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Engineering Identity, Slackers, and Goal Orientation in Team Engineering Projects

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Abstract -- This research paper will describe the results from a qualitative investigation of long-running, team-based engineering projects at a small liberal arts college. Long-running, team-based engineering projects are projects in which groups of students perform an engineering task over three or more weeks. These projects comprise a significant portion of the engineering curriculum at the college, and students at the college have reported in exit surveys that these projects have had significant impact on the formation of their engineering identity.

The initial hypothesis of this paper was that positive team experiences, facilitated by similar goal orientations among team members, contribute to increased performance in team projects and enhanced engineering identity. To examine this hypothesis, ten semi-structured interviews were administered to seven students in two courses. The courses were a first-year introduction to engineering design and a third-year, industry-sponsored capstone project class. Students in the introductory course were interviewed twice, once at the beginning of the semester and once at the end of the semester, to capture changes in their views of team-based projects, while students in the third-year course were interviewed once at the beginning of the semester. The interviews were designed to investigate student goal orientations, engineering identity, team formation strategies, and team experiences.

The interviews did not support the initial hypothesis, but they confirmed a variety of prior literature on group work and revealed two novel conclusions. First, slackers on teams resulted in changes in the goal orientations of other team members. Second, students attributed their engineering identity development only to individual development of technical skills, and not to their participation in an engineering team.

1 Introduction

Group work in academic settings has several benefits for students when compared to traditional lessons: studies have shown increased academic achievement [1]–[4] and greater social interaction and critical thinking skills [1], [4] when students participate in group work. Group work has also been shown to be particularly beneficial for underrepresented groups in STEM because group work has been linked with reinforcing students' sense of belonging, self-concept, and self-efficacy [5]. Belonging, self-concept and self-efficacy are in turn associated with persistence in STEM [3].

However, the benefits of group work are not always universal. Underrepresented students sometimes experience diminished or even negative effects from group work [3], [6] because group work may degrade a student's sense of belonging in engineering [7]. Prior research has

suggested these negative impacts may be mitigated or exacerbated by details of team composition for group work, such as team member goal orientations [6] and team-forming mechanisms [8]. Students' sense of belonging in engineering is important for students' development of engineering identity [7], [9].

As a result, it is important to cultivate effective engineering teams that help all students reap the benefits of group work. This work sought to identify interventions that improved student experiences in long-term, team-based engineering projects. Interventions that were already in use at a small, STEM-focused liberal arts college were evaluated by interviewing students in team-based engineering project courses.

The initial hypothesis of this study was informed by engineering-identity trajectory theory. The hypothesis was that similar goal orientations among team members, facilitated by team forming strategies, would lead to positive team experiences, which in turn would contribute to increased engineering identity and increased performance in team projects. The hypothesis was not well supported by the results, but there were still two novel outcomes from the interviews. First, the detrimental role of slackers on teams, identified by [4] and [10], was seen to be caused by slackers changing the goal orientations of other team members. This differs from prior studies, which have focused on slackers' effect on interdependence. Second, though students reported that team projects facilitated the development of engineering identity by allowing them to develop technical skills individually, they did not think their teams were important to that change. This is a surprise when compared to prior studies, which identify belonging and self-efficacy as equally important to engineering identity formation.

More detail on data collection, analysis and the resulting theories appears in the following sections. Section 2 is a review of relevant literature. Section 3 describes the methods used in the study. Section 4 presents the results, a pair of composite narratives constructed from interview transcripts. Section 5 contains discussion of the results, including a comparison of the results to the hypothesis of the paper. Finally, section 6 concludes the work.

2 Background

This work centers long-term group projects and their role in students' development of engineering identity. Engineering identity is a type of identity, where the concept of "being an engineer" is included in the construction of a student's identity. Aschbacher describes the construction of identity as follows: "as students develop knowledge, competence, and meaning from these social interactions, they begin to construct their identities...in relation to these communities" [11].

Engineering identity is dependent on institutional and curricular structures, such as institutional recognition of students as engineers, as well as students' self-perception of their capabilities "as powerful thinkers and doers in a specific field of study" [12]. Women and students that belong to an ethnic minority often feel that they do not academically or socially belong in engineering, which impacts formation of engineering identity [7]. These feelings can come from differences in ethnic/cultural values and socialization, internalization of negative stereotypes, ethnic isolation or perceptions of racism, or a lack of faculty role models and mentors [13].

This work particularly relies on the framework of identity-trajectory, which was applied to engineering education research by Thomas [14]. Identity-trajectory focuses on three concepts that help explain the evolution of engineering identity over time, especially "for those early in their academic career," that are referred to as intellectual, institutional, and network strands of identity [14]. The intellectual strand of identity describes growing knowledge of engineering, which often includes hands-on skills. The institutional strand of identity describes recognition as an engineer by external entities, like academic departments or professional societies. The network strand of identity describes the development of a network of collaborators and mentors.

Identity trajectory suggests that long-term group projects (section 2.1) are particularly salient to identity development because they weave together all three strands of identity: long-term projects are an opportunity for intellectual development, require use of institutional resources like machine shops or labs, and encourage networking with peers and professors. Long-term projects particularly affect the network strand because students collaborate for a long time. Therefore, this work hypothesized that interventions that enhanced students' experience of the network strand would bolster their engineering identities. The following subsections describe literature on factors that are salient to the network strand of engineering identity: team forming strategies (section 2.2), goal orientation within teams (section 2.3), and positive interactions between team members (section 2.4).

2.1 Long-Term Group Projects

Colbeck et. al [4] interviewed students who had completed a first-year engineering design course, and the authors described their observations of student experiences in a long-term project using the concept of interdependence: the degree to which students were reliant on one another for their ultimate goals through distinct roles and resource division on teams. They found that creation of positive or negative interdependence in a team contributed to the development of communication and problem solving skills. The work also identified the role of a "slacker", which was a group member "who failed to complete their fair share of team tasks" [4]. Slackers often shaped the interdependence of a team because students tried to pick teams and distribute tasks strategically to account for slackers. The role of slackers is also examined in a study by Payne and Monk-Turner [10], which found that slackers, despite their minimal contribution to the group's work, often have a strong, negative impact on the experience of group members.

2.2 Team Forming Strategies

There are three common methods of forming groups (among many variants, hybrids and less common methods): student self-assignment, random assignment, or assignment by instructors [5]. This work hypothesizes that assignment by instructors can improve learning outcomes, and some evidence for that hypothesis can be found in the literature on randomly assigned groups: randomly assigned groups need to be encouraged to have good teamwork [8], and students in randomly assigned groups gain enhanced self-efficacy in their teamwork skills [16], which contributes directly to group members' individual judgements of enhanced learning [16]. Other evidence is available in [8], where Dawes and Senadji applied an assortment of team forming strategies in civil engineering and electrical engineering courses with substantial final projects. The authors asserted that the team formation methods affected the performance of the teams.

2.3 Goal Orientation

In educational settings, goal orientation is typically divided into two categories: performance, with approach and avoidance variants, and learning [6]. Research has shown that students with goals oriented towards learning rather than performance have higher academic achievement and self-efficacy [17]. Members of teams that had similar goal orientations showed improved satisfaction with other team members [6]. Conversely, teams with diverse goal orientations have been shown to negatively impact team effectiveness and individual outcomes, but these issues can be alleviated by the presence of a team leader to orient the team and allow it to benefit from the perspectives of different team members [6]. Goal orientation is not purely individual: a study of engineering students found goal orientation is partially determined by perception of what is important to teammates [18].

2.4 Positive Interactions and Friendship Among Group Members in Group Work

Webb et al. [19] found that the quality of interactions in a group was predictive of performance in a group, and Wooley et. al. [20] have found that the "collective intelligence" of a group solving simulated laboratory tasks is determined by the type of interactions they have. These findings suggest that effective team dynamics within a learning group improve performance. Other studies link these positive interactions to friendship. Myers found that self-selected groups, which favor group selection among friend groups, reported higher relational satisfaction and learning during group tasks [21]. Theobald reported that having a friend in a group activity in a STEM class was predictive of group comfort levels [22].

3 Methods

This study used qualitative methods: narrative analysis was applied to transcripts of semi-structured interviews. Interviewers asked second and third year engineering majors at a private, STEM-focused small liberal arts school about their experience in semester-long engineering project courses, and their answers were used to construct narratives describing the

evolution of students' engineering identity through these courses. An understanding of those courses is important to understanding the methods and results of the study, so the courses are discussed in section 3.1 below. In addition, the methods used to recruit subjects are discussed in section 3.2, the semi-structured interviews are discussed in section 3.3, and the transcript analysis is discussed in section 3.4.

3.1 Curricular Environment

All engineering majors at the school are required to take three team-based project courses before the end of their third year: a first-year/second-year introduction to engineering design and manufacturing (course A), a second-year course focused on experimental practice and field deployments (course C) and a capstone project, during which third and fourth year students work for an industrial client (Capstone). All students, regardless of major, also take a second-year systems engineering course taught using a combination of small, active-learning classroom sessions and partner-based laboratories (course B). A small number of students perform research with faculty members (Research), which is often conducted in groups. These details are summarized for each course in Table 1.

3.2 Recruitment

The interview subjects were recruited from course A and Capstone. Subjects were recruited by administering a survey to students in both courses to assess each student's interest in participating in a study. The survey questions focused on student experiences of teams, and invited students to leave contact information to participate in a follow-up discussion. All students who indicated that they were open to a follow-up discussion were interviewed.

3.3 Interviews

This study used semi-structured interviews to gather data. The semi-structured interviews were designed to interrogate student experiences with three topics: team forming strategies, goal orientation, and engineering identity. The interview protocol is summarized in Table 2.

The timing of the interviews was deliberate, and helped to reconstruct engineering identity trajectories. Third-year students in Capstone were interviewed once at the beginning of the semester. Students in course A were interviewed both at the beginning and the end of the semester. This timing was selected for two reasons: first, school year is a statistically significant factor in engineering identity [9], and second, third-years interviewed at the start of the semester had recently completed course C and had not yet completed significant work in Capstone, which made them better able to comment on their recent team experiences in course C.

Course	Course Level	Team Forming Strategy	Topic
A	First year/Second year	Assignment by instructors	Design process
B	Second year	Student self-assignment	Systems engineering
C	Second year	Random assignment	Experimental engineering
Capstone	Third year	Assignment by instructors	Student-led project

Table 1. Engineering Courses taken by Interviewees

There were slight differences between the first and second interviews conducted with students in course A. The first interview was identical to interviews conducted with Capstone students. It was focused on obtaining information about the student's background, their prior engineering team experiences, their initial impression of their team, and their experience with the engineering curriculum so far. The Second interview used the same set of questions detailed in Table 2, but the interviewer focused on probe questions related to the subject's recent engineering team experience, goal orientations and team dynamics.

Interviews were conducted using online video calls. Each interview lasted between 40 to 60 minutes. Immediately after each call, the interviewer made notes about the subject's affect and the major themes of the interview on a standardized interview summary form.

Seven students were interviewed. Three students from class A were interviewed twice and four students from Capstone were interviewed once, which resulted in ten total interviews.

3.4 Transcription and Restorying

The restorying method is an emerging tool in narrative research that allows researchers to chronologically order an individual's story [23]. Semi-structured interviews often feature repetition and breaks in story continuity and setting. Restorying reorders the narratives chronologically, allowing for a more cohesive story to emerge [23]. In this study, restoried narratives consisted of quotes pulled from an interview transcript that were reorganized to show a chronological story of experiences in team-based engineering projects. This process largely preserves the interviewee's voice and language, but minor edits were made to the text for grammatical clarity.

Each interview was transcribed verbatim by the researcher who conducted it. Two researchers read through all the interview transcripts and independently constructed 2-3 page restoried case narratives for each interview. To account for differences between researchers in the restorying process, the two restoried narratives for each interview were compared against each other. No significant differences were found between any pair of restoried narratives.

Construct	Question
Open-ended Icebreaker	To start with a general question: how is engineering going?
Engineering Identity	(Third-years) When did you start to feel like an engineer at [school name]? [PROBE] What about the experience in [class name] made you feel that way? (Second-years) Has your experience at [school name] made you feel like an engineer? [PROBE] Why do you think you feel that way?
Team Experience	Could you tell me about your team experience in [class name]? [PROBE] What about [class name] made you feel that way? Could you walk me through what a typical team interaction looked like? Did you ever feel that your team could function better than it did? [PROBE] How could it have functioned better?
Team Forming	Do you think there are different ways of forming teams that would have been more suited to you?
Goal Orientation	Have you ever felt some team members wanted something different out of the project?
Identity	Do you consider yourself to be a minority student and, if so, has it impacted your time as an engineering student?
Team Experience	We've talked about bigger groups. Could you instead tell me about your experience on teams of two?

Table 2: Sample interview protocol

3.5 Conceptually Clustered Matrix (CCM)

A list of themes was generated from the restoried interviews. The most common themes were used as the columns of a conceptually clustered matrix [24], where individual interviews made up the rows and themes made up the columns. Each cell in the matrix contained quotes from the interview that supported the theme. The conceptually clustered matrix allowed researchers to identify patterns in student experiences and separate these patterns by theme.

3.6 Composite Narratives

Patterns in the conceptually clustered matrix revealed two categories of team experiences: positive and negative team experiences. If subjects described a team as having "a very good team

dynamic" or said "I had a pretty good team experience," the team experience was categorized as positive. If subjects described a team saying "my team had a lot of issues" or "my experience beat me down", the team experience was categorized as negative. Researchers used participant language from the eleven restoried narratives to build two composite narratives that reflected positive and negative team experiences.

Narrative compositing is an unusual analysis technique for semi-structured interviews, but this analysis served the goals of this study. The combination of narrative analysis and semi-structured interviews was used to track how multiple factors affected engineering identity across many semesters. Semi-structured interviews allowed every interviewee to share their experiences with each of the factors in the hypothesis: team formation methods, goal orientation within teams, and positive group interactions. Narrative analysis helped to combine interviews into engineering identity trajectories; though each interview captured a student at one point in their identity trajectory, composite narratives helped to combine those interviews to reveal changes in identity across the curriculum. This combination is consistent with [25], which argues that "A first-person composite narrative tells the underlying story behind a collection of individual experiences."

4 Results

The two composite character narratives are presented below. The first composite character, Adrian, had positive experiences with teams. The second composite character, Blake, had negative experiences with teams. The composite characters have gender neutral names, and gender neutral pronouns are used throughout, because the narratives draw from participants of multiple genders. Section headings within the narratives were added by researchers to indicate the organization of themes in the narrative. Italicized text was added or modified by researchers for grammatical clarity. Otherwise, the narratives are the participant's own language.

4.1 Composite Narrative #1: Adrian

Course A

I like project based things. I like working with my hands, trying to be creative. The Course A hammer was a really great experience, *I* spent a lot of time on it, *it was* very rewarding. And then the project was pretty good. I think *Course A* helped me learn what engineering at *my college* would be like as far as learning about the design process and team management and kind of the more logistical side of engineering and team and product management. I *felt like an engineer* more in Course A *because it felt less* hand-holdy *than* Course B. In Course A the curriculum is based around exploring on your own and answering questions. *Compared to Course B,* I *had* so much more liberty in what I *chose* to do in projects than in problems.

Overall I had a pretty good team experience. *My teammates and I* were able to be friends with each other, I think we had similar goals, *and* there wasn't a freeloader. Everyone on my

team *was* down to do whatever. I *didn't feel* like I *was* the only one doing leadership type tasks. And I think the quality of work *was* great as well. We're all friendly now. I think it would *have been* hard if *my team* had someone who didn't really want to do the work that much, which I think doesn't happen that much at *my college*.

We put in our team contract that we wanted to be able to socialize a little bit at the beginning of meetings because we *wanted* to have *a* sense of camaraderie. I think our biggest goal *was* just learning as much as we *could* about the design process and also about solidworks and modelling. We talked a lot about keeping the distribution of work even *and trying* to rotate tasks a lot. You know, if there *was* someone more familiar with SolidWorks, *then* not letting them do all of the solidworks. *It would have felt* weird to have one *person* either doing most of the work or dealing with the logistical side of things and not getting to do as much technical work. We all want to be involved equally and with every part of the project. Our main priority *was* not getting the grade and getting everything done. I think the priority *was* learning.

Course C

Course C has been instrumental. The real engineering feeling came out in Course C. I think maybe it was the fact that it was a challenge. *There's a* collective sense *that* Course C is a hard class but you come out of it knowing how to approach problems like an engineer. And that came from the professors as well. *They* were like "by the end of this class you'll be an engineer," *which* created a sense of this class as a defining moment. We could get stuff working, *we could* troubleshoot our own issues. For every hour I put into it, I got an extra bit of confidence in myself. It was seeing the results in my lab scores improving, my write-ups improving that really felt good. *That's* what made me feel like an engineer and then definitely the hands-on stuff, all the physical building. I felt like it was more applicable to what I want to do.

Course C had a very good team dynamic for me. Honestly it was one of the best *team* experiences I've ever had. Everyone seemed to grind an equal amount. In the lab we just kind of got things done. Very early on we established that we weren't really trying to get A's, we were just trying to get a lot out of it, so that helped with the stress. We were patient with each other. I don't remember getting annoyed. One time our bread board rail was broken, but by the time we realized, it was too late *to fix it. So my teammate and I* just said good job, we did our best, it wasn't our fault.

I know my goal for the class was to just get good at solving engineering problems, like random weird problems that I don't know how to solve, which I think is what Course C is teaching you a little bit. I think my team's goal was kinda the same. We were like we should do as good as we can but don't kill ourselves trying to get an A if it's not going to happen. I would say *my team was* more concerned about learning than performance just in general.

I think my team experiences in Course C were a lot better *than previous team experiences,* because it seemed like we were all just friends. I like talking to people so the feeling of becoming friends with your team for some reason means a lot to me. And we didn't really have any team issues at all. Just feeling comfortable around each other did that. We established

we like to crack jokes sometimes, that's cool. It wasn't hard to get anyone to speak up at all. I'm generally the person on a team who breaks the awkward silences because I hate just sitting there but a couple weeks into the semester I never felt like I was breaking any awkward silences, I felt like we were all just having a conversation.

Capstone

Right off the bat, I got good vibes from this team. I was like wow this is the first meeting I've had where I'm the one who talks the least. That's awesome. It's just a bunch of really cool people personality wise. And our team leader is super good at making sure everyone feels comfortable. I think we're all really motivated to get something out of the project, and we're motivated by the project having a positive impact. Capstone so far has been a continuation of both Course C and my research. Capstone is making me feel like I actually know what I'm doing.

Research

My research has been really important to me. *Because* of COVID, I have to be sitting on a terminal running modeling software. I never had any experience with modeling before and neither had my teammates, but combined the five of us were able to get everything up and running again and we had very successful trials. Research is along the lines of like Course C with building confidence because when I joined research I didn't know anything that was going on. It felt like three weeks of trying to pretend that I knew what was happening and then at a certain point *the professor* just kind of trained us to do research on our own. I'd look up the papers, and I'd read it on my own, and I'd realize what was going on, and my better understanding of the subject boosted my confidence to help me.

Yeah so my *research* team. I almost want to call them friends at this point. Over the zoom calls it's very nice to talk with them because they're all incredibly interesting people, and I want to know more about them. It seems like what would happen was two people would take ownership over a mini project and they'd do their best to understand it and they'd share it with the group and then other people in the group would also be doing the same thing. So we'd have our focuses and then we'd try to catch other people up to speed. I like that style. With everyone like taking ownership of things, I kind of felt like I had to take ownership of some things and find things to take ownership of. I'm still struggling with finding things to research but I'm getting there.

Remote Work

When we were remote, chat software added to the positive team experience. I was very skeptical at first, *but* it was as close as you could be to being in a room with someone because you can speak up if you have a question. I think if all we did was our meeting for half an hour we wouldn't have worked well as a team but the fact that we were also showing our personalities allowed us to work a lot better. Because we gained comfort we were better able to benefit from each other's expertise.

4.2 Composite Narrative #2: Blake

Course A

It felt like there was a really strong divide in the class between teams who had people who had been doing design before, like if you were on the robotics team *or your* parents are engineers so you have been exposed to it before. Those teams seemed to present more like an engineering team in terms of what they produced and how they understood the material. And then *for* the other half, the team was more for emotional support than what an engineering team should be, of technical collaboration. *My first team experience* definitely beat me down, I did not want to be an engineer after working on that team. 'Cause it was like I'm starting out ten years behind and everyone else is just understanding this. *And then* what happens is you need to get it done by a certain deadline, so the people with more experience end up taking on more of the work because they can do it faster. So the people with the experience get the practice and the people without experience *don't get* the actual technical skills that are gonna get them into industry. Because *this past semester was* remote, I *didn't get* to do the hands-on work in the machine shop, which is what I was most excited about with this class. It turned into a lot of project management which I recognize is valuable but isn't a thing that I'm deeply passionate about. The things that I was putting a lot of time into weren't things that I felt I really benefited from.

My Course A team had a lot of issues. Two of us *had* been doing a lot of additional work. And that *was* kind of self-fulfilling because as soon as we *established* that we *were* willing to do things if no one else *was* doing them, then the assumption *was that we would* do them. If you have people who have different levels of investment, I think that is really challenging because either the more invested people will end up being disappointed or they wind up doing all of the work. *Additionally, one team member* wasn't contributing that much in meetings. When we were assigned action items, he would always be behind. He would always just be trying to hold up his fifth of the team. Out of three people I was saying fifth because it wasn't a third. *In a meeting with two of us, our Professor said,* "assume he is not going to do anything, and make it a happy surprise when he does." Teams shouldn't operate in a way that assumes people aren't going to do what they're supposed to do. Towards the end, *the team* was very divided. It felt like half of us wrote the paper, half the team built the thing, and then one person just got carried. There is no resentment anymore. I just would never want to be on a team with these people again.

I think *there* was more *of a* "get this finished" *attitude.* Especially on that last weekend – there's so much you have to do and it's just like we gotta get through it and then we'll be done. I guess it came from like towards the end maybe feeling like the project wasn't as good as we wanted it to *be.* I definitely was way more worried about just getting the basic things done and getting basic deliverables in than iterating more and trying to find the best possible solution. Like obviously it's a learning experience, but obviously I'm trying to do well in this class. I'm just trying to finish the project with a grade that I'm happy with. And that was kind of impacted by all of the team dynamics. We've been really frustrated with the class in terms of the team dynamics, the effort put in.

Course C

One of my teammates – sometimes it felt like they weren't putting in as much effort as should have been put in for the class. There were like a couple times when we had to remind them to send things in or they would send stuff in and it just wouldn't be up to where we wanted it to be so we would have to ask them to resubmit or just edit it for them. *There were also* a couple issues with one person being late to meetings. It annoyed me. Punctuality is a big thing to me. I guess my attitude to work is like let's meet and get done with it, and a lack of punctuality makes that drag on, so I was frustrated with that.

Capstone

I think it's partially because we're on zoom but we're just a lot more quiet than I would like. There are a lot of awkward pauses. In the liaison meetings, *there are periods where* no one talks for 30 seconds, *which* should not be happening. I feel like everyone is just a little bit uncomfortable. I do feel like I have to filter myself more, even. Partially because it's online and partially because we can't really gauge what's okay to say and what's not. I *also* really wanted to do stuff with hardware, but it doesn't seem like we're really gonna get to do any of that which kind *of* sucks but I mean it makes sense because it's all basically online.

One teammate has a very free spirit. We decided that we would support him and try to get him to be more structured. He was only late to like one meeting, I think. Tardiness really bugs me, but I really understand it if it's like once or twice. Like once you get the three times with tardiness, I'm like tired. I had a bad team experience with that.

Research

More than any other team I've been on at *my college*, feeling like there was a free rider happened the most in research. It's something I'm really insecure about, like that's how I'm perceived by team members, but it is really hard to be on a team where someone isn't doing any work.

Remote Work

Before online I really liked *engineering*; now it's probably because I'm taking the classes I didn't really want to take – that's why it's like partially bad. *And in one class,* to make up for the *hands on experience in the* curriculum, we have one problem *on each problem set* that's data focused. It's kinda hard to visualize what we were theoretically doing *in lab* if you're just giving us one paragraph.

It's rare to actually make good friends over Zoom. Meeting over Zoom makes it harder to get into that easy conversation that was able to happen for previous teams that I've been on. I think *Zoom* changes the flow of conversation because you have one person *who* is speaking and everyone else is listening, so there isn't the opportunity for side comments or to have two separate conversations at once within a full team meeting. *And then with teammates, if they don't have their* camera on you can't see facial expressions. *So* whenever we're giving feedback it

feels more formal, like I have a driven mission to talk to you about this rather than a passing water bubbler conversation.

I feel a little bad because when we went remote my internet was terrible, and I couldn't be on the phone calls with *my team*. So I felt like *a* dead weight on the team. I kind of wish I could say sorry to them for that, but they understood that it was out of my control.

5 Discussion

As a reminder, the initial hypothesis of this paper was that similar goal orientations among team members would drive positive team experiences, which in turn would contribute to engineering identity and increased performance on team projects. The following three questions are discussed in an attempt to validate the hypothesis: Did goal orientation drive positive team outcomes? (5.1) Did positive team outcomes drive engineering identity? (5.2) Finally, did team forming mechanisms drive positive team outcomes? (5.3)

The results also suggested two additional themes strongly enough to merit discussion, though they were not in the hypothesis: positive social interactions with teammates drove positive team outcomes (5.4), and remote learning undermined team interactions and engineering identity formation (5.5).

5.1 Did Similar Goal Orientation Drive Positive Team Outcomes?

Adrian's narrative of positive team experiences revealed a pattern of teams emphasizing the goal of learning over the goal of performance, which is expected based on [11]. Their team placed value on team members being involved with every part of the project and "getting a lot out of it" rather than performance and "trying to get an A."

Blake's narrative reveals the role a slacker plays on a team. Although the composite narratives refer to this role using the terms "freeloader" or "free rider," the characteristics line up with the definition of a "slacker" provided by previous literature [4][6]. The slacker on Blake's team affected the team's ability to complete work, introducing tension between performance and learning goals. Goals shifted from learning to "getting basic things done" to finish the project.

Blake's experience makes a strong case that the presence of a slacker shifted the goal orientations of other team members from learning to performance. There is evidence that this shift is motivated by student time constraints: Blake says "there's so much you have to do and it's just like we gotta get through it and then we'll be done". Prior literature, like [4], describes student time constraints as a type of resource interdependence, which slackers strain by forcing students to distribute tasks strategically to account for a slacker's lack of work. The observation that team members change their goal orientation in response to slacker-induced overwork is new.

5.2 Did Positive Team Outcomes Drive Engineering Identity Formation?

Neither composite narrative linked team outcomes to engineering identity. Both Adrian and Blake said their engineering identity was tied to individually gaining technical and hands-on skills.

Adrian said their engineering identity was developed in the experimental engineering course, course C. They suggest that "the real engineering feeling" came from a combination of the course being challenging, encouragement from professors, gaining confidence, and hands-on experience. Though course C is a team-based project based course, Adrian does not connect engineering identity with their team experience. Instead, Adrian says, "for every hour I put into it, I got an extra bit of confidence in myself" and "all the physical building" made them feel like an engineer.

Blake's lack of engineering experience and feeling of being behind their peers had negative impacts on their feeling of being an engineer. Blake "did not want to be an engineer after working on that team" where they felt that their technical experience was further behind their peers. Further, Blake expresses frustration with lack of technical experiences available on their team, stating that often, "the people without experience *don't get* the actual technical skills that are gonna get them into industry."

Literature aligns with the observations in that a students' awareness of their own ability is a significant contributing factor to engineering identity [14]. However, the composite narratives reveal that students do not credit institutional and curricular structures for shaping their engineering identity. With few exceptions, Adrian and Blake describe engineering identity in relation to their individual technical ability, valuing their own self-efficacy over community membership or recognition by the institution.

5.3 Did Team Forming Mechanisms Drive Positive Team Outcomes?

Students did not tie the team formation methods to positive or negative team experiences. The students discussed team formation strategies generally, but did not relate them to their team experiences, or express that formation of a team had a noticeable effect on the team itself. Students may be poorly positioned to comment on team formation because they are on relatively few teams during their education, and the formation methods for those teams are often opaque.

5.4 Positive Social Interactions with Teammates Drove Positive Team Experiences

For Adrian, a sense of camaraderie among teammates was something important to them. They describe their Course C team experience as being better than others "because it seemed like we were all just friends." In their research group, their team was better able to work together because they could show their personalities. The comfort among teammates allowed them to "benefit

from each other's expertise." Adrian also pointed out that in some of their teams, the team intentionally fostered this friendly environment by including it in their team contract.

Many of Blake's experiences were shaped by the remote learning environment, which made it hard to connect with classmates. Blake noticed that remote learning made for a quieter environment, did not allow for side conversations within groups, and made communication between teammates difficult.

These observations are consistent with various literature that shows a link between effective social dynamics in teams and performance [21], [22].

5.5 Remote Learning Undermined Social Interactions and Engineering Identity

Students were learning remotely in the second half of the spring 2020 semester and all of the fall 2020 semester as a result of the COVID-19 pandemic. Interviews for this study were carried out in fall 2020. Though this study did not aim to uncover effects of the remote learning environment, the topic naturally came up in interviews. Remote learning affected students' ability to communicate with teammates and reduced opportunities to build hands-on skills.

Blake expressed that remote learning made communication with teammates harder, citing quieter team interactions and more "awkward pauses." They suggest that the remote learning environment is responsible for some of these shifts because it changes the flow of conversation that would usually happen in teams. Blake states, "you have one person who is speaking and everyone else is listening, so there isn't the opportunity for side comments or to have two separate conversations at once within a full team meeting." Blake described the Zoom atmosphere as "less casual", saying "whenever we're giving feedback it feels more formal, like I have a driven mission to talk to you about this rather than a passing water bubbler conversation."

The remote learning environment reduced opportunities for hands-on learning, as well. Blake looked forward to the hands-on experience in engineering classes, and they felt the remote learning experience took that away: "I also really wanted to do stuff with hardware but it doesn't seem like we're really gonna get to do any of that which kind of sucks."

6 Conclusion

This work reported on a series of ten semi-structured interviews of students in long-running engineering project courses. The interviews were analyzed by restorying and then compiling the restoried interviews into a pair of composite narratives. The interviews were designed to interrogate a few factors that could affect teams -- goal orientation, team formation, and engineering identity -- but the interviews also identified other factors that were significant to team experiences -- positive social interactions with team members, and remote learning.

The results confirmed prior findings about group work. In concordance with previous literature, positive team experiences were linked to learning goal orientations, while performance goal orientations were linked to negative team experiences [6], [17]. Similarly, positive social interactions on teams were associated with positive team experiences [21], [22]. Remote learning was seen to be detrimental to positive social interactions.

Slackers on teams were seen to change student goal orientations. This observation extends prior literature [4], [10], which found that slackers damaged team interactions by reducing interdependence within teams. The new observation suggests a new mechanism for slackers' negative influence: distributing work away from a slacker overloads other team members and changes their goal orientation to (avoidant) performance.

Contrary to our hypothesis, there was no link between team experiences, positive or negative, and engineering identity. Instead, engineering identity was linked to acquisition of technical and hands-on skills during long-term projects. This matches prior literature that suggests ability is crucial to engineering identity development [11], but it suggests that students are unaware or dismissive of the connection between institutional recognition, community and engineering identity [12]. This skills-centric view of engineering identity suggests remote learning is particularly harmful because it offers fewer opportunities for students to develop hands-on skills.

Future work could examine student perceptions of technical skills to determine how salient they are to engineering identity. Future research could also center the experience of slackers in long-running engineering team projects: while prior literature has focused on their detrimental impact on team experiences, little research has been done from their perspective.

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