Butting Heads: Competition and Posturing in a Paired Programming Team

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***Abstract*— This Research to Practice Full Paper contributes to the study of undergraduate engineering students' beliefs and educational experiences. Scholars have documented the educational experiences of students including the marginalization of women and underrepresented racial minority groups. Although the experiences of marginalized groups are likely impacted by privileged and majority student groups, comparatively little research has directly focused on the actions and perspectives of dominant students. Additionally, few studies combine the research methods necessary to examine both student beliefs and classroom actions. In this paper we focus on perspectives and actions of dominant groups which may be linked to marginalization. In particular, we focus on the ways students understand and enact the culture of competition in engineering, which has been linked to marginalizing student experiences and reproduced male demographics. Our study uses ethnographic one-on-one interviews and video-recorded interactions to examine the collaboration and perspectives of two White male students in a 10-person laboratory section of an active learning introductory programming course for electrical engineers. Key findings include students' posturing about broad academic status and local assignment expertise that seemed to be triggered by prior experience and shared identities. In addition, views of peers as adversaries rather than partners in their work created a competitive interaction which was counterproductive to their learning and work. These findings suggest that students may be triggered into reproducing a competitive masculine engineering culture. Implications for instructors include the possibility that in some cases talking about and reflecting on competitive approaches in lab can potentially shift student behavior.**

Keywords—Institutional Culture, Active Learning, Ethnography, Competition, Paired Programming.

I. Introduction

A significant recent effort in the engineering education research literature has focused on the opportunities and challenges encountered within paired active learning settings. Many scholars have noted the success of paired learning in making students more confident in their work and improving their likelihood to successfully complete the course [1], as well the quality of learning and social development [2]. Furthermore, researchers have noted the opportunity in active learning settings to strengthen the connection to "real-world" engineering practices [3]. Other scholarship has raised challenges with equitable participation in active learning settings [4],[5]. In spite of its importance for student learning, there are comparably few pieces of research on active learning in engineering education that has documented the in situ enactment of paired programming work, including the ways that opportunities afforded to one student might interact with or constrain opportunities for a partner or peer.

Contributing to this enactment are the incoming experiences, beliefs, and attitudes of students regarding the discipline of engineering and engineering education. Student's home community, SAT scores and parents' educational level all are significant indicators on the probability of passing an entry level engineering course [3]. Results show that there is a direct correlation of incoming experiences to self-efficacy beliefs within these entry level courses [6]. Past researchers have also explored the demographic tendencies related to pre-college factors and self-efficacy, which resulted in trends like gender variation, but the research did not follow a methodology connecting prior beliefs and present actions [7],[8]. Noting the importance and interconnection of prior experience and student participation, we combine interview and participant observation methodologies to examine their connection.

This paper explores participation in an early active learning lab setting to find ways to promote learning and growth for all students, specifically with an attention to dominant and non-dominant identity students. The ethnographic study unpacks why unproductive competitive participation norms emerged and how open communication about these roadblocks shifted these students' participation into more productive experiences. We turn now to an emerging literature base on competition in engineering and education.

II. Literature on Competitive Culture in Engineering and Education

Scholarship on diversity and inclusion in engineering education has noted the presence of overarching cultural norms that create marginalizing experiences for underrepresented students [9],[10]. Notable among these marginalizing cultural norms have included demographic normativities such as whiteness and masculinity [11],[12], competition [13], and the social technical divide [14]. There is

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a growing consensus within the diversity and inclusion scholarship that these marginalizing cultural norms are important for instructors to identify, understand, and influence.

In spite of this recognition, there is comparably less work on the in situ enactment of engineering educational culture and the nuances of engineering educational settings and work [15],[13],[16]. Educational anthropology scholars have noted previously that educational culture is complex, subtle, and not as simple as planning with equitable best practices. In seminal ethnographic literature on the subject of competition and meritocracy in education, McDermott [17] found that middle school students working on paired programming could dominate or control an interaction with or without keyboard control. Similarly, Carlone [18] found that K-12 science teachers could prioritize reformed and equitable principles on the surface of their curriculum but reify traditional forms of knowledge in subtle ways, with important implications for gender patterns in access to the identity of "science person." Thus, in these cases the ethnographic education research literature helped K-12 instructors understand and see nuanced dimensions of the enactment of educational culture.

Scholarship from education research has also suggested that competition can be a counterproductive educational norm. Competition can impact students who are losing at a perceived classroom competition [19],[20],[13]. Kohn has argued that competitive framings often emerge or are explicitly promoted within education as a motivating force. Kohn notes that competition's structure requires one winner and many losers [19], and is in spirit counter to the explicit goals of most instructors in education for many or all students to make progress in and recognize the value of their learning. Competitive norms can focus students on performance and products and work counter to supporting learning.

One plausible reason that competitive culture has not received such an in depth critical examination in research literature may be that it is such a significant part of both engineering and education that it is taken-for-granted as ordinary and expected in these settings [15]. Additionally, competition is a noted masculine homosocial norm [21],[22] and may have been an accepted feature of the masculine-dominated engineering discipline. In order to question this taken-for-granted norm and add to the understanding of competition in engineering pedagogical settings, we examine classroom participation norms in an undergraduate lab with this critical view of competition, in addition with implications for learning, equity, demographics, inclusivity, and the culture of engineering.

III. Methodological Approach

The paper builds on analytical work in cultural production [18],[23],[16] which seeks to understand how persistent demographic cultural norms are reproduced or counteracted in society. Similar to cultural production work by [15], this paper attempts to look at interactional mechanisms reproducing culture. It also builds on cultural construction which examines the ways culture constructs the local educational facts which create inequities [17]. In prior work, Secules [24] wrote about the cultural process which constructed an individual student as "not cut out for" engineering in an introductory undergraduate programming course. This paper continues in a cultural construction vein, in that it disrupts preconceived categories identifying students and shifts analytical focus to the dominant normative culture and the ways in which it is being enacted and constructed within a local classroom setting.

The educational context is an introductory programming course with a lab-based component. Students are enrolled as an alternative to a lecture-based course. Labs are 3 hours long once a week. In the lab class in question 9 White or Asian men are enrolled, and 1 Asian woman. Secules was a research assistant employed by a grant to collect data on the novel course effort. Although survey data and classroom artifacts were collected for the broader grant, for the analysis at hand the primary research methods were 1) semi-structured participant interview, 2) video recorded lab interactions, and 3) participant observation field notes. Students who were recruited were interviewed early-to-mid-semester and post-semester. The ethnographic dataset is being revisited for secondary analysis by Uhlar, an undergraduate student at a different University from which the data was collected. Having experienced first hand, the challenges associated with paired active learning, Uhlar formed the current analytical frame focused on the consequences of competition for pedagogy and learning in paired lab settings.

Next, a brief ethnographic analysis will set the scene of the classroom setting, introduce to central characters, and develop several prominent themes that have both local and broader consequence for thinking about enactments of educational culture.

IV. Analysis

The students varied over lab sections but certain patterns emerged. Each pair of students were given one computer, one raspberry pi, and one keyboard/mouse combination to use to complete the labs. The participation norms between paired students were sometimes difficult to navigate. Lab pairings assigned by the TA were changed intermittently if the TA wished or if students complained.

Within this complex social interaction, a broader pattern for lab work persisted across groups. In a given paired programming lab, one student tended to take the lead, to suggest most of the programming strategy, to contribute most of the intellectual material, and to command the keyboard and type most often. This pattern had negative consequences for non-dominant students, including women, underrepresented racial minority students, and students who did not as often enter into the dominant role. This pattern persisted in varying degrees across semesters and seemed to have a negative impact on student learning, as students for whom the task was easier were taking on most of the work, while students for whom the task was beneficially challenging were not engaging. Notable about this pattern was how infrequently it

was contested, by either the more dominant group member or the less.

One day during the third semester of data collection of classroom observation by Secules, two subjects, Erik and Newton (pseudonyms), stood out. As White men, both students are from a "dominant" demographic both sociologically and for an engineering context (although Erik's specific ethnic identification was with an eastern European country). In the local lab setting they were also "dominant" in the everyday sense, often being the student to control the keyboard and the group direction. To Secules, these two students looked to be working collegially, the one keyboard moved back and forth between the students, taking turns entering lines of code into the program. In a busy room it looked as if they were sharing the work while bouncing ideas off one another, but unfortunately that wasn't the case. Erik complained to the TA about the pairing after the class, and the lab video showed that the keyboard turns were contentious. At several points either Erik or Newton would take the keyboard back from the other, ignoring the other person's chain of thought to pursue their own ideas. In reflective follow up interviews Secules asked Erik and Newton about this interaction to understand why it occurred, what it had meant to them, and what they think about their participation norms going forward.

We think Erik and Newton represent an interesting case to explore as an extreme case where the exception proves the rule: the conflict Erik and Newton experienced usually didn't emerge because the dominance Erik and Newton both pursued was usually uncontested in the lab interactions. Their interactions also make contributions to the local classroom culture which recreate engineering as competitive and dominated by White men. Thus we see Erik and Newton as representing a broader concerning pattern which impacts many more participants in engineering education. Whereas studies of culture, learning, and marginalization in engineering typically leave out cultural norms like competition and cultural identities like White and masculine, we use Erik and Newton's story as a launching point to consider the ways competitive White masculinity underlies much of the effective context of engineering learning.

A. Prior Influences and Expereinces Regarding Engineering Work

We found that the reflective interviews revealed some key preconceived thoughts and beliefs that contributed to their participation in the lab setting. In the interview setting, students often shared unique takes on why they started studying engineering without influential prompts by the interviewer. Our one subject Erik, had a specific memory of labor intensive work of with his dad fixing a household electrical project:

> Erik: I wanted to be in electrical because ever since, somewhere around eight or nine years old, my dad was fixing our broken telephone, and the reason it broke was because, they had old lead solder on all the connections, and that cracks after a while when it gets cold, so he was sitting there re-soldering them with like this rosin core stuff, and he taught me how to do that.

We can imagine how these memories with an influential person like Erik's father shaped his life in many ways. For Erik the drive to study engineering is now associated with using one's hands, and being able to complete real world practical tasks. We can imagine that the masculinity associated with this sort of engineering role could be pivotal to the way that Erik enters into and conceives of his engineering work going forward. As well, Erik also shared how a negative prior group work experience in high school shaped his views of his current lab partner:

> Erik: [Newton] reminded me of that guy. He was my best friend for a while. Then he did some--
>
> Interviewer: A High school friend?
>
> Erik: --High school guy, yeah, and, uh, he's brilliant, but me and him don't talk anymore, and that happened after his competitiveness reached a point where he would go into my personal life to compete.

Erik describes a male friend he lost friendship with when competitions over academics and personal life (including heterosexual relationships) overtook their interactions. Newton, who is our other research subject; "immediately reminded me of that friend that I worked with" [Erik]. Thus the frustration of working with a new competitive engineering partner brings back a memory of a buried friendship.

On multiple occasions, Erik brings up his lack of internship experience and what he is doing to try and secure one for the upcoming summer. From this quote, "no one actually out there shows you how to be a college student," [Erik] we get the impression that Erik doesn't have a strong mentor figure in college like he had with his dad growing up. In multiple sessions of lab time, Erik often talks to the TA, either asking for help on the lab or about advice on career and internship pursuits. Erik admits talking with the TA often about internships, adding that "it's pretty rare that freshman ever get, internships just because, they're freshman" [Erik]. He shows the importance on internships and why he considers them a valuable measure of progress and worth as an engineer. We can read in his contextualization about the rarity of early internships a potential defense against an insecurity that he has not yet reached this consequential milestone.

Our other subject, Newton, found an electrical engineering internship, in a peculiarly early circumstance, right out of high school. His father's friend offered Newton an internship once he graduated where he has been working for a few years. Newton used this position to allow him to increase his confidence in studying engineering. Newton was given an opportunity that in his mind gave him valuable additional experience beyond that of his peers. Newton regularly refers

back to his internship when talking about programming experience, although comparatively this was Newton's first programming school-taught class, similar to the rest of his peers in this class. But again, qualifies his lack of programming classes by reminding the interviewer of his internship experience, "I haven't personally taken programming classes before, but through my internship I learned a lot about MatLab" [Newton]. Thus Newton and Erik are making parallel and opposite justifications for their respective positions and relevant experiences regarding programming, and internship experiences or lack thereof are a powerful marker of progress for both students. Newton saw his internship as a valuable opportunity of working with others in a real world setting.

Both students bring certain past experiences with them into their early years in engineering. These experiences have inherently carried certain elements of masculine culture along with them, and the culture of engineering they perceive to a great extent recreates an engineering where each individual must compete against one another to be successful. Additionally, both students note the importance of internships as an indicator of how successful you have been thus far. Although they are on both their minds, Erik sees internships as a point of insecurity while Newton sees them as a point of pride.

B. Posturing with Peers to Compete Locally and More Broadly

The way our subjects postured seemed connected to their insecurities and fear of failure. Our subjects are worried about their present performance and future beyond college, and this constant worry seems to come from comparing oneself to the rest of the class.

These two students that we followed held an idea that their peers were adversaries towards the individual success in class. In an interview, Erik explains his thought process on working with his peers, "if you have like someone who's ten times more successful than you, and you compete against them, then you actually have a goal. You actually reach something" [Erik]. Thus, in a classroom setting where he is forced to work with someone else he feels that this peer will not ordinarily be beneficial. Erik even explains how he enjoys working alone to process information, negating some of the key intended academic benefit of this course. On the other hand, Newton had no problem working with partners but notes that his peers only using him for his data, "I feel like it's me doing a lot of [the code] and [Erik] maybe benefits from [the code]" [Newton]. Here, he is proud that he is the one who is providing the answers.

Competition between the two often emerged when they came across a roadblock in the code. If the two men got stuck on a part of the lab they would sit in silence for multiple minutes. After they sat in frustration one of the two would suggest which direction they should try and move towards. In almost every instance, once something was suggested the other person would contradict the statement. For instance:

> Newton: So we good then on that average? (looks to Erik with two thumbs up)
>
> Erik: Yea, go ahead and do a "dot i".
>
> Newton: Yeah it was just mainly, and like I said, when we actually call it to define the "i" and "i" minus 1, minus 2, minus 3, etc. but here…
>
> Erik: Yeah I know man, but I just like doing things [inaudible]... because they are so efficient.
>
> Newton: Well yes and no though, why use a "for loop" when you don't have to. If that makes sense? It's not more efficient if you don't have to use--
>
> Erik (interrupting): I just want to do it because I've become--
>
> Newton (interrupting): (Smiles) For practice?
>
> Erik: I've become literate with "for loops". Well look at this (points to computer screen) you see the fine things here, an experience programmer at a company would be like you don't need to do that...
>
> Newton: (Leans back in chair) Well it depends...
>
> Erik: Here's how you do it...
>
> Newton: It depends upon on... I don't know, like I said "for loops" are slow. Just because you can do a "for loop" doesn't mean you should.
>
> Erik: Ok.
>
> Newton: I mean... it comes with MatLab, at my internship I would get told this all the time... I could do a "for loop" then you don't realize in some situations how you know doing a "for loop" how an… [Inaudible] could do instead, yea you could do a "for loop" but it's going take immensely longer, then two lines of not putting in a "for loop"...
>
> Erik: Ok.

On a surface level it looks as if the students reach an agreement on the course of action, but in reality they are contradicting each other's approaches while formulating and justifying their respective approaches. In the spectrum of this class and size of the data they would be running, that time is obsolete. There were multiple interactions that preceded this way. Erik would have suggested a certain style of code while Newton would then disagree with his opinion citing that it is not how coworkers at his internship would do it. This interaction seemed to frustrate Erik over time. This subtle

antagonism was also perceived by the two students about one another:

> Erik: I hate that when he's like, "Would you agree with me?" It doesn't sound like a question, "Do you think this is the right way to do it?" It sounds more like, "I figured it out, and I don't care what you say."

When Erik took a secondary supporting role, Newton typed all of the code and followed each line with a contradicting "does that make sense to you?" type statement. Erik and Newton cared more about doing it their way than about working together with and making sure both parties understood the code they are writing. Neither party is willing to learn from the other. When both students still doubted one another they placed their trust in the Teaching Assistant (TA) of the lab. Wary of their peer's opinion they turned to the only person in the room who had the additional authority of already having taken the class. Newton even indicates that he believes without the TA everyone in the class would not complete the majority of the lab:

> Newton: I know of course the TA's are here and do a good job at answering your questions but if they weren't here for example, if there were no TA's in the picture and you were just given this lab paper, how would you expect people to build a circuit?

Both Erik and Newton are confident in their approaches to solve a problem but do not trust in the other's opinion. As a result, the students are constantly frustrated with one another and posture themselves in a closed, unproductive way. If there was an issue the TA would be trusted for advice, something that was never reciprocated between Erik and Newton. The dominant classroom norm to be right is seen between two masculine students whose embodiment of competition causes the two students to butt heads.

C. Control and Active Paired Programming Learning Participation

Through the videos in lab we see how both students view control as a way to express their level of knowledge to the class. They are in a competitive, finish first mindset when they step into the lab. In video recordings, Erik is seen inquiring on what steps nearby lab groups are on, seeming to compare his team to others. Newton on the other hand focuses on the lab groups who are struggling. In an interview he says, "[The other lab group] spent so much time just trying to get their circuit wired up. So now they only have an hour to get the coding part, which was what the overall objective of what the lab was." [Newton], demonstrating a critical awareness of others' progress. Also, in multiple video segments Newton is seen attempting to help other lab groups by taking their keyboard and typing code himself, an example of Newton showing off his knowledge to his peers.

Erik and Newton spend a lot of time in the lab passing the keyboard back and forth. This is a fight for control of the one item that controls the lab. This control is not just physical but social and intellectual. By having the keyboard, a student can impose his personal decision on what will be typed and furthermore justify why he is typing each line of code by verbally communicating his knowledge. This phenomenon demonstrates the difficulty of a lab interaction with similar levels of prior knowledge, where the direction for solutions becomes a power struggle and a proxy for status. Both students felt or purported that they had a stronger grasp of the material. For example;

> Newton: I need to find an average too-- Ummm... So, we also just need to put an average in here, so now it has the average
>
> Erik: We can make the average float?
>
> Newton: Uh yeah. I'm just trying to think of how it's best to do the average, uh…
> (leans over to neighboring lab group)
> cause okay so…
> (leans and points into computer screen)
>
> Erik: "For loop", or do you want to make an average function?
>
> Newton: Nah, I don't really want to do a function; I mean all of this stuff...
>
> Erik: The thing is, it makes it easier. Well it doesn't matter, it's going to be the same amount of work actually…

Newton was vocal in his approach when working with Erik, while on the other hand Erik on needed time to process his thoughts, "I can't just jump around the page because that'll mess with what I'm thinking about" [Erik]. They notice this struggle in an out of class interview:

> Erik: I think my personality comes off as like abrasive sometimes, um, just because I like to be like in control of things, and with [inaudible], like we were working fine. With Cheryl, it's even working out too. But with Newton, I think me and him were like too similar. That's why I don't like him.

Erik notes the similarity of personalities with Newton and speaks on the struggle for successful labs. Newton had similar things to say in his out of class interviews stating that he feels like he is in control of the lab and Erik has to sit back while he takes control, "I feel like a little bit maybe it's me doing a lot of it and [Erik] maybe benefits from it" [Newton]. Overall, both students felt while working with similar peers that they individually were pulling the majority of the weight while the other solely benefited off their work.

Physical, intellectual, and social control were seen the duration of Erik and Newton working with one another. We see that overall any conversation the two students had were unproductive since they were not truly listening to what the other had to say. Each lab, Erik and Newton were critical of other students finishing early and racing to get done. The students struggled to reach agreements and hindered the success of each lab they collaborated on.

D. Relfections and Changes in Participation

Throughout the semester both Erik and Newton had the chance to work with different classmates. Some of these students were similar in race and gender as Erik and Newton, but other lab partners were not. We see that in working with new partners our subjects had an opportunity to become cognizant of their actions in the lab. Erik and Newton had issues because neither student would cede control to the other. "I had issues with like working with Newton, just because he's got like... it might be slightly hypocritical of me to say, but I can't stand like arrogant people" [Erik]. Previously, Erik noted the similarity between himself and Newton, but now he is calling Newton arrogant which seems to come from the lack of openness when communicating their problems together.

Both students speak on the fact that these short interviews have impacted how they work with others throughout the rest of the semester. They are competitive towards each other but once they are paired a different demographic student they are able to look back and reflect on their participation. Erik was able to explicitly vocalize this in one of our interviews, "I always like to think about my behavior and see like what I can like change about myself. What was good or bad. I really didn't like the way I dealt with like Newton" [Erik]. He used what made him the maddest when working with Newton and specifically allowed another female student [Cheryl] to do that one thing; control the lab:

> Erik: Yeah, but that's why I am trying with Cheryl. I haven't, I barely touched the keyboard.
>
> Interviewer: Yeah, I saw that. Okay, so that's, that was a conscious thing? You can…
>
> Erik: No, it was a conscious thing.

Control was the biggest issue Erik had with Newton, it seems Erik was triggered into a defensive and controlling mindset in lab by this paring. Newton was not as reflective during the interviews, but he still spoke about how he is more susceptible to Erik as a partner after an interview session, "today we were working together as partners, but to have his input, like today I tried to seem like I was open to what he had to say" [Newton]. Both students had an opportunity to work with a peer of similar race, gender, or academic level and had a very hard time throughout the semester. Working together was a frustrating and unproductive struggle, but a necessary reality and a learning experience. These students were interviewed by a researcher asking solely about the class as a whole, and through the one-on-one interviews they demonstrated their potential to reflect and change their behaviors regarding peer lab work.

V. Conclusion and Implications

Throughout their teamwork with each other, Erik and Newton were not able to eliminate this dominant, competitive culture, at the detriment of their learning, performance, and enjoyment of the lab. Erik was often forced to take an inferior role in their paired work, all the while receiving contradicting statements once Newton solved the next line of code. They constructed a dominant engineering classroom interaction based on posturing and control. The destructive norms these students created led two equally matched students to butt heads and hurt the success of one another. In other cases, more dominant students can prevent their peers from being successful often without their realizing it. We see this in every occasion where Newton or Erik shoots down one another's ideas. Talking and working together through tough problems is the fundamental principle of paired active learning, while viewing peers as adversaries is antithetical to pedagogical goals of learning throughout participation.

During active paired learning, instructors have an opportunity to make clear the importance of individual participation. Springer, Stanne, and Donovan, [25] found that teaching cannot be reduced to formulaic methods and that active learning is not the cure for all educational problem, but for Newton and Erik, encouragement of participation is crucial not only to the learning process as a whole but also to their peers. Similar personality type peers will often face interpersonal problems in groups, especially when the students participate in the role of a "teacher and pupil" [2]. However, as we see when Erik works with Cheryl, more advanced and dominant students can be encouraged to take a secondary role in paired situations to enable better learning for the non-dominant student. This adjustment seemed to ameliorate Erik's need for control while consciously allowing her to control the keyboard the majority of the lab. Ultimately, instructors could make students' participation role an important and evaluated component of their work in class, rather than a sole focus on finding the right answer.

This work is not often investigated using this type of methodology: video recordings combined with interviews. The majority of research is constructed with large pools of subjects followed by survey type analysis [7],[8]. We chose to dive in depth into the lives of two early engineering students. One-on-one interviews enabled us to draw deeper connection between the background and participation of these students, such as when Erik draws similarities between his past poor class partner experiences and Newton. Similarly, for both students, we were able to see how prior experience or lack thereof with early internships impacts the learning, status, and knowledge flow of the classroom.

In research, active learning is found to support the benefit of constructive and interactive activities as a means to increase student cognitive gains [26] but researchers should continue to explore the ways in which a culture of competition

and control can undermine those gains and negatively impact student learning and affect. In this vein, Secules is pursuing an ongoing research agenda on educational culture and the overlapping impacts of demographic normativities and dominance.

Finally, as an undergraduate engineering major himself, Uhlar suggests that students keep in mind the reason our peers are in class, which is to learn and be as successful as possible. Students come from all types of demographics and influences for studying engineering so we must do our best to counteract marginalizing engineering cultural norms by creating an environment that supports learning for all, even if that means taking secondary roles in paired active learning settings.

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