
		Professional and Interpersonal Tasks	–0.49
		Written Report	–0.53
	Professional and Interpersonal Skills	Project Management	0.36
Self-Efficacy	Engineering	Professional and Interpersonal Tasks	–0.36
		Oral Presentation	–0.41
	Tinkering	Engineering Tasks	–0.34
		Oral Presentation	–0.34
		Written Report	–0.35

Significance level of $p < 0.05$.

Table 10. Significant correlations between changes in engineering confidence or self-efficacy and proportion of time devoted to task clusters at the small private engineering college

		Task Cluster	Correlation Coefficient
Commitment to Completing an Engineering Degree		Tinkering Tasks	–0.37
Confidence	Math and Science Skills	Calculations	–0.37
	Professional and Interpersonal Skills	Math and Science Tasks	–0.47
		Tinkering Tasks	–0.45
		Brainstorming	0.40
		Hands-On Work	–0.46

Significance level of $p < 0.05$.

At the SPC, there were several significant correlations between changes in engineering confidence or self-efficacy and the proportion of time devoted to certain tasks (Table 10), but many of them were negative. The time spent on Tinkering Tasks was significantly negatively correlated with changes in two confidence measures (Commitment to Completing an Engineering Degree and Confidence in Professional and Interpersonal Skills). Changes in Confidence in Math and Science correlated negatively with time spent on Calculations. The only significant positive correlation observed was that between the change in Confidence in Professional and Interpersonal Skills and the time devoted to Brainstorming.

For students at the Large Public University, there were several significant correlations between engineering confidence or self-efficacy and the proportion of time devoted to different categories of tasks (Table 11). Three classes of tasks were correlated with changes in a number of measures of confidence or self-efficacy: Solving Open-Ended Problems, Professional and Interpersonal Tasks, and Written Report. Spending a large proportion of time on Solving Open-Ended Problems correlated *negatively* to Confidence in Solving Open-Ended Problems as well as in Math and Science, while more time spent on Professional and Interpersonal Tasks correlated with a positive change in these confidence measures. More time spent on the Written Report was correlated to decreases in Commitment to and Confidence in Completing an Engineering Degree, and positively correlated to changes in Confidence in Math and Science.

These findings are illustrated by one student's report of their experiences, in which they described their mastery experiences in technical communication:

> "[I really felt that I was learning when I did] a lot of the writing and I actually learned a lot about, like, the technical communication side of it through the project. . . There were a lot of things even just about presenting that, like, I never really had thought about or learned. . . I feel I learned a lot about that."

Table 11. Significant correlations between changes in engineering confidence or self-efficacy and proportion of time devoted to task clusters at the large public university

		Task Cluster	Correlation Coefficient
Commitment to Completing an Engineering Degree		Written Report	–0.55
Confidence in Completing an Engineering Degree		Written Report	–0.39
Confidence	Solving Open-Ended Problems	Solving Open-Ended Problems	–0.55
		Professional and Interpersonal Tasks	0.41
		Oral Presentation	0.40
		Sketching	–0.39
	Math and Science Skills	Solving Open-Ended Problems	–0.51
		Professional and Interpersonal Tasks	0.53
		Brainstorming	–0.50
		Written Report	0.48
Self-Efficacy	Engineering	Oral Presentation	0.38
		Project Management	–0.39

Significance level of $p < 0.05$.

However, later in the interview, they discussed their plans to transfer out of engineering:

> "[My goal for] the course was really—I wanted it to be a course that would make me go, okay, yeah, this is exactly what I want to do. I want to do engineering. And actually, coincidentally, it didn't. I actually didn't really like it that much, in general. . . I'm thinking maybe about transferring out just because of that, so it succeeded, really. It gave me a good idea of what engineering was like, 'cause it showed me the whole, like, thinking process. It showed me all that."

5. Discussion

The results presented here showcase several aspects of student experience in project-based courses. There are some limitations to this study that keep the results from being completely generalizable: since data is self-reported by students, the time spent on tasks could be estimated or inaccurate, as evidenced by a related study that found that student-reported time spent on tasks aligned imperfectly with student activities [58, 67]. Another limitation of this study is that it is impossible to draw a boundary around a particular course; any changes in self-confidence and self-efficacy over a semester integrate everything that happens during that time. The effect of this is likely to be most significant in the first semester, as matriculating students find themselves in an unfamiliar social and academic environment. Finally, this study is limited by a fairly small sample size; at the LPU, in particular, the sampled students are a subset of the much larger student body.

Nevertheless, it is clear that the experiences students have are highly contextual: students in each setting reported significantly different project experiences and demonstrated different changes in engineering confidence and self-efficacy. However, there were also some patterns that were common to both academic settings.

5.1 Engineering confidence and self-efficacy may not improve

At the LPU, there were significant increases in a number of engineering confidence and self-confidence measures, while at the SPC there was only one significant change: a significant decrease in Confidence in Math and Science. Although engineering confidence and self-efficacy have been shown to be important to students' identity, motivation, and learning, it has also been observed previously that persistence in an engineering major does not correspond with monotonically-increasing confidence [58, 67].

Confidence in Math and Science, specifically, has been found to stay constant or decrease even for successful engineering students, particularly near the beginning of an engineering curriculum, as was the case with the students in this study. Despite this decrease, there was no observed decrease in students' Confidence in, or Commitment to, Completing an Engineering Degree. A decrease in confidence can be due to a number of possible reasons, particularly at the onset of university studies. Students who are accustomed to being highly-ranked in high school may be experiencing a decrease in confidence after comparing themselves to their new set of peers who are equally high-achieving.

Students could also realize, as they learn more about what the practice of engineering entails, how much they do not know and have yet to learn [59] Their self-confidence thus remains constant or drops even as they are developing new skills.

Also, given that confidence and, in particular, self-efficacy are highly contextual, it is possible that students' Confidence in Math and Science was self-rated as lower due to specific aspects of the project experience: students spent very little time on math and science tasks as part of the project. However, it is likely that students were spending time on Math and Science tasks outside of the course, as a part of their core curriculum.

5.2 Undertaking certain tasks may be negatively related to engineering confidence and self-efficacy

An increase in engineering confidence or self-efficacy throughout a project course does not necessarily indicate that students spent time on the intended skills throughout the project, as evidenced by the lack of correlations between changes in engineering confidence or self-efficacy measures and the proportion of time devoted to corresponding tasks (for example, changes in Tinkering Self-Efficacy did not correlate with time spent on Tinkering Tasks) (Tables 10 and 11). While students at the LPU exit the project as more confident engineers-in-training, with significant increases in four of the measures, we can also consider the mastery experiences that students are engaged with, as represented by the tasks that students are undertaking. One of the clearest and most striking examples of this was around technical communication.

Students at the LPU spent approximately 40% of their time on Oral Presentations and Written Reports (Fig. 3), far more than the students did at the SPC (Fig. 2) which was in line with the structure and deliverables of the two courses. However, at the LPU, there were also several *negative* correlations observed between the initial values of each of the five Confidence and Self-Efficacy measures and the time devoted to the Written Report (Table 9). Also, the time spent on the Written Report *negatively* correlated to a change in Commitment to, and Confidence in, Completing an Engineering Degree (Table 11). These findings are also consistent at the SPC, that a higher incoming Engineering Self-Efficacy is negatively correlated with time spent on Professional and Interpersonal tasks, suggesting that students confident in their technical skills select themselves out of what may be perceived to be less technical tasks. Together, these findings paint a consistent picture that students with lower engineering confidence and self-efficacy may feel that the best way for them to contribute to the project is by taking on the professional task of writing (rather than taking on technical tasks), or they may focus on writing by default, by lacking the self-efficacy to take on (or be tasked with) challenging technical tasks. Furthermore, spending more time on these tasks may decrease the student's likelihood of staying in the engineering major; see the quotes above from the student above who spent more time on writing, and then chose to transfer out of engineering which provides a narrative for the observed correlation between time spent on technical communication tasks and the decrease in Commitment to and Confidence in Completing Degree.

However, also at the LPU, there were significant positive correlations between other non-technical activities and changes in engineering confidence and self-efficacy. There was a significant positive correlation between the proportion of time spent on Professional and Interpersonal Tasks in general (which includes Communication, Teamwork, Oral Presentation, etc.) and changes in Confidence in Solving Open-Ended Problems and in Math and Science. Also, spending time on Oral Presentations, specifically, correlated positively with changes in Confidence in Solving Open-Ended Problems and in Engineering Self-Efficacy (Table 11). These findings imply that while spending time on writing, in particular, may be associated with a negative impact on students' engineering confidence or self-efficacy, spending time on other professional tasks, such as teamwork, communication, and social skills, may be associated with a positive effect on student self-efficacy and confidence.

5.3 Spending time on tasks may not increase related confidence or self-efficacy

Although there were some correlations between initial levels of engineering confidence and self-efficacy and proportion of time spent on task, as discussed above, there were no significant correlations between any engineering confidence measure and the time devoted to the corresponding task. For example, students who had high initial levels of Confidence in Math and Science did not necessarily spend more time on calculations or other Math and Science tasks. Also, as seen in one students' experience quoted previously, students may opt out of certain tasks due to lack of experience or confidence in that area.

5.4 Task choice is complex

While initial levels of confidence or self-efficacy may not have a quantifiable effect on task choice, several students' comments suggest that confidence or prior experience may play an important role in students' task choice, and thus future work needs to consider the factors beyond confidence or self-efficacy to investigate in considering what impacts task choice. This is consonant with previous studies which suggest that students who have a lower perceived status in the eyes of their peers may complete less technical tasks, or abstain from doing the more challenging hands-on engineering work (in both cases, either because they choose to or because they are assigned those tasks) [14]. Status may be assigned based on a variety of factors:

gender, nationality, personality, or primary language, as reported by one student at the LPU:

> "I wrote all the technical sections of the reports because we found that [a teammate] was having problems with the English language in general, like just writing in the level that our professor wanted, so I would write that for him. And I believe I was that type of person on the presentation, too."

In a traditionally male-coded field like engineering, female students may be assigned a lower status, and thus be assigned (implicitly or explicitly) tasks such as scheduling, communicating or completing technical communication deliverables, in lieu of more technical tasks. Thus, the effect of gender status must be considered when studying first-year students' project experiences or engineering confidence and self-efficacy, particularly because studies have found that women have lower engineering confidence or self-efficacy than their male counterparts [19, 58, 60, 61]. Although the results presented here are not separated by gender, future work will focus specifically on the differences found between gender groups in terms of engineering confidence and self-efficacy changes and the time spent on task. Furthermore, although many studies show that mastery experiences are the most significant contributor to self-efficacy, women, in particular, also place high value on vicarious experiences and social persuasion [62], and thus women's engineering confidence and self-efficacy may be more affected by factors beyond the tasks they complete.

5.5 Devoting time to a task does not indicate mastery

This study has also revealed that time spent on a task may not be a good proxy for having a mastery experience. Spending more time on a task is linked to becoming a "master" or "expert" at that task [63], in line with our understanding that practice is often a required for mastery. This is perhaps best known in popular culture in the form of Malcolm Gladwell's "10,000 hour" rule, which suggests that at least that much time spent on an activity is a prerequisite to developing a high level of expertise [64]. However, a more recent study provided evidence that there may sometimes be a *poor* correlation between time on task and mastery experiences. [65]. When considered in the context of engineering education, Hambrick's findings suggest that students may have a mastery experience despite spending very little time on a task; for example, a student may learn how to use CAD software easily to quickly create a model, but that time spent will still be a mastery experience because they feel further affirmed in their CAD skills. Conversely, students may spend more time on an activity because they are struggling with the task, rather than moving towards success or skill development, with the result that they feel *less* affirmed in their abilities due to the difficulties they had completing the task. This may explain why, for students at the LPU, spending a higher proportion of their time on Solving Open-Ended Problems Tasks correlated *negatively* to changes in Confidence in Solving Open-Ended Problems (Table 10); more generally, it could also explain the observations that spending more time on a certain task (for example, Tinkering) did not correlate to an increase in the related measure (Tinkering Self-Efficacy).

5.6 Other contributors impact students' engineering confidence and self-efficacy

The complexity of our findings illustrate that there are few clear links between the time devoted to certain tasks and overall improvement in engineering confidence and self-efficacy measures. But the results reported here were primarily focused on mastery experiences; while important, other contributors to self-efficacy, such as physiological factors, social persuasion, role models, and vicarious experiences [4] may also be playing a significant role in the development of student self-efficacy, and this hints at an area for more thorough future research. One student specifically cited physiological factors as a reason for not taking on challenging tasks:

> "When you do something new, you don't really understand it so you could get really negative emotions because you don't understand it, so it keeps you away from doing it. So like with me, [with the circuit work,] I really struggled with it, because I didn't know how circuits work and practical stuff so I really hated it that time. Because I hated it, I didn't develop, like I didn't want to do it. Just thinking about going into the [circuits] lab made me afraid, so I avoided it but then when I got rid of that fear and then found out that I could actually make it work, that's when I started getting really interested in it. It's like wow, I can actually do that, it works. And it's like a cycle, you know, if you do it once and you got it, then you can get the next, and next, and next and then you improve."

Another student mentioned social persuasion as a contributor to his self-confidence:

> [The instructor] "really made sure that it had a positive outlook, which was really important because various times I had sort of low self-confidence, and so that really helped a lot to know that it was okay to fail, and that in the process, the process was more important than the net result."

6. Implications

Hands-on engineering design experiences, especially early in the curriculum, serve a vital role in exposing students to engineering practice, with all the engagement and identity development that entails. While the relationship is complex, these types of experiences can affect student engineering self-efficacy; ideally for the better, but certainly also for the worse. This suggests that care and consideration must be used to design learning experiences that serve all students as well as possible. While it may be difficult to design learning experiences that are one-size-fits-all or that specifically foster the development of engineering self-efficacy, this research nevertheless points to some actionable directions that educators can take to improve team-based experiences for students.

6.1 Distribute mastery experiences equitably

In line with earlier work [58] our data suggests that comparative confidence or self-efficacy may be a more tractable target than absolute measures; that is, rather than working to increase them *per se*, educators might focus on addressing possible gaps between demographic groups. The evidence of this and other studies suggests that students do not all engage in the same types of learning experiences over the course of a project, and this may remain a concern if students are gaining different skill sets or increases in confidence or self-efficacy, particularly if these differences fall along gender or other demographic lines. Or, it can be an issue if these differences otherwise reflect a constrained choice: for example, the inverse relationship observed between Engineering Self-Efficacy and time spent on tasks in the Professional and Interpersonal Skills cluster for students at the LPU might suggest that these students are shortchanging the development of their writing and project management skills. Some approaches that can be used to establish parity of mastery experiences might include making significant individual skills development part of the project, establishing a rotating system for roles on the team, or asking students to explicitly articulate their learning goals to their teammates and to create a project plan that allows each student to address them [66].

6.2 Scaffold mastery experiences

As course activities are generally intended to be mastery experiences, with associated positive effects on self-efficacy, it may make sense to explicitly scaffold them to both foster the desired learning outcomes and to help students feel mastery (rather than frustration, for example). The simplest examples of this would be CAD tutorials or fabrication workshops, in which skills are explicitly developed in a structured way, to help students use their limited time effectively, experience challenging engineering activities, and feel like they are learning. Similarly, teaming experiences, particularly early in engineering programs, can be positioned as learning how to function in teams, with explicit scaffolding for team behavior and formative assessment throughout. This could mean more individual work, or teaming experiences may be explicitly positioned as formative, with appropriate scaffolding to help students learn to work better in teams. In general, well-scaffolded activities that all students participate in are likely to mitigate any possible impact of incoming self-efficacy on task choice.

6.3 Address other contributors to self-efficacy

Finally, while the focus of educators is typically on the design and delivery of mastery experiences in the form of learning experiences, it may make sense to explicitly address the other contributors to self-efficacy: being conscious of what role models are observed by students, and deliberately shaping an academic culture that fosters social affirmation of all students (which would likely require explicitly addressing issues of implicit bias).

7. Conclusions

While self-efficacy is considered to play a primary role in task choice, and mastery experiences have long been considered to be the most significant contributor to self-efficacy, the relationship between the two is complex. These findings illustrate that confidence or self-efficacy may not improve as a result of working in a project, or accruing "mastery experiences." Furthermore, spending time on certain tasks did not necessarily lead to increases in confidence in the related area (for example, spending more time on calculations did not correlate to an increase in Confidence in Math and Science). One consistent result across settings was that multiple incoming confidence/self-efficacy measures correlated negatively with time spent on non-technical tasks (specifically, writing) and, at the LPU, spending more time on these tasks also correlated negatively to a change in confidence. This study illustrates that the relationship between time spent on tasks and the development of engineering confidence and self-efficacy is complex rather than predictive.

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