Studying the Resource Networks of First-year Engineering Students: Establishing a Data Collection Method

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Abstract:
This work-in-progress paper describes our process for developing a data collection method to study the resource networks students use to complete engineering homework problems through network analysis. Network analysis is the study of connections between objects or people. Networks are composed of nodes and edges, where nodes are objects or people and edges represent the connections between nodes. There have been multiple education studies within and outside of engineering that use network analysis to understand peer connections within a course. However, there are few studies that have applied this method to study how students use resources within a course.

The goal of our larger work is to examine the use of resources by first-year engineering students in order to understand what resources they use, when they use particular resources, and how they use the resources to complete homework assignments. To begin addressing this goal we needed to establish a method to collect data that allows us to create and analyze time-series problem-solving processes. The methods used to collect this data must include survey items which allow researchers to capture the resources students use (e.g. instructors, teaching assistants, peers, class notes, online sources, textbooks, and discussion boards) and the order in which they use these resources.

Introduction
One of the overarching goals of an undergraduate engineering education is to give students the ability to critically analyze and select tools to solve complex problems. We strive to develop students as self-regulated learners who are “metacognitively, motivationally, and behaviorally active participants in their own learning processes” [1]. This awareness includes students’ ability to identify resources to support their learning and solve complex problems. Some engineering programs teach students study strategies, which may include the use of resources; however, often times these lessons are general and students may struggle to translate these lessons into their courses. While there has been some work that investigates students’ ability to use prescribed resources [2], there have been very few studies that have allowed students to self-describe or identify the resources they use without instructor intervention. In order to further develop programs and curriculum that supports students’ use of resources within their courses, it is important that we gain a better understanding of what resources students use, when students use specific resources, and how students use these resources. As such, our research seeks to use social network analysis to explore the combinations of resources that students use to complete classroom homework problems. We are interested in identifying the combinations of resources that students use the most and whether the combinations of resources led to positive grade outcomes for the students. For our work, we are interested in looking at how students use resources beyond their peers, such as textbooks, notes, online information, and instructors.

Within engineering education, there have been a number of studies that use social network analysis (SNA) to study interactions between peers in engineering courses. One study used SNA to understand how diversity among students affects their interactions in a first-year engineering course [4]. Similarly, a group from the University of Washington used social network analysis to study peer interactions of students who were in the same classroom, not including the interactions between students and TAs nor between peers who were in different class periods [3]. To collect this data, both of these studies developed a survey that prompted students to identify who they worked with in and outside of their course section [3], [4]. Another approach that has been used to collect data for SNA, is through
classroom observations. This method was used by a research team at Qassim University to determine the effect of social interactions between individual students, groups, and tutors on student performance (grades) [5]. The results from the Qassim University study found that with high accuracy, they could predict a student’s performance based on the observed interactions of the student. Another form of data collection that does not use the self-report method is through social media. A team from the Federal University of Parana in Brazil used the social networking site, Twitter, to determine users’ opinions on multiple different car manufacturing companies without the use of questionnaires [6]. The researchers collected data in the form of tweets containing language about one of the selected manufacturers and used social network analysis to make networks of positive and negative feedback regarding the cars. This study found that the use of social media in SNA can be beneficial for companies to be able to get customer feedback without sending out questionnaires. A research group from South China Normal University combined multiple sources of data to find the influencing factors in interactions between teachers in a virtual learning community. These data included data from social media and questionnaires, finding value in multiple data sources [7]. We considered the methods used by multiple studies to identify the methods that would be most appropriate for our study.

This paper presents our process to establish the methods to collect data pertinent to identifying 1) what resources students use, 2) how students use those resources, 3) and why students chose to use those specific resources. The following sections will describe the evolution of our process to collect data from the students. In total, we will discuss three versions of the survey.

General Study Approach and Context
This study took place within a first-year engineering course that requires students to complete and submit a written problem associated with the content from each lecture. These problems range in difficulty and require multiple steps. For this work, we identified problems in the course that students typically find challenging because we believed students would be more likely to use resources on these problems.

To collect the data for our network analysis, we decided to use a survey in which the students self-identify the resources they used to complete their assignment. Specific details about the survey can be found in the ‘Development of Our Survey Instrument’ section. Self-report data was selected because of the nature of the context in which we are studying student resource use. Unlike other work that has been done within SNA, for our context, there is not a single location or timeframe in which observations could be conducted to observe students’ behaviors while they complete the assignment.

Fifty-two students elected to participate in our study by completing Version 1 of our survey during the spring 2018 semester. The data about the resources that students used was found to be valuable to the course, so completing the survey was incorporated as part of two paper homework assignments during the spring 2018 semester. The students were not required to have their data included in the research study to get credit for completing the assignment. Eighty-eight students completed Version 2.1 and 93 students completed Version 2.2. An IRB approved process was followed for all data collected.

Development of Survey Instrument
The general format of the survey was created using methods outlined by Pearson et al. [4]. All versions of the survey instrument were created and distributed through Qualtrics.

Survey Version 1
Version 1 of the survey instrument was first created in February 2018. This survey sought to collect information about student resource use as well as peer-to-peer connections. This iteration of the survey served as a pilot to prove that relational network data as well as resource data could be collected in an
effective manner. Within the survey, students were asked whether or not they worked with other students in their section, or outside of their section. Both of these questions were multiple-selection questions with carry-forward logic. If a student selected peers that they worked with, they were taken to a question which asked them to describe how they worked with that student. Next, students were asked if and how they used teaching assistants and course instructors as resources. Students were then asked to select which resources they used from a multiple-selection list with an “other” option that allowed students to write in a response. Options were created by the researchers based upon their perception of available resources for the course. The concluding question asked students to rate the difficulty of the homework and demographic information.

Results from Survey Version 1
This survey instrument was effective in collecting data that allowed us to create both a peer connection network and a weighted edge resource network, shown in Figure 1 and Figure 2. This data was useful in helping us understand what resources students use.

There were gaps in the qualitative data collected that limited our ability to address when and how students used specific resources. Our goal was to collect data about the specific processes and resources students used on a single homework assignment, but some students reported their generalized process. Additionally, there was a lack of detail in students’ responses, which may have been because the questions about resource use were at the end of the survey. As such, we moved this question in the next iteration.

Survey Version 2.1
Version 2.1 of the survey was used in September 2018 in a first-semester, first-year exploratory engineering course. This survey instrument was very similar to the first version of the survey with a few structural changes. For example, questions about resource use, shown in Figure 3, were moved to the beginning of the survey. In addition, other resource options that students reported in the “Other” section of the Version 1 Survey were added as selection boxes in this version. Following the multiple-selection question about resources utilized, students were then asked to describe the process while considering resources they used to complete the PHW assignment. Following these questions, students were again asked to identify peers, teaching assistants, and instructors that they worked with.

Results from Survey Version 2.1
Survey Instrument Success: Version 2.1 of the survey provided greater insight into student resource use and their perception of resources compared to Version 1. This additional insight was gained through the open-ended question about the students’ resource selection and problem-solving process. For example, if a student used a resource more than once in their process, or used a resource in different ways, the question of describing their process was extremely useful. With regards to teaching assistants, some of the insight that we gained were why the students trusted TAs, “I also listened closely to the TAs advice...”

Figure 1: Basic Peer Network showing connections between students created using data from survey Version 1.

Figure 2: Weighted Edge Network showing combinations of resources from data collected in survey Version 1.
because they have been through the class before”, as well as different ways they use TAs within the same process, “After that, I asked a TA a question about the way I was labeling my coordinate system. ... I may also ask a TA to see if my first justification is logical for this problem.” One student, who had only used one of the resources available through the course identified flaws in their current problem-solving process through the reflective portion of the survey, “I waited way too long to get started, and adapted the basic kinematic equations into vertical and horizontal motion as taught in class”.

In general, students’ responses focused on the specific homework assigned rather than homework problems for the course as a whole. Only 10% of the participants used generalized language in their process description (i.e. generally, typically, usually, I always…, etc). One example of a generalized response was, “PHW 1.7 did not require any outside resources for my work. Typically, I will use googled information and ask my peers questions, but for PHW 1.7, I only used prior knowledge”.

Survey Instrument Improvements: One of the issues that we found in this survey was that students typically selected more items in the multiple-selection question than they addressed in the open-ended portion of the survey. Only 45% of the participants mentioned all of the resources they selected in the multiple-selection resource question in their problem-solving process description. This is a knowledge gap, as we do not know how students are using resources selected and to what capacity. While the lack of description for some students was problematic, we did find that some students provided very strong time-sequenced data in their problem-solving process description. One student even went so far as to order the steps in their process without being prompted to do so:

“1. I began working on the homework with a couple of friends in EF 157 who were also in the process of completing the assignment, mainly receiving help with part A, finding the time
2. We compared our answers several times throughout, as well as the process by which we got them, in order to ensure that they were at least the correct method.
3. When I needed a formula, I consulted my class notes to find the correct one.
4. I ended up leaving the group before finishing my homework, and I used the internet and Canvas notes to answer the couple of questions that arose while I was finishing the assignment.”

The level of detail provided by this participant was extremely valuable and is something we hoped to be able to capture from all of our participants in the next iteration of the survey.

Implications for Practice: In addition, a practical application to Version 2.1 was added to the course as students were shown the weighted edge resource network, displayed in Figure 4, to help them recognize potential resources they had not identified before. Students were encouraged to use resources that were determined in Version 2.1 to be underutilized - including TAs and instructors.
**Survey Version 2.2**

Version 2.2 of the Survey was used in November 2018 in the same course as Version 2.1, but later in the semester, using a different homework assignment. The overall format from Version 2.1 of the survey was maintained. One of the most meaningful changes in the survey was adding a back-button. It came to our attention that this had not been available in prior iterations when a student typed “I didn't work with him, I accidentally hit the wrong button on this survey” in the description of how they worked with an instructor. The addition of the back-button allowed students to change their response if they forgot an item or realized that they had made an incorrect selection.

Version 2.1 did not give the desired time-sequence data because the open-ended response question asking about the student’s process was not structured enough so that the student would respond with a time-ordered description of his/her process. Therefore, instead of having a multiple-selection question and then an open-ended description of the student’s process, logic was used to carry-forward selections from the previous page, Figure 5. These selections then filled in a column of a matrix shown in Figure 6 where students were asked to rank the order in which they used resources (with 1 signifying the first resource used) and describe how they used the resource in their problem-solving process.

We hoped that the addition of this new question presentation would provide better insight into resource use, as all resources selected in the multiple-selection portion of the survey would require a description (unlike Version 2.1). We also asked students to identify any barriers to resource use, to better understand why some students may not be using resources available to them.

**Results from Survey Version 2.2**

In order to begin analysis of this version of the survey, 20 students were randomly selected from the survey participants. Overall, we have found that this survey led to better depth of responses than Version 2.1 of the survey. While students wrote very little about each resource, greater detail was provided about the process as a whole -- as the description for each resource selected in the multiple-selection required a description through force validation in this survey. This led to students describing...
how they used each resource in their survey, as well as when they used the resource, with less effort, which can be seen in Table 1.

Table 1: Summary of two students’ responses from Survey Version 2.2

<table>
<thead>
<tr>
<th>Student</th>
<th>Rank Order of Resources</th>
<th>Description of How Resources Were Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>1. Classmates 2. Internet to “Google” Information 3. Notes Posted to CANVAS 4. Notes from Class 5. Textbook 6. Screen Capture Video 7. Online Homework Answers</td>
<td>1. We collaborate on the correct method to use to solve the problem and whether or not the answer is reasonable. 2. I use this to find real life comparisons for answers for my justifications. 3. When I remember solving a similar problem in class, I will check my work with the notes as I go to make sure I do it correctly. 4. I use my notes to find any equations I might need. 5. If I cannot find a certain equation that I think I need, I sometimes use the book to find those equations. 6. The screen capture videos are helpful for me every once in a while because the problems that are solved are very similar to the PHW. 7. If I have exhausted all of the previous options and am still stuck, I will ask one of my TAs for further help.</td>
</tr>
<tr>
<td>86</td>
<td>1. Classmates 2. Notes from Class 3. Internet to “Google” Information 4. Notes from CANVAS</td>
<td>1. We worked collaboratively, and if someone got stuck, the other would describe how to solve the issue. (ie. “How did you find the normal force?” “Sum of forces”) 2. rereading notes, equations, and applicable examples where needed 3. mostly for conversions or clarification of a topic 4. rereading equations [sic]</td>
</tr>
</tbody>
</table>

Of the students who completed the survey we found that 16% of the students listed their classmates as the first resource they use when solving the specific homework assignment. 34% of the participants in the study selected “Notes from CANVAS” as the first resource that they utilize. Through this survey, we are able to make statements like this and track the process that students walk through while completing assignments. This survey allowed us to sort the responses by the order in which students used resources, which is extremely useful in analysis, as well as future applications of the data. Our hypothesis is that the current structure is more guided than simply asking students about their problem-solving process. This structure requires less reflection on their own problem-solving process, but still provides us with meaningful data. Cyclical resource use (using a resource early in the process and returning in it) was lost in this iteration of the survey.

Future Work

In the future, we plan to continue analyzing the qualitative data from the Survey Instrument Version 2.2 to learn about possible differences in the data we collected. We also plan to add grade correlations to the specific responses on the Version 2.2 Survey Instrument to identify the resource networks and combinations that proved to be the most productive for the students in the course. Through this analysis we will be able to identify trends in how students are using resources so that we can make better recommendations to future students. In addition, the concerns about barriers to resources, or resources that students would like to become available can be turned into practical solutions in the classroom. In addition to the things that can be learned from the qualitative data contained in this survey, we hope to construct both peer networks and resource networks based on the data using concepts from social network analysis.
References:


