Can discussion boards disrupt gendered and racialized discussion patterns in math classes?

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Social Network Analysis is a method to analyze individuals' social accessibility and power. We adapt it to change inequitable issues in STEM postsecondary education. Equity issues in mathematics education, such as underrepresented women and racial disparities, are prevalent. With the social capital perspective, we investigate the demographic characteristics of influential students and their social networks. Seventeen participants are undergraduate students in an inquiry-oriented linear algebra course. The number of nominations on discussion boards as "Shout-out" is data to measure influence and map the social network. By analyzing data with UCINET, we found that (1) the most influential students are non-White males and the principal components of the network are male-dominant, and (2) there is a female-dominant small cluster and female students have reciprocal networks. This study suggests further discussions of (1) how discussion boards position students with the social capital perspective and (2) intersectionality, especially for women of color.

Keywords: Social Network Analysis, Equity, Classroom Discussions, Discussion Boards, Linear Algebra

Introduction

Social Network Analysis (SNA) connotates analysis with the perspective that "individuals are tied to one another by invisible bonds which are knitted together in a criss-cross mesh of connections" (Scott, 1988, p. 109). Also, SNA has been used in various areas such as social mobility, corporate power, and class structure (Scott, 1988). Henderson et al. (2018) suggested using SNA for "change" Science, Technology, Engineering, and Mathematics (STEM) fields in higher education. Specifically, Henderson et al. (2018) argue to improve the dearth of historically underrepresented groups in STEM by using SNA. As a tool and theory, SNA can facilitate uncovering social structure, analyzing engagement of targeted participants, and supporting quality teaching with postsecondary education reform efforts. Thus, we speculate to examine a link from SNA to ways of analyzing student interactions in classrooms and considering issues of equity. On the other hand, Linear Algebra is one of the most important and core courses for STEM undergraduate students. Thus, our assumption is that students' (in)equitable experiences especially regarding race and gender in a linear algebra class are associated with persistence and/or academic achievement. This study aims to answer the following research question: What are the characteristics of influential students, as identified by student nominations, in discussion board posts—with regard to demographic characteristics, especially race and gender in a linear algebra class?

Literature Review

In mathematics education, "equity issues" are a hot topic (Gutiérrez, 2009), especially in terms of race and gender. According to Borum and Walker (2012), "Mathematics is historically a White male-dominated field, so the norms or standards created to center on the ideologies of that specific group" (p. 374). Also, undergraduate mathematics classes are gendered and racialized spaces in general (Leyva et al., 2021).

Women are underrepresented in STEM (Ceci & Williams, 2007; Hill et al., 2010) and it has been an issue especially in higher education (Ong et al., 2011). Around 50% of the U.S. Bachelor's degrees and Master's degrees in mathematics were earned by women in 2014, but only 28.9% of the population of the U.S. doctorate degrees are women (National Science Foundation, 2017). Women keep disappeared through the higher level of education, and this implies that women in mathematics have intensively and gradually underrepresented experiences. This is explained by the phrase 'a leaky pipeline', which refers to "the loss of capable women from more senior roles in STEM disciplines" (Resmini, 2016, p.3533). Also, STEM fields have "chilly" social climates for female students, which means unwelcoming and hostile to women (Ferreira, 2002). Still, sexism in STEM majors exists, and it can be either explicit and flagrant but also implicit and subtle (Ernest et al., 2019). In particular, it has been documented that women sometimes speak less, especially in a public place in inquiry-oriented and/or discussion-based mathematics classes (Leyva et al., 2021).

Furthermore, in terms of race, mathematics is White and Asian dominant. Also, historically STEM is the white-dominant field, so racial disparity is also a crucial challenge (Lee et al., 2020A). As compared to white male students, the women and/or non-white students leave more from STEM majors (Kokkelenberga & Sinha, 2010). Plus, the hierarchical shapes by stereotypes of Black and Latin college students in STEM are perceived to have a lack of innate ability in their major (McGee, 2016). Racial stereotypes are prevalent in mathematics and these stereotypes cause Black undergraduate students in mathematics not persistent by facing lower academic expectations, limited opportunities to engage, and lacked encouragement in STEM fields (McGee & Martin, 2011). Similar to sexism in STEM, racism, particularly racial microaggression is an influential factor in the underrepresentation of college students of color in STEM (Lee et al., 2020B).

On the other hand, we adapted the social capital perspective to examine student ties and influence in the linear algebra class with consideration of possible equity issues in terms of race and gender. The social capital theory refers to inform the value of social connections in "families, youth behavior problems, schooling and education, public health, community life, democracy and governance, economic development, and general problems of collective action" (Adler & Kwon, 2002, p. 17). The social capital theory also views social ties "as avenues through which resources of many different kinds are shared and accessed" (Henderson et al., 2018, p. 4). Between actors, ties provide access to ideas, power, and resources. Thus, actors can look for strategies to be accessible to the new resources and/or power (Henderson et al., 2018). In the linear algebra class, the actors are students, and we assume that the actors will build up ties as their strategical access to other actors as resources. If a student is traditionally privileged or dominant in mathematics, then they may be more accessible, which means they may achieve more strengthened networks.

Study Context, Data Sources, and Methods of Analysis

While the benefits of active approaches to learning are well established (Freeman et al., 2014), the way in which these approaches can be implemented to consistently support different minoritized populations of students remains an open question (Theobald et al., 2020). One particular form of active learning that is popular in undergraduate mathematics is inquiry-based or inquiry-oriented instructional approaches. Such approaches feature student inquiry into mathematics through collaborative problem-solving (see e.g. Laursen & Rasmussen, 2019). However, there is evidence that in some inquiry-based settings students' experiences and learning systematically vary by gender (Laursen et al., 2014; Johnson et al., 2020; Ernest et al., 2019), and we believe that similar variation may exist based on race.

This study was conducted as a part of a broader project aimed at developing curricular materials for inquiry-oriented linear algebra. The linear algebra class was taught in the 2020 Fall semester, as an online-formatted course due to the COVID pandemic, and the application for the synchronous online-formatted classes was Zoom. When students had group activities, they went to the breakout rooms on Zoom so that they discuss. Participants of this research are undergraduate students who took the course "Applied Linear Algebra 1" at a public university in the southern United States. Thirty-six students enrolled in the course, and 17 students consented to use their data. Four of the participants who consented are female, and the other 13 participants are male. More than half of the participants (10 students) are White, including all four female students. Thus, seven non-White participants are all male.

The main data source is discussion boards on Canvas. The discussion boards were assigned biweekly, involved posting an individual write-up to problems they had worked on in groups during previous classes. Particularly, one of the reflection questions includes making a "Shout-out" that aims to celebrate the good ideas and successes of one another. The shout-out does not necessarily have to mention another student in the class, but it can include former teachers or helpful materials in the class. We counted the number of nominations for shout-out of a total of three discussion boards, whose scope was a single unit of instruction. On these "Shout-out" posts, a student can shout out to multiple students. Then, we used UCINET (Borgatti et al., 2002), which is an application to analyze and map networks, to visualize the social network in Linear Algebra class.

Findings

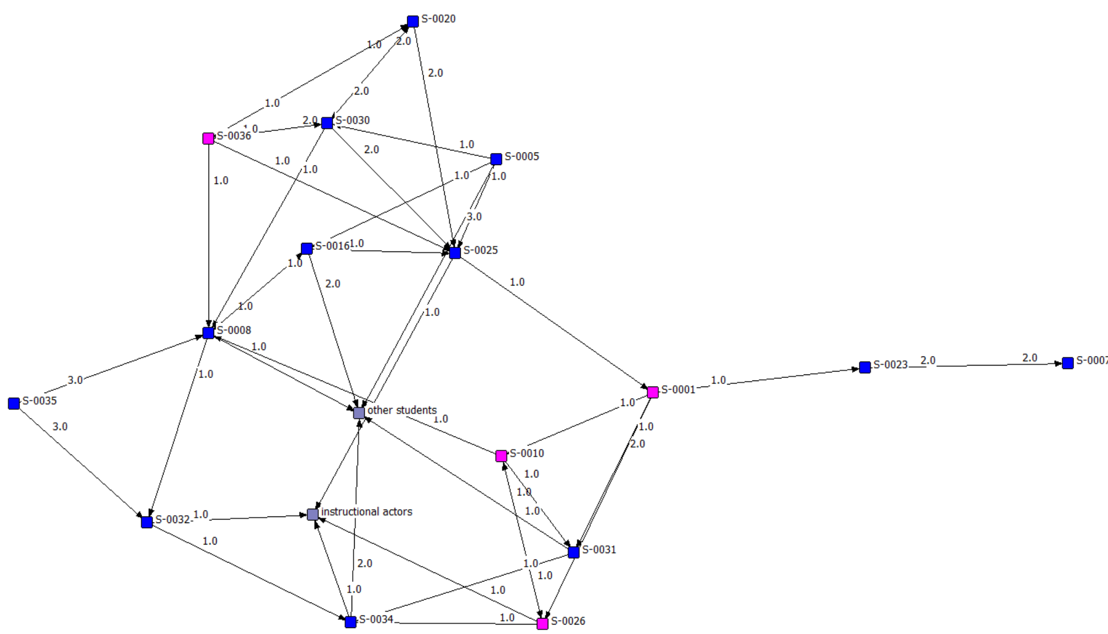

Figure 1. *Social Network in Applied Linear Algebra 1 Class*

Note. Blue dots and pink dots represent male and female students, respectively. Other students are students who did not consent to use their data, and instructional actors mean outer actors such as asynchronous video or a student's former instructor.

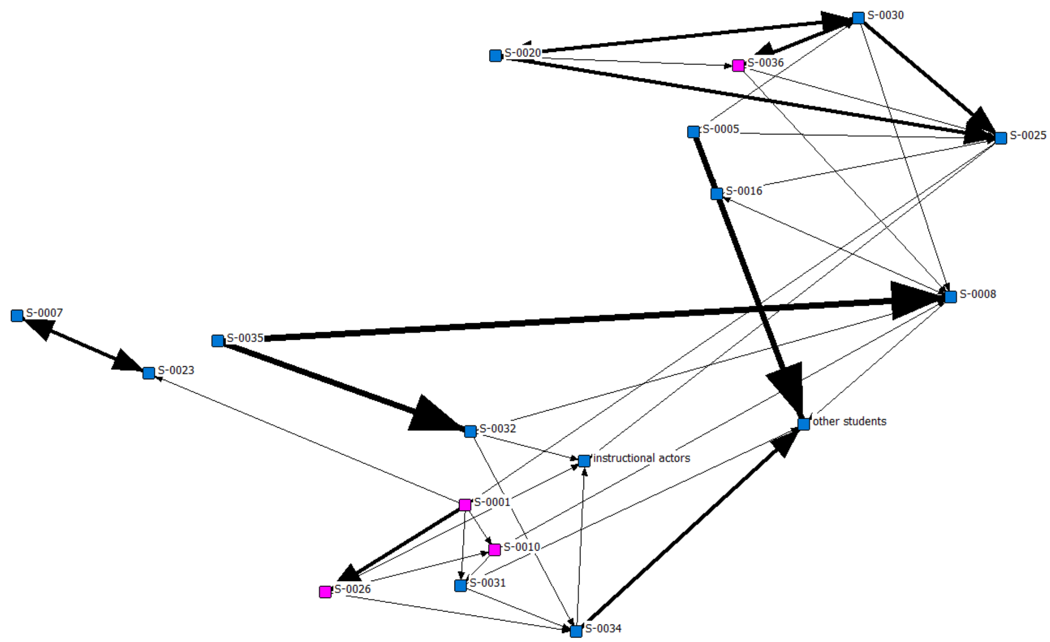

Figure 2. *Principal Components of the Social Network in Applied Linear Algebra 1 Class*

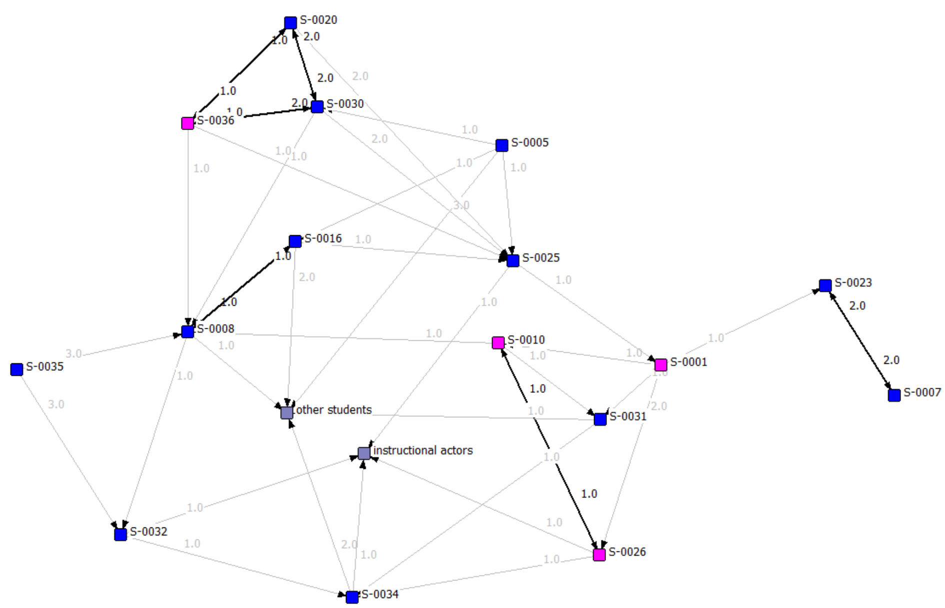

Figure 3. *The Reciprocal Network in the Applied Linear Algebra 1 Class*

Among students, two students were nominated most, S-0008 and S-0025 (See Figure 1). Two students were nominated a total of 8 times out of 37 through three discussion boards, including one time of self-nomination by S-0025. To discuss demographic information of two students, (1) two students are both male and (2) they are non-white students. Specifically, S-0008 is Hispanic who came from a South American country and S-0025 is Black. This racial information is reversed to that of traditionally dominant in mathematics–White and Asian. Also, the principal components (See Figure 2), which show the largest number of nominations, mainly involve nominations of male students including the two most influential students.

Besides, in the social network, we see a small female-dominant cluster among females S-0001, S-0010, S-0026, and one male S-0031 (See Figure 1). As we already discussed, the mainstream was flowing through the male-dominant networks. Though this small female cluster is less principal than male-dominant nominations, they shout out to each other and build up their network. Particularly, S-0001 shout out to S-0010 once and S-0026 twice, and S-0010 and S-0026 shout out to each other once. We could not document how race affects female students because all female students who consented to participate are White.

Overall, the nominations were one-way, rather than reciprocal. Figure 3 shows the reciprocal network and the number of reciprocal ties 6 among the total of 37 ties of the social network. One interesting point from the reciprocal network is that three female students out of four were involved in the reciprocal network. The reciprocal ties connect either male students—A female student S-0036 is connected to two male students S-0020 and S-0030 as reciprocal ties, or another female student—S-0010 and S-0026 nominated each other at separate discussion boards.

Discussion

In this class, it seems racial issues among male students may not be a big deal. This is because the most nominated students have racial diversity—Latino and Black, compared to the traditionally dominant group—White and Asian. However, we think that gendered issues can be discussed more because (1) according to the number of nominations, female students may be less influential in the whole class, and (2) female students have a lack of racial diversity since all female participants are White. However, (1) the small female group implies that "Women Helping Women" and (2) the nominations are more reciprocal than male students so it may be interpreted that female students would attempt to "reciprocate" rather than to "receive".

We speculate that discussion boards may function as a way to interrupt some of the ways in which discussions are gendered and raced, as the mathematical content of posts/contributions is foregrounded since everyone has equal space to contribute, and there may be social positioning that precedes the post when everyone is expected to post and there may be less social positioning that precedes an online post when everyone is expected to post, as compared to speaking during a whole-class discussion. However, still, the finding may indicate less racial diversity among female students than one of the male students, and even female students of color in the course did not consent to use their data for research. This reminds us of the potential discussion of "intersectionality", which means an individual's experience of discrimination or privilege is explained by the intersection of an individual's various identities such as race, gender, class, sexual orientation, and others (Crenshaw, 1989; Coaston, 2019). Our future work can be relevant to the evidence of the following question with the intersectionality perspective: Can the discussion boards reorganize access to social capital in a math class?

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