

A Social Network Analysis of Online Engagement for College Students Traditionally Underrepresented in STEM

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Little is known about the online learning behaviors of students traditionally underrepresented in STEM fields (i.e., UR-STEM students), as well as how those behaviors impact important learning outcomes. The present study examined the relationship between online discussion forum engagement and success for UR-STEM and non-UR-STEM students, using the Community of Inquiry (CoI) model as our theoretical framework. Social network analysis and nested regression models were used to explore how three different measures of forum engagement—1) total number of posts written, 2) number of help-seeking posts written and replied to, and 3) level of connectivity—were related to improvement (i.e., relative performance gains) for 70 undergraduate students enrolled in an online introductory STEM course. We found a significant positive relationship between help-seeking and improvement and nonsignificant effects of general posting and connectivity; these results held for UR-STEM and non-UR-STEM students alike. Our findings suggest that online help-seeking has benefits for course improvement beyond what can be predicted by posting alone and that one need not be well connected in a class network to achieve positive learning outcomes. Finally, UR-STEM students demonstrated greater grade improvement than their non-UR-STEM counterparts, which suggests that the online environment has the potential to combat barriers to success that disproportionately affect underrepresented students.

CCS CONCEPTS • Human-centered computing~Collaborative and social computing~Collaborative and social computing design and evaluation methods~Social network analysis • Applied computing~Education~E-

learning • Human-centered computing~Human computer interaction (HCI)-Interaction paradigms-Web-based interaction

Additional Keywords and Phrases: Help-seeking, Online discussion forums, Underrepresentation in STEM, Social network connectivity

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1 INTRODUCTION

Learning is inherently a socio-cognitive process and, in online environments, social connections among students may be crucial for discourse, community, and, ultimately, learning [15,61]. Discussion forums typically serve this function in online courses and are interactive tools that support the social and interdependent nature of learning [64]. Social learning analytics, an emerging field of research for investigating students in online courses [23,59], provides an important lens to understand student behavior in discussion forums that impact learning.

Unfortunately, challenges in the online space can also impede learning. Among the most worrisome is that students can lack a sense of community [40], which disproportionately impedes successful learning outcomes among diverse learners [37]. Because online courses can leave students feeling isolated and disconnected, a challenge for such courses is to find ways to build and support community, which may be essential for collaboration and promoting positive learning experiences online [52]. The Community of Inquiry (CoI) framework [24] accounts for this need for community; specifically, CoI posits that teaching, cognitive, and social presences are all necessary components for building online collaborative learning communities. Researchers have used the CoI framework to examine student interactions in online courses [8,36,55] and have found that a sense of community can be fostered in online learning communities, which has benefits for achievement [15,45,52].

In the context of asynchronous online courses, students' self-regulated learning (SRL) behaviors are also likely to play a role in their academic success and their participation in a collaborative learning community [56]. However, we know from research in face-to-face classrooms that SRL strategies like help-seeking can be problematic for students, especially UR-STEM students, because they often feel that, by using these, they may be viewed as incompetent [27,53]. The consequences of avoiding help-seeking, such as decreased academic performance and lower feelings of community in traditional classrooms, have been well documented [11,69]. However, much of the research on online discussion forums has yet to consider the ways in which help-seeking is used in these classes—for example, distinguishing between help-seeking discussion forum posts (e.g., asking a question or indicating a need for help) and other posts. In this study, we investigate whether this issue may be exacerbated for students who are traditionally underrepresented in STEM—such as first-generation college students, women, and minoritized groups (collectively referred to as UR-STEM students).

The present study uses social learning analytics to examine the relationship between online engagement (i.e., forum participation) and success for UR-STEM and non-UR-STEM students for one semester of an online STEM course. In the following subsections, we discuss the theoretical model for this study, as well as our motivation for investigating the following three measures of online engagement: 1) general forum posting behavior, 2) help-seeking, and 3) connectivity with respect to help-seeking.

1.1 Theoretical Model: Community of Inquiry

Collaboration and engagement are necessary for success in online courses, especially in asynchronous contexts, where students may be more susceptible to disengagement [52]. The CoI model [24] argues that learning occurs through three interdependent processes: cognitive presence, social presence, and teaching presence. Cognitive presence refers to the construction and confirmation of understanding through collaboration [24]. Social presence, the most widely researched component of the CoI framework [49], refers to the ability of a learner to establish purposeful social bonds through communication. Teaching presence refers to the design and facilitation of learning or instruction [e.g., 1,2]. The CoI model is crucial for our investigation, given the understanding that social and cognitive presence are facilitated through interactions in online discussion forums and that teaching presence can be performed by anyone in the community, not just instructors [24,32].

1.2 Engagement in Online Courses

Online discussion forums provide opportunities for a range of collaborative learning behaviors that contribute to cognitive and social presence, including seeking help, providing help, exchanging resources, sharing knowledge, and working together in small groups [13,43,62,66]. In this regard, a number of studies have shown that active forum use and participation are related to greater cognitive presence and better overall course performance [34–36,42,51]. In a nutshell, existing research suggests that engagement in discussion forums may be related to key learning outcomes under the CoI framework.

That being said, we do not know if the established relationship between engagement and course outcome holds for UR-STEM students in the same way that it holds for non-UR-STEM students. Marginalization and longstanding underrepresentation in STEM often leave UR-STEM students experiencing additional barriers not experienced by their non-UR-STEM peers, such as a lack of social support, negative stereotypes, lower academic self-efficacy, and a lack of sense of belonging, which may work together to impact their engagement and achievement [2,22,31,44]. Past research on UR-STEM students in online courses has shown that the online environment increases accessibility to STEM programs for these students [19,70] and there is evidence that UR-STEM students engage with online learning platforms differently from their non-UR-STEM peers [3]. Unfortunately, some UR-STEM students (in this case, first-generation college students) may be lacking the SRL skills necessary for success in online courses [68], and other UR-STEM students (women) have been found to be more likely to perform poorly in or drop out of online vs. in-person STEM courses (compared to men) [71]. However, exam scores for UR-STEM and non-UR-STEM students have also been found to improve at a similar rate throughout an online course [4] which suggests that the online environment may provide important opportunities for learning for UR-STEM students despite the difficulties faced by this population.

In sum, evidence shows that UR-STEM and non-UR-STEM students exhibit different online learning behaviors, and that online learning platforms may present both advantages and challenges to UR-STEM students. However, there is little work investigating how the online learning behaviors of UR-STEM students relate to their learning outcomes. Given the established relationship between engagement and achievement from previous research, there thus remains a need to investigate whether UR-STEM and non-UR-STEM students show similar patterns in terms of the relationship between engagement in online courses, measured here as their forum participation, and course outcome. This leads us to our first research question (RQ1): Is posting to discussion forums related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the relation of posting to improvement?

1.3 Help-seeking: A Self-regulated Learning Behavior that may Support Social and Cognitive Presence

Although posting to the forum is one promising indicator of how students engage with the course content, we have also chosen to look more carefully at a particular SRL behavior in online forum posts: asking for help on the course's online discussion forum. We have chosen to go beyond looking solely at the level of engagement as indicated by the number of forum posts because, in the context of asynchronous online courses, we realize that students' SRL behaviors likely play a role in their success beyond general forum participation; that is, by employing help-seeking behaviors, students have the opportunity not only to clear up misconceptions, but also to connect with peers, thereby increasing both cognitive and social presence.

The most crucial reason we have chosen to investigate help-seeking is because it is positively related to superior learning outcomes [20,28,33,39,50]. In college classrooms, seeking help early in the semester is related to high achievement [63]. Moreover, students who seek the least help may be those who perform the most poorly in online courses [29].

Although help-seeking has been shown to be a useful SRL behavior in face-to-face contexts, we have no idea of its effect beyond the benefits associated with simply posting. Moreover, given the potential threat to one's academic identity [48], we do not know whether help-seeking is equally effective (beyond simply posting) for UR-STEM and non-UR-STEM students. This leads us to our second research question (RQ2): Is asking for help on the forum related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the help-seeking and improvement, beyond what we can predict from posting alone?

1.4 Connectivity

As detailed in the previous sections, participating in online discussions can be beneficial for academic success. Research has demonstrated that the most active students in discussion forums have better academic performance than less-active students [42]. Researchers have employed social network analysis techniques to measure network relations [10,17,25,30,65] and have found that network structure is related to performance [72]. Overall, exploring social connections among students is a useful lens for examining the learning and teaching that occurs in collaborative digital environments [26].

In a community of inquiry, students who are central or influential to the community (i.e., highly connected) promote discourse and interactions that are essential for building cognitive and social presence [57]. Highly connected "student facilitators" are central because they exchange resources, information, and connect others [55]. Moreover, there is a relationship between sense of community and position in a network [14]. For example, learners who are peripheral in a network feel less connected to a community than students who are more connected. This is concerning, because differences in students' cultural backgrounds impact network patterns [60], potentially leaving UR-STEM students at a disadvantage. This leads us to our third research question (RQ3): Are higher degrees of connectivity (asking for help and responding to requests for help) on the forum related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the connectivity and improvement, beyond what we can predict from posting alone?

2 METHODS

2.1 Participants

We analyzed data from 70 students, out of a total of 94 who initially enrolled in one semester of a fully online introductory natural science course at a large public university in the midwestern United States. We removed a total of 24 students: 16 students who dropped the course and 8 students with missing improvement scores (i.e., paper-based exams for students needing accommodations, not recorded in the online system and only having final letter grades available in the learning management system). All data were available for analysis only after the course had been completed and students' grades had been finalized.

Students included 44 UR-STEM students (34 non-males; 13 Black, Hispanic, and Native American students; and 16 first-generation college students) and 26 non-UR-STEM students. Because some students fit multiple UR-STEM categories (e.g., a Black first-generation college student), any student who identified as any one of our three UR-STEM groups was categorized as a UR-STEM student to protect the privacy of their records (per the Family Educational Rights and Privacy Act; FERPA).

2.2 Measures and Analytic Plans

Students were required to post to the online forum each of 13 weeks during a 16-week semester (students took exams during the remaining 3 weeks). Posting to the forum accounted for 5% of students' grades. Each week, the instructor created several lead posts, generally consisting of an exam-like problem. Students could join in on any of the instructor-created posts, and they were required either to (a) post a solution to the initial problem, (b) post a question about the problem in an *initiating* post, or (c) answer a question that had been posted by another student. When coding help-seeking and help-giving, we chose to analyze initiating posts (i.e., the first post in a thread of posts) and responses to those initiating posts to determine whether (and which) posts generated the requested help. Coding and analysis were restricted to initial posts because we believed that these would set the tone for help-seeking and thus were an ideal place to begin. Support for selecting this sample of initial posts comes from theory and empirical work in psycholinguistics (see [46]). The 70 students produced a total of 942 initiating posts during the semester.

We defined our student outcome measure, improvement (i.e., gains in relative performance), by calculating students' scores during the first half of the semester and compared them to the second half of the semester by subtracting the first-half scores from the second-half scores. Although there may have been improvement within the first half of the semester, this was difficult to measure because we did not have frequent assessments and the assessments that were most frequent—quizzes—had severe ceiling effects because students could retake them, unlike exams. We scaled and centered this improvement measure to create our outcome measure (i.e., improvement as our dependent variable).

To identify help-seeking, a pair of coders coded approximately 20% of the data and obtained substantial agreement (Cohen's $\kappa = .83$; see [38]). Disagreements and cases of uncertainty were discussed and reconciled by the two coders. We reliably identified help-seeking forum posts, including any forum post that directly (e.g., "If anybody would be willing to help me figure this out, I'd greatly appreciate it") or indirectly (e.g., "I'm stuck on the energy diagram for question 3 letter D") requested help, or asked a question (e.g., "For number 6, what does the bolded line and the dashed line mean?"). Posts that did not indicate help-seeking were coded as not help-seeking. Although many forms of help-seeking occur online, our help-seeking model captured students' spontaneously produced content-related questions and requests, which either explicitly or implicitly indicated a request for help between students in their course's online discussion forum.

Out of the 942 initiating forum posts, 143 posts (15.2%) received a reply. Of the initiating posts, a subset of 326 posts were categorized as help-seeking requests, of which 130 (39.9%) received a response and were included for analysis. We constructed two directional 70x70 matrices with integer values (i.e., counts): one representing the relationship between all students' posts (to calculate *Students' Connectivity/Influence*) and the second representing only the posts with requests for help (to calculate *Help-Seeking Requests*).

We used social network analysis [6,7,67], particularly measures of degree centrality [67], to consider relations between help-seeking requests and responses (i.e., filtering out the non-help-seeking posts in the forum). Specifically, *out-degree* measured the number of outbound links, representing the number of help-seeking requests (reaching out to peers), and *in-degree* measured the number of inbound links, representing the number of responses that a student gave to help-seeking requests.

As a measure of students' course forum connectivity and influence, we used the PageRank algorithm to compute each students' influence in the class [5]. We used this weighted variant of eigencentality to assign a score to each student based on their direct connections, as well as their connections' connections. Hence, this measure takes into account how well connected each student is beyond their direct pairs of posts-and-responses because it accounts for how many links their connections have throughout the network (i.e., in the course forum). The PageRank method considers each students' posting behaviors in terms of their entire influence in the course forum, both in terms of numerical occurrence, as well as the cascading linkage to other "influential" students [18]. This measure was calculated considering all post-response pairs that these students exchanged. Although the PageRank algorithm has limitations (e.g., it does not capture timing and content of links), we believe it is appropriate given that RQ3 focuses on the direct and indirect link structure of students in the course forum (not its timing or content analysis).

To evaluate all of our research questions and decide between competing models, we included the variables of interest (e.g., out-degree as a proxy of help-seeking request) in our regression models, and compared these nested models against the baseline (reduced) model using the general regression test (a.k.a. extra sum of squares test) [41]. Standardized betas were calculated using the R package `lm.beta` [1]. We also provide visual representations of our analyses, which show network relations and main effects using the R package `igraph` [12].

3 RESULTS

In this section, we answer each of the three research questions. We do so by comparing nested regression models in a sequential manner. Hence, our first model serves as the baseline (reduced model) for comparison against gradually more complicated models.

$$\text{Baseline Model: } y(\text{grade improvement}) = a + \beta_1(\text{UR-STEM status}) + \beta_2(\text{Forum Posts}) + \epsilon \quad (1)$$

$$\text{Help-Seeking Model: } y(\text{grade improvement}) = a + \beta_1(\text{UR-STEM status}) + \beta_2(\text{Forum Posts}) + \beta_3(\text{Help-Seeking Requests}) + \epsilon \quad (2)$$

$$\text{Connectivity Model: } y(\text{grade improvement}) = a + \beta_1(\text{UR-STEM status}) + \beta_2(\text{Forum Posts}) + \beta_3(\text{Students' Connectivity/Influence}) + \epsilon \quad (3)$$

$$\text{"Full" Model: } y(\text{grade improvement}) = a + \beta_1(\text{UR-STEM status}) + \beta_2(\text{Forum Posts}) + \beta_3(\text{Help-Seeking Requests}) + \beta_4(\text{Students' Connectivity/Influence}) + \epsilon \quad (4)$$

3.1 Research Question 1: Is posting to discussion forums related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the relation of posting to improvement?

Results of our baseline regression model (1) indicated that there was a significant effect between students' UR-STEM status and grade improvement [$\beta_1 = .28, F(2, 67) = 2.38, p = .020$], however the number of posts to the forum was not [$\beta_2 = -.02, F(2, 67) = -0.20, p = .839, ns$]. For the sake of completeness, we tested an alternative model (1*) considering the interaction between the number of forum posts and students' UR-STEM status. This interaction was not significant ($\beta = -.34, F(3, 66) = -1.80, p = .076, ns$) and a comparison between models (1) and (1*) supported the idea that neither model was significantly different in predicting grade improvement [$F(66, 67) = 3.25, p = .076, ns$]. A Mann-Whitney test indicated that the number of posts to the course forum was not significantly different for UR-STEM and non-UR-STEM students, $U = 587, z = -0.47, p = .635, ns$; (UR-STEM students $M = 13, SD = 10.5$; non-UR-STEM students $M = 14, SD = 15.9$).

To examine the main effect of students' UR-STEM status and grade improvement, we conducted a Mann-Whitney test. This analysis supported the conclusion that UR-STEM students demonstrated greater grade improvement than their non-UR-STEM counterparts, U (non-UR-STEM = -0.36, UR-STEM students = 0.21; scaled mean grade improvement) = 714, $z = 2.40, p = .016$). We present these results graphically in Figure 1, which shows the distributions of standardized grade improvement for both UR-STEM and non-UR-STEM students.

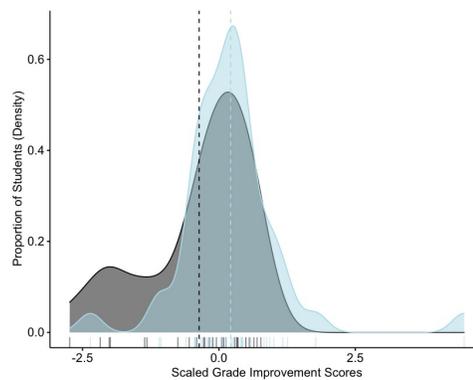


Figure 1: Improvement for UR-STEM students (in the lighter shaded area) and the non-UR-STEM students (in the darker shaded area)

3.2 Research Question 2: Is asking for help on the forum related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the help-seeking and improvement, beyond what we can predict from posting alone?

Results of our model (2) indicated that there was a significant effect of asking for help [as measured by students' out-degree centrality scores, $\beta_3 = .27, F(3, 66) = 2.06, p = .043$] in relation to grade improvement. Once again, we observed an effect of students' UR-STEM status and grade improvement [$\beta_1 = .25, F(3, 66) = 2.19, p = .032$], but no significant effect of the number of forum posts ($\beta_2 = -.15, F(3, 66) = -1.14, p = .259, ns$).

To explore if UR-STEM students and non-UR-STEM students showed similar or different patterns in terms of their help-seeking, we tested an alternative model (2*) considering the interaction of UR-STEM status and grade improvement. This interaction was not significant [$\beta = -.24, F(4, 65) = -1.03, p = .308, ns$], and the comparison between models (2) and

(2*) reinforced the idea that both models were not significantly different in predicting grade improvement [$F(65, 66) = 1.06, p = .308, ns^1$].

The comparison between models (1) and (2) yielded a significant difference in explaining students' grade improvement ($F(66, 67) = 4.25, p = .043$). This result suggests that asking for help on the forum was related to grade improvement, beyond what could be predicted from posting to the course forum. Figure 2 illustrates the impact of help-seeking posts on grade improvement.

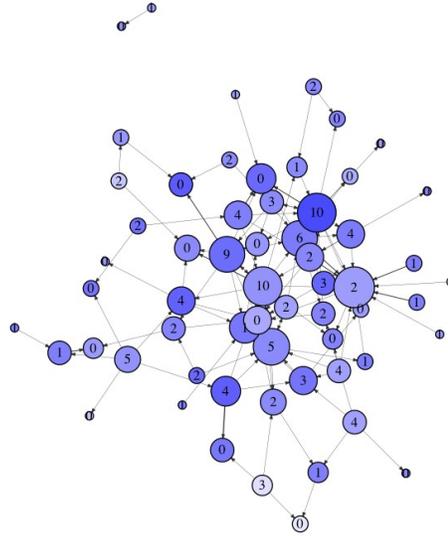


Figure 2: Social Network of help-seeking posts and their relation to grade improvement. The number inside each node conveys help-seeking requests (out-degree centrality scores). Grade improvement is represented by the continuum of color gradation (darker shading indicates greater grade improvement). The size of the nodes and thickness of the lines are proportional to the number of help-seeking (and help-giving) relations between students, and each arrow departs from the student asking for help.

3.3 Research Question 3: Are higher degrees of connectivity (asking for help and responding to requests for help) on the forum related to improvement, and do UR-STEM students and non-UR-STEM students show similar or different patterns in terms of the connectivity and improvement, beyond what we can predict from posting alone?

Results of our model (3) indicated no significant effect of students' forum connectivity (as measured by students' PageRank scores; $\beta_3 = .003, F(3, 66) = 0.03, p = .977, ns$) on their grade improvement. Once again, we observed an effect of students' UR-STEM status and grade improvement [$\beta_1 = .28, F(3, 66) = 2.27, p = .026$], but the number of forum posts again showed no significant effect [$\beta_2 = -.02, F(3, 66) = -0.20, p = .839, ns$].

Following the same procedure as in the previous analyses, we compared our model (3) with an alternative model (3*) that includes the interaction term of students' UR-STEM status and their connectivity on the course forum. We observed no significant differences between UR-STEM students and non-UR-STEM students in terms of their connectivity to each

¹ Although not predicted in this study, we have also explored models that included students' *in-degree* centrality scores. This measure could be considered as a proxy of helping other student(s) in the course forum. We found no evidence that helping others contributed to students' own grade improvement, as well as no evidence that UR-STEM and non-UR-STEM students differed in their pattern of helping others. For a future study (with a larger sample), we will explore the patterns of response, taking into account the order and hierarchy of responses.

other on the forum, indicated by a non-significant interaction term [$\beta = .13, F(4, 65) = 0.15, p = .880, ns$] in model (3*). The subsequent comparison between models (3) and (3*) was also not significant [$F(65, 66) = 0.02, p = .880, ns$]. Figure 3 illustrates the connectivity between UR-STEM students and non-UR-STEM students, showing that both groups interacted with each other and occupied a diverse dynamic of center and periphery influence in the course forum.

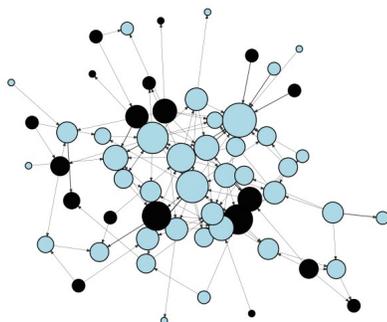


Figure 3: Social Network of connectivity among students. UR-STEM students are represented as light-shaded circles and non-URSTEM students are represented as dark-shaded circles. The size of the circle indicates the influence of each student.

Furthermore, the comparison between models (1) and (3) was not significant [$F(66, 67) = 0.01, p = .977, ns$]. This result suggests that the degrees of connectivity in the course forum (posting and responding to posts) did not help to explain variances related to grade improvement beyond the baseline model.

The transitive results of comparing models (1) versus (2) (significant), and (1) versus (3) (not significant) provide evidence that asking for help on the forum explained more variance in grade improvement than merely the degrees of students' connectivity in the course forum (see Table 1 for a summary).

Table 1: Summary of Regression Models for Variables Predicting Grade Improvement (n = 70)

Variables	Model 1 – Baseline			Model 2 – Help-Seeking			Model 3 – Connectivity			Model 4 – Full Model		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Forum Posts	-.001	.01	-.02	-.01	.01	-.15	-.001	.01	-.02	-.01	.01	-.16
UR-STEM Status	.57	.24	.28*	.52	.24	.25*	.57	.25	.25*	.50	.25	.24*
Help-Seeking				.12	.06	.27*				.12	.06	.27*
Forum Connectivity							.20	6.99	.003	2.43	6.90	.04
<i>R</i> ²		.08			.14			.08			.14	
<i>Adjusted R</i> ²		.05			.10			.04			.08	

Notes: * $p < .05$. ** $p < .01$.

Models 1*, 2*, and 3* included UR-STEM Status interaction terms. None of these interaction terms or models yielded significant results and were not represented in this summative table.

Finally, we fit a full model (4) with both variables (help-seeking and students' connectivity in the course forum) added to our baseline model (1) for verification purposes of RQ2 and RQ3. The comparison between models (4) and (2) was not significant [$F(65, 66) = 0.12, p = .730, ns$], reinforcing the importance of asking for help to improve grades in this STEM online course, beyond measures of students' connectivity.

4 DISCUSSION

4.1 Interpretation of Results

This investigation explored the relations between online engagement and course improvement for students traditionally underrepresented in STEM in an online introductory natural science course. Using a learning analytics perspective, we capitalized on social network analysis to understand how participation in online discussion forums (i.e., social presence), and particularly requesting and responding to requests for help (cognitive presence) was related to improvement (i.e., our measure of learning outcomes) from the first half to the second half of the course.

Our first research question sought to determine whether posting to the discussion forum was related to grade improvement, and whether this pattern held for UR-STEM and non-UR-STEM students alike. We found that the number of discussion forum posts was not related to improvement, and this relationship held when accounting for one's status as a UR-STEM vs. non-UR-STEM student. Thus, simply, posting to the discussion appeared to have no significant relation to improvement.

At first, our findings seem to differ from those reported in studies that have found a positive relationship between forum engagement and achievement [36,42,51]. A possible explanation for this discrepancy is that, in the present study, we chose to use the number of posts as our measure of overall forum engagement. However, previous research has generally taken into account additional measures of forum use (e.g., number of posts viewed, total time spent on the forum, number of words written) when deriving an overall measure of engagement [34,42,51]. Thus, while forum use, understood as a broad range of behaviors, may contribute to learning, our results suggest that one's level of posting alone did not have a significant relation to success.

Second, relatively few studies have examined the relationship between forum engagement and course improvement, the measure of success used here. Thus, even if other research has located a relationship between posting frequency and other measures of success (e.g., final course grade), our findings cannot support the conclusion that posting has a positive impact on one's improvement from the beginning to the end of the course, for UR-STEM or non-UR-STEM students.

We also found that UR-STEM students showed greater improvement than non-UR-STEM students between the first and second half of the course. This finding is encouraging because it lends further support to the notion that the online environment may play a positive role in overcoming some of the difficulties traditionally experienced by UR-STEM students in face-to-face settings [4]. However, given that we know that UR-STEM students still face challenges in online courses [68,70], further research is necessary to determine steps that should be taken to make the online environment an inclusive space that promotes learning equally and optimally for students of all backgrounds.

Our second research question sought to determine whether help-seeking was related to improvement beyond what we could predict from posting behavior alone. We found that help-seeking was significantly related to improvement, suggesting that help-seeking among the students in this course served the intended purpose of acquiring information and building cognitive presence online. We suspect that help-seeking in online classes may be especially valuable to supporting student learning because students can ask for help whenever they need it, as opposed to just during class or office hours, which may be more typical in face-to-face classes. Additionally, students in online environments may ask questions in relatively informal ways, given that they expect their peers to provide responses (compared to having to formalize your question, e.g., for the professor in class or TA in office hours), potentially affording them the opportunity to focus on the content of the question more than on the form. Of course, this is speculative, and future research might compare requests for help explicitly directed to peers versus those directed to instructional staff to examine the frequency and form of these requests, especially those from UR-STEM students in college STEM courses.

Although we found that UR-STEM status was again significantly related to improvement, UR-STEM status did not interact with help-seeking to predict improvement. Thus, contributing to the forum discussions by asking for help appears to be a successful self-regulated learning strategy, significantly related to improvement for all students, whether they were an UR- or non-UR-STEM student. We find it heartening that the UR-STEM students in this sample did not appear to experience the barriers to help-seeking that others have found [21,47], although we recognize that many previous studies examining this issue were conducted in face-to-face educational contexts [54], which may play a role in the behaviors that students exhibit and thus in the reported findings. We reckon that the requirement to post, the explicit endorsement of asking a question (one of the 3 types of posts allowed), and perhaps the relative anonymity of the online space all can contribute to an amelioration of the barriers to seeking help often documented for students from these UR-STEM groups.

Our third research question sought to determine whether forum connectivity was related to improvement beyond what we could predict from posting alone. Surprisingly, we found that higher degrees of connectivity (posting and responding to posts) was not related to improvement. A full model with connectivity and help-seeking did not predict improvement. Our results contradict other work that has found that students' position and influence in a network is related to performance [16]. However, an important distinction is our unique measure of academic performance (i.e., improvement), which may not be responsive to being highly connected on the forum. Moreover, we did not find significant differences in UR-STEM and non-UR-STEM students' forum connectivity. UR-STEM students' relatively high engagement with seeking help and their corresponding improvement in the course suggests that, as others have shown, a sense of community can be fostered in online discussion forums through asking for help [14,15,52]. However, our investigation did not directly measure sense of community, but our measure of social presence (i.e., forum participation) speaks to sense of community in that students had opportunities to read and respond to their peers' posts on a weekly basis, which likely contributed to forming a community of learners. These results are encouraging because it appears that students who are not influential forum members (i.e., have low PageRank scores) can benefit from the community of inquiry (sometimes vicariously, by reading others' posts, and sometimes by not consistently responding to the same students, week after week) and can have positive learning outcomes. What appears to matter the most for course improvement, at least from the data reported here, is help-seeking, not a student's connectivity.

4.2 Limitations

The study of social networks is complex and extensive, and our data were derived from a single semester of an online course discussion forum. The small sample of students ($n=70$) limits the generalizability of the study. Another limitation is that a substantive content analysis of the discussion posts was not undertaken. We only considered asking for help or not, and more specific coding of the content may reveal more about why help-seeking was linked to improvement. Furthermore, this study does not utilize self-reports to understand larger contextual factors (relevant to UR-STEM students), social and cognitive presence (from the community of inquiry model [58]) or sense of community [14,52], which could prove useful to triangulating results from the discussion forum data.

4.3 Implications and Conclusions

This study took advantage of a methodological approach—social network analysis and learning analytics—for capturing and understanding the socio-cognitive learning experiences of traditionally underrepresented students in STEM. In particular, utilizing a learning analytic approach to explore discussion forum data from an online STEM course, we capitalized on social network analysis to capture learner interactions. Our results revealed that help-seeking was a

significant contributor to course improvement (i.e., evidence of learning), but we did not find evidence that the frequency of forum posts and connectivity were related to improvement in the course.

Our results imply that educators should emphasize asking for help in online discussion forums so that students will do this instead of struggling. Perhaps more educators should require engagement in discussion forums because of the benefits noted in this report. Furthermore, we hope that instructors include recommendations for using discussion forums and how to use them in their course syllabi and in online learning resources to build technology-and-online learning literacy.

Moving forward, we suggest that future work in learning analytics can compare absolute performance (e.g., final grade) in addition to improvement to provide a nuanced understanding of learning outcomes. Analyzing improvement alongside absolute performance is useful for capturing a full picture of learners' growth in a course, where final grade alone does not always reflect knowledge gained.

An implication for research is that it is important to continue to investigate how help-seeking supports learning outcomes, especially for students who are underrepresented in the courses they are taking. Understanding how this particular—and potentially other—self-regulated learning strategies impact learners in online courses may shed [15,61] light on the general and unique benefits and constraints of learning in the online space.

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REFERENCES

- [1] Stefan Behrendt. 2014. *lm.beta: Add standardized regression coefficients to lm-objects*. Retrieved October 28, 2020 from <https://CRAN.R-project.org/package=lm.beta>
- [2] Sylvia Beyer. 2014. Why are women underrepresented in computer science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades. *Computer Science Education* 24, 2–3 (July 2014), 153–192. DOI:<https://doi.org/10.1080/08993408.2014.963363>
- [3] Nigel Bosch, R. Wes Crues, Genevieve M. Henricks, Michelle Perry, Lawrence Angrave, Najmuddin Shaik, Suma Bhat, and Carolyn J. Anderson. 2018. Modeling key differences in underrepresented students' interactions with an online STEM course. In *Proceedings of the Technology, Mind, and Society* (TechMindSociety '18), Association for Computing Machinery, New York, NY, USA, 1–6. DOI:<https://doi.org/10.1145/3183654.3183681>
- [4] Nigel Bosch, Eddie Huang, Lawrence Angrave, and Michelle Perry. 2019. Modeling improvement for underrepresented minorities in online STEM education. In *Proceedings of the 27th ACM Conference on User Modeling, Adaptation and Personalization* (UMAP '19), Association for Computing Machinery, New York, NY, USA, 327–335. DOI:<https://doi.org/10.1145/3320435.3320463>
- [5] Sergey Brin and Lawrence Page. 1998. The anatomy of a large-scale hypertextual web search engine. In *Proceedings of the seventh international conference on World Wide Web* 1998, 107–117.
- [6] Carter T. Butts. 2008. Social network analysis with sna. *J. Stat. Soft.* 24, 6 (2008), 1–51.
- [7] Carter T. Butts. 2016. *sna: Tools for Social Network Analysis*. R package version 2.4.
- [8] Secil Caskurlu. 2018. Confirming the subdimensions of teaching, social, and cognitive presences: A construct validity study. *The Internet and Higher Education* 39, (October 2018), 1–12.
- [9] Secil Caskurlu, Yukiko Maeda, Jennifer C. Richardson, and Jing Lv. 2020. A meta-analysis addressing the relationship between teaching presence and students' satisfaction and learning. *Computers & Education* 157, (November 2020), 103966. DOI:<https://doi.org/10.1016/j.compedu.2020.103966>
- [10] Po-Yao Chao, K. Robert Lai, Chen-Chung Liu, and Hung-Ming Lin. 2018. Strengthening social networks in online discussion forums to facilitate help seeking for solving problems. *Journal of Educational Technology & Society* 21, 4 (2018), 39–50.
- [11] Gail Conway, Eda Jean Jugarap, Voltaire Marquez, Karina Crisostomo, and Jerome Ouano. 2018. Examining the salience of school connectedness in college students' academic help-seeking behavior. *Philippine Journal of Counseling Psychology* 20, (February 2018), 61–80.
- [12] G. Csardi and T. Nepusz. 2006. The igraph software package for complex network research. *InterJournal, Complex Systems*, 1695. Retrieved October 28, 2020 from <http://igraph.org>
- [13] David D Curtis and Michael J Lawson. 2001. Exploring collaborative online learning. *Journal of Asynchronous Learning Networks* 5, 1 (2001), 21–34.

- [14] Shane Dawson. 2006. A study of the relationship between student communication interaction and sense of community. *The Internet and Higher Education* 9, 3 (July 2006), 153–162.
- [15] Shane Dawson. 2006. Online forum discussion interactions as an indicator of student community. *Australasian Journal of Educational Technology* 22, 4 (November 2006). DOI:<https://doi.org/10.14742/ajet.1282>
- [16] Shane Dawson. 2008. A study of the relationship between student social networks and sense of community. *Journal of Educational Technology & Society* 11, 3 (2008), 224–238.
- [17] Shane Dawson. 2010. ‘Seeing’ the learning community: An exploration of the development of a resource for monitoring online student networking. *British Journal of Educational Technology* 41, 5 (2010), 736–752. DOI:<https://doi.org/10.1111/j.1467-8535.2009.00970.x>
- [18] Ying Ding, Erjia Yan, Arthur Frazho, and James Caverlee. 2009. PageRank for ranking authors in co-citation networks. *Journal of the American Society for Information Science and Technology* 60, 11 (2009), 2229–2243. DOI:<https://doi.org/10.1002/asi.21171>
- [19] Jennifer C. Drew, Sebastian Galindo-Gonzalez, Alexandria N. Ardissonne, and Eric W. Triplett. 2016. Broadening participation of women and underrepresented minorities in STEM through a hybrid online transfer program. *CBE-Life Sciences Education* 15, 3 (September 2016). DOI:<https://doi.org/10.1187/cbe.16-01-0065>
- [20] Stéphane Duchesne, Simon Larose, and Bei Feng. 2019. Achievement goals and engagement with academic work in early high school: Does seeking help from teachers matter? *The Journal of Early Adolescence* 39, 2 (February 2019), 222–252. DOI:<https://doi.org/10.1177/0272431617737626>
- [21] Erkan Er, Theodore J. Kopcha, Michael Orey, and Wendy Dustman. 2015. Exploring college students’ online help-seeking behavior in a flipped classroom with a web-based help-seeking tool. *Australasian Journal of Educational Technology* 31, 5 (November 2015). DOI:<https://doi.org/10.14742/ajet.2527>
- [22] Bernhard Ertl, Silke Luttenberger, and Manuela Paechter. 2017. The impact of gender stereotypes on the self-concept of female students in STEM subjects with an under-representation of females. *Front. Psychol.* 8, (2017). DOI:<https://doi.org/10.3389/fpsyg.2017.00703>
- [23] Rebecca Ferguson and Simon Buckingham Shum. 2012. Social learning analytics: Five approaches. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (LAK '12)*, Association for Computing Machinery, New York, NY, USA, 23–33. DOI:<https://doi.org/10.1145/2330601.2330616>
- [24] D. Randy Garrison, Terry Anderson, and Walter Archer. 2000. Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education* 2, 2–3 (2000), 87–105. DOI:[https://doi.org/10.1016/S1096-7516\(00\)00016-6](https://doi.org/10.1016/S1096-7516(00)00016-6)
- [25] Dragan Gašević, Amal Zouaq, and Robert Janzen. 2013. “Choose your classmates, your GPA is at stake!”: The association of cross-class social ties and academic performance. *American Behavioral Scientist* 57,10 (March 2013), 1460–1479. DOI:<https://doi.org/10.1177/0002764213479362>
- [26] John Gerard Scott Goldie. 2016. Connectivism: A knowledge learning theory for the digital age? *Medical Teacher* 38, 10 (October 2016), 1064–1069. DOI:<https://doi.org/10.3109/0142159X.2016.1173661>
- [27] Christopher Herring and Joachim Walther. 2016. Academic help-seeking as a stand-alone, metacognitive action: An empirical study of experiences and behaviors in undergraduate engineering students. In *Proceedings of the 2015 ASEE Annual Conference*, June 26–29, 2016, New Orleans, LA, USA. DOI:<https://doi.org/10.18260/p.26490>
- [28] Gail Horowitz, Laura A. Rabin, and Donald L. Brodole. 2013. Improving student performance in organic chemistry: Help seeking behaviors and prior chemistry aptitude. *Journal of the Scholarship of Teaching and Learning* (August 2013), 120–133.
- [29] Kun Huang and Victor Law. 2018. Learners’ engagement online in peer help. *American Journal of Distance Education* 32, 3 (July 2018), 177–189. DOI:<https://doi.org/10.1080/08923647.2018.1475982>
- [30] Shazia K. Jan and Panos Vlachopoulos. 2019. Social Network Analysis: A Framework for Identifying Communities in Higher Education Online Learning. *Tech Know Learn* 24, 4 (December 2019), 621–639.
- [31] Dawn R. Johnson. 2012. Campus racial climate perceptions and overall sense of belonging among racially diverse women in STEM majors. *Journal of College Student Development* 53, 2 (March 2012), 336–346.
- [32] S. Joksimović, D. Gašević, V. Kovanović, B. E. Riecke, and M. Hatala. 2015. Social presence in online discussions as a process predictor of academic performance. *Journal of Computer Assisted Learning* 31, 6 (2015), 638–654. DOI:<https://doi.org/10.1111/jcal.12107>
- [33] Stuart A. Karabenick. 1998. Strategic help seeking: Implications for learning and teaching(1st ed.). Routledge, New York, NY. DOI:<https://doi.org/10.4324/9781410602701>
- [34] Vitomir Kovanović, Dragan Gašević, Srećko Joksimović, Marek Hatala, and Olusola Adesope. 2015. Analytics of communities of inquiry: Effects of learning technology use on cognitive presence in asynchronous online discussions. *The Internet and Higher Education* 27, (October 2015), 74–89.
- [35] Vitomir Kovanović, Srećko Joksimović, Oleksandra Poquet, Thieme Hennis, Shane Dawson, Dragan Gašević, Pieter de Vries, Marek Hatala, and George Siemens. 2017. Understanding the relationship between technology use and cognitive presence in MOOCs. In *Proceedings of the Seventh International Learning Analytics & Knowledge Conference (LAK '17)*, Association for Computing Machinery, New York, NY, USA, 582–583.
- [36] Vitomir Kovanović, Srećko Joksimović, Oleksandra Poquet, Thieme Hennis, Pieter de Vries, Marek Hatala, Shane Dawson, George Siemens, and Dragan Gašević. 2019. Examining communities of inquiry in Massive Open Online Courses: The role of study strategies. *The Internet and Higher Education* 40, (January 2019), 20–43.
- [37] Alex Kumi-Yeboah, Guangji Yuan, and James Dogbey. 2017. Online collaborative learning activities: The perceptions of culturally diverse graduate students. *Online Learning* 21, 4 (December 2017), 5–28.
- [38] J. Richard Landis and Gary G. Koch. 1977. The measurement of observer agreement for categorical data. *Biometrics* 33, 1 (1977), 159–174. DOI:<https://doi.org/10.2307/2529310>
- [39] Jamie-Lynn Magnusson and Raymond P. Perry. 1992. Academic help-seeking in the university setting: The effects of motivational set, attributional

- style, and help source characteristics. *Res High Educ* 33, 2 (April 1992), 227–245. DOI:<https://doi.org/10.1007/BF00973580>
- [40] Thomas Mays. 2016. Graduate inquiry: Social capital in online courses. *Mid-Western Educational Researcher* 28, 2 (2016), 162–186.
- [41] Roderick P. McDonald and Moon-Ho Ringo Ho. 2002. Principles and practice in reporting structural equation analyses. *Psychological Methods* 7, 1 (2002), 64–82. DOI:<https://doi.org/10.1037/1082-989X.7.1.64>
- [42] Libby V. Morris, Catherine Finnegan, and Sz-Shyan Wu. 2005. Tracking student behavior, persistence, and achievement in online courses. *The Internet and Higher Education* 8, 3 (July 2005), 221–231.
- [43] Nor Fariza Mohd Nor, Afendi Hamat, and Mohamed Amin Embi. 2012. Patterns of discourse in online interaction: seeking evidence of the collaborative learning process. *Computer Assisted Language Learning* 25, 3 (July 2012), 237–256. DOI:<https://doi.org/10.1080/09588221.2012.655748>
- [44] Robert T. Palmer, Dina C. Maramba, and T. Elon Dancy. 2011. A qualitative investigation of factors promoting the retention and persistence of students of color in STEM. *The Journal of Negro Education* 80, 4 (2011), 491–504.
- [45] Krystle Phirangee, Carrie Demmans Epp, and Jim Hewitt. 2016. Exploring the Relationships between Facilitation Methods, Students' Sense of Community, and Their Online Behaviors. *Online Learning* 20, 2 (June 2016), 134–154.
- [46] Martin J. Pickering and Simon Garrod. 2004. Toward a mechanistic psychology of dialogue. *Behavioral and Brain Sciences* 27, 2 (April 2004), 169–190. DOI:<https://doi.org/10.1017/S0140525X04000056>
- [47] Adnan Qayyum. 2018. Student help-seeking attitudes and behaviors in a digital era. *Int J Educ Technol High Educ* 15, 1 (May 2018), 1–16. DOI:<https://doi.org/10.1186/s41239-018-0100-7>
- [48] Jennifer C. Richardson, Adrie A. Koehler, Erin D. Besser, Secil Caskurlu, JiEun Lim, and Chad M. Mueller. 2015. Conceptualizing and investigating instructor presence in online learning environments. *The International Review of Research in Open and Distributed Learning* 16, 3 (June 2015). DOI:<https://doi.org/10.19173/irrodl.v16i3.2123>
- [49] Jennifer C. Richardson, Yukiko Maeda, Jing Lv, and Secil Caskurlu. 2017. Social presence in relation to students' satisfaction and learning in the online environment: A meta-analysis. *Computers in Human Behavior* 71, (June 2017), 402–417. DOI:<https://doi.org/10.1016/j.chb.2017.02.001>
- [50] Michelle Richardson, Charles Abraham, and Rod Bond. 2012. Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin* 138, 2 (2012), 353–387. DOI:<https://doi.org/10.1037/a0026838>
- [51] Cristóbal Romero, Manuel-Ignacio López, Jose-María Luna, and Sebastián Ventura. 2013. Predicting students' final performance from participation in on-line discussion forums. *Computers & Education* 68, (October 2013), 458–472. DOI:<https://doi.org/10.1016/j.compedu.2013.06.009>
- [52] Alfred P. Rovai. 2002. Sense of community, perceived cognitive learning, and persistence in asynchronous learning networks. *The Internet and Higher Education* 5, 4 (January 2002), 319–332. DOI:[https://doi.org/10.1016/S1096-7516\(02\)00130-6](https://doi.org/10.1016/S1096-7516(02)00130-6)
- [53] Allison M. Ryan, Paul R. Pintrich, and Carol Midgley. 2001. Avoiding seeking help in the classroom: Who and why? *Educational Psychology Review* 13, 2 (June 2001), 93–114. DOI:<https://doi.org/10.1023/A:1009013420053>
- [54] Katerina Schenke, Arena C. Lam, AnneMarie M. Conley, and Stuart A. Karabenick. 2015. Adolescents' help seeking in mathematics classrooms: Relations between achievement and perceived classroom environmental influences over one school year. *Contemporary Educational Psychology* 41, (April 2015), 133–146.
- [55] Jo L. Shackelford and Marge Maxwell. 2012. Sense of community in graduate online education: Contribution of learner to learner interaction. *The International Review of Research in Open and Distributed Learning* 13, 4 (October 2012), 228–249. DOI:<https://doi.org/10.19173/irrodl.v13i4.1339>
- [56] Peter Shea and Temi Bidjerano. 2010. Learning presence: Towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. *Computers & Education* 55, 4 (December 2010), 1721–1731. DOI:<https://doi.org/10.1016/j.compedu.2010.07.017>
- [57] Peter Shea, Suzanne Hayes, Sedef Uzuner Smith, Jason Vickers, Temi Bidjerano, Mary Gozza-Cohen, Shou-Bang Jian, Alexandra M. Pickett, Jane Wilde, and Chi-Hua Tseng. 2013. Online learner self-regulation: Learning presence viewed through quantitative content- and social network analysis. *The International Review of Research in Open and Distributed Learning* 14, 3 (2013), 427–461. DOI:<https://doi.org/10.19173/irrodl.v14i3.1466>
- [58] Peter Shea, Suzanne Hayes, Sedef Uzuner-Smith, Mary Gozza-Cohen, Jason Vickers, and Temi Bidjerano. 2014. Reconceptualizing the community of inquiry framework: An exploratory analysis. *The Internet and Higher Education* 23, (October 2014), 9–17. DOI:<https://doi.org/10.1016/j.iheduc.2014.05.002>
- [59] Simon Buckingham Shum and Rebecca Ferguson. 2012. Social learning analytics. *Journal of Educational Technology & Society* 15, 3 (2012), 3–26.
- [60] Karen Stepanyan, Richard Mather, and Roger Dalrymple. 2014. Culture, role and group work: A social network analysis perspective on an online collaborative course. *British Journal of Educational Technology* 45, 4 (2014), 676–693. DOI:<https://doi.org/10.1111/bjet.12076>
- [61] Emma J. Stodel, Terrie Lynn Thompson, and Colla J. MacDonald. 2006. Learners' perspectives on what is missing from online learning: Interpretations through the community of inquiry framework. *The International Review of Research in Open and Distributed Learning* 7, 3 (December 2006), 1–24.
- [62] Zhong Sun, Chin-Hsi Lin, Minhua Wu, Jianshe Zhou, and Liming Luo. 2018. A tale of two communication tools: Discussion-forum and mobile instant-messaging apps in collaborative learning. *British Journal of Educational Technology* 49, 2 (2018), 248–261. DOI:<https://doi.org/10.1111/bjet.12571>
- [63] Evan Szu, Kiruthiga Nandagopal, Richard J. Shavelson, Enrique J. Lopez, John H. Penn, Maureen Scharberg, and Geannine W. Hill. 2011. Understanding academic performance in organic chemistry. *J. Chem. Educ.* 88, 9 (September 2011), 1238–1242. DOI:<https://doi.org/10.1021/ed900067m>
- [64] Kok-Eng Tan. 2017. Using online discussion forums to support learning of paraphrasing. *British Journal of Educational Technology* 48, 6 (2017), 1239–1249. DOI:<https://doi.org/10.1111/bjet.12491>

- [65] Ramón Tirado, Ángel Hernando, and José Ignacio Aguaded. 2015. The effect of centralization and cohesion on the social construction of knowledge in discussion forums. *Interactive Learning Environments* 23, 3 (May 2015), 293–316. DOI:<https://doi.org/10.1080/10494820.2012.745437>
- [66] Xu Wang, Diyi Yang, Miaomiao Wen, Kenneth Koedinger, and Carolyn P. Rosé. 2015. Investigating how student's cognitive behavior in MOOC discussion forums affect learning gains. In *Proceedings of the 8th International Conference on Educational Data Mining (EDM '15)*, June 26-29, 2015, Madrid, Spain, 226-233.
- [67] Stanley Wasserman and Katherine Faust. 2009. *Social network analysis: Methods and applications*. Cambridge University Press, Cambridge.
- [68] Peter E. Williams and Chan M. Hellman. 2004. Differences in self-regulation for online learning between first- and second-generation college students. *Research in Higher Education* 45, 1 (February 2004), 71–82.
- [69] Greta Winograd and Jonathan P. Rust. 2014. Stigma, awareness of support services, and academic help-seeking among historically underrepresented first-year college students. *Learning Assistance Review (TLAR)* 19, 2 (Fall 2014), 17–41.
- [70] Claire Wladis, Katherine M. Conway, and Alyse C. Hachey. 2015. The online STEM classroom—who succeeds? An exploration of the Impact of ethnicity, gender, and non-traditional student characteristics in the community college context. *Community College Review* 43, 2 (April 2015), 142–164.
- [71] Claire Wladis, Alyse C. Hachey, and Katherine Conway. 2015. Which STEM majors enroll in online courses, and why should we care? The impact of ethnicity, gender, and non-traditional student characteristics. *Computers & Education* 87, (September 2015), 285–308. DOI:<https://doi.org/10.1016/j.compedu.2015.06.010>
- [72] Heng-li Yang and Jih-hsin Tang. 2003. Effects of social networks on students' performance: A web-based forum study in Taiwan. *Journal of Asynchronous Learning Networks* 7, 3 (2003), 93–107.