



## **How Engineering Students Study: Alone, Together, or Start Alone, End Together**

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# How Engineering Students Study: Alone, Together, or Start Alone, End Together

## Abstract

This study interviewed 33 students from four different institutions in a variety of engineering and computer science majors in order to understand how and why students study the way they do. The institutions involved in this research include two types of Carnegie 2010 Classifications (Master's L and RU-VH), geographical locations in the northwest, northeast, and midwest, both public and private institutions, and enrollments varying from 3,500 to 29,000 students (total undergraduates among all majors). Although this interview pool does not provide a large sample size, and thus results must be interpreted qualitatively and with caution, we found that a majority of students begin their studying alone and seek help only later when they run into trouble with their coursework. Despite the fact that this *Start alone, End together* model for studying was the predominant approach among interviewees, the reasons for choosing this mode of studying vary. For example, students at the small Women's college in this study reported easy accessibility to faculty as a reason to refrain from studying in groups, while students at the large research university reported a need to focus properly, learn fully, and make the most efficient use of limited time as the prevalent reason for beginning their study alone. Furthermore, when asked how they prefer to study, many students shift from a *Start alone, End together* model to a *Start alone, End alone* model, suggesting that students may have unrealistic expectations of being able to complete assignments and study on their own. Still other students, while making the best of *Start alone, End together*, expressed that they would much rather work in a group from start to finish. The results of our student interviews suggest the need for a larger study that investigates how prevalent the *Start alone, End together* model of studying is among a large, representative sample of engineering and computer science students and if it is an arrangement that students are genuinely seeking or simply settle for in their informal study group strategies. Furthermore, if most students favor or wind up in a *Start alone, End together* model of studying on their own in informal academic activity, this would suggest the need for faculty and other instructors to structure team or group activities to allow for a period of working alone before progressing toward building genuine and productive teamwork among members of a group.

## Introduction

Working together as a team has distinct benefits over working alone. In the educational context, working together in a learning-by-doing mode leads to more active learning, greater retention, increased motivation, improved communication skills, and strengthened interpersonal skills over more solitary learning styles.<sup>1</sup> Yet, when students form groups, whether via faculty intervention or by individual choice and selection, these benefits are not realized automatically. Simply put, forming a group does not mean a team is at work, nor does it necessarily mean that the achievement gains promised by teamwork will be realized. In fact, when a group is formed without adequate guidance and preparation, the group is far more likely to be hindered by vague goals, poor management, conflict, social loafing (unequal workload), and similar problems that prevent it from evolving into a well-functioning and high achieving team.<sup>2,3,4,5,6</sup> Thus, we would expect that informal groups which evolve outside the classroom without faculty intervention or facilitation would be even more likely to fail than those formed within the course context. Is this what happens to study groups? Do students try to work in groups, find it impossible to form a

team out of the group, and simply give up and work alone? Or does another dynamic evolve that allows connections and collaboration with other students to proceed successfully despite the odds stacked against the informally assembled, team seeking group?

This research looks at these questions by using qualitative methods to evaluate how students study, why they study that way, and how they prefer to study. We focus on these informal study groups or teams, because they may be just as important as or in some cases, even more important than more formal course experiences, both solitary and group based.

## **Background**

Effective teamwork is highly valued within the higher education setting for a number of reasons. While employers have historically emphasized collaboration and teamwork as essential skills for college graduates,<sup>7,8</sup> the use of teams in the workplace has increased substantially over the last decades,<sup>9</sup> making the ability to work in and manage teams an even more essential condition for employability. Working in a team has been shown to lead to higher achievement along multiple dimensions including higher order cognitive thinking,<sup>10</sup> social skills, motivation, and retention.<sup>1</sup> Yet, the research involved in looking at these learning gains is often mixed because not all faculty provide adequate preparation and groundwork for student groups to evolve into effective teams.<sup>1</sup>

Successful team experiences may be even more important in engineering education than in other fields because of the tendency toward solitary learning that many students face in their engineering programs. Much engineering instruction is still oriented toward solitary effort, ranging from a traditional lecture style offered to the student in the classroom to the assignment of individual work outside of it.<sup>11</sup> The tendency toward solitude both in listening and performing may be instrumental in causing certain students to opt out. For example, women often cite a feeling of isolation as a reason for leaving the major or considering leaving engineering altogether.<sup>12</sup> In studying both genders, a lack of belonging is the primary non-academic reason why students choose to leave engineering.<sup>13</sup> Thus, in addition to the inherent educational benefits of successful teamwork, students working in these teams may also gain one of few opportunities to develop the level of community necessary to both engage and stay in the major.

Yet, there remain some inherent conflicts for many engineering students between working in groups and working alone. For example, engineers are significantly less extraverted than most other professional groups<sup>14</sup> and are therefore more prone to working alone.<sup>15</sup> Some studies even support studying alone as a pathway to greater performance than working in groups.<sup>16</sup> However, the challenging and grueling nature of many engineering programs<sup>17, 18, 19</sup> can make it impossible for all but the brightest students (if that) to succeed in complete solitude. In class, the choice to work alone or work in groups is often up to how an individual faculty member chooses to teach, value teamwork, and prepare the student for that teamwork. Outside of class, however, students are often left to their own devices in choosing how they study, whether alone or with others. How these students evolve study habits that accommodate their personalities as well as their academic needs for assistance is the focus of this study. Knowing how students self-organize in their study routines, both solitary and group-based, can assist faculty and other practitioners, both inside and outside the classroom in preparing and supporting students to evolve their group work into more genuine teamwork.

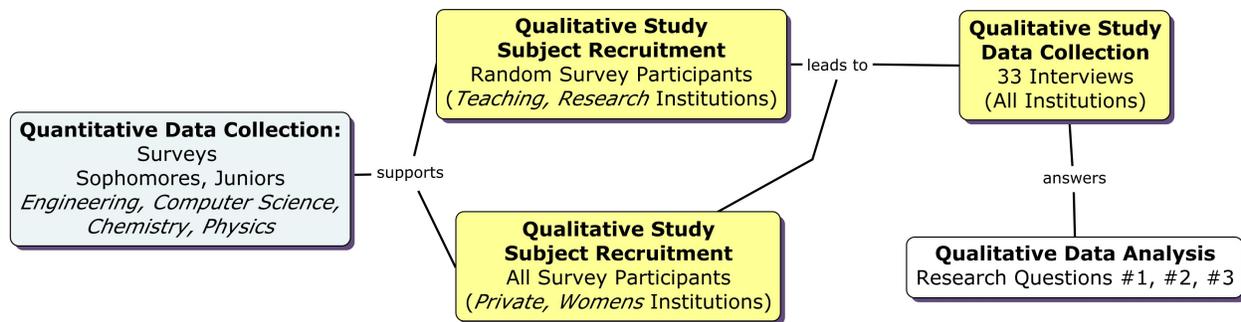
## Methods

This research is part of a larger five-year, multiple-institution research study that examines connection, community, and engagement in STEM education. In this larger study,<sup>20</sup> patterns of belonging, connection to community, and related affective outcomes are investigated with the goal of predicting and improving engagement and connection to community across a diverse range of institutions, students, teaching styles, and faculty. We are currently in the last year of this broader study funded by the National Science Foundation.

This part of the study focuses on how students majoring in engineering and computer science study and includes data collected from the following four institutions:

- **Private/Faith Based (Masters L):** A small teaching institution in the Pacific Northwest of 3,238 undergraduates, whose mission emphasizes building graduates of competence and character by providing tools of rigorous learning and modeling a grace-filled community. This institution offers six engineering and computer science majors that are based on and informed by a Christian world view. Class sizes typically range from 15-20.
- **Research (RU/VH):** A large research institution and flagship university in the Pacific Northwest which serves over 29,000 undergraduates and confers over 12,000 degrees annually. This institution offers ten engineering and computer science undergraduate degrees, and is characterized by large classes in freshman and sophomore years (100-500) and smaller classes in junior (40-80 students) and senior (15-40 students) year. Most students are competitively admitted to engineering and computer science majors after their second year.
- **Teaching (Masters L):** A medium-sized institution of approximately 13,504 undergraduates in the Midwest that combines an emphasis on teaching with emerging innovations in research, serving a regional student population. This institution offers over ten undergraduate degrees in engineering and computer science. Class sizes typically average 25 students, with upper division classes averaging about 15 students.
- **Women's (Masters L):** A small women's college of approximately 1,792 undergraduates in the Northeast with fifty majors, including computer science, biology, biochemistry, bio-statistics, chemistry, environmental science, health informatics, mathematics, and physics degrees in STEM, but no engineering degrees. This institution offers a liberal arts education for its undergraduates integrated with professional work experience. Class sizes are typically 6-12 students, with the largest class size around 20.

A qualitative methods approach was used to investigate how students studied, how they preferred to study, and why they did so. Rather than focusing on the prevalence of certain styles of studying, the goal of this study was to “cast a net” and understand the breadth of what styles of studying students reported seeing, which styles they preferred, and why they liked certain styles over others. The basic structure of the research design for this component of our larger study is described graphically in Figure 1.



**Figure 1: Research Design**

### ***A. Research Questions***

Three research questions were addressed in this part of our study.

#### **Research Question #1:**

*How do students study?*

The answer to this question provides insight into how students may resolve the tension between an introverted personality and the need to work together to survive a challenging curriculum. While more extraverted personalities are expected to self-organize into study groups, more introverted students may find a hybrid style or styles of study that balances this tension.

#### **Research Question #2:**

*How do students prefer to study?*

Knowing student preferences for studying can provide faculty with some insight into how to structure assignments that bridge student preferences with effective student grouping (and teaming) outside of class.

#### **Research Question #3:**

*Why do students prefer to study this way?*

While we have made some presumptions about how introverted students will prefer to study, the answer to this question can provide valuable, additional insight into why students study the way that they do.

### ***B. Subjects and Procedures***

Over 1750 engineering, computer science, and science students in total from these four institutions began participation in this study by completing a survey of their experiences including participation in communities both in and outside of school, as well as their feelings about the degree to which they belong (or do not belong) in these communities. Details regarding this survey are described elsewhere.<sup>21</sup> At the Research and Teaching institutions, students were then randomly selected from this survey pool to participate in interviews. Because of smaller overall sample sizes in the survey population, at the smaller schools (Private, Women's), all students from the survey pool were recruited for interviews. A total of 33 interviews were conducted across the four institutions. The distribution of interview participants is summarized in Table 1 and includes students majoring in bioengineering, civil engineering,

civil and environmental engineering, computer engineering, computer science, electrical engineering, general engineering, and mechanical engineering. Because the interview participants were a self-selected subset of the survey respondents, it is possible that some bias existed in the participant population, in that those students who chose to attend interviews may have been those who were inherently more interested in how they and others studied.

Each interview lasted 30-45 minutes. Interviews were conducted by a single researcher at each institution who followed a semi-structured protocol based on the research questions. In addition to the core questions, interviewers were encouraged to ask follow-up questions (or prompts) to obtain richer data. All interviews were audio recorded and transcribed. No identifying information was retained in the transcripts except for major, gender, and ethnicity when voluntarily provided by the interviewee (it was made clear during the interview that responding to these demographic questions was strictly optional). Although asking for gender and ethnicity data at the beginning of the interview may have made the interviewee aware of stereotypes regarding his or her gender and/or ethnicity, the nature of the interview questions did not directly relate to an established stereotype (of how certain genders or ethnic groups study), and the risk of bias introduced by this stage in the interview was considered minimal. The social expectations of women to prefer working in teams may be an exception, but since interviewees viewed the four study styles prior to the interview (detailed in the following section), the risk of changing an impression or answer established well in advance of being asked to identify gender was also considered minimal.

**Table 1: Participant Demographics\***

Institution	Total N (%)	Men	Women	Asian	Black	Caucasian	Hispanic
Private	5 (15%)	4	1	-	-	5	-
Teaching	13 (39%)	5	6	-	-	8	-
Research	9 (27%)	3	5	3	1	1	-
Women's	6 (18%)	0	6	2	-	2	1
Total	33 (100%)	12	18	5	1	16	1

\* Gender and Ethnicity numbers do not add up to *N* because some participants chose not to respond to demographic questions

### **C. Instruments**

Those who agreed to participate in interviews began by viewing four brief videos on YouTube<sup>22</sup> prior to the interview. These videos depicted four of the most frequently cited types of studying described by students in a previous phase of this research. After introduction and consent procedures were completed, the interviewer asked the student participant to state his (or her) major, ethnicity, and gender, and then formally began the interview by asking students to talk more about these videos with the following questions:

- Which of the four situations you just saw in the videos do you see happen most often in your <student's major> experience at <institution>?

- Independent of what you actually see happen in your academic life, which of these situations do you PREFER for studying in your <student's major> program?
- Which of the students in these videos do you most relate to?

Although the three research questions in this study were primarily addressed through analysis of responses to the above three questions, the interview protocol also included the following additional questions:

- So far, we've talked mostly about what goes on in your study groups. Let's shift a little bit to the classroom. From the distinct types of situations you see in the videos, what types of interaction with other students do you prefer in the classroom?
- Now, getting away from the classroom and into your lab experiences. Of the distinct situations in the videos, what type of situation do you prefer when in a lab?
- Shifting one more time from labs now to project teams, of the distinct situations in the videos, what type of situation do you prefer when working on a project or with a project team?
- Tell me about a group or place or community in your life outside of your academic work where you really feel accepted. What about that community (group or place) makes you feel accepted?
- What would it take for you to feel that way (accepted) in a study group?
- What would it take for you to feel that way (accepted) in a classroom?
- What would it take for you to feel that way (accepted) in a lab?
- What would it take for you to feel that way (accepted) in your major?

When the student had completed answering these questions, the interviewer asked, "Anything else you would like to add?" and then concluded the interview.

#### ***D. Data Collection and Analysis***

Transcripts and field notes from focus groups were analyzed qualitatively. An initial coding scheme was developed based on the research questions, was piloted with a small number of transcripts, and was revised accordingly in order to fully capture data addressing the research questions. Full coding and content analysis of all transcripts were then completed by a single researcher in order to identify relevant concepts within the data, as well as emerging trends and themes.<sup>23, 24, 25, 26</sup> Two passes of thematic coding were then done to more fully understand the identified themes, first focusing on addressing Research Questions 1 and 2, and then a second pass focusing on Research Question 3. This analysis focused on both gaining an understanding of patterns of study habits and preferences, as well as identifying and understanding common differences and similarities across participants.

### **Results and Discussion**

In interviewing 33 students at four different institutions, we found that students tended to speak about how they study and how they prefer to study in four distinct styles (Table 2). The first style, which we call *Start together, End together*, is the "Extrovert Ideal"<sup>15</sup> to working on assignments or projects, and involves coming together as a group at the beginning of an assignment or project and remaining in close contact periodically through its duration. This style was observed (as the way students studied within the major at a particular institution) by

individual interviewees in a substantial minority of cases at three of the four institutions except the Women’s institution, where very small class sizes and ready accessibility to professors substantially reduced the need and interest to form study groups. Six of 33 interviewees (or 18%) stated that this style dominated how they study at their respective institutions while 9 of 33 (or 27%) expressed that *Start together, End together* was their preferred form of studying.

The second and third styles observed from our interviews together made up a majority of existing styles at all four institutions and a majority of preferred study styles at three of the four institutions. These styles are characterized by the student’s desire to begin a task alone and then evolve into a different mode of studying as the task progresses toward completion. We call the first of these two *Start alone* styles: *Start alone, End together*. This pattern of studying tends to focus on a formal agreement among students to come together at a preset time(s) to discuss difficulties, compare answers, and engage in other benefits of collective effort. The second variation, *Start alone, End almost together*, while similar in philosophy to *Start alone, End together*, tends to be more casual and less structured. In this pattern of studying, students typically agree with a group of other students to begin a task on their own, and then come together toward the end of the task to check answers, work out difficulties, and engage in other forms of collaboration as the need arises (or as the deadline approaches). Typically, students do not meet face-to-face in this second variation of *Start alone*, but use communication technology (Facebook, text, e-mail, phone, etc.) to touch base at whatever time and through whatever means they find convenient and appropriate to resolve difficulties or check answers with one another. Twenty-seven (or 82%) of the 33 interviewees saw these two related patterns of studying as the most frequent in their majors, yet only 14 (or 42%) expressed that they preferred this study style.

**Table 2: How Students Study and How they Prefer to Study (Summary)**

Study Style	Start together, End together	Start alone, End together	Start alone, End almost together	Start alone, End alone
<i>Private Institution</i>				
Observed	2	1	2	-
Preferred	4	-	-	1
<i>Research Institution</i>				
Observed	2	5	2	-
Preferred	1	3	2	3
<i>Teaching Institution</i>				
Observed	2	3	8	-
Preferred	4	2	3	4
<i>Women’s College</i>				
Observed	-	-	6	-
Preferred	-	-	4	2
<i>Totals</i>				
Observed	6	9	18	-
Preferred	9	5	9	10

The last style was one marked by solitude from beginning to end. What makes *Start alone, End alone* interesting, however, is that not a single interviewee stated this was how he or she actually studied. Instead, over 30% (10 of 33) of study participants said that they preferred this style over

what they were actually doing. *Start alone, End alone* allowed students to begin, work on, and complete tasks all on their own, without assistance from their peers. The fact that this style was notably absent at all four institutions but often desired by students does raise some concerns about student expectations of their own ability to learn. It seems that many students believe that they should be able to complete tasks, assignments, and projects on their own without help from the outside, whereas many faculty design assignments to be exactly the opposite – to be challenging enough that help from peers and other resources will be necessary to complete them.

Each of these study styles, including how students expressed what they saw at their institutions, what styles they preferred, and why they preferred certain styles, are described in detail, next.

### **Research Question #1A:**

*How do students study? (Detail in Table 3)*

Most students interviewed observed that most often their peers began an assignment, project, or study session alone and then came together at the end to work with fellow students. This style of *Start alone* and then coming together toward the end of an assignment or when difficulty was encountered, was observed to be the predominant style of studying for all four institutions in this study. This way of studying had two distinct variations: (a) *Start alone, End together*; and (b) *Start alone, End almost together*.

#### *Start alone, End together*

Students who reported studying this way tended to decide in advance that they would begin a task or assignment alone and also would come together toward the end of an assignment or study period and meet to review their work and resolve any disagreement in solutions or approaches to problems. For example, Becky observed that most of the students in her major (bioengineering) cohort studied this way:

In my major, the most often I would say was the second scenario where you do have a study group but everyone has already attempted to try to do the problems, and then we kind of just go over the problems that we don't quite understand and see if we can all come together to solve it. Yeah, so that's the most prevalent one that I've seen in my cohort. (Becky, Research)

Mark, although in a different major (electrical engineering) at the same institution, made a similar observation. What he reported seeing most often in his major was similar to the scenario where:

They kind of all started off doing their own thing and then they ended up grouping together when they found a problem they all needed help on. ... Like even my study group is sitting over there and you can tell all three of us are sitting together but we're not talking, we're doing our own studying and then we'll talk when we need something or have a question. (Mark, Research)

#### *Start alone, End almost together*

While many students observed their peers coming together in a structured group meeting to do their work, many also observed that coming together did not always involve a great deal of planning or structure. Instead, one form of communication technology or another took the place

of face-to-face encounters, often on an impromptu basis. Sometimes the communication was as simple as a phone call or e-mail:

Usually I get through them all, and then it's like, well this one I don't know how to do, you call someone. (Matthew, Teaching)

We don't have study groups in the computer science major. Basically if we have questions regarding code or a professor has given us some homework and we have questions, we tend to email each other. We don't do study groups at all. (Xingyi, Women's)

Other times, structured or scheduled meetings were replaced by other forms of communication due to extenuating circumstances, like the weather:

Because sometimes, especially in the spring, you know, nobody wants to get up and go to the library because of the weather, and at night without the bus.... Some people in the library, some people in their own apartment, some people in the ACC, and they just work on their own, and if they have an issue, they just come back and...personally I prefer [if] we can get together with the math here before, and then we get together try to solve things. But it's not always like you have this, so just deal with whatever you have. (Melani, Teaching)

Regardless of the type of technology used to connect with other students, the *Start alone, End almost together* style was very similar to the *Start alone, End together* style where students intentionally decided to begin a task on their own and then as difficulties arose or the assignment came to an end, to come together. Unlike the *Start alone, End together* style, however, *Start alone, End almost together* students tended to favor electronic communication, informal, less structured, or less scheduled exchanges over planned meetings. Combined, these two styles dominated the study styles observed by students at three of four institutions (Teaching, Research, and Women's).

Surprisingly, students did not express a concern about working together as a potential pathway to academic dishonesty where a member of the group would simply seek to obtain solutions to problems based on the efforts of others in the group. As one student explained:

Usually I get through them all, and then it's like, well this one I don't know how to do, you call someone. I mean, emailing them, then you're just getting the solution. I mean, I feel like once you're deep in the major, no one actually does that because you'd have failed out by then. (Matthew, Teaching)

In large part, students were motivated to learn in these informal groups rather than engage in social loafing. This was true for the *Start Alone, End Together* models of studying as well as *Start together, End together* which, unlike the other institutions in this study was the dominant style of studying at the Private institution.

#### *Start together, End together*

Although to a lesser degree than the previous two styles, *Start together, End together* was observed by students at all institutions except the Women's institution. Anna summarizes what she observes happening in her study life simply and effectively:

We're all on the same page and we're all working together. (Anna, Private)

These students tended to value teamwork and community enough that it overtook individual preferences toward studying alone, either in part or in total. At the Private institution, most students interviewed observed this style as the predominant one in their majors, while at other institutions, only some students mentioned this model of studying.

### *Summary*

What we hear from students in terms of what they see happening in their study lives is that most of the time, students begin studying alone. Then, at a preset time or when they can no longer move forward on their own, these students choose to come together with their peers, either through traditional in-person meetings or via electronic means including Facebook, e-mail, phone, text, and similar means. If this strategy is the one that students observe and participate in most during their undergraduate experiences, then perhaps it makes sense for faculty and other instructors to build "alone time" into the beginning of project and other group activities to match what students already do in their informal learning activities.

### **Research Question #2:**

*How do students prefer to study? (Detail in Table 3)*

As we listen to interview participants transition from what they see in their undergraduate study habits to what they prefer, many students shift from *Start alone, End together* (or *almost together*) to the *Start alone, End alone* style, despite the fact that no students report seeing this style in action in their majors and home institutions. These students expressed strong convictions that working entirely on their own was the best choice for them:

I really, I need time to sit down and process it on my own. ... Without the context of why you're doing that, I just don't retain it. (David, Research)

I tend to study better by myself, because I stay more focused that way. (Julie, Women's)

One student preferred to *Start alone, End alone*, but also to have the option to rejoin with peers in the middle of the studying cycle:

For me personally, I would say it works better if I start by myself and then reach out for questions and come together as a group and then probably finish up by myself. (Ralph, Research)

Other students preferred to stay with the *Start alone, End together* model that they saw most often in their informal study habits:

I prefer starting out separately and then ending up together because at the end you still have questions, whereas if you start together and then end separately or something like that, you might not have help when you need it. (Michael, Teaching)

**Table 3: How Students Study and How they Prefer to Study (Detail)**

Student	<i>Actual Study Style</i>				<i>Preferred Study Style</i>			
	Start together, End together	Start alone, End together	Start alone, End almost together	Start alone, End alone	Start together, End together	Start alone, End together	Start alone, End almost together	Start alone, End alone
<i>Private Institution</i>								
Elliott	X				X			
Anna	X				X			
Derek			X					X
James			X		X			
Philip		X			X			
<i>Research Institution</i>								
Sayo		X						X
Ralph	X					X		
Ishana		X			X			
Alex			X				X	
David			X					X
Jessica	X						X	
Becky		X				X		
Mark		X						X
Angela		X				X		
<i>Teaching Institution</i>								
Joel			X				X	
Arial			X				X	
Gerard			X					X
Russell		X			X			
Melani			X			X		
Joy			X					X
Ella			X		X			
Kelly	X				X			
Ruth		X					X	
Luke			X					X
Matthew			X					X
Michael		X				X		
Bruce	X				X			
<i>Women's College</i>								
Julie			X				X	
Rachel			X				X	
Xingyi			X				X	
Ivana			X					X
Maya			X				X	
Marilyn			X					X

Still other students expressed a desire to move from *Start alone* to *Start together*:

Ideally I like to see situation #1 where we start together and end together so that way we can be more efficient and get things done faster. (Philip, Private)

I like working with other people around. I think it's just good to have people to bounce ideas off of, and it's just far more productive. (Ishana, Research)

### **Research Question #3:**

*Why do students prefer to study this way?*

Despite the fact that the *Start alone, End together* model for studying predominates among interviewees at all four institutions, the reasons for doing so vary. For example, students at the small Women's college in this study reported easy accessibility to faculty as a reason to refrain from studying in groups:

It's easier to contact professors, especially since the computer science department is really small. ... I feel like, for computer science, it would probably work best to like, talk to your peers, rather-- if the teachers weren't so accessible, then it would make sense to ask people. But since the computer science department here is so small, it's not a big deal. (Rachel, Women's)

In contrast, students at the large Research institution reported a need to learn fully and make the most efficient use of limited time as their primary reasons for beginning their studies alone:

For me personally, I would say it works better if I start by myself and then reach out for questions and come together as a group and then probably finish up by myself. So, do have some outreach but it's better to kind of figure it out for myself. ... I don't really get a whole lot out of group studying because one person typically knows it and they end up just giving the answers to everyone else. (Ralph, Research)

Hopefully, sometimes, I'll be able to get through the whole problem by myself. But in those instances where I can't get through it, I usually ask somebody for help. So I think it helps in that I struggle with it by myself instead of having someone tell me the answer right away. (Jessica, Research)

Students at the Teaching institution reported similar benefits to beginning their studies alone and joining a group later on in the process:

I learn better if I try to kind of talk through the problems, then figure it out on my own before going to the group to get help. (Ruth, Teaching)

Interestingly, students who wanted to *Start together, End together* had the same reasons for choosing to do so (e.g., to learn more fully and to make best use of limited time and resources) as those who wanted to *Start alone, End together*:

First off, working together, the ability to ask questions and answer them at the same time with other people. Um it also keeps things organized so that it doesn't get out of hand or take too much time or waste time trying to catch each other when you're available. (Kelly, Teaching)

Getting together lets you both ask questions, confirm your understanding with other people. And also, if you understand something really well you can help someone else with it, which helps you learn it really well. (Elliot, Private)

One student expressed a desire to *Start together, End together* regardless of whether he liked it or not, based on an underlying desire to work more effectively in teams:

It's kind of hard sometimes you need a second mind to realize, oh, it's this way. Bang your head against the wall, like 'oh yeah.' ... It helps me to learn how to work in teams. That's, I think, an essential skill at least for my major too because in the professional world engineers work in teams quite a bit so it's very supportive of understanding how to interact with people who are not on the same level as you, how to communicate things that they don't understand and how to communicate what you don't understand to a teammate. So it's very enlightening as to how to more effectively work in teams. (Philip, Private)

Still others thought their personalities were simply best suited to studying alone from start to finish:

I tend to study better by myself, because I stay more focused that way. (Julie, Women's)

I'm more of the independent just doing things on my own. (Ivana, Women's)

### *Summary*

In describing why students chose to study the way they do, students emphasized institutional influences, educational benefit, and personality style most often in their responses. Many of those who chose *Start alone, End together* (and its variation *Start alone, End almost together*) justified their choices based on very similar reasons as those who chose to *Start together, End together*. These reasons include maximizing learning and reducing the time it takes to learn. The students at the Women's institution were distinct in that they chose to study in more solitude because professors were highly accessible, despite recognizing that working with peers would give them some benefit that going directly to the professor with questions could not. Finally, those who preferred to *Start alone, End alone*, often commented that this was a function of their personality more so than an awareness of any particular benefits to learning or efficiency that came from studying in solitude.

### **Limitations and Implications**

*Limitations:* We recognize that in drawing data from only four institutions, the generalizability of our findings may be limited. However, the inclusion of four diverse types of institutions in the study does allow for the representation of a wide range of student experiences. Despite the relatively small size of the data set, we feel that our findings are valuable, as they provide insight not only into how students are studying and how they prefer to study, but also potential misconceptions about how they should be studying. Another limitation of this analysis is that it examines only informal study groups, and excludes more formal group efforts including laboratories, design projects, and other formal team effort in the curriculum. While it can be

argued that this limits the usefulness of our results to only informal group work (that which students decide on their own to pursue), we argue that the choices students make when completely left to their own devices are highly indicative both of what they prefer in more formal group efforts and what promotes their best performance.

*Implications:* The insights provided by this study regarding the most common and most preferred modes of studying in four different campus environments can inform efforts to better support students in their academic work. For example, our findings indicate that students largely prefer less structured types of academic support. That is, starting alone and ending in various states of togetherness. This suggests that structuring assignments, projects, or other group work that require students to work together from the beginning may not be attractive to all students, whereas providing a means for students to easily connect and work together after they have started alone may be more productive. Instructors can draw from the results of this research to query students on their desired structure of teamwork (start together, end together or start alone, end together) or offer different types of structure or flexibility in group projects that allow students to start alone or start together, depending on individual preference.

In addition, knowing that students express a preference for studying alone, regardless of their actual current study habits, suggests that it might be helpful for students to learn more about the benefits of working in teams so that they can modify the *Start alone, End together* style to include others at times when they stand to reap the most benefit from working as a group (and hopefully, also as a team). Like many other studies from the educational research community, this research speaks to the need to inform students of the results, so that students can be better aware of what choices are most prevalent among their peer group, thus reforming stereotypes in that regard and encouraging students to gain greater awareness of what types of communities and relationships best support them in their academic endeavors. In addition, future research should also consider whether start alone, end together modes of studying and working together improve or detract from academic outcomes.

### **Concluding Remarks**

This study has taken a qualitative look at how students study, how they prefer to study, and why they study that way. Among 33 students at four diverse institutions, students most frequently express that they tend to begin studying alone and at some point in the process, rejoin with their peers to reap benefits in learning and efficiency in their work. The preference for starting alone is consistent with the reduced tendency toward extraversion that engineers express compared to other professionals. The popularity of *Start alone, End together* in engineering calls for engineering faculty to adjust the ways in which they facilitate teams in the classroom (and encourage formation of groups outside the classroom) to include a period of working alone.

Despite the prevalence of *Start alone, End together* modes of studying expressed by students in this study, not all students agree with this model. Some prefer to *Start together, End together* and some would rather study in solitude from beginning to end. The range of preferences for studying speaks to a need to value, facilitate, and encourage a diversity of group work in the classroom and outside of it. Furthermore, those who firmly believe they should be able to *Start alone, End alone* may have misconceived expectations about how learning in engineering should

go and these misconceptions must be resolved before redirecting students to some level of interaction and collaboration with their peers for fuller and more efficient learning.

Since this study is qualitative in nature, it is important in future work to determine two things: (a) the prevalence of these actual and preferred study styles in a larger population; and (b) effective means to identify student preferences for group work in multiple types of situations (laboratories, design projects, problem sets, etc.). This study has exposed patterns of study and working together that can form the basis for a follow-up quantitative study.

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