Promoting Student Support in an Online Fundamental of Electronics Course

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Abstract—Contribution: This article discusses instructor decisions that support social capital development in an online, asynchronous, team-based introduction to electrical engineering course.

Background: Online learning is changing how instructors and students interact with each other and course materials. There is a need to understand how to support students’ social capital development during online engineering courses.

Research Questions: What aspects of an online, asynchronous, team-based, introductory electrical engineering course gave students instrumental and expressive social capital? What decisions did the instructor make to support the development of strong and weak social ties?

Methodology: A case study approach was used to analyze interview data from the students, instructor, and graduate teaching assistant (TA) from an online course.

Findings: The results indicate effective lecture delivery and a team-based format can provide students with instrumental social supports they need to meet learning objectives in an online asynchronous, introduction to electrical engineering course. To facilitate the development of expressive support and stronger ties, instructors should incorporate these goals in their course design decisions.

Index Terms—Asynchronous, case study, introductory electrical engineering, online learning, social capital theory, team based.

I. INTRODUCTION

A. Online Learning

OVER the last several years, there have been many initiatives to increase online learning opportunities within engineering programs. While the COVID-19 pandemic and associated shift to emergency remote teaching has caused a heightened sense of urgency, online learning is not new to engineering higher education [1]. A study found that in 2002, of the 994 schools surveyed, two-thirds indicated that online learning was a part of their long-term strategic plan [2].

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By 2014, 28% of undergraduate students had taken at least one course online [3]. In 2012, the National Academy of Engineering, at a forum to discuss educating the engineers of the 21st century, concluded that online learning “changes the game” in engineering education, and faculty will remain essential throughout transition [4].

Despite online learning’s growing prevalence in engineering courses, there is much still to be understood about what type of design and delivery methods works well for specific engineering content and course purposes. Most studies that have focused on students’ engagement take a perspective of learning with a community of inquiry [5]–[7], rather than focusing on the resources and supports the course relationships provide. The research on building supports in online engineering courses is especially rare. The purpose of this study is to investigate ways to support students during online engineering courses through the development of social capital, which is described in the theoretical framework.

B. Social Supports

Students need social support to succeed and persist, both in person and online, and these social supports need to be specifically designed into the courses they take. However, social supports are different to develop online because students are often physically far apart from their classmates and instructors, and working more independently than during in-person courses, leading to feeling of isolation and low levels of support [8]. Social presence is especially important in online environments, where effective social interaction is a key indicator of student outcomes [9], pointing to the need for students to establish meaningful connections with others during online courses. Building community and social supports in online courses can help students feel more connected to others in the course as well as be more connected to the course learning. Students value activities designed to promote social interactions on online asynchronous team-based courses [10]. This suggests the integration of team-based learning in asynchronous online courses presents opportunities to cultivate students’ engagement and learning. Likewise, research shows mechanisms that promote interactions with fellow students in informal ways, such as online coffee hours and discussion forums [11], as well as in required team work [12] help students connect and develop relationships. When instructors intentionally designed their courses to promote social interactions: 1) students acknowledge those activities helped
them to develop a better teamwork and that they feel more connected with their classmates and instructors [13]; 2) students describe the course environment as more welcoming than the environment of other face-to-face courses [14]; and 3) students report feeling more connected with their instructors and peers [15].

C. Social Capital Theory

This study utilizes the social network theory of social capital to examine interactions and relationships within the classroom [16]–[18]. This sociological lens has been used in engineering education research to characterize student persistence in their engineering major [19]–[21]. Social capital has also been used to explain student development of professional identity in an online context [22]. Social capital theory considers the resources and information gained from social relationships, suggesting that these relationships provide two types of supports: 1) expressive and 2) instrumental. Instrumental social capital is linked to tangible resources and support that directly help an individual achieve a goal [17]. For engineering students, instrumental supports may take the form of a classmate providing help on a homework assignment or a professor connecting a student to a job opportunity [20]. Expressive social capital, on the other hand, provides support relating to an individual’s overall emotional, physical, and mental well being [17]. For engineering students, this may take the form of a family members encouraging a student to persist during a challenging time, or professor normalizing a student’s difficulties in the curriculum by sharing their own past struggles [20].

Expressive social capital generally derives from frequent, intimate relationships, characterized by informal interactions with close friends and family; these interactions are known as “strong ties” [23]. “Weak ties” on the other hand describe relationships that are less intimate and a characterized by more infrequent contact [23]. Weak ties are important sources of new information and resources that may not currently exist in an individual’s immediate social network [17], [23]. Weak ties can be particularly useful because they are frequently sources of instrumental support [17], [23]. This sociological lens is used to characterize the features of an online asynchronous engineering course that provides resources and information through social relationships.

D. Research Overview

This study examines course design decisions undertaken to provide social support in an online asynchronous engineering course. A case study of an electrical engineering course is examined in which the instructor and students faced many challenges in developing relationships: the course was conducted completely asynchronously online; it was a fast-paced, summer course; students were often in different time zones or in uncertain living situations due to the COVID-19 pandemic; and the curriculum is typically viewed by students as very challenging. Research on similar courses in normal times have shown high failure rates [24]. Social capital framework [17] is used to examine how the instructor supported student learning through fostering social capital. The following research questions are addressed.

What aspects of an online, asynchronous, team-based, introductory electrical engineering course provided students with instrumental and expressive social capital?

What instructional decisions support the development of strong and weak social ties in such a course?

II. METHODS

A. Case Description

The course is an introductory electrical engineering course that enrolled electrical, mechanical, industrial, and nuclear engineering students in the Summer 2020 semester. The learning objectives are focused on fundamental circuits analysis. The instructor has many years of teaching this course in person. He was prepared to teach the course virtually prior to the university shifting online during the pandemic and therefore, had course materials prepared before the pandemic. The instructor has been involved in his institution’s migration of an increasing number of courses online and has sought to incorporate educational research-based insights into his approach by collaborating with a variety of experts in education and electrical engineering.

The instructor prerecorded lectures that were available online for the students to listen to on their own time, and the teaching assistant (TA) held weekly synchronous recitation sessions. Additionally, there was an online course discussion board to which students could post questions. The professor and TA distributed the load of answering these questions. Students were assigned to groups of four to five students based on their availability for common work times. These groups formed teams that met frequently throughout the term (at least once a week) to work on homework assignments and submitted them together, receiving a single grade as a team. For quizzes and exams, grades were based on an individual submission and a team submission. For quizzes, students took a timed quiz individually and then directly afterward assembled with their teams to take a different quiz on the same material and submitted a group response. For exams, a similar procedure was followed with more time in between except that the exam the team worked on together was the same as the one they had taken individually. The instructor had twofold intentions with this format; first that the students would be required to get together with peers to discuss the course content and learn from each other, and second, so that they could collaborate with others to improve their grades without “cheating.”

B. Data Collection and Analysis

A case study approach was used to examine an introductory electrical engineering course taught online during a summer term [25]. Data were collected from six different sources. Three were from students, an: 1) undergraduate student support (USS) survey; 2) student open-ended survey responses; and 3) student interviews. Data sources also included: 4) instructor interviews; 5) TA interview; and 6) course documents such as the course syllabus. Seventy-nine students
completed the USS survey and open-ended survey responses and eight students were interviewed.

The USS includes a sociological “name generator” that prompts participants to list the names of specific individuals who provided support for the course, and then provide some information about each person listed [20]. Students’ individual USS responses (data source 1) were directly used to generate a tailored interview guide for each interview participant, a technique that has been previously used in engineering education to characterize students’ social capital [19]. During the interviews, each participant was asked to provide details about the ways in interactions with the named individuals served as sources of support for the course [20]. Follow up questions from each participant’s data from the open-ended portion of the survey (data source 2) were also asked during the interviews, which prompted participations to give additional detailed responses (comprising data source 3). In this way, the two sources of survey data were triangulated with interview data and thus, the findings presented here along with direct quotes from the interviews are connected to the survey data.

Interview data analysis followed qualitative content analysis procedures [26], [27]. The analysis focused on the interactions that participants had described as providing support, and given the research questions, focused on participants’ interactions with classmates, the instructor, and the TA. First, all student interviews were transcribed and all examples of students’ descriptions of how course interactions provided them with social capital were identified. These interactions were categorized into two main themes: 1) support from the instructor (in the forms of lectures and the course discussion board) and 2) support peers (through the student teams). These themes represented the primary ways in which students received support during the asynchronous course. Specific examples of each theme were then coded based on the social capital theory; specifically, each example was identified as providing either instrumental or expressive support. The coded results were triangulated by other the data sources. That is to say, the instructor and TA interviews (data sources 4 and 5) were coded for all quotes related to course supports and the instructor and TA perspectives were compared with the student interview data (data source 3). Then, the selected quotes from the instructor, TA, and student interviews were compared to relate the instructional decisions and instructor/TA perspective to the students’ experiences. Throughout this process, the research team circled back to the syllabus and other course documents (data source 6) when needed to clarify or triangulate details, such as timelines and assignment names. The following section describes the results of this process.

The demographics of both the survey and interview participants were representative of the university as a whole and a range of final grades in the course. Of the students interviewed, two were majoring in mechanical engineering majors, one in nuclear engineering, one in industrial engineering, and four in computer engineering.

III. RESULTS

This section addresses the first research question by describing what aspects of the course help students develop instrumental and expressive social capital using quotes from the students and instructor. It also addresses the second research question by describing the decisions the instructor made to support the development of social ties. Overall, results show that students built social capital through weak ties, which consisted of infrequent, less intimate interactions with other members of the course that provided primarily instrumental support needed to achieve the learning objectives of the course. There were also examples of expressive support that significantly added to the students’ experiences beyond the immediate learning objectives of the course and gave insights into ways in which online courses can provide students with support to build social capital in asynchronous, online courses.

A. Support From Instructor

The instructor made intentional decisions to provide instrumental support to the students. For example, he described approaching the lectures with the following mindset.

I had in mind FAQs [frequently asked questions] that come from the students in a live lecture, and so, a lot of times I would ask the same question to myself while I was recording the video and say things like, you may be wondering about A or B, or oftentimes, students get confused between this topic and this topic. There were other times when I would say, “you may be thinking this question right now, but it will be answered in a future video.” I really think it was about [my substantial teaching] experience and paying attention to the students when I had the opportunity to teach live.

The instructor used his prior experience teaching the course to create lecture videos that would provide students with instrumental support. He also participated along with the TA in providing the students instrumental support through the course online question board where students could pose content questions and receive answers.

Students’ interviews and other data indicate that the instructor was successful in providing them sufficient instrumental support. Every single student interviewed described the effectiveness of the recorded lectures. For example, a student stated that “[the instructor] helped me a lot because those videos taught me everything about the course and that was like the heart of the course.” Another said the following:

He was very clear, easy to follow... He would go through and solve the circuit with us, which I thought was very helpful. Like, whenever I’d have a question, he would just answer it later in the video... Yeah, very clear, very to the point. [He] told us what we needed to know and I liked how he talked about [real-world] application [of the subject matter].

This student did not feel the need to ask follow-up questions because they were answered in the videos.

Some students noted that they would have had opportunities to build stronger ties with their instructor in an in-person course. For example, a student stated the following.

[My relationship with the professor] was much different [online than it would have been in person]. For example, if [the class] was in person, then
maybe if I had a question about something and instead of asking my groupmates, I would raise my hand and ask in lecture. And maybe over time he’d actually kind of know me as somebody who was asking questions.

In this example, the students expressed the hope of being known as an engaged student who asks questions, and the missed opportunity to build that connection with the instructor during the asynchronous lectures.

B. Support From Teams/Peers

The instructor anticipated that supporting ties that would provide both instrumental and expressive support during an online class would be difficult and that the upheaval caused by COVID-19 would compound the problem. The team approach was designed to address this both by helping the students to build community around the material through instrumental supports and by providing expressive supports. He explained how he designed this, along with his collaborations with colleagues as follows.

I would say the priority was [fostering connection among teams] around the course content. We didn’t design anything that was outside of this—at least, it was not intentional design. But we were anticipating that once [the student teams] get together on a weekly basis to talk about the assignments and the homework, we were hoping that they will not just talk about the assignment, [and that those meetings would] be an opportunity to socialize and perhaps even connect with other human beings.

The instructor understood the value of expressive support and hoped that the teams would foster that.

Students’ comments suggest that the team approach provided both instrumental and expressive supports, just as the instructor had intended. For example, a student said in an interview, “I loved interacting with other students and my team during this class. I feel like it helped so much in understanding concepts and seeing them from another point of view.”

Another student said the following.

[My teammate] was even someone I talked to afterward, and maybe he was like probably my closest friend in the class… We just kind of talked about other things, like going back to campus, about other scheduling things, about classes… He was also nice to be with.

This development of expressive support was relatively rare; it was more common not to develop strong ties. A student said the following.

[Working with my team] was purely just doing the work. I didn’t really have a relationship. I didn’t have any kind of friendship or anything with them. It was simply, you know, Let’s finish this… I honestly do not remember their names.

This kind of experience was more common. In such cases, the team approach provided instrumental support but not expressive support.

Without strong ties, students do not feel as accountable to others involved in the course as they might otherwise. For example, a student said that the online format inevitably created a reduced feeling of accountability… “Because I did not really meet with my other classmates for homework, [team work time] was more focused toward the group quizzes and the work that we would be doing as a group.”

This student reflects on the difference in accountability because the team only meet for group quizzes and did not interact on any other aspects of the course, such as doing homework or attending lectures together. While the teams in this course provided strong instrumental support, not all of the students developed the strong ties with their teammates necessary for expressive support in this online environment.

IV. DISCUSSION

The results show that students developed weak ties that provided instrumental support [17] through prerecorded videos, the course discussion board, and teamwork. The types of support are outlined in Table I.

A few students received expressive support from teams as well. This article adds to our understanding of how students recognize interactions within an asynchronous online course looking for social support [10] and point to effective ways to implement instructional decisions that lead to opportunities to build social capital in engineering courses. These observations contribute to the research body illustrating what kind of activities and settings an online asynchronous course can implement to give its students opportunities regarding the social support they need. This research also reveals the need for more tools to provide expressive support within an online course.

Intentional instructional decisions contributed to students’ receipt of instrumental support. For example, the instructor created engaging, informative lecture videos, in line with best practices found in other research, such as a focus on demonstration style and incorporating applications into lectures [28]. He also sought to provide students with other avenues for instrumental support. These decisions included developing the course discussion board and providing students with teams to work with on homework and quizzes. Although the teams varied in their success in providing students with support, the
nature of the teams, specifically having required team assignments that necessitated students working together at least once a week, provided some instrumental support for students.

Expressive supports do not simply happen in an online, asynchronous course; they need to be purposefully planned. In this case study, few students described experiencing expressive supports. Most got the help they needed to solve homework problems from their teammates but did not feel any connection to them. This suggests the need for new strategies. Research on in-person teaching that have potential to be adopted in the online format suggests that, for example, the instructor expressing pride and confidence that students can succeed, encouraging good health and habits, and helping students understand engineering culture and their place within it might provide the expressive supports the instructor hoped to provide [29], [30].

As online learning continues to grow, it is important that instructors explore how to promote expressive supports in such courses. This expressive support through strong ties would have been especially useful during the COVID-19 pandemic, when students are experiencing increased stress and anxiety [31], because expressive supports through strong ties provide necessary resources for emotional and mental wellbeing. Going forward, as higher education begins to understand the new normal after the COVID-19 pandemic and as online learning continues to “change the game” [4], the need to promote social capital in online courses will persist.

V. LIMITATIONS

This study focused on how the design and delivery of an online engineering course influenced students’ experiences and their reflections on their learning. The study did not include student performance on assessment, a limitation future work might address. However, when redesigning a course, student experience and their reflections of learning are crucial to understanding to better support learning.

VI. CONCLUSION AND IMPLICATIONS

In an online, asynchronous, introduction to electronics course, the instructor sought to provide students with avenues for instrumental support. The findings demonstrate that an online, asynchronous, team-based course can provide opportunities for students to build social capital, but that most of the result will be instrumental support and expressive support is unusual. Students’ comments suggest that the recorded lectures and other resources were an effective way of delivering the course content. They also suggest that the instructor’s and TA’s availability to help them with questions in a timely way through the course question board were extremely useful. Students also gained instrumental support from team building. Those who gained expressive social support had a supportive team interested in their own learning. These examples suggest that explicit instructor decisions and planning to promote such support might be successful in the future.

The study findings suggest that both instrumental and expressive social capital can be developed in an online, asynchronous, electrical engineering course that supported students to be successful and have positive experiences in a traditionally very difficult course. As online course delivery continues to expand, instructors should make decisions to explicitly plan in opportunities for students to develop social capital in technical engineering courses. The structure and format of this course provides a model for future courses to build on to improve how students are supported and develop social capital in online courses. Instructors should aim to develop new ways to support students’ development of strong ties that will help hold them accountable for high-quality work in online courses and research should investigate the results of their efforts.

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