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STEM Faculty's Support of Togetherness during Mandated Separation: Accommodations, Caring, Crisis Management, and Powerlessness

Ian Thacker [1,*], Viviane Seyranian [2], Alex Madva [3] and Paul Beardsley [4]

[1] Department of Educational Psychology, University of Texas at San Antonio, San Antonio, TX 78207, USA
[2] Department of Psychology, California State Polytechnic University, Pomona, CA 91768, USA
[3] Department of Philosophy, California State Polytechnic University, Pomona, CA 91768, USA
[4] Center for Excellence in Mathematics and Science Teaching, Biological Sciences Department, California State Polytechnic University, Pomona, CA 91768, USA
* Correspondence: ian.thacker@utsa.edu

Abstract: The emergence of the COVID-19 pandemic initiated major disruptions to higher education systems. Physical spaces that previously supported interpersonal interaction and community were abruptly inactivated, and faculty largely took on the responsibility of accommodating classroom structures in rapidly changing situations. This study employed interviews to examine how undergraduate Science, Technology, Engineering, and Mathematics (STEM) instructors adapted instruction to accommodate the mandated transition to virtual learning and how these accommodations supported or hindered community and belonging during the onset of the pandemic. Interviews with 25 STEM faculty at an undergraduate Hispanic Serving Institution revealed a wide range of accommodations they made to their courses and how they managed communication with students. Faculty strived to support student belonging with responses ranging from caring to crisis management, though some faculty expressed feelings of powerlessness when unable to accommodate certain challenges. The case of a responsive and flexible instructor is presented to highlight a productive response to a crisis. These retrospective findings point to strategies to support faculty teaching in virtual learning environments in the future; increasing opportunities for student–student and student–faculty interaction, supporting faculty in learning technologies that support these interactions and addressing faculty's feelings of powerlessness.

Keywords: belonging; COVID-19; online instruction; STEM education; higher education

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1. Introduction

The emergence of the COVID-19 pandemic initiated major disruptions to higher education systems [1–3]. Physical spaces that previously supported interpersonal interaction and community were abruptly inactivated, and faculty largely took on the responsibility of accommodating classroom structures in rapidly changing situations. Educators across the world made efforts to adapt to the rapidly changing circumstances of COVID-19 to support their students through academic and life challenges [1], while educators themselves experienced unprecedented personal and professional challenges [4,5]. Instructors in STEM disciplines faced unique challenges, some of whom had previously relied on physical spaces for conducting lab assignments, leading field experiences, or writing equations; and the ways in which faculty adapted to these challenges and supported students personally and academically had significant impacts on student engagement and feelings of togetherness [3,6]. The lens of online learning communities is considered to be foundational to the advancement of research and practice in online learning contexts [7,8].

Despite this prior empirical research, which largely focuses on student outcomes, little is known about the experiences of STEM faculty, the specific instructional methods they

used to adapt to ever-changing circumstances from the pandemic, and the various strategies and general responses to support the classroom community during this time of need. The purpose of this study was to identify online teaching practices that undergraduate STEM instructors at a Hispanic Serving Institution (HSI) employed after the mandated transition to online instruction and the specific strategies and responses they used to support classroom community and relatedness. Now that more than two years have passed since the start of the pandemic, we can learn from the responses of STEM faculty to better inform current practices, given that distance learning is becoming more commonplace at postsecondary institutions [9].

Theoretical Framework

To examine different accommodations for supporting classroom relatedness and community, we drew from the literature on belonging from Self-Determination Theory (SDT). Self-Determination Theory posits that students are motivated to learn when three psychological needs are satisfied: competence, autonomy, and relatedness [10]. Consequently, faculty can provide motivational support that focuses on satisfying these needs. Specifically, instructors can: (a) organize classroom structure, scaffold lessons, and provide feedback to support students' feelings of competence; (b) provide choices, personal relevance, and use non-controlling language to support feelings of autonomy; and (c) take time to interact with students and facilitate interactions between students to support feelings of relatedness and belonging [11,12].

Of the three fundamental needs in SDT, the need for relatedness is central to this study. Relatedness is the need to feel connected with others, including with instructors and other students [10,13–15]. Feelings of belonging and academic engagement can be supported in multiple ways, such as teacher–student relationships [16,17] and student–student relationships [18]—both of which can contribute to students' sense of community [19,20]. Undergraduate STEM students' feelings of belonging to their academic and classroom community predict persistence, achievement, and degree completion, particularly for historically underrepresented groups of students in STEM [15,21–30].

When the COVID-19 pandemic forced universities to transition to virtual instruction and introduce online modalities, new challenges emerged with respect to building learning communities [3,8]. Learning online tends to require a greater degree of self-regulation than face-to-face interaction [31] and demands greater "presence" from instructors and students. Namely, according to the New Community of Inquiry model [8], productive online learning communities require strong social, cognitive, learning, and teaching presences, which are structured by the online setting, content, and means for communication enabled by the online environment. The online learning community and the forms of "presence" are considered to be distributed among students and instructors and is enhanced through student–student and student–faculty interactions, building of relationships, and online discourse, whether interactions occur asynchronously, synchronously, or a combination of the two (bi-synchronously).

University instructors can play a critical role in facilitating relationships and online learning communities. Faculty can act as community organizers who help develop feelings of efficacy, belonging to one's institution, and classroom community, which are key factors that motivate students to pursue and persist through undergraduate STEM programs and are associated with motivational and achievement outcomes [15,21,25–28,32]. For example, a multi-method study surveying and interviewing undergraduate STEM students during the onset of the pandemic at a HSI revealed that students who reported receiving more interactive and synchronous virtual instruction (i.e., synchronous lectures and breakout groups) also experienced greater feelings of belonging, engagement, and STEM interest, with stronger relationships among students who identified as African American and Hispanic/Latinx [6]. Interviews with these students also revealed that they derived feelings of classroom belonging and engagement from the faculty's efforts to support student–student and student–faculty interaction, as well as from experiences outside of class, such

as campus communities and feelings of belonging related to their own confidence and competencies [6]. As such, the specific ways in which faculty adapted their classrooms were linked with consequential outcomes for students.

However, additional research conducted during the onset of COVID-19 suggests that STEM instructors in higher education faced challenges of their own [3–5,33–36], which may have interfered with their ability to establish and maintain community in the classroom. STEM faculty reported encountering issues of inequitable technology access among students, difficulties engaging students in class and in lab activities, and high levels of stress during the early stages of the pandemic [8,35,36], all of which may have contributed to stifling community development. For example, Cheirichetti and Backer [34] collected survey and interview data from engineering faculty in California during the onset of the pandemic. Faculty reported high levels of stress stemming from concerns about their family and students' well-being. They concentrated the majority of their pedagogical efforts on adapting assessments to accommodate the mandated transition to virtual learning, leaving little time to rebuild classroom community. Colclasure et al. (2021) [4] conducted interviews with 14 faculty at a predominantly undergraduate institution in the Midwestern United States and identified that they faced specific teaching challenges (pedagogical, work–life balance, interactions with students, and physical/mental health) and student challenges (lack of motivation and learning patterns, issues with technology access, additional responsibilities students had to attend to, student mental health, and lack of learning community). With regards to the identified lack of learning communities, the authors found that faculty tended to attribute the dissolution of learning communities to the loss of face-to-face learning. Donham et al. (2022) [33] investigated barriers and supports to student learning during the transition to remote teaching at a minority-serving institution in the United States. Interviews with 31 STEM instructors and surveys of 69 students in May of 2020 revealed specific supports and barriers that faculty and students perceived for teaching and learning in STEM. Faculty found interpersonal communication with colleagues to be supportive of their teaching and identified academic integrity concerns and technological difficulties as teaching barriers. Students identified course structure, classroom technology, and community as supports for their learning and identified the virtual classroom environment, student availability, and lack of student–student intercommunication as learning barriers. Further, a review of the literature on school responses to COVID-19 found that students' and instructors' proficiency and training in using technology for distance learning was important for knowledge building [37], and the authors concluded that institutions should create structures for knowledge sharing in this regard (c.f. [38]). Although these studies did not specifically investigate specific practices that faculty used to respond to the issue of student belonging in the classroom, they do begin to underline the presence of numerous personal and professional obstacles along their path during the virtual transition to online learning.

In addition to identifying faculty challenges, some researchers have investigated specific approaches and strategies that faculty adopted during the pandemic. Kim et al. (2021) [5] interviewed 37 college instructors across multiple disciplines about whether they were able to focus on addressing the development of "whole students", along with teaching the subject matter. Findings revealed that faculty adopted three different approaches: empathy and caring, reflectivity and facilitating of inquiry, and adaptability and flexibility in supporting students. Nearly all faculty engaged in practices to support classroom community, such as helping students to "get to know each other".

Despite this research covering the breadth of faculty experiences of stress and hardship during the onset of the pandemic and the general approaches to modifying instruction that they adopted, few studies specifically investigated the concrete tools and techniques faculty employed to build community among students in STEM, and even fewer were conducted at HSIs representing historically under-represented groups of students in STEM.

We therefore asked:

1. How did STEM faculty adapt instruction and communication with students to accommodate the mandated transition to virtual instruction?
2. How did STEM faculty respond to challenges during the virtual transition to support classroom community and relatedness?

2. Methods

To answer these research questions, we conducted 25 interviews with STEM faculty at an HSI in the southwestern United States during the early days of the COVID-19 pandemic (May of 2020). This study was also conducted in tandem with a related study led by our team that concentrated on student perspectives and outcomes conducted in STEM courses at the same institution [6].

2.1. Participants

One-on-one interviews were conducted with 25 STEM faculty; 40% were non-tenure track (lecturers, adjunct professors, or assistant adjunct professors) and 60% were tenured/tenure line (assistant professor, associate professor, professor, professor and associate chair, professor emeritus). Faculty were mostly men (72%), and from the colleges of science (60%) or engineering (40%). Faculty had a median age of 42 years old and identified as White (60%), Asian (28%), Black/African American (8%), or another race (4%), and 12% indicated that their ethnicity was Hispanic. All faculty were provided with informed consent forms prior to participating and were compensated USD 50 (funding for their on-campus account) for participation. All study procedures, materials, and informed consent forms were registered and approved by the Institutional Review Board of California State Polytechnic University (IRB-20-83).

2.2. Faculty Interviews

STEM faculty were interviewed from 11–21 May 2020, during the week immediately following the end of the semester. Interviews were conducted in a one-on-one setting via Zoom by five different interviewers: three faculty, one project evaluator, and one graduate student. Interviewers asked faculty 10 questions with follow-up questions and probes about how they were coping with the pandemic, specific changes they have made to their courses as a result of the pandemic, challenges and successes during the transition, and about how students' sense of belonging and classroom community have changed as a result of the pandemic, if at all (see Appendix A for interview questions). These interviews had an average duration of 47 min (SD = 8.5 min).

2.3. Qualitative Analytic Strategy

All interviews were recorded through Zoom. They were transcribed, open coded, and then analytical memos were constructed by the research team [39,40]. Through iterative coding and reflection [41], a number of themes emerged that highlighted dimensions of classroom accommodations made by faculty to support student feelings of connectedness and belonging. Codes were created, compared, consolidated, and used to create a codebook before it was used by two undergraduate research assistants who independently coded all transcripts. An NVivo query revealed that all central codes had interrater agreement greater than 95% at the sentence level. Incidents of codes were included in the analyses if they had been coded by one or more of the coders. The final codebook with definitions is presented in Appendix B. Lastly, we conducted a case-study analysis [42,43] and assessed the entire body of analyses produced during the study in order to refine, confirm, or refute our preliminary codes and themes.

3. Results

3.1. Accommodations to Instruction (RQ1)

To answer our first research question, we present frequency counts of codes from faculty interviews (Table 1). Results show that instructors used a variety of synchronous

and asynchronous teaching modes and methods to keep in contact with students, with the most frequent mode of instruction being asynchronous pre-recorded lectures, followed by student–teacher interaction during whole-class discussion.

Table 1. Teaching Practices and Responses to Challenges to Supporting Student Relatedness Reported by Faculty During Interviews (N = 25).

Variable	%
Accommodations (RQ1)	
Asynchronous Use of Pre-Recorded Lecture	96%
Student–Teacher Interactions During Whole-Class Discussion	92%
Communication with Students via Email	72%
Student–student Interactions During Whole-Class Discussion	56%
Synchronous Office Hours	52%
Asynchronous Discussion Boards	28%
Breakout Groups for Formal Interaction	12%
Survey Distributed to Class	12%
Texting with Students	8%
Breakout Groups for Informal Interaction	4%
Responses to Challenges (RQ2)	
Caring for Students	100%
Crisis Management	100%
Powerlessness	32%

Faculty also communicated with students via email, synchronous office hours, and two faculty reported that they kept in contact with students via text messaging. Faculty also supported inter-student communication by creating opportunities for whole-class discussions, breakout groups for formal and informal interactions, and through asynchronous discussion boards. Some faculty also distributed surveys to students to check up on them and inform their practice. All faculty engaged in efforts to communicate with students and accommodate their academic and personal needs during this time of crisis, with some faculty dedicating specific efforts to creating spaces for students to interact with each other.

3.2. How Did STEM Faculty Respond to Challenges during the Virtual Transition to Support Classroom Community and Relatedness? (RQ2)

A theme that emerged from STEM faculty interviews regarded their general responses to challenges to supporting student relatedness during the transition to online learning (see Table 1 for a summary). Ultimately, the interview data revealed that responses fell into three categories: faculty expressed that they cared for their students (100%), expressed that they took action to manage crises and solve problems (100%), and expressed a sense of powerlessness over some student challenges that they were unable to address (32%). Below, we elaborate on each response and provide examples.

3.2.1. Caring

All faculty expressed a sense of caring about students in statements emphasizing that they like, respect, accept, take seriously and show concern for students affected by the pandemic. For example, one STEM faculty noted that she would check in with students during the first few minutes of her synchronous lecture:

> I will simply say, 'Hey, guys, how are you doing? Hopefully, everybody is safe. Hopefully everybody is staying home. Hopefully everybody is practicing safety guidelines. Hopefully everybody's family and friends are safe.' . . . Towards the end of the semester, [a student] told me, 'I really appreciate those little things you say at the beginning of the class. It makes me feel so much better.'

Other faculty showed increased levels of encouragement and compassion. One faculty member said, "I always try and tell them how great they are. But I've amped it up about

100 fold [after the lockdown]". Another said that the crisis "...has made me much more patient, and not that I wasn't understanding or compassionate before, but much more so than I was and understanding and lenient". Other faculty increased the amount of contact they made with students. One faculty member said:

> I also decided that, when I got the feeling that they needed me the most. I left my cell phone number so they can text me, especially if they have difficulties with those online quizzes . . . Just, you know, I don't want them to stress.

This finding is consistent with Kim et al. (2021) [5], who conducted interviews with 23 faculty from across multiple disciplines and found that many approached their students with empathy, care, and by centering student emotions.

3.2.2. Crisis Management

All faculty shared instances when they had to make quick decisions and take action to accommodate the transition to virtual learning. A common problem that many STEM faculty encountered was the challenge of writing complicated equations in an online environment without the use of chalkboards or whiteboards. One faculty member noted,

> My normal presentation style involves a lot of drawing on the blackboard, which unfortunately the Zoom tool for doing that is terrible. So, actually, early on I went out and bought a whiteboard and set it up in my closet. I've been working it, I've been doing most of my lectures from the closet because it's the room that has a door on it and keeps the toddler out.

This situation highlights an instance where faculty rapidly adapted to emerging personal and professional crises. While this instructor adapted remote instruction to replicate face-to-face situations, other faculty responded to crises by developing new ways of engaging students (see Section 3.3 Case Study for an example), as found in prior research [3].

Faculty also reported responding to crises by adopting new technologies to replicate face-to-face situations. Faculty purchased document projectors, downloaded apps for tablets, and scanned pdfs of handwritten equations on paper to accommodate this challenge (c.f. [37]). However, while not all STEM disciplines encounter the issue of equation-writing, other disciplines encountered their own unique challenges. For example, an earth sciences professor discussed the challenge of adapting a field-based geology course for online instruction, noting that for the main field experience:

> I did it synchronously, actually, on Zoom. We did like four hours a day, two days in a row . . . And so, you know, basically we alternated between having the students watch YouTube videos and then some Q&A sessions. And, you know, sometimes I throw a few extra slides or do like a Google Earth tour of the field site or something like that.

In addition to using visualization technology to replicate the learning content from a field experience, this instructor also shared that they aimed to replicate social experiences, for example, by displaying a campfire animation on Zoom fifteen minutes before class began to encourage informal student–student conversation. Despite these efforts to manage this crisis and support student belonging, this instructor noted that the field experience simply "wasn't the same". Many of the STEM faculty that we interviewed mentioned the challenges of adapting lab and field experiences for an online environment, oftentimes lamenting the inadequacies of virtual environments for their subject matter. The challenge of adapting lab experiences for remote instruction was also a common theme among studies on STEM faculty responses to the pandemic [3]; and supporting faculty in this regard remains an ongoing concern [37,38].

3.2.3. Powerlessness

Although all instructors expressed care for students and took active steps to manage students' learning needs and crises in the context, some instructors described certain challenges as seeming insurmountable and approached these situations by attributing external causes and expressing a general sense of powerlessness to overcome them. Feelings of powerlessness were often expressed in terms of situations in which faculty felt that they could do nothing to change the situation, as evidenced by statements from faculty indicating that some student situations were outside of their control or that some situations were the students' responsibility to handle.

Some faculty shared that creating spaces for student–student interaction was particularly difficult because of the transition to online learning and implied that addressing the issue was outside of their control. For example, when explaining that students were no longer working together on group projects, a faculty member said, "Every person ha[d] a partner and that has pretty much fallen away . . . I don't think they really see much of a sense of working in partnership if they're not together in the lab. So I think that's been a loss". Other STEM faculty described the challenges of recreating socially interactive classroom and lab environments as "really hard", "disconnected", "absolutely frustrating", "a real loss", with some lamenting that they simply "have no information" about student interactions. This suggests that STEM faculty who felt unable to support student–student interactions in their classes also tended to experience a depleted sense of agency and powerlessness.

In addition to declining student–student interactions, some faculty commented on a general decrease in teacher–student interactions and class participation in their courses after the transition to virtual learning. Some noted the hopeless feeling of seeing unresponsive "black rectangles" on a screen and declining attendance and participation in class. One instructor said, "I will be spending an hour talking and the only thing you hear is that silence". Another said:

> I am asking myself, are they still there? So, I keep on checking the participants and I see that, a couple of things, 80 in one class, 60 in another [out of 120], they have stopped coming altogether after one week. But it's nothing I could really do.

Some professors were very distraught about declining participation and opportunities to interact with students, some even expressing that they intended to change professions due to the associated anxiety. Instructor powerlessness over supporting students' sense of community may be one (of many) potential factors that explain feelings of stress and anxiety expressed by faculty in prior research conducted during the onset of the pandemic [4,34].

3.3. Case Study: Terry's Synchronous Physics Course

To illustrate the themes and codes related to STEM faculty's accommodations and approaches during the virtual transition, we present the case of Terry, the pseudonym of a STEM faculty member who responded to emerging crises with flexibility and caring. Terry was an adjunct instructor of physics and taught several synchronous introductory physics courses. Terry was in good spirits during the interview. When asked how their life was impacted by the pandemic, Terry said, "I don't mind not driving everywhere", expressing relief that their six-hour commute between multiple universities was eliminated due to the transition to virtual learning.

Terry enjoyed teaching online better than in person and viewed the transition to virtual learning as an opportunity to improve their approach to teaching. When redesigning the course, Terry borrowed ideas from the gaming community to improve the accessibility and quality of online instruction and adopted a host of technologies to make it work. Terry made use of various software and online platforms. While revamping synchronous lectures, Terry used live-streaming through YouTube, which allowed for multiple levels of video quality for students with poor internet as well as protection of the audio and video feed against "Zoombombers". Terry also used Xplicit to quickly switch between

multiple cameras to capture the lecture and written equations and mentioned regularly using Gradescope and Top Hat for assessment and classroom management. Terry shared that, during this revamping, the main focus was on ensuring that students have the tools to master the course content: "I just want to get students to learn the stuff they need to be okay next semester, and not really worrying about grades".

Terry noticed changes in student–student and student–instructor interactions as a result of the transition to virtual learning and thought it was important to create comfortable spaces for students to maintain personal connections with each other. In response to increasing feelings of isolation among students, Terry said,

> I've tried to sort of cheer everyone up. You know, I'll bring my cat in front of the camera every now and then and make a joke or tell something about my personal life at the beginning of every lecture for just a minute or two. Just try to make life and not just business. And the students seem to appreciate that.

Another strategy Terry used to support student–student interaction was opening the course 20 min early to allow students to interact in the chat, "sometimes students will join, and they'll be talking to each other in the chat".

However, there were tradeoffs that Terry experienced by opening the classroom up to student interaction. Terry had initially used Zoom to run the classroom, allowing the class to contribute to the audio and video experience of the class, but transitioned to YouTube after experiences of "Zoombombing". Terry noted that YouTube "makes it fairly easy to block any Zoombombing, you know, as they're calling it now. There's just no way for them to add any audio or video into my stream. They're only there on the chat and then on the chat it only takes one button to hide the chat or kick the person out. So, it's fairly easy to control the environment on YouTube . . . .". Terry switched instructional platforms to limit students' means of interaction but was careful to ensure that they still had a way to interact. As with Terry, many faculty members were thrust into situations requiring crisis management and had to resolve tensions between too much and too little control over the environment.

Terry represents an instructor who cared about the students, showed substantial grading flexibility and adaptability, and responded swiftly to crises with action. Terry also seemed to have background knowledge of technologies that were transferred to the current context. Like Terry, all faculty also expressed care for their students and made accommodations for their courses, although not all were as technology-savvy as Terry, nor as quick to respond to challenges and ever-changing circumstances. Terry's pedagogical decisions and skills seemed to effectively nurture the students' feelings of inclusion and connectedness, which we discuss in the next section.

4. Discussion

We sought to learn how faculty adapted their classrooms to accommodate the pandemic and what approaches they took to support classroom community and relatedness. We found that faculty made numerous accommodations to their courses by adjusting how they communicate with students and by creating new opportunities for students to communicate with each other and occurred in both synchronous and asynchronous settings.

Interviews also revealed that STEM faculty unanimously showed deep care for their students, which was expressed as empathy, liking, respect, acceptance, or taking students seriously. Consistent with Kim et al. (2021) [5], we found that faculty approached the pandemic crisis and transition to virtual learning by centering student emotions, checking in regularly with students, and adapting and accommodating instruction to meet students' learning needs, including providing increased academic support, flexibility, adding effort to improve instruction, or reaching out to students personally.

Such efforts on the part of faculty have been shown to have meaningful impacts on students' motivation and engagement, as shown in our parallel study surveying and interviewing students at the same institution during the same time frame [6]. Namely, in our multi-method study, we surveyed and interviewed undergraduate STEM students

during the onset of the pandemic at an HSI. Findings revealed that students who reported receiving more interactive and synchronous virtual instruction (i.e., synchronous lectures and breakout groups) also experienced greater feelings of belonging, engagement, and STEM interest, with stronger relationships among students who identified as African American and Hispanic/Latinx [6]. Interviews with these students also revealed that they derived feelings of classroom belonging and engagement from the faculty's efforts to support student–student and student–faculty interaction, as well as from experiences outside of class, such as campus communities and feelings of belonging related to their own confidence and competencies [6]. The current study investigated faculty perspectives behind the efforts to support togetherness during the transition to online learning and illustrated effective strategies and responses to major challenges.

As such, our findings may be useful for college instructors and policymakers redesigning online learning environments to foster relatedness. Faculty efforts to support interpersonal relations and classroom community have a meaningful impact on students. Although faculty efforts in the current study occurred spontaneously as a result of necessity imposed by the pandemic, institutional structures should be put into place to add additional support for interpersonal relations in virtual learning spaces [38]. As distance learning becomes more commonplace in higher education [7], enhancing synchronous and asynchronous interactions between students and their peers and instructors may be important at many levels (e.g., for belonging, self-efficacy, and academic performance), particularly for under-represented groups in STEM (c.f. [6,44–46]).

Faculty also demonstrated strong crisis management abilities in handling unanticipated challenges as they arose. Consistent with prior research, we found that flexibility was a major hallmark of effective crisis management [5], yet our findings provide a more nuanced illustration of the STEM-specific crises that arose as a result of the virtual transition to online learning. Faculty needed to rapidly make accommodations due to prohibited use of laboratory spaces, field experiences, and physical tools for writing mathematical equations. Such pressures led faculty to generate innovative solutions such as rearranging physical spaces in their homes, adopting new technologies, or enhancing their knowledge of existing technologies. However, many faculty mentioned that some of the virtual substitutes for in-person laboratory or field experiences were inadequate (c.f., [3,6,34,36]). As such, administrators, policymakers, and curriculum designers in higher education should take into account the unique needs of STEM faculty in online learning settings and prepare more detailed plans and invest in unearthing innovative strategies for accommodating discipline-specific laboratory experiences in online settings. In this way, it would alleviate the burden and responsibility for faculty to facilitate student success in virtual settings.

We also found that challenges associated with fostering an online community—such as the lack of participation on Zoom and persistent absences—appeared to some faculty as impossible to overcome, which manifested as a sense of powerlessness. Feelings of control are related to self-determined motivation and persistence [10], and faculty need to be supported in feeling in control of their course environment to avoid feelings of powerlessness. Higher education institutions should therefore attend to both students and faculty with the goal of supporting their feelings of agency and reducing a sense of powerlessness (also see Bensimon et al., 2019 [47]).

4.1. Limitations

As with all research, this study has necessary limitations that we would like to acknowledge. Namely, there is a possibility that our sample was not fully representative of STEM faculty experiences during the lockdown. This study was conducted approximately two months after the lockdown mandates and transition to online learning, and there may have been faculty who chose not to participate in our study because severe COVID-19 threats (e.g., economic, health, or childcare demands) outweighed the benefits of participating in our study. Although we made efforts to incentivize faculty to participate in the study and contacted faculty across all departments, sampling bias may still be an issue.

4.2. Implications

Despite the limitations, this study has implications for college instructors and policymakers redesigning online learning environments to best support student feelings of belonging and community.

First, increasing opportunities for synchronous peer–peer and student–faculty interactions may be key for helping students navigate the feelings of isolation and lack of belonging that can result from a purely virtual college experience. In our parallel study, we found that many students in STEM courses relied on synchronous modalities such as interactive lectures, office hours, and synchronous chat features to feel connected to their class, with prominent benefits for students who identified as black or Hispanic [6]. Interactive lectures, chat windows, synchronous office hours, and breakout rooms are standard options for online teaching, but our findings suggest that rates of instructor use of these options could be significantly increased. Professional development geared towards supporting faculty as they use technology to enable student–student and student–faculty interactions is one possible remedy for this issue. However, further research is still warranted to investigate effective discipline-specific strategies that STEM faculty can employ to help engage and foster a sense of community, social interaction, and belonging for students studying STEM in online settings. These insights would be useful to share with any faculty who find themselves having to transition to online learning in the future.

Second, our findings highlight the importance of investing in technology training for faculty and developing strategies to promote flexibility in educational delivery. Terry illustrates the case of faculty who showed high levels of adaptability and innovation in acting fast to synthesize multiple technologies to support student interaction. This quick action was dependent on Terry having a high level of technology proficiency and skillset that could be incentivized by institutions of higher education in professional development.

Third, faculty themselves experienced stress and anxiety as a result of feeling powerless against low levels of student participation and attendance rates. Institutions of higher education might anticipate this issue in the future by systematically encouraging student–faculty communication, student–student communication, supporting students who may have issues with technology or connectivity, and providing faculty with physical and mental health support to cope with a sense of powerlessness. Another means of preventing feelings of powerlessness among STEM faculty might be to provide them with special training around STEM-specific teaching methods for increasing student participation and community in online learning spaces. If equipped with effective tools and strategies for enabling and facilitating classroom interactions, STEM faculty may feel a heightened sense of empowerment and agency when teaching online.

Fourth, our findings showed that STEM faculty rose to the situation and showed high levels of empathy and care for students during a time of crisis. Future research might follow up with faculty to assess whether such high levels of care have endured in the years that have passed since the onset of the pandemic and what effect this may have had on students.

5. Conclusions

In sum, our study suggests that STEM faculty strived to support togetherness and classroom community by managing crises and expressing care for students during times of mandated physical separation. Our findings generally suggest that increasing opportunities for student–student and student–faculty interactions may be key for helping students and faculty navigate feelings of isolation that can result from a purely virtual college experience. STEM faculty accommodations and responses to crises offer lessons learned that might inform STEM instructors and administrators. Briefly, between this study and our related study [6], findings suggest:

- STEM faculty efforts to support social interaction between students and faculty seemed to have important benefits for student engagement and belonging. This was true for both asynchronous and synchronous practices and was consistent across faculty and student reports.

- Technology proficiency seemed to be related to faculty adaptability. Institutions of higher education should consider directing resources toward supporting classroom technology proficient STEM faculty with a focus on enhancing social interactivity.
- Helping STEM faculty create or re-create classroom communities and lab environments in online spaces might also help them feel increased agency and efficacy, and decrease powerlessness during times of crisis.

Practitioners and researchers should consider the unique challenges facing STEM faculty when building online classroom communities—such as replicating laboratory and field experiences—and designing and testing professional development programs to empower them with the skills to persist through and overcome those challenges.

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Appendix A

Faculty Interview Prompts
(Note, sub-items represent potential follow-up questions.)

1. How has your life changed as a result of the pandemic?
   a. How are you coping?
   b. How do you feel about it?

2. How are you balancing the needs of yourself, your family, and loved ones with the needs of your students and the university?

3. How has your course changed as a result of the pandemic and the online transition?
   a. How do you feel about it?

4. How was the transition to online teaching?
   a. What has been going well in this transition?
   b. What has been a challenge in this transition?

5. What kinds of accommodations have you made to your course to support students during the pandemic?
   a. How effective has [this accommodation] been so far?
   b. Any other accommodations you have made?
   c. [If not mentioned] How have you modified exams and/or handwritten homework assignments?

6. How do you think students' sense of belonging in the course (classroom community) has changed due to the online transition and the pandemic, if at all?

7. Is there anything that you have done to support students' social connections and sense of community during this online transition?
[If participant simply replies "yes"] What specifically have you done to support students' social connections and sense of community during this transition?

8. What is your biggest worry right now?

9. What are you hopeful for right now?

10. We would love to hear anything additional you think is important for us to know about how you are coping with the pandemic and teaching during this time.

Potential Probing Questions Applicable to all Items
a. *Can you tell me more about . . . ?* b. *Can you give me an example?* c. *How do you know?* d. *I don't understand.*

Appendix B

Codebook for Faculty Interviews	
Synchronous Practices	
Texting	Evidence that the instructor was texting or receiving texts from students about coursework (e.g., upcoming assignments, quizzes, etc.) or outside of regular coursework (e.g., health, safety, housing, family issues, etc).
Synchronous, Whole-Class Interactions (S-T)	Evidence that the instructor was using live-stream technology to deliver formal instruction and assignments to their class (e.g., gave lectures through Zoom or through a live YouTube feed) or informal content (e.g., to have a conversation to check in with students to see "how they are doing").
Synchronous, Whole-Class Interactions (S-S)	Nudges, activities, or spaces created by the instructor to intentionally support group building and inter-student connections (e.g., instructor put up animation of campfire and walked away from computer to allow students to chat). This also includes evidence that the instructor was aware of students live-chatting about course topics with each other about formal or informal topics during synchronous interactions.
Breakout Groups	Evidence that the instructor used breakout groups to encourage students to discuss course material or to discuss topics outside of course material (e.g., used breakout groups for informal check-ins).
Office Hours	Evidence that instructor held live office hours to support students' academic or personal needs
Asynchronous Practices	
Email	Evidence that the instructor emailed students about coursework (e.g., quiz grades, upcoming assignments) or informal topics (e.g., about health, safety, housing, family situations, etc.)
Asynchronous Interaction (S-T)	Evidence that faculty used technology to asynchronously deliver instruction (e.g., using blackboard to post pre-recorded lectures, receive assignments, give feedback on assignments, administer quizzes or exams, etc.) or about informal topics
Asynchronous Interaction (Discussion Boards) (S-S)	Evidence that faculty required students to use asynchronous technology to interact with each other about coursework (e.g., participate in student-led discussion boards about course topics) or about informal topics (e.g., respond to the prompt, "what is your favorite pizza topping")
Surveys & Responses	Evidence that instructors gathered formative feedback from students (e.g., surveys, class-emails, discussion board, asynchronous poll) to assess formal aspects of instruction and coursework (e.g., assessed whether students enjoyed online assignments or whether lecture is "moving too fast", etc.) or informal aspects of students' lives that fall outside of normal coursework (e.g., to assess students' emotional state, ask about how students are coping, or about safety issues, etc.)

Codebook for Faculty Interviews	
Approaches, Behaviors, Feelings	
Caring	Evidence that faculty expressed thoughts, behaviors, or feelings that they care about students and want them to feel as if they belong or are accepted (e.g., statement showing that they like, respect, accept a student, take students seriously or show concern for students who may be lonely).
Crisis-management/Problem-Solving	Evidence that faculty member reacted to pandemic-specific situations or crises (e.g., responding to a technology issue with online testing that was not present before the pandemic, cold call students or ask intense questions to get a rise out of unresponsive "black boxes", emails to students that have critical absences or who have missed crucial assignment due to the pandemic).
Inaction due to a sense of powerlessness	Evidence that faculty member did not take action in on a particular issue because they felt that they could not control the situation (e.g., talks about declining student interaction and togetherness due to absences as if it is outside of their control, there is nothing they can do about it, or as if it is the students' responsibility).

Note. S-T indicates that the code refers to student–teacher interactions. S-S indicates that the code refers to student–student interactions.

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