Ask for Help: Online Help-Seeking and Help-Giving as Indicators of Cognitive and Social Presence for Students Underrepresented in Chemistry

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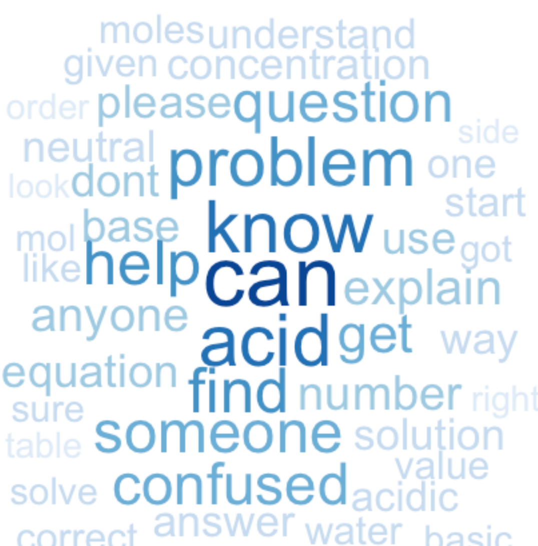
ABSTRACT

Help-seeking is an essential tool for student success. Still, students, especially those underrepresented in STEM (UR-STEM) and those underrepresented in chemistry (UR-Chem), may be reluctant to employ help-seeking for academic success. Understanding help-seeking in online courses is crucial for developing equitable learning environments where students can engage with a community of inquiry. We analyzed help-seeking behaviors and responses to requests for help in an online college-level chemistry course's discussion forum. We found that requests for help were responded to equally, regardless of how explicitly students appealed for help. Furthermore, we found that UR-Chem students requested and responded to help similarly and received help at greater rates than their non-UR-Chem peers. Results support that productive and substantive help-seeking and help-giving discussions occur in an online discussion forum. Ultimately this work highlights a necessary learning skill, help-seeking, thereby informing chemistry instruction, and learning.

GRAPHICAL ABSTRACT



KEYWORDS
First-Year Undergraduate/General, Second-Year Undergraduate, Chemical Education Research, Collaborative/Cooperative Learning, Internet/Web-Based Learning, Minorities in Chemistry, Women in Chemistry

INTRODUCTION

The global pandemic has altered instruction across the world, and many educators are grappling with the challenges of teaching online. One particular concern for many online chemistry instructors is the need to incorporate active learning techniques.[1–4] Because chemistry is a complex discipline where many concepts are abstract and rely on visual representations,[5] this may exacerbate the difficulty of successfully including active online learning in chemistry.

Some of the barriers to success in learning chemistry online are directly related to conceptual issues in learning chemistry whereas others are related to the way in which students progress through the major. Conceptual issues within chemistry that may interfere with success in learning chemistry online include the use of models and analogies to explain abstract topics, threefold representation of matter (e.g., macroscopic, microscopic, symbolic), and chemistry terminology.[5] Moreover, in the context of introductory college chemistry courses, "gatekeeper" topics like mole concepts and stoichiometry[6] hinder students' progression in chemistry and other science-related fields (i.e., where chemistry courses are requirements). Why is this relevant? As more students take online courses, gatekeeper concepts and topics have the potential to increase attrition rates, [6–8] especially for students who face systemic barriers to their success. Therefore, an investment in understanding successful online learning behaviors is crucial for chemistry instructors.

Given some of the conceptual and structural barriers to success in chemistry online courses, the overall goal of this investigation is to explore and understand chemistry students' online learning behaviors so that we can be positioned to support their learning. More particularly, we focus on the relationships between *help-seeking and help-giving for students who are traditionally underrepresented in chemistry* (UR-Chem) because engagement with an online collaborative learning community gives these students opportunities not only to get their questions answered but also to build social connections.[9] In the research reported here, UR-Chem students include students taking chemistry courses who are (1) non-male students, i.e., women and non-binary gendered students, (2) first-generation college students, (3) and racially minoritized students, including African American/Black, Hispanic/Latino(a), and Native American/Alaskan Native students. We provide more detail about the demographic features of the students participating in this study in the Methods. We use the term UR-STEM when discussing others' research conducted in STEM disciplines other than Chemistry.

Establishing social connections is essential for feeling included in a learning community and UR-Chem students may be more vulnerable to leaving STEM if they feel isolated. Thus, we frame help-seeking and help-giving as an equity issue because not having access to help-seeking and help-giving could be diminishing UR-Chem students' access to opportunities for success in chemistry. Ultimately, this work can inform instructional and learning strategies to support student learning in online CHEM—and online STEM—college courses.

REVIEW OF THE LITERATURE

Theoretical Framework and Background

Five bodies of literature help to frame the investigation reported here: (1) Community of Inquiry (CoI), which serves as our major theoretical framing; (2) help-seeking, and why it is related to both the cognitive and social presence implicated in the CoI theoretical framework, especially in chemistry; (3) help-seeking in the online environment, which points to the particular context of this study; (4) help-giving, and its role in cognitive/social presence, chemistry, and online learning; and (5) how help-seeking and help-giving impact UR-Chem students. Next, we discuss each of these framings.

Community of Inquiry (CoI)

Online collaborative learning communities consist of students and instructor(s) who interact to achieve learning goals.[10–12] Garrison, Anderson, and Archer, in their explication of the CoI model, posited that learning occurs within the community through cognitive, social, and teaching presence.[11] Our investigation focuses most explicitly on the first two components: cognitive presence, which focuses on constructing meaning, and social presence, which focuses on learners being able to project themselves socially and emotionally.[11] However, when students support learning outcomes, they can contribute to teaching presence, for example by providing guidance and answering questions, among other behaviors. All three components are interrelated and are crucial for our investigation because collaboration is essential for learning.[11]

Help-seeking and its benefits

There are cognitive and social benefits of help-seeking, which may be especially relevant to students' cognitive and social presences within communities of inquiry. Gasiewski and colleagues have found that students who feel welcome and comfortable in their classrooms are more likely to collaborate with their peers and to ask questions.[13] Thus, students who have a sense of connectedness may experience academic and cognitive advantages compared to students who feel isolated and disconnected.

When students seek help, they are engaging in a self-regulated strategy that requires them to (1) be aware that they have a lapse in understanding and then (2) act on that awareness to reduce that lapse.[14] Help-seeking can be fundamental in chemistry for developing scientific literacy and knowledge at least in part because fostering students' question-asking capabilities is crucial for the development of successful problem-solving skills in chemistry,[15] and question-asking shares many commonalities with help-seeking.[15,16] Furthermore, much of learning in chemistry happens in collaborative settings that emphasize active learning, because it improves students' critical thinking and problem-solving skills.[17,18]

Researchers who have investigated in-person chemistry courses have consistently found a positive relationship between help-seeking and academic performance.[19,20] For example, Horowitz, Rabin, and Brodale[21] found that engaging in help-seeking activities (e.g., attendance at problem-solving sessions) had a significant impact on organic chemistry performance. In the same vein, Szu and colleagues[22] found that the highest-achieving students sought instructor help early. Santos-Díaz, Hensiek, Owings, and Towns[23] surveyed undergraduate students enrolled in chemistry courses (i.e., general, physical, organic) about their goals and achievement strategies. Their results indicated that students consistently reported help-seeking as a reliable and useful strategy.

Help-seeking online

Likewise, research in online courses also indicates cognitive and social benefits of help-seeking. The online environment typically can provide opportunities for active learning (cognitive presence) and community-building (social presence) among students.[24] For example, researchers have reported significant positive relationships between discussion forum participation and final performance in an online course,[25] as well as between perceived social presence of online peers and instructors and one's satisfaction with course discussion forums.[26] Furthermore, researchers have reported a positive effect of help-seeking and learning outcomes.[27–30] From this work, we can surmise that help-seeking in online discussion forums may be a useful way to increase social presence and cognitive presence, while simultaneously fostering active learning.

Overall, these studies support the notion that help-seeking is useful for success in chemistry. However, more research directly investigating help-seeking in chemistry is needed, because there may be unique issues relevant to learning chemistry online, which leads to the first research question:

1a. Given the social and cognitive benefits of help-seeking, we ask: How prevalent are help-seeking behaviors in an online chemistry discussion forum?

Help-giving and its benefits

Although help-*seeking* has received some attention from researchers, less is known about help-*giving* (i.e., responses or replies to requests for help) in academic settings. Nevertheless, available research suggests that helping behavior (i.e., an aspect of teaching presence) may play an important role in students' academic performance (cognitive presence) and in their discourse and reflection, supporting their building of community (social presence).

An aspect of help-seeking is the evaluation (or reflection) of the help-seeking attempt.[16] This means that students evaluate the help that is given; whether it was helpful or communicated in a way that induces stigma or feelings of incompetence. A help-seeker's response to the help given can empower them to continue asking for help or discourage them from seeking help in the future. Thus, help-giving (i.e., receiving help) plays an important role in persistence and positive learning outcomes, both cognitively and socially.

Help-seeking and help-giving go hand in hand, and help-seeking can be a catalyst for jumpstarting discussion among learners where help-givers can support collaborative meaning-making. If a student asks for help and a peer responds with useful information, that fosters learning between both students, because the help-seeker has a knowledge gap filled, and the help-giver assessed and explained their knowledge to a peer.[31]

However, much of what we know about help-giving comes from studies of in-person collaborative peer-learning, where students learn material and solve problems in small groups.[32–35] These studies have consistently reported a positive relationship between giving help and academic achievement.[36,37] In related work in chemistry courses, participation in optional peer-learning sessions has been found to be related positively to both retention and academic performance.[38–41]

Despite the likely importance of help-giving in online chemistry courses, studies investigating this issue are particularly lacking. Among studies that have explored this topic, Huang and Law[42] found an interaction effect of help-seeking and help-giving on achievement in an online course, such that students who provided the least help were also those who benefited the most from seeking help. This suggests that students who most need help also may not be prepared to give help. In a similar vein, Dawson[43] found a negative correlation between students' sense of community and unanswered forum posts, which indicates that unaddressed requests for help in online spaces may be associated with decreased social presence.

Overall, evidence suggests that help-giving contributes to learning within a community of inquiry but studies that explicitly investigate help-giving in online chemistry courses are needed, which leads to the research question:

1b. Given the social and cognitive benefits of help-giving, we ask: How prevalent are help-giving behaviors in an online chemistry discussion forum?

How is help sought?

Help-seeking is a catalyst for facilitating engagement among students, and the phrasing and tone of a request for help may be related to the magnitude and types of replies garnered.

Past research has shown that academic help-seeking encourages and improves interactions between students, where requests for help that are clear, open-ended, and relevant play a particularly important role in improving the quality of classroom discussions.[44] Furthermore, in online courses, students who pose questions on discussion forums have a higher chance of receiving a response, when compared to those who only praise, encourage, or agree with others in their posts.[45] Furthermore, the more explicit an online question is, the more likely it is to receive a response from another individual.[46]

The online space may provide some important and useful affordances for student learning, which may provide ways to identify, seek, and receive help that overcome barriers in traditional in-person classrooms.[47–50] For example, in online forums, students can view all previous questions to see if a similar question has already been answered. Given that we anticipate that the trajectory of learners gaining experience using discussion forums is increasing, it is necessary to understand how different ways that students seek help is responded to by peers, which leads to the research question:

2. Does the way in which the help is sought matter for increasing interaction among students?

a. Does asking for help increase a student's chances of getting a response?

b. And, if so, which types of requests for help (whether implicit or explicit) elicit responses?

Impacts of Help-Seeking and Help-Giving for UR-Chem Students

Although help-seeking has been linked to academic success, students may not seek help, even when they know they need it.[51] Barriers to seeking help may impact UR-Chem (women, racially minoritized, and first-generation college students) and non-UR-Chem students differently. Research on help-seeking in in-person classrooms shows that students' underrepresentation could inhibit help-seeking[52,53] and data suggest that racially minoritized students tend to engage in less help-seeking outside of the classroom (e.g., attendance at office hours) than non-racially minoritized students.[54] Gender norms further complicate this picture[55–57] in that women may feel threatened when admitting that they do not know something[58] but, to confound matters, gender roles regarding masculinity discourage men from asking for help because it may make them look weak.[56] In related work, researchers have found that first-generation college students were less likely than their peers to seek help,[59] and subsequent research has demonstrated that this may be because first-generation college students are concerned with burdening their peers and facing judgment or that they have uncertainty about navigating college environments.[60,61]

However, research that shows that UR-Chem students tend to have greater communal learning goals[62] than non-UR-Chem students, which in turn could counter some of the barriers to seeking help and, instead, encourage help-seeking. In general, although help-seeking leads to positive learning outcomes, students can face barriers to help-seeking and pressures to avoid help-seeking, especially if they are from a demographic group underrepresented in chemistry.[63]

While help-seeking is an important skill that benefits all learners for filling knowledge gaps, UR-Chem students benefit from help-seeking in other ways, too. Feeling empowered to ask questions can be a sign of feeling welcomed and comfortable in a learning environment, which is positively related to retention and satisfaction in STEM.[64–66]

In online courses, the cues that students receive could negatively impact their sense of belonging. For example, not receiving responses at all or receiving unhelpful answers or dismissive posts can deter students from help-seeking. It is possible that threats to seeking help might be different in online than in in-person courses because identity markers may not be salient and there is relative anonymity, complicating how UR-Chem students might be at times disadvantaged and at other times advantaged in learning online. The relation between help-seeking, help-giving, and academic achievement is further complicated because negative experiences have a lasting impression on students. Thus, we ask, in general, about how help-seeking and help-giving might differentially impact UR-Chem compared to non-UR-Chem students:

3. What are the impacts of help-seeking and help-giving on UR-Chem students?

a. Do UR-Chem and non-UR-Chem students seek and receive help at different rates?

And, to give a clearer picture of what these requests and responses look like in an online chemistry class, we ask:

b. Can we document fruitful and substantive discussions happening in online discussion forums?

METHOD

Participants and Data Source

The data come from 94 students who enrolled in and completed an online, asynchronous, early curriculum, college-level chemistry course. The course was entirely online, with online lectures (videos and readings), course materials (e.g., syllabus, schedule), and an online discussion forum. Students used the online learning management system LON-CAPA (Learning Online Network with Computer-Assisted Personalized Approach) for this course.[67] Students were required to post to the online forum during 12 weeks of the 16-week semester. Each week, the instructor posted several questions and students were directed to interact with the discussion forum either by asking a question about one of the questions, posting an answer to one of the questions, posting a new question, or answering another student's question. The syllabus explicitly stated "If you contribute to the discussion with an acceptable post you will earn 5 points for that period. If you do not post or if your post doesn't meet the criteria listed above, you will earn zero points for the discussion period." If a student did not provide a post for the week, they could not earn the points for that week. Posting to the forum accounted for a maximum of 5% of students' grades. The instructor rarely interacted with the discussion forum except to offer an occasional "thumbs up."

All data were available for analysis only after the course had been completed and students' grades had been posted.

Students included 50 non-male, 19 AHN (African American/Black, Hispanic/Latino(a), Native American/Alaskan Native), and 25 first-generation college students. Because some students had multiple UR-Chem statuses (e.g., a female first-generation college student), any student who identified as any one of our three UR-Chem groups was categorized as a UR-Chem student (n = 62). The remaining students (n = 32) were categorized as non-UR-Chem students.

Coding and Analysis of Help-Seeking and Help-Giving

We used a previously developed coding scheme[30] to code for four levels of help-seeking, based on the explicitness of requesting help. We identified and reliably coded 20% of the data (Cohen's $\kappa = 0.83$); [68]and provide examples in Table 1.

Table 1. Types of help-seeking identified in forum posts.

Code	Description	Example
No Questions & No Help-Seeking (H-S:0)	No questions, no mention of uncertainty	"I think we might need to use the data to plot for k." "Potential of E increases by change in pressure."
Question Asked, but no Appeal for Help (H-S:1)	Contained questions or indicated uncertainty without indicating struggle or recognition of the community	"How does Hess's Law relate to entropy?" "Why is the hybridization sp3? Wouldn't it be sp2 since there are three electron pair domains?"

Implicit Appeal for Help (H-S:2)	Asked a question or indicated uncertainty and indicated struggle and/or recognition of the community	"I am struggling to draw the energy diagram for 3d. How do I begin to draw this?" "How were we supposed to go about question 13?"
Explicit Appeal for Help (H-S:3)	Directly asked for help or indicated they needed a response	"Hey I am still having some difficulty… If anyone has any tips I would greatly appreciate it. Thanks for the help"

We chose to analyze initiating posts (i.e., the first post in a thread of posts) for help-seeking and responses to those initiating posts, to determine whether (and which) posts generated the requested help. Any reply to an initiating post was considered help-giving. Support for selecting this sample of initial posts comes from theory and empirical work in psycholinguistics.[69] Moreover, Wang, Reitter, and Yen[69] have observed that in online forums the first post in a thread had a special role in dialogues in online communities.

Forum posts were anonymized prior to content-coding via natural language processing methods that remove names and other identifying information.[70] Demographic information was also stored separately from posts to avoid influencing coders' decisions. The anonymization method and all analyses were IRB-approved.

We did not analyze instructor forum threads (i.e., initiating posts made by the instructor and the responses to these posts) due to interests in peer interactions. We also removed and did not analyze introductory, first-week posts, where students described themselves because they were not content related. Moreover, posts that did not fit in the help-seeking coding scheme (i.e., not pertaining to chemistry content, such as comments about a favorite show) were removed from the analysis. In total, we analyzed 1,095 initiating help-seeking posts and their respective responses (help-giving posts).

To answer RQ1a, RQ1b, RQ2a, RQ2b, RQ3a, we conducted mixed-effects logistic regressions to model help-seeking posts and responses, using the *lme4* package[71] in R 3.6.1. Post-hoc multiple pairwise contrasts were implemented with the package *multcomp*.[72] This approach allowed us to control for students' actions as repeated measures (because students could request and respond to multiple posts), and model unbalanced observation per-group designs.

To answer RQ3a, we selected four examples of help-seeking requests and help-giving responses based on the substantive nature of the conversations and where both help-seeking and help-giving that indicated a shared struggle occurred. To determine substantive examples of discourse, we calculated the word counts of responses to help-seeking requests (i.e., help-giving replies) and chose the messages with the largest word counts. In addition, we flagged help-giving replies indicating that help was given (e.g., hopefully this helps!) or a shared struggle/confusion with the help-seeker (e.g., I was stuck on this problem too). We believe that these cases were important to explore because they speak to the social affective component of learning where students present themselves as real people.[11]

RESULTS

RQ1a & RQ1b: How prevalent are help-seeking behaviors and responses to help-seeking requests in an online chemistry discussion forum? How prevalent are help-giving behaviors in an online chemistry discussion forum?

Twenty-eight percent (n=312) of the 1,095 initiating posts indicated some request for help (i.e., HS:1, HS:2, or HS:3). Of the initiating posts that indicated some request for help (i.e., H-S:1, H-S:2, H-S:3, n=312), 116 received replies and thus were treated as help-giving.

Table 2. Requests for help and requests that garnered at least one response.

Level of Help-Seeking (H-S)	Number of H-S requests	H-S requests garnering a response
0	783	51 (7%)
1	47	13 (28%)
2	150	61 (41%)
3	115	42 (37%)

RQ2a & RQ2b: Does the way in which the help is sought matter for increasing interaction among students? Does asking for help increase a student's chances of getting a response? And, if so, which types of requests for help (whether implicit or explicit) elicit responses?

To examine which types of requests for help (whether implicit or explicit) elicit responses, we found that asking for help—implicitly (at level 1 or 2) or explicitly (level 3) combined—was significantly more likely to generate a response from another student compared to just posting a non-help-seeking (level 0) remark ($\hat{\beta}$ = 2.15, p < 0.001); however, there were no significant differences across the levels of explicitness in asking for help in terms of getting the help that was requested (i.e., we found no significant differences among help-seeking levels 1, 2, or 3; see Table 2). More specifically, no significant differences were found for the proportions of responses between Implicit (HS:2) and Explicit

Requests (HS:3, $\hat{\beta}$ = -0.29, $p > 0.10$, ns); Questions (HS:1) and Implicit Requests (HS:2, $\hat{\beta}$ = 0.32, $p > 0.10$, ns); or Questions (HS:1) and Explicit Requests (HS:3, $\hat{\beta}$= -0.60, $p > 0.10$, ns).

RQ3a: What are the impacts of help-seeking and help-giving on UR-CHEM students? Do UR-Chem and non-UR-Chem students seek and receive help at different rates?

Next, we examined who requested and who received responses to their requests for help. UR-Chem students produced slightly more posts requesting help than non-UR-Chem students, but that difference did not reach standard levels of significance ($\hat{\beta}$ = 0.69, $p < 0.10$). UR-Chem students received more help than their non-UR-Chem peers ($\hat{\beta}$ = 1.66, $p < 0.05$) (see Table 3).

Table 3. UR-Chem and non-UR-Chem students' requests for help and replies to those posts.

Level of H-S	Posts at this level by UR-Chem students (N)	Posts made by a UR-Chem student with a reply	Posts at this level by non-UR-Chem students (N)	Posts made by a non-UR-Chem student with a reply
0	451	23 (5% of 451)	332	28 (8% of 332)
1	31	9 (29%)	16	4 (25%)
2	103	48 (46%)	47	13 (28%)
3	84	32 (38%)	31	10 (32%)
Total	669	112 (17% of 669)	426	55 (13% of 426)

RQ3b: Are there fruitful and substantive discussions happening in the discussion forum?

To demonstrate the nature of student interactions, we selected a few examples of help-seeking and help-giving exchanges that contained extensive replies indicated by word count with replies that mentioned a shared struggle or "hope this helps." We conducted this qualitative analysis to examine ways in which students helped their peers and communicated their knowledge in discussion forums. The data we analyzed for this purpose are displayed in Table 4.

Table 4. Productive requests for help and help-giving exchanges.

Conversation	Request for help	Help-giving reply
1	I was unsure of how to do this problem during the test and even now given the correct answer. how do you go about it? (UR-Chem student)	First you have to figure out the amount of moles of HBr in the solution. Keep in mind that the number of moles of acid equals the number moles of the base in a Strong Acid/Base titration. Since the concentration of KOH is given and the amount of KOH to reach the equivalence [point], you can figure out the number of moles of the KOH needed which is equal to the number of moles of HBr. (.3338 *1.76=.5875 moles). Now we figure out the number of moles of KOH in the solution after 145 mL of it has been added. Multiply .145 L by the concentration of KOH(1.76 M) to get this value. (.2552 moles). Finally we have to see what the limiting reactant is, in this case it's the base since there's less moles of base than the acid (.2552 vs .5875 moles). So all of the base gets used up, and we subtract the moles of acid by the moles of base. After doing this we get .3323 moles of base. We then need to figure out the concentration by doing moles/ Liters of the entire solution. This is .3323/(.145+.773). We then take the -log of that value to determine pH. (non-UR-Chem student)
2	I am having trouble with Question 3. I'm having trouble with the geometry and with the energy diagrams specifically. Can anybody help me out? (UR-Chem student)	I had some trouble with the energy diagrams as well- I found the second part of this video to be helpful … as well as the chapter on hybridization from the …[course] book, if you have it. (UR-Chem student)
3	In the first problem of the Homework. How do we go about drawing the structure in its regular form? The thing that seems to be throwing me off the most are the hydrogen atoms that are attached to the structure.... (UR-Chem student)	The way I do it is by starting from one of the lines on the outside circle and then continuously drawing everything as I go along. Hope that helps. (non-UR-Chem student)
4	Anyone know how to get this [a problem where one has to determine how the mass of the electrode will change given a change in non-standard cell potential]??? (UR-Chem student)	Use the equation: E= E°-(RT/nF) *ln(Q). you need to find Q. Use an Ice table I 1.00 1.00 C -x +x E 1.00-x 1.00+x products/reactants Solve for X using the equation. Once you find x multiply X by the molar mass of the element that you're trying to find. For me It was Cd. so (112.4)x. add 100g to that and that should be your answer. (Help-giver 1;UR-Chem student)

	For this question, you need to notice that it gave you [chemical ion] = 0.09306V(in my case). Next, find [electric potential] standard, which could be found by using the given info. In my case, it was 0.098. Then, subtract 0.09376 by 0.098, and let this equal to -RT/nF*ln(Q). In my case, n was 2, so when I do all of the algebra, I get 1.3913 for Q's ratio. Now, the question says the reaction was set under standard conditions, so we know that the ratio is just (1+X)/(1-X). Solving for X, I got 0.1636 Molar. We still are under standard condition, so we know that the volume is 1L. Multiply 1L to 0.1636 Molar, I get 0.1636 mol. I know there was a change for both substances, but we are only interested in Pb2+, so all I have to find out is the mass change. Thus, 0.1636 * 207.1(molar mass of Pb) = 33.8725g. Finally, add this mass to 100g, then this gives me the answer. correction. not mass change. I meant the change in concentration. (Help-giver 2; non-UR-Chem student)

In this first conversation, a student made an implicit request for help (HS:2) on a problem where the answer was already known. Despite having the correct answer, the help-seeker appealed to the community (i.e., class peers) for an explanation on the process of arriving at the correct answer. A peer responded with a detailed explanation (over 200 words) that included steps and justifications on how to solve the problem. This exchange represents the give and take of online discourse: the help-seeker admitted that they still had a question even after the answer was known, which could be potentially embarrassing, and a peer responded with substantive help.

In the second conversation, a student made an explicit request for help (HS:3) and a peer responded by providing specific resources such as a relevant video and chapter to read. Also, this exchange represents an aspect of social presence because the help-giver communicated a shared struggle in drawing energy diagrams.

In the third discussion, a student made an explicit request for help (HS:3) expressing difficulty with drawing chemical structures. A peer responded with advice on how they approached this kind of problem and ended their comment with “hope that helps” indicating their attempt to offer help. In this conversation, a visual aid would be beneficial for the help-seeker and help-giver for explanatory purposes; however, uploading images was difficult in the learning management system. This example highlights the unique challenges to learning and communicating chemistry content online.

In the fourth conversation, a student explicitly sought help (HS:3) about a specific problem, while it is unclear what the problem in question is. The help-seeker elicited three responses from two students. The first help-giver provided an equation and explained that an ICE table (initial, change, equilibrium concentrations or pressures) calculation was needed to solve the problem. The first help-giver provided the process to solving the problem while recognizing the help-seeker's answer may have been different because they solved problems with different elements and quantities. Another student replied to the help-seeking request with their process for solving a similar problem. The second help-giver provided a substantive response with directions and explained how certain choices were made (e.g., "reaction set under standard conditions"). This discussion demonstrates how students work through their knowledge gaps by seeking help and how they work collaboratively by giving help.

The four conversations between students capture the nature of the help-seeking and help-giving in the discussion forums. From their discourse, it is shown that students work together to address misconceptions and provide guidance and directions needed for problem-solving. These examples speak to how the students' interactions represent cognitive, social presence, and teaching presence.

DISCUSSION

Interpretation of results

Help-seeking and help-giving are integral for peer learning and fostering collaborative sense-making by building social and cognitive presence because much of learning in STEM, including in chemistry, happens in group settings.[31,38–41] This investigation explored the relations between help-seeking and help-giving for students, particularly traditionally underrepresented students in chemistry, in an online college chemistry course's discussion forum.

We found that the majority of initiating posts were not help-seeking requests, and, of all help-seeking requests, only about a third garnered at least one reply. We have several hypotheses about why so many posts were not help-seeking requests. First, even if a student went to the forum intending to ask for help, given that such a large portion of initiating posts were solutions, it is possible that potential help-seekers viewed those posts and found an answer to their question. Of course, we do not have a way of knowing whether that was the case, but, if so, it further supports the usefulness of discussion forums for seeking help via asking questions and information-seeking (e.g., viewing previous discourse to see if a similar question was answered). Second, students' posts only accounted for 5% of their grades; this relatively low percentage may have led students to post whatever took the least amount of time and crafting an appeal for help may have required more investment than what the 5% of their grades was worth. Third, it is possible that the students formed study groups and communicated outside of the course discussion board to ask for and receive help. We suggest this possibility because we found instances in the student-generated introductory, first-week posts where students expressed interest in creating study groups. However, because we could not track help-seeking and help-giving outside of the forum, we can only hypothesize that students did not use the forum for help-seeking and giving because they may have satisfied these needs elsewhere.

Our results showed that when students asked for help, they received more responses than when their posts did not include a request for help. We also found that the explicitness of the request was not related to the likelihood of getting a response. These results are encouraging because they suggest that students can recognize and will respond when someone in their online class community needs help, even if the need for help is implied rather than stated outright. However, the response rate was not high; there were many posts in which students asked for help that went unanswered.

We found that UR-Chem and non-UR-Chem students produced similar levels of help-seeking posts. However, we found that UR-Chem students received significantly more help than their non-UR-Chem peers. These findings indicate that there may be communal values driving these interactions. Research suggests that there is cultural significance in collaborative learning for racially minoritized students[73,74] and that UR-STEM students value communal learning opportunities.[62] This value could be reflected in our sample where most of the students fit into at least one underrepresented category (non-male students make up the majority of students in this course) and their presence may have played a role in driving the dynamic of the interactions and fostering a welcoming and collaborative environment. These positive findings differ from results reported for in-person classrooms;[75,76] help-seeking may be particularly difficult in these traditional in-person classrooms because of the prevalence of stereotypes and microaggressions[77,78] and where social identity markers are more salient.

To answer RQ4, we chose examples of productive help-seeking and help-giving exchanges to shed light on the nature of helpful replies. The examples of help-giving replies provide concrete examples of how students built cognitive and teaching presence by responding with an answer, explanation, and providing resources that addressed the question. Furthermore, the discourse between students speaks to an aspect of social presence, which is communicating in a similar struggle. It is encouraging for students to know that they are not alone in their confusion, and sometimes just knowing they are "not the only one struggling" can be encouraging and help to build community. Future investigations should explore the content and helpfulness of the replies. Although these are a few examples, they speak to the functionality of discussion forums.

Our results demonstrate that UR-Chem students were active in generating requests for help and replying to requests. These findings demonstrate that threats to help-seeking for students traditionally underrepresented in chemistry may be alleviated in the online space relative to what they experience in traditional in-person chemistry courses. We recognize that our findings may not generalize across course-level, discipline, and classes that are less diverse in UR-Chem representation than the course we analyzed for this investigation. However, it was encouraging to see that groups of students that are typically marginalized in chemistry were not shy or hesitant to contribute to the discussion forums and get the help they needed. Overall, these results stress the importance of seeking help especially for students traditionally underrepresented in STEM.

Limitations and Future Directions

Our data were derived from a single semester of an online chemistry course and therefore the small sample of students limits the generalizability of the study. Our results may not generalize to other contexts with less representation of UR-Chem students, however, this is not a concern because context matters, especially when discussing marginalized populations.[79] In all cases, but especially when considering marginalized students, we want to bring attention to the social and systemic barriers that particularly impact the educational experiences of marginalized students.[80–85]

Another limitation is that our investigation does not undertake a student-level analysis of discussion forum interactions. Our results show trends among students, but it would be interesting to explore individual students who were active in requesting help and giving help. We would also like to look for students who are not active in the discussion forums and then become active, or the opposite pattern, and attempt to determine what prompted the change in their behavior pattern. For instance, if a student is active towards the beginning of the semester and does not garner responses, their help-seeking requests may decrease, or they may stop seeking help altogether. There is more research needed in this area.

When we analyzed responses to requests for help, we ignored much of the substance and function of those responses, except to note which words frequently occurred in those responses. We could have also examined whether the replies were instrumental or expedient.[86] That sort of analysis may reveal more information about help-seeking's relation with responses to requests for help. It would be interesting to investigate how potential help-givers respond (or not) to posts where it is evident that the help-seeker is looking for a "quick and easy answer" and not looking to do work on their own.[87] In the future, we plan to undertake qualitative exploration of the responses to requests for help to shed light on the relative helpfulness of responses and how they can help build or undermine the community of inquiry. This will enhance the understanding of the use and efficacy of discussion forums, which can inform instructional practices.

The current investigation leaves room for multiple future studies. Replicating this study in different chemistry courses like organic chemistry and in other STEM disciplines is an area of interest for future work. Furthermore, more investigation into the relation of help-seeking, help-giving, and learning outcomes is needed to give insights into the ways in which help-seekers and help-givers are positioned for positive course outcomes. A motivation for this is to explore whether engaging in metacognition and reflecting on what you know (i.e., help-seeking),[88,89] and then explaining to someone else (i.e., help-giving) is beneficial for learning.[90] Finally, we suggest that future research investigate ways to improve online supports for seeking and receiving help.

IMPLICATIONS FOR TEACHING AND RESEARCH

A major finding from this investigation is that students who are traditionally underrepresented in chemistry do not shy away from seeking help in online discussion forums. Our results imply that educators can normalize the use of online discussion forums to support cognitive and social presence in online chemistry courses. Furthermore, by providing extensive feedback and responding with help, students act as teachers (teaching presence).

We list some practical recommendations for the facilitation of help-seeking and fostering a community of inquiry in online chemistry courses which are informed from experience teaching chemistry online and relevant scholarship. Instructors can:

- start the discussion threads themselves or require discussion participation.
- provide incentives for posting in discussion boards (e.g., give extra credit).
- streamline discussion activities by providing practice problems that encompass a range of difficulties and problem types (e.g., theoretical, numerical, or algorithmic).
- offer positive feedback to students who are using the discussion boards.
- make comments about the value of the discussion boards in lectures/announcements.
- incorporate the conversations and topics discussed in the forums into lectures (e.g., pick one or two help-seeking requests every week to explain in lecture).
- incorporate help-seeking tips into their curricula so that students understand that it is a beneficial learning strategy and not indicative of incompetence. More transparency about the nature of help-seeking and its benefits could lessen students' help-seeking avoidant tendencies.

An implication for research, based on the finding that discussion boards can facilitate digital collaborative learning, is to examine the use and efficacy and different types of discussion forums and whether there are certain features that can improve their quality. For example, features such as ease of uploading images may be advantageous for chemistry students and instructors for communicating diagrams, structures, and visual interpretations.

Ultimately, this work can inform instructional and learning strategies to support student learning in online STEM courses. Above all else, a potentially easily accomplishable task, such as asking for help, can open the door for empowering students to establish social connections and to learn from others.

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