

Exploration of First-Year Students' Resource Networks to Complete Engineering Homework

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Abstract— This Research Work in Progress paper presents our initial findings using network analysis to explore the resources (peers, teaching assistants, faculty, textbook, class notes, online, etc.) first-year engineering students use to complete homework in their engineering course. We designed a survey with open and closed-ended items to begin to explore what resources students use and why they use specific resources when completing a course assignment. Based on the data related to what resources students use, we created a weighted edge network using the statistical software, R. Through this analysis we identified the pairs of resources that were used the most by students. The open-ended survey responses were analyzed using conventional qualitative content analysis to understand why students use specific resources. This analysis identified four themes (contingency, isolation, convenience, and comfort) that represent how students make decisions about resources to use when completing homework.

Keywords—social network analysis, first-year engineering, mixed-methods

I. INTRODUCTION

Numerous studies have shown that students' social capital (people they know and have access to) influence their success and retention within engineering programs. Social support and the development of social capital has been proven to play an important role in a student's academic success [1]. While social relationships have been correlated to student success, these relational networks must also show characteristics of trust and support in order to be viable. These relationships may be formed by sharing responsibilities on an assignment or viewing a classroom as an inclusive community. The development of social capital and self-efficacy relies heavily on a student's perception of their academic environment as an inclusive community. If this is not the case, "students who need help may not seek help" as they may "fear being labeled as incompetent or lacking ability" by both peers and faculty members [2]. In addition to fostering an inclusive community and approachability, instructors also aim to teach students how to use resources (people, books, online, notes, etc.) to complete assignments and expand their knowledge. Ideally, this would happen early in students' undergraduate careers and be applied throughout their engineering education.

In this work, we used the basic framework of Social Network Analysis and applied it to resources available in an undergraduate classroom to better understand the resource networks students develop and use to complete homework assignments. The goals of this preliminary study were to 1) identify how students use available resources (teaching assistants, instructors, textbook, notes, online resources) in order to complete Paper Homework Assignments (PHW) and 2) gain an understanding of why and how students use these resources through a mixed-methods research approach.

II. RELATED WORK

Social Network Analysis (SNA) is the exploration of "large networks with self-organization, not bound to a predefined size" [3]. The purpose of network analysis is twofold: (1) to understand what influences the formation of relational ties in a given population and (2) to understand how the structure of ties may influence outcomes for an individual in the network [4]. SNA has been used in diverse fields to show the relationships between different actors, or nodes. Typically, these studies focus on either the factors that influence formation of the relationship or the role that belonging to a specific social network can have on an outcome. While this type of research has been conducted in various fields, ranging from social science to human disease, there is an unlimited wealth of knowledge within the realm of engineering education that has yet to be explored. Some work has been done in engineering to develop relational networks, visual representations of students' interactions in a classroom. These networks were used to investigate the possible connections between a student's position in the network and their performance on an assignment. The results of this work showed that student's performance on an open-ended design project was higher for students that had multiple interactions with other high performing students [3]. Similar analysis techniques can be applied to investigate the resource networks individuals create to gain knowledge and understanding within the context of a course. These resource networks would include people as well as other resources such as textbooks, the internet, and course notes. Limited work has been done to look at networks that include both people and resources.

The effectiveness of interpersonal interactions and resource utilization within the context of a STEM classroom have been researched previously. Interpersonal interactions, even between unequal ability groups (in the case of one study: post-graduate tutors and junior high students as tutees), were proven effective provided that, “explanations are timely, specific to the help-seeker’s misconception or lack of understanding, and given at a level of elaboration that the help-seeker needs and comprehends” [5]. Student resource utilization research is less common with much of the research focusing primarily on how students use required resources [6], rather than what resources students choose to use.

III. METHODS

A. Participants

Participants were recruited from a second-semester, first-year honors engineering course that includes students from all engineering majors. The participants were not offered an incentive to participate in the study or complete the survey. All research procedures and instruments were approved by the IRB. Thirty-nine of 104 students completed the survey, which is a response rate of 38.6%. The demographics of the survey population align with those of the class.

B. Course Context

In the course, students complete PHW associated with each lecture. Students are required to document all of their work on these problems and follow a problem-solving process. Their work is assessed using a problem-solving rubric. We selected a PHW assignment in the 12th week of the semester, because of the problem’s complexity and likelihood that students would need to use their available resources to complete the problem.

The course is co-instructed by three faculty instructors, who have an open-door office hour policy. There are five undergraduate teaching assistants (TAs) and one graduate TA. The TAs hold drop-in help hours during the week, facilitate the Tuesday and Thursday lab sections of the course, run review sessions before exams, and grade PHW and exams. Students are encouraged to work together to complete their PHW. Each student has different numbers for the variables in the problem and will have a different final answer. The TAs are not given the answers until the students have submitted their work. This is done to prevent students from using the TAs to simply check their answer and encourage them to ask about the process they are using to complete the problems.

C. Survey Instrument

The survey instrument developed for this study included open and closed-ended items. In this first part of the survey, students were asked to identify the faculty instructors and TAs they consulted with on their most recent PHW by selecting “yes” or “no” next to each instructor’s name. A textbox was included for each TA and faculty member listed, with a prompt asking how they consulted each person (Figure 1). In the next part of the survey, students were also asked to list other resources they consulted and describe how they decide

Please indicate any TAs you worked with or consulted on the PHW.

	Did you work with or consult this TA?		Describe how you worked with or consulted this TA.
	Yes	No	
TA 1	<input type="radio"/>	<input type="radio"/>	<input type="text"/>
TA 2	<input type="radio"/>	<input type="radio"/>	<input type="text"/>

Fig. 1. Example survey item from first part of the survey.

what resources to consult. This section of the survey was open-ended to ensure we captured the full range of resources students use rather than making assumptions from an instructor or researcher viewpoint. We disseminated the survey two days prior to the students submitting their PHW and kept it open for five days after the PHW deadline.

D. Analysis

Responses specific to what resources the students used to complete the PHW were analyzed as a weighted edge network in the statistical software R 3.4.0 [7] using the igraph [8] package. The resources were treated as nodes and the edges were defined as students who used the two resources (nodes).

Based on the survey responses, we first created a table of ones and zeros to identify the resources each student used. To do so, we condensed the data about the specific TA or faculty

instructor the student consulted into two columns (TA and faculty instructor), placing a one in the cell if the student reported consulting a TA or faculty instructor, respectively. Similar columns were created in the table from the open-ended responses about the other resources students used. In order to do this, we had to first make a list of all the resources the students listed.

From this table, we created an adjacency matrix, with the resources as the column and row headings, to capture the number of students that used each combination of resources. For example, if three students reported using both the textbook and TAs, we placed a 3 in that cell, and if no students reported using online answers and faculty instructor, we put a 0 in the corresponding cell.

We used conventional qualitative content analysis to analyze the responses to the other open-ended survey items to begin to understand why and how students used different resources. This type of qualitative analysis was employed because conventional content analysis is common in studies whose goal is to describe a phenomenon in which there is not an existing theory that can be used to describe it [9]. In this study, the phenomenon being investigated was students’ decision-making process in selecting resources to complete PHW. The data for each open-ended question was sorted by student. The first step in analyzing the data was to read all of the open-ended survey responses. This allowed us to gain a holistic understanding of the data before further analysis. After the holistic review was completed, key phrases related to our goal of understanding why and how students select resources were identified and extracted. These key phrases were then analyzed across participants to identify similarities and differences in how students approached using resources to

complete PHW. From this comparison, we identified patterns in the data that were used to inform themes that can be used to begin to explain why and how students use particular resources to complete a class assignment.

IV. RESULTS AND DISCUSSION

A. Descriptive Quantitative Analysis

To gain an initial understanding of the resources students used, we calculated the number of students who used each resource (Table 1) and the number of resources each student used (Table 2). From this analysis, we identified that notes and marked-up notes were used the most and faculty instructors and online homework answers were used the least (Table 1). On average, students used 1.9 resources to complete the assignment, with the number of resources used ranging from zero to four (Table 2).

Table 1: Summary of the number of students that used each resource	
	Number of Students
Textbook	10
Notes	17
Marked-up Notes	17
Internet Search	10
Online Homework Answers	4
Faculty Instructor	4
Teaching Assistant	14

Table 2: Summary of the number of students that used a specific number of resources.	
	Number of Students
No resources used	1
1 resource used	12
2 resources used	17
3 resources used	6
4 resources used	3

B. Network Analysis

To begin to understand the resource networks students use to complete a course assignment, we created a weighted edge network to identify the most common combinations of resources used by the students. In this network (Figure 2), the resources are the nodes and the edges represent the number of students who used the two connected resources.

This analysis shows the students who used online answer forums did not consult faculty instructors or conduct an

internet search. Additionally, more of the students who used online answers consulted a teaching assistant than notes or their textbook. Perhaps this is because of the type of information the students were hoping to gain from the resources; however, additional work is needed to gain a more complete understanding of how and why students used particular resources.

Apart from online answers, the other resources (teaching assistant, textbook, notes, marked notes, internet search, and faculty instructor) were used in combination with each other by at least one student. The most common combination of resources used by the students were teaching assistants and notes followed by teaching assistants and the textbook.

B. Qualitative Analysis

The open-ended survey responses were analyzed using conventional qualitative content analysis. Through this analysis, four major themes emerged: contingency, isolation, convenience, and comfort. We looked at these themes across participants and in terms of how difficult the students rated the difficulty of the assignment from extremely easy (1) to extremely difficult (7).

1) *Contingency*: Many students described that their approach to utilizing resources was dependent on the amount of time the problem took them or the perceived difficulty of the PHW. There were multiple examples of student responses that included the idea of contingency. In these responses, students tended to use phrases such as “it depends” or mentioned feelings about the difficulty of the assignment, like if they became “stuck” on a problem.

2) *Isolation*: Many students explained that they started the problem alone, initially relying solely on themselves and inanimate resources such as textbooks and notes. The students who found the PHW slightly (5) to moderately difficult (6) often noted a progression. One student addressed this progression by saying “I always try to solve the paper homework alone using the notes and textbook, if unable I then consult other class members, then lastly look on the internet for help.”

There were some students who isolated themselves and only used inanimate resources. One commonality across these students is that they found the problem to be only slightly difficult (5). One student stated that he decides on resources, “based on what I need” and that, “most of the time if I am stuck I use the lecture notes to find the correct formulas. They are very useful!!” While this student appeared did not reach out to faculty instructors or TAs (this was confirmed by looking at the bipartite network analysis), he make connections to other course resources.

3) *Convenience*: Students often reported using resources that were easiest to access, whether that was a TA, faculty instructor, or the internet. The theme of convenience often emerged when students were explaining why they used a specific TA or faculty instructor as they were completing the assignment. Typically, TAs and faculty instructors were chosen because they were in the same place as the student at

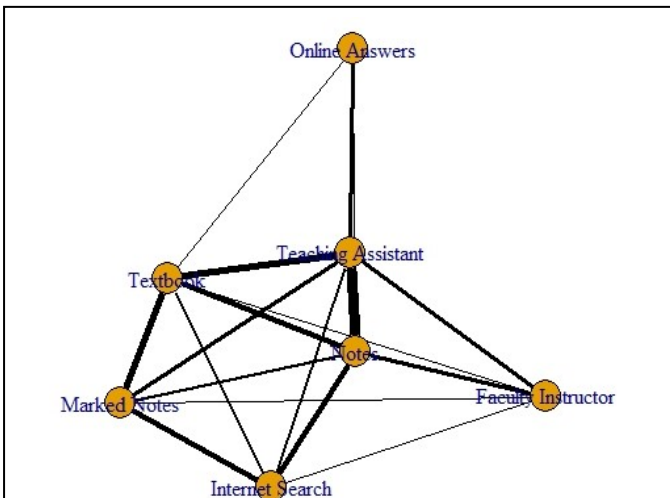


Fig. 2. Weighted edge network of resources used. The weight of the edge indicates the number of students that used the connected resources.

the time the student was working on the PHW. Additionally, some students noted the use of resources based upon what they had with them at the time that they completed the homework, such as a computer or notes from the course.

In some instances, convenience helped students overcome isolation. One student who found the problem very difficult discussed working with his roommate, but “simply because he was present in the room and working on the same assignment as me. If not for the fact that we live together, I would not have sought his or anyone else’s advice on the work I did for this assignment.”

4) *Comfort*: Students tended to use resources, both human and inanimate, that they were comfortable and familiar with. Their level of comfort was often connected to prior interactions with the resource. These feelings of comfort and familiarity often created a sense of trust. One student described this trust while talking about lecture notes, “I have used them previously and I knew they would be helpful.” The idea that a resource could be trusted was a major part in the comfort level of students and their willingness to use the resources.

C. Specific Cases

To begin to understand more about the specific ways students use combinations of resources, we identified specific cases to highlight. These specific cases include Student 38 who did not report using any resources; Student 9 who consults all of the faculty instructors, one TA, the textbook, and their notes; and Student 11 who consults all three faculty members, three TAs, the internet, and their notes.

A closer look at Student 38 reveals that he consults with his peers on homework, stating that he uses the “same people every time”. From the data collected in this study, it is unclear how he uses his peers as resources. The PHW requires students to look up constant values. Since this student does not report using resources other than peers, he is either getting these values from the people he works with or he does not consider the source he pulls constant values from as a resource. In our future work it will be important for us to make this distinction so that we have a more complete view of each students’ resource networks. Student 38 rates the PHW as moderately easy, which may further explain why he did not feel the need to use multiple types of resources.

Student 9 made connections with each of the professors and one of the TAs. In their description of how they used the faculty instructors, they state that they use them for “checking answers” and clarifying the problem statement. This is different from how he uses outside resources, like his textbook or notes, which he uses only as references for constants and base equations.

Student 11 stands out because she consulted three different TAs and all three faculty instructors. From the TAs, she sought to understand “what the question was asking and how to approach it”. Her questions to the faculty instructors were concentrated on “how I should approach it [the homework question], as well as asking how reasonable my answers were.” When asked how she chose her resources she

described, “Whichever TA is available when I am working on the PHW, if none are available I ask a professor, and if none of them are available I use the internet.” While it seems that there is a clear distinction between the types of questions she asks faculty instructors as opposed to the TAs, her open-ended response to the selection process does not show this.

V. LIMITATIONS AND FUTURE WORK

In this study, we wanted students to think about a specific PHW when they responded to the survey questions; however, based on some of the qualitative responses it seems that a subset of the students thought about PHW in general. As a result, they may have reported using more resources because they were thinking across all the PHW they completed during the semester. In future work, we will continue to refine our data collection methods to prompt students to provide information about the resources they used on a single assignment.

Because we wanted to stay open to all possible resources students used to complete their PHW, we had students write in the resources they used. This resulted in some of the responses being ambiguous and difficult to interpret. For example, if a student wrote “notes” it was not always clear if they were referring to notes they took in class or the marked-up notes posted by the instructors. We had two students report using notes and marked-up notes, so we know that for some students these terms had different meanings. In future work, we plan to have students select from a list of possible resources that we generate based on this study.

VI. NEXT STEPS FOR THIS WORK

The goal of the next phase of this work is to gain an understanding of how the resource networks students establish contribute to their grade in the course, on exams, and on homework. As such, we will generate resource networks for each student and analyze them with respect to the grades students earned on the homework, exam, and course. From this analysis, we expect to begin to identify if it is the number of resources or a pattern of resources that correlates to students’ success. Following this analysis, we use a multilayer network to overlay the resource networks with the peer networks students used to complete the assignment. This analysis will allow us to identify connections between resource and peer networks and further explore the correlation between students’ networks and the course performance.

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