2024

"I'm Not Teaching Them Per Se": Designing and Delivering Asynchronous Undergraduate Online STEM Courses

Regina L. Garza Mitchell
Western Michigan University, regina.garzamitchell@wmich.edu

Whitney DeCamp
Western Michigan University, whitney.decamp@wmich.edu

Brian Horvitz
Western Michigan University, brian.horvitz@wmich.edu

Megan Grunert Kowalske
Western Michigan University, megan.kowalske@wmich.edu

Cherrelle Singleton
Western Michigan University, cherrelle.j.alexander@wmich.edu

Innovative Higher Education (2024) 49:91–111
https://doi.org/10.1007/s10755-023-09670-9

"I'm Not Teaching Them Per Se": Designing and Delivering Asynchronous Undergraduate Online STEM Courses

Regina L. Garza Mitchell[1] · **Whitney DeCamp**[2] · **Brian S. Horvitz**[1] · **Megan Grunert Kowalske**[3] · **Cherrelle Singleton**[1]

Accepted: 31 July 2023 / Published online: 28 August 2023

Abstract
Although online courses have been a part of academia for nearly 30 years, they are still perceived as "different" than face-to-face instruction. Through in-depth interviews with four instructors, we explored how STEM faculty approach teaching asynchronous online undergraduate STEM courses. The faculty interviewed for this study viewed online courses as "not regular class[es]" and teaching those classes as "not teaching per se." Each of the instructors had assumptions about what a classroom was and about good instruction, but even for instructors who taught online for multiple years, those assumptions remained grounded in the face-to-face environment. There is a need for greater discussion about what it means to teach in an online environment.

Keywords Online education · Undergraduate STEM · Teaching · Technology · Pedagogy

"I'm Not Teaching Them Per Se": Designing and Delivering Asynchronous Undergraduate Online STEM Courses

Historically, university undergraduate science, technology, engineering, and mathematics (STEM) courses – particularly those that require laboratory work – have been averse to incorporating online instruction (Horvitz & Zinser, 2011; Seaman et

✉ Regina L. Garza Mitchell
regina.garzamitchell@wmich.edu

[1] Department of Educational Leadership, Research, & Technology, Western Michigan University, Kalamazoo, MI, USA

[2] Department of Sociology, Western Michigan University, Kalamazoo, MI, USA

[3] Department of Chemistry, Western Michigan University, Kalamazoo, MI, USA

al., 2021; Walton Radford, 2011). Despite the reluctance to put STEM courses online, the growth of online courses outpaced that of higher education overall prior to the COVID-19 pandemic (Seaman et al., 2018, 2021). As a result of both planned expansion and the emergency shift to online instruction with the advent of the pandemic, many institutions have increased their online offerings, even in STEM fields. However, moving STEM courses online requires more than a shift of venue.

The use of technology – particularly online instruction – alters instruction and instructional practices (Major, 2015; Major & McDonald, 2021). It also changes the way that faculty work and the type of work that they perform (Garza Mitchell, 2009; Smith, 2010). A shift to teaching online affords an opportunity to examine instructional choices and (re)consider how faculty approach instruction. This change in modality also offers the potential to alter instructional choices to improve undergraduate STEM teaching (Major, 2015). This type of change in teaching must go beyond individual faculty and encompass the broader systems in which they work (Association of American Universities (AAU), 2017; Dancy & Henderson, 2005). Systemic change, however, is not possible until we are first able to take stock of what individuals are currently doing and why. A better understanding of current teaching practices and related perspectives is therefore a prerequisite for building towards institutional or discipline-level change.

In this study, we explored how four faculty members approached teaching asynchronous online undergraduate STEM courses, with particular attention to how they engaged in teaching. The purpose of this study was to explore how instructors design and teach asynchronous online courses. Asynchronous courses are online courses that do not require real-time meetings between instructors and students, allowing students to complete the coursework at different times of day; asynchronous courses can and typically do, however, have time frames and deadlines for completing assignments. The guiding research question was: How do instructors design and teach asynchronous online undergraduate STEM courses? The decision to use asynchronous courses was guided by several practical and theoretical considerations, including: (a) that asynchronous online courses were more common at the selected university at the time of data collection, (b) that asynchronous courses are presumably more distinct from in-person or synchronous courses given the communication difference, and (c) the potential challenges in creating instructor presence, as described in the CoI framework (Garrison & Arbaugh, 2007) when content and communications are not shared in real-time.

Community of Inquiry

When online courses are taught asynchronously, students and instructors do not meet at the same time. Instead, instructors create or provide course materials, usually placed within a course management system, and students may access the materials at their own pace (though there may be deadlines). Teaching asynchronously can be complicated, and communication cues may be missing or misinterpreted. Instructors are not always aware of these subtleties and how they may impact the teaching and learning environment (Major & McDonald, 2021), and some may have the incorrect

assumption that teaching in this manner is a matter of simply providing materials and allowing students to work on their own, without interaction beyond email.

However, effective teaching requires engagement (Barkley & Major, 2022), regardless of the setting. The community of inquiry (CoI) framework for online education suggests that a deep, meaningful learning experience can be created in an asynchronous online environment through developing social, cognitive, and teaching presence (Garrison & Arbaugh, 2007; Garrison et al., 2000, 2010). Social presence refers to building community and developing interpersonal relationships (Garrison & Arbaugh, 2007). Cognitive presence focuses on the extent to which learners construct and confirm meaning through discourse and reflection (Garrison et al., 2010). Teaching presence refers to the design and organization of the course and the way(s) in which the instructor facilitates discourse and directs instruction (Garrison & Arbaugh, 2007; Wilson & Berge, 2023). Rather than focusing solely on *teachers*, teaching presence considers the roles of both instructors and students working in collaboration to form a community. As Shea et al. (2022) describe, "the CoI model stresses that whereas instructors provide leadership in teaching presence, students are also involved in its development and maintenance" (p. 151). The teaching presence aspect is key to creating the types of interactive learning experiences desired in an online environment and is the basis for framing this study.

Teaching presence is a necessary element of the CoI framework, as this is how the social and content-related interactions are defined (Garrison & Arbaugh, 2007), and it serves as the framework for this study. Meaningful teaching presence requires an instructor to be knowledgeable about not just the technology but to consider how their choices in organization, design, and interaction are perceived by students and whether the actions will result in the intended outcomes. It also implies that course design plans for student engagement and interaction among and between students and instructors. This perspective aligns with the concept of TPACK in that instructors must make connections between how technology is used in relation to pedagogy and content, which may result in different knowledge about and approaches to teaching (Mishra & Koehler, 2006).

TPACK

Mishra and Koehler (2006) developed a framework aimed at developing instructional knowledge for technology integration called technological pedagogical content knowledge (TPACK) to think about what teachers need to know about teaching with technology, including online, and how they might develop it. The premise is that there are three components at the heart of good teaching: content knowledge, pedagogy, and technology – and the relationships between them (Koehler & Mishra, 2009). The relationships between these elements form a new knowledge, which is TPACK (Barkley & Major, 2022; Koehler & Mishra, 2009; Major & McDonald, 2021). TPACK is necessary because in order to effectively teach online, instructors must understand not only how to use technology but the ways in which the technology interacts with pedagogy and the assumptions behind its use. For example, inter-

action using an asynchronous discussion forum presents a different conversation than a group of people sitting together in a room discussing the same topic.

Teaching in an online environment is complex, and knowing how to use technology is not enough to ensure effective teaching occurs. Part of the problem in teaching with technology, particularly teaching online, is the tendency to look only at the technology rather than how it is used (Mishra & Koehler, 2006). Instructors must be able to use different technologies and determine how they best serve their teaching and learning goals (Major & McDonald, 2021). Simply using technology or putting a course online does not mean that pedagogical innovation occurs (Kirkwood & Price, 2014; Koh, 2020) or that a course has been designed for engagement in learning. Thus, instructors who teach online must not only consider what constitutes good teaching but how they can use available tools to promote effective teaching and learning in an online environment.

Teaching Online

More than six million undergraduate students enrolled in at least one online class in 2019 (Seaman & Seaman, n.d.), but it is unknown how many of those courses were in STEM fields. One report on teaching STEM courses online during the COVID-19 pandemic indicated that there are no "hard data on STEM enrollments" in online courses, though there is a perception that STEM lags behind other disciplines in regard to online offerings (Seaman et al., 2021, p. 5). A 2008 study conducted by the United States Department of Education found that students enrolled in computer and information sciences programs participated in online coursework at a higher rate (27%) than the then-average 20% of all undergraduate students (Walton Radford & Weko, 2011). However, it is unknown whether those courses were in the STEM field. The same study indicated that 8% of students in computer and information science enrolled in distance education degree programs compared to 4% of all undergraduate students, while students enrolled in other STEM programs tended to enroll in both distance education courses and programs at *lower* than average rates. This outcome is not surprising given the traditional hands-on approach to many STEM courses, particularly in laboratory situations.

Faculty who taught STEM courses online during the pandemic expressed concern about students' ability to complete laboratory assignments online and about the online environment and students' preferred learning styles, but were optimistic about online laboratory work - though one faculty member noted that "it takes a lot of thought, time, and development effort to make that happen" (Seaman et al., 2021, p. 20). Overall, the study revealed mixed faculty perspectives about the shift to online STEM education.

Two major shifts are occurring for faculty teaching online, one in the way that teaching and learning occurs and the other in the very nature of teaching work itself. Faculty moving a course online may do so on their own, sometimes in consultation with an instructional designer, or they may use a course that was previously developed by another instructor or course designer.

The nature of online courses has pushed and reshaped the essential tasks and skill sets that faculty have traditionally held. This new pedagogical skill set is dominated by instructional design theories and principles that describe how to accomplish the essential online course tasks. (Smith, 2010, p. 49). The shift to teaching online results in structural changes to teaching, such as how a course is delivered, the tools and technology associated with course delivery, and course design (Garza Mitchell, 2009). The potential also exists for changes to the faculty role.

The sharing or splitting of tasks associated with instruction is broadly referred to as unbundling. For example, rather than a single faculty member overseeing a course, the roles may be split into course design, delivery, and assessment (Gehrke & Kezar, 2015; Smith, 2010). Thus, a faculty member teaching online may or may not design and develop the course that they are teaching.

Undergraduate STEM Teaching

The desire to improve undergraduate STEM education is well documented (AAU 2017; Henderson et al., 2011; Miller et al., 2021; President's Council of Advisors on Science and Technology (PCAST), 2012; Singer et al., 2012). Changes in teaching and learning require systemic change in order to normalize evidence-based teaching approaches that improve student learning and retention (AAU, 2017; Dancy & Henderson, 2005; Henderson et al., 2011). Shifting to teach STEM courses online requires additional adjustments related to technology, pedagogy, and course design.

Traditional models of instruction center lecture as a primary means of teaching. Despite evidence that shows diversifying teaching strategies improves student learning and engagement (e.g., PCAST, 2012; Freeman et al., 2014; Singer et al., 2012) and that active learning approaches improve student outcomes, lecture remains the predominant mode of teaching in the STEM classroom (Henderson et al., 2011; Stains et al., 2018; Yik et al., 2022). Lecture can be an effective method of teaching, particularly in combination with critical reflection, interactive activities, and discussion (Brookfield, 2017; Dolan et al., 2018; Harrington & Zakrajsek, 2017). However, teaching with lecture-only risks an emphasis solely on cognitive aspects of learning without considering the social and technical aspects. A lecture-approach assumes teaching and learning are transmission-based rather than interactive or co-constructed (Pratt et al., 2016; Shea et al., 2022).

Evidence-based student-focused methods in the traditional classroom include making lectures more interactive, increasing student interactions, involving students in collaborative activities – even in larger classes – and collaborative group activities (Singer et al., 2012). Engaging students in active learning has demonstrated improvements in learning (Singer et al., 2012). Because "few higher education instructors receive formal training in pedagogy" (Major & McDonald, 2021, p. 53), it is not surprising that these methods have been advocated for years in face-to-face formats with little success (AAU, 2017; Henderson et al., 2011). Yik et al. (2022) conducted a study of introductory chemistry, physics, and mathematics instructors to examine the malleable factors that influenced their incorporation of active learning practices and found that instructors tended to lecture more when teaching large classes or in

classrooms that make it difficult to implement active learning (i.e., those with fixed seating). A question remains as to how and if those approaches to teaching are undertaken in online undergraduate STEM courses. Understanding more about teaching in an online environment offers additional opportunities for learning about pedagogy and incorporating these types of student-centered approaches.

Methods

This project was part of a larger exploratory sequential mixed methods study in which we developed a self-report protocol (DeCamp et al., 2022) and an observation protocol (Horvitz et al., 2021) to better understand online undergraduate STEM instructional practices. In-depth interviews with four faculty members and observation of their online classes were initially conducted as part of the development process of these protocols.

For the current study, we employed a basic interpretive qualitative approach (Merriam & Tisdell, 2016) to better understand the faculty's experiences teaching online, asynchronous undergraduate STEM courses. A basic interpretive approach was selected because we were interested in how instructors made sense of teaching in an online environment and their experiences designing and teaching courses within that environment (Merriam & Tisdell, 2016). One team member conducted interviews with four faculty members from one regional university, hereafter referred to as Regional University. Each interview lasted approximately one hour. Teams of two to three researchers also observed the participants' online courses. We re-analyzed the interviews to move beyond reviewing the technical elements of teaching online and instead explored how each of the instructors acted, reacted, and interacted with their courses and students (Saldaña & Omasta, 2022). We also reviewed pertinent documents such as course descriptions and findings from the online course observations to enhance the description and understanding of the context in which the courses were designed and taught. The qualitative approach allowed us to give particular consideration to the context surrounding the knowledge shared by the participants as well as their individual experiences, and a basic interpretive approach was selected (Merriam & Tisdell, 2016).

Initial interview questions were generated based on an extensive review of the literature, with an emphasis on teaching presence, as defined in the CoI framework (Arbaugh et al., 2008; Garrison & Arbaugh, 2007; Garrison et al., 2000). Questions focused on aspects of instructional design, pedagogy, participants' view of themselves as instructor, expectations of students in the course, and faculty presence in the course. The interviews were transcribed verbatim prior to being coded.

A two-step process consisting of multiple rounds of coding and analysis were employed. The first step included a blend of descriptive and in vivo coding, in which the transcripts were reviewed inductively to better capture the meanings in the participants' experiences (Saldaña, 2021). First-cycle codes were generated based on participants' words (e.g., "not teaching them per se," "it's all just business," "concern," etc.) in order to grasp what was significant to the instructors or a descriptive word or short phrase (e.g., instructor challenges, pedagogy, course development, etc.).

We employed pattern coding as a second-cycle coding method in order to identify broader codes that helped to condense the codes into a smaller number of categories to identify themes (Miles et al., 2020; Saldaña, 2021).

Ensuring trustworthiness is an ongoing process in qualitative research. Lincoln and Guba (1985) asserted that credibility and applicability of findings are necessary to establish trustworthiness. Credibility refers to ensuring that the findings make sense given the data we have (Merriam & Tisdell, 2016), or whether the data is plausible (Tracy, 2010). We employed multiple methods of data collection (interview transcripts, online class observations) and reviewed pertinent documents, including the university website and policies, to establish context and ensure credibility of the findings. In addition, multiple members of the team reviewed the findings to ensure their confirmability. We described the context in which these faculty members taught their courses to encourage transferability of findings and provide an understanding of the particular circumstances in which the courses were taught and designed.

Because the researchers act as the instrument in qualitative inquiry (Merriam & Tisdell, 2016; Saldaña & Omasta, 2022), it is important to consider our own positionality as researchers in this study as a form of trustworthiness. All of the study authors have taught online courses. Two of the authors have experience in instructional design, one has led online and distance education departments, and one has more general experience in information technology. Our experiences influence the way we interpreted the information shared and our understanding of the stories told about teaching online, but we made every effort to ensure our interpretation of findings derived from the participants' words.

Participants

All participants taught online courses at Regional University (RU)[1]. It is important to note that the interviews were conducted in 2018, prior to the COVID-19 pandemic that resulted in a university-wide shift to fully online courses in 2020. At the time of the study, teaching these STEM courses online was not typical. RU is a mid-sized university that had a robust, if small, online presence. The instructors were unionized, with unions for full-time faculty, part-time instructors, and graduate assistants. Online training was provided but not required for instructors who taught online. At the time of the study, few faculty development options were available for faculty interested in learning more about teaching online, however the university did have a course development process that encouraged faculty to work with an instructional designer to develop their online courses. The unions' contracts included academic freedom provisions and allowed faculty to have ownership over their course materials, meaning that materials are shared between instructors on a mutual, voluntary basis.

The four participants represented different disciplines within the broader STEM field. Two participants taught introductory-level statistics courses: Pamela was tenured/tenure-track, and Delores was a part-time instructor and also held another posi-

[1] Pseudonym.

tion at the university. The third participant, George, was a long-term, non-tenure track instructor who taught geology courses at RU full-time for over 15 years. The fourth instructor, Lucy, was a graduate student who taught an anatomy course for non-science majors. These instructors were representative of the major faculty types at RU: tenured/tenure-track faculty, non-tenure-track renewable faculty, graduate assistant, and part-time instructor. Additional information about the instructors and their courses is provided in Table 1.

Findings

Instructors in this study shared their goals for teaching, how their courses were designed, and how they approached teaching STEM courses in the online environment. Teaching presence, one aspect of the community of inquiry (CoI) framework, was used as a lens to help organize the findings from this study. Teaching presence is a construct that encompasses aspects related to course design and organization and to instructor behavior during the course (Arbaugh et al., 2008).

Course Design and Organization

All participants "inherited" an online course that was originally designed by another faculty member. George described the course design as a sort of group process:

> It goes back probably 25 years now with various professors that have carried it forward. And everyone has left their mark on the course, and added things that they thought were important. So it's not just me, but it's probably about seven or eight different professors at this point.

The structure of the courses themselves, for the most part, tended to stay as they were originally designed as most participants made only minor, content-related changes. For example, one instructor said, "I went with the structure from the previous instructor of just how they had it organized." Other reported changes consisted of updating

Table 1 *Faculty Participants*

Name	Instructor Role	Course and Department	Course Characteristics	Number of Students
Lucy	Graduate Student/Instructor of Record	Anatomy & Physiology / Biology	Introductory course for non-major students	35
George	Non-tenure track renewable professor	Geological Sciences	Junior-level course	200
Pamela	Tenured/Tenure-track professor	Statistics / Business	Introductory course, pre-requisite for Business majors	70
Delores	Part-time, non-tenure track instructor	Statistics / Statistics and Mathematics	Introductory course	80–90

Note: All names provided are pseudonyms. Course and department names have been slightly modified to mask identifying information

content and/or adding questions to the quiz and exam question pools. The instructors had the freedom to change the course as they wished, but the accepted practice was to make only minor modifications. Pamela, who taught both online and face-to-face sections of her statistics course, was the only instructor to describe making substantive changes to the content of her course, though those changes still related primarily to content. "When I took over the class, slides were already created. I worked on updating the slides and creating handouts. The online [course] gets shortened versions of the handouts." She also recorded her own lecture videos for the course.

All courses were organized similarly in modules that consisted of video and/or text-based lectures, quizzes, and tests, with some instructors adding additional elements. Students had one or more weeks to complete each module. Some instructors incorporated publisher-created programs or content into their courses, but for the most part, the content was created or collated by faculty within the university.

George described the organization of his geological sciences course in terms of what a student had to do:

> Once you got started, the very first thing we would ask you to do is take what we call the syllabus quiz. It's pretty simple. It's like, "How many credits is the course worth?" You know? "Who's your professor?" Things like that... And nothing in the course opens until they get 100% on their syllabus quiz… And it tells them how the online course is going to work. And this way we're trying to make sure that they understand what we're expecting of them.

George was the only instructor who included this type of orientation to the course. However, the rest of his course organization was similar to the others in that it contained modules with lessons or lectures, assessments, and assignments.

Lucy included short text excerpts to provide "lecture" content. She explained:

> They have to read the book. And then there are a few assignments that I give them a week to complete. One is the discussion... The other is a lab assignment... And the other thing is they have to do online quiz[zes].

The statistics courses incorporated the use of videos in addition to text lectures. Pamela explained:

> We have it organized basically by weeks, so week one, they have the outline with the lecture notes, the video lectures and then for each portion of that, they'll have a quiz.
> The quiz is meant to be similar to the workshops in the regular classroom, except that's basically a multiple choice format. So, they typically do two of these quizzes a week and then... we have two midterms and a final exam.

She also described the differences between the online homework assignments and the in-person workshops.

> They will have a homework assignment to complete at the end of the week. That's the main thing... We also do workshops, which are more traditional homework, where they have their course-pack. The homework is online. It's an online system. They click their answers and it automatically grades it for them. Then we have workshops which are these problems from our course-pack. They can submit that in drop box. The great thing with that is they can show their work a little more, whereas the online homework system, they either get it right or they don't.

Even though both Delores's in-person and online courses incorporated the online learning system platform, students submitted their homework differently in ways that potentially impacted grading and comprehension of material.

Content-wise, the instructors described their courses as being very similar to the face-to-face sections. The goal for the courses was for students to learn the same content regardless of the class format. Delores said: "We do have sections that run in a regular classroom, so of course, we need to keep them as much the same as possible." Pamela agreed that the content was very similar. "They have online homeworks, they have online exams. They'll submit things online, where in-class they will hand it in."

Emphasis on Lecture

Each of the participants' online courses contained didactic information in either text or video format. The statistics courses incorporated lecture videos, while the geological sciences and anatomy courses relied on text documents. George's class had text-based lectures in the form of lessons followed by quizzes.

> You would read a lesson. For instance, the first one would kind of be how science works, and how you think about science. Then... there would be a quiz. And then there would be a second lesson, which would be the tools of science... Then you take another quiz.

Lectures were viewed by all participants as necessary. In Lucy's class, for instance, students were provided an introduction to the required reading prior to doing their weekly assignments:

> There's basically an introduction for the reading assignments, and I've written it out almost like a lecture for the students, so the main points and diagrams and figures that are pulled from the textbook that they're supposed to read…

Delores viewed her course design in relation to the face-to-face section of the course that she taught. She supplemented her video lectures with handouts.

> The [face-to-face class] will have one handout per chapter. The online will have those chapters broken down into topics. They will have four handouts for one chapter. But then they still get the same material presented to them. I base it on what I do in [the face-to-face] class and I break it down further into

> smaller handouts. That way they don't have an hour-long video. They have four 15-minute videos that they have to watch.

The emphasis on lecture material in the courses was strong, as each instructor viewed lecture as a key element of their courses.

Discussion Forums

As part of the university's course template (provided to instructors by instructional designers *if* the instructors chose to work with a designer), each class had three optional discussion forums set up where students could introduce themselves to the class, ask each other for help, and have non-class-related discussions amongst themselves. None of the participating instructors participated on those forums or required students to use them, though they were all included in their courses. The instructors noted that those forums "are available" to students. As one instructor observed: "I find the discussion sections, and the chat boards almost never get any response."

Lucy was the only participant who integrated discussion forums as part of her course design. Her students were required to complete one to two discussions per week. She described those discussions as more of a question-and-answer assignment than an attempt at developing interaction:

> The way it's set up right now with a few questions or prompts that they have to answer, it's almost like a checklist, so, it's not really a discussion then, it's kind of just them putting in their answers but everyone can see it.

She stated that she is "not very present in the discussion itself. I leave it for the students to talk to themselves." But she does check in at the end of the discussion.

> I might give them a case study about some sort of ... Maybe it's about diseases of the heart, blood... I'll answer questions about symptoms and manner of diagnoses, so it is more like real-world applications so that they can apply what they're learning…The discussions tend to be more clinical.

The discussions provided an opportunity for students to apply what they were learning to real-world situations and functioned as a space where students could receive feedback.

Assessment

Instructors felt it was important to assess student learning in this environment to ensure they understood the concepts and content being taught. Some courses had laboratory work, some had other homework assignments, and all had required quizzes and tests.

Students in Lucy's anatomy and physiology course had laboratory assignments that required them to purchase equipment and conduct experiments. They then submitted text documents to show the results of their work. Lucy explained, "The way

they can do [the lab assignments] is the lab manual that they order comes with a kit, and the supplies for them are easily obtained from a grocery store or something like that." She did not require them to submit visual proof of conducting the experiment.

> They don't have to take pictures, but they do have to record the numbers and measurements. Granted, yes, someone can fake that... When I used to take labs as an undergraduate, I've seen people not do anything where they experiment and kind of just get numbers off of somewhere else when it comes to writing the lab write-up because you don't write the lab write-up in class.

The lab write-ups served as assignments.

Quizzes and tests were the predominant mechanisms used for assessing students' work, with all courses having required quizzes and tests. Typically students had at least one quiz at the end of a module, in addition to mid-term and final exams. Some instructors provided non-graded self-assessments for students in the form of quizzes to afford students the opportunity to take the quizzes multiple times so they could learn the material through drill and practice.

Students received mainly general feedback from the quizzes and tests, such as whether their answer was correct or incorrect, though some received further feedback. The faculty expressed a concern about cheating on the exams, and one way they attempted to dissuade cheating was through developing large question banks to ensure students received different questions. One instructor explained,

> The big thing was, how can we give students variety? Instead of asking them the same question every single time and the same students getting the same questions. Now they're getting different stories, they're getting different questions. I can't copy from the person next to me, and they're also getting feedback each time that's unique to whatever their specific answer is.

The design of the courses, focusing primarily on lecture, quizzes, and tests, reflected the instructors' focus on students learning content.

Instructional Roles and Goals

All of the instructors viewed their main goal as teaching content. Each was passionate about teaching, but they did not view their work in online courses as teaching. Lucy described her course as "not that difficult, and so it is more catered to students who just need to satisfy a requirement for university." She explained her approach to teaching:

> Most of the time I just want to do my job well, and satisfy the students, but at the same time making sure that it's about teaching the content and so it is kind of a more formal approach. It is really nice to see when students become passionate about it and I hope that my teaching will engage them enough for that, but I don't try to make them really love the subject.

Her emphasis on content and on being able to apply what they learned in the field was shared by the other instructors. Delores's perspective is representative of the instructors' feelings, "The biggest thing is we want them to have an understanding of statistics. Preparing them because realistically… most of them are not going to be stats students."

Online Courses Run Themselves

Because the online courses were taught asynchronously, the instructors placed the bulk of their time in preparing the online course *prior* to the semester starting. Pamela noted that "all the work is done in advance…Once it's set, it pretty much is a machine that runs itself." She noted that "the most [time I spend on the class] in any week is an hour." Delores estimated spending "couple hours a week, maybe" on the course. She explained:

> It's mostly emails, going and looking at grades, quizzes. I'm coordinating basically off [another class], so I spend a lot of time getting all the other sections ready and meeting with TAs and stuff. The online classes tend to run themselves.

George noted that it took less time to put the course together the longer he taught it.

> We've been putting this together for a few years. So it almost gets to a point where I just spend a week before the semester begins, and I just go in and I'm resetting dates, checking [changes]…By the time the semester rolls in about all I have to [do] is simply go through emails, check grade sheets, make sure people are doing what they're supposed to be doing. And that's the teaching.

Lucy spends one day each week on grading, "and then throughout the week, before the assignments go live or that module goes live, I'll make sure that everything is in order." It took her one month to set the course up before the semester started.

In discussing how they taught their online courses, the instructors revealed that teaching online was very different from teaching face-to-face. Lucy said, "I personally feel like I'm still trying to figure out the online stuff cuz I definitely feel more comfortable when I [am] teaching in person." George explained that if he is too tired at the end of the day, he will not log on to the online course until the next day. "It's easy to put it off because it's out of sight, out of mind." He noted it was the same for the students. "What I'm finding is that the students always wait until the last minute, and I'm kind of going, 'Well, you waited until the last minute.'"

All participants noted a sense of automation with the online courses. The bulk of the work was in the preparation and set-up of the courses, *prior* to the start of the semester. They then spent some time "checking in" to their online classes. The asynchronous online nature made it easy to "forget" about the class or postpone checking in, similar to what their students experienced.

Interaction

A lack of interaction was something each of the instructors experienced when teaching their online courses. They felt a void between themselves and the students in these courses. The interview questions asked solely about online courses, but the instructors tended to frame their responses by talking about the differences between teaching online and face-to-face, often referred to as a "regular" class. This comparison was especially evident when discussing how they interacted with students.

Some instructors posted a picture of themselves in the course along with a brief biography, but they did not feel that resulted in students knowing them. "My personality never really comes out, [students] don't see any quirks or whatever, it's all just business. I answer questions, post reminders. What they see is through the lecture, perhaps through my writing," Lucy explained. Delores described the online environment as "quiet."

> I would say with teaching a regular class I like to be able to interact with my students. You judge with their faces, are they getting it, are they not getting it. You can frequently stop the lecture and just, do you have any questions? We also, in doing the workshop activities in the regular class, we're walking around, we're interacting with the students. Lots of times they're afraid to ask a question, so at that point they can.
> With the online it feels a little differently. I do respond to emails and I try to answer as best I can, but it's more quiet, I guess, so there's not as much interaction and I think with just the sheer volume of students we've had, we've basically kept with multiple choice quizzes for the grading.

The lack of interaction in the online courses was a concern shared by all of the faculty participants.

Delores described how walking around a physical classroom, which she referred to as "regular classes," helped with interaction.

> I love our workshops in the regular classes, being able to walk around, interact with the students. I always tell my TAs, "Walk around, don't just stand at the front because they won't come to you"…and I guess if I could find ways to incorporate some of those aspects into an online course, I would definitely be open to hearing how that would work.

George felt that in a face-to-face class, interaction would happen in different ways, such as students talking to each other, learning how to ask and answer questions "in the background of going to class." He viewed it as an important element that was missing from the online environment.

> We have taken the socialization part of the class out of the class…And you can sit in your room all by yourself at your computer and do an online class, and just never have the opportunity to practice any of those [socialization] skills.

All instructors noticed that they received fewer questions from students and had fewer interactions with them in the online courses. Pamela attributed this to the way feedback was provided. "I don't have as much interaction in the sense of they are already getting the feedback…I do get questions over email." She interacted with students in her online course primarily through email and online course announcements.

The lack of interaction and the idea that teaching was done before the semester started did not align with the participants' espoused views of teaching. Their views of teaching centered on the norms of teaching face-to-face. Although the focus of teaching in both environments was on teaching content, the instructors described interacting with students in more active ways in the face-to-face classroom. They did not expect that interaction was desired in an online environment nor that they should attempt to engage with students in similar ways, and there was a feeling of "out of sight, out of mind." Their thoughts regarding themselves as teachers in online classes are best summed up by Pamela, who said, "I'm not teaching them per se."

Discussion

The instructors in this study had all taught online for multiple years, but they still viewed online teaching as "other." Teaching their undergraduate STEM courses online was a deviation from the norm of teaching face-to-face and was perceived as lesser. Their idea of teaching was still grounded in a physical classroom. When asked about teaching, they all referred to the face-to-face environment. While they attempted to ensure the *content* for both online and face-to-face courses was the same, they did not seek to engage with their students the same way they did in the face-to-face environment. Interaction in the online courses was limited mostly to sending an email to students if their grades were low or they were not submitting work. One instructor noted:

> In [the face-to-face] class they'll at least walk up to me and talk to me at the end of the class. And I say that's the easiest way to get a hold of me…Online, it's "Oh, I've got to sit down, I've got to type in some stuff. Then I've got to wait for a reply. Then I've got to think about it." Then if I didn't quite get it I've got to send them another email. And it becomes a fairly lengthy process in the communication.

This response was interesting because the instructor did not hold online office hours or offer to schedule a phone call or video conference with the student rather than waiting for email. The danger in this "fairly lengthy process" of emailing was that the conversation could get lost or postponed, or it might occur close to a deadline.

The lack of interaction was not perceived as a design flaw or as something that could be improved by the instructor. Although some of the instructors noted that their students engaged in group work and had discussions in face-to-face courses, they did not seek to have similar engagement in online courses. The focus on content only did not provide engagement for students or the instructor (Barkley & Major, 2022). The instructors had considered technology and teaching content, but they did not

consider the ways in which the online environment impacted students. The focus was on cognitive presence but the instructors did not establish a climate that supported or promoted discourse between instructors and students or between the students themselves (Garrison et al., 2010). This led to the instructors feeling disconnected from both the class and the students.

George felt strongly that students do not develop social skills online. He said, "I would argue that we're short-changing them if we don't give them some face-to-face experience." As a result of referencing the norms of a face-to-face environment, the instructors in this study did not feel that students wanted or received interaction in an online environment, though they also did not seem aware of ways in which they could develop faculty presence or social presence within their courses (Garrison & Arbaugh, 2007). This may stem from the existing course design, but the instructors did not seem to realize that engagement and interaction were possible in the online environment. This study did not focus on the types of training and support provided to these online instructors, but it is an area worth considering for future research.

Each of the faculty members in this study taught courses that had been created by other faculty. Although all participants updated parts of the course, their focus remained predominantly on updating *content*. This aligned with their perspectives of teaching being focused primarily on content. They all referred to teaching online as setting up the course and ensuring the content was ready to go. The lack of engagement through discussion or group work, which occurred in their in-person classes, was a concern, but they felt that was a characteristic of the online environment. This perspective could reflect a systemic issue that hinders a shift from traditional teaching practices to those that require changes in perspective (Dancy & Henderson, 2005; Henderson et al., 2011).

Because they did not develop their courses, these instructors did not feel a sense of ownership. The courses were the product of numerous faculty and existed as part of an assembly line in which the faculty member's job is to teach what is already there, regardless of whether or not that design fits their teaching style. This assembly line approach is an example of how the traditional faculty role is unbundled (Gehrke & Kezar, 2015; Smith, 2010). The instructors viewed teaching online as populating question banks, a much different approach than they took with their face-to-face sections. Unbundling instruction, in this case, resulted in faculty feeling that their teaching was limited to preparing the course and grading. Instructors felt the students did not know who they were, and they did not know their students. The structure of the pre-developed courses had implications for the way that those courses were taught.

The TPACK framework suggests that instructors must have content knowledge, pedagogical knowledge, and technological knowledge to teach effectively (Barkley & Major, 2022; Major & McDonald, 2021; Koehler & Mishra, 2009). In theory, the overlap of those three areas creates a form of new knowledge that results in meaningful teaching. Engagement plays a role in this type of instruction, particularly the aspect of teacher presence (Arbaugh et al., 2008; Garrison & Arbaugh, 2007; Garrison et al., 2000). That aspect was missing from online instruction in this study. The instructors' view of the online environment seemed to be something separate, apart from what they thought of as teaching. An instructor who developed their course

from scratch may have different experiences and feelings related to ownership and what it means to teach the course.

Henderson et al. (2011) found that it is not enough to simply share best practices about teaching; successful strategies to develop reflective instructors tend to focus on individual or group consultation or collective communication to share approaches. In other words, to shift focus from instruction to learning requires a systemic change not only in course structure but the way that teaching and learning is discussed and implemented. It must be a group effort, one that starts with examining current practices.

Implications for Practice

Moving undergraduate STEM courses online provides an opportunity for faculty to reflect on their teaching: What are their goals? What is the best way to accomplish those goals? Are they incorporating evidence-based practices? This type of reflection can be done individually, such as by using a self-observation tool that encourages instructors to consider how they teach and how students learn (Horvitz et al., 2021). Just the act of thinking about teaching can lead to improvements (Barkley & Major, 2022), but engaging in purposeful reflection can also help develop a knowledge base of what instructors know and what they need to know in order for effective teaching and learning to occur in the online environment (Major & McDonald, 2021). Faculty should use reflection not just to consider *what* they do, but *why* they do it (Ravanal Moreno et al., 2021).

When thinking about teaching online asynchronous courses, faculty should also consider what they are *not* doing and why. Using the faculty who participated in this study as examples, questions might include: Why are they not hosting online office hours? How might they be able to build connections with students in a space that they may not immediately associate with developing community? Instructional support through a faculty development or instructional design center would aid in this type of reflection. Supporting faculty through instructional consultations related to technology modeling, pedagogical realignment, and deepening practice have been shown to enhance instructors' TPACK creation (Koh, 2020). Before that can happen, however, views of teaching must change so that support is provided for evidence-based teaching that improves student learning (Dancy & Henderson, 2005; Henderson et al., 2011).

Undergraduate STEM courses, particularly those that serve as introductory courses, may be large lecture classes. When classes are large, instructors tend to lecture rather than use active learning techniques (Apkarian et al., 2021). It makes sense that the same may hold true of large online courses. However, active learning strategies increase student learning and retention (Apkarian et al., 2021; Yik et al., 2022), as does developing relationships and rapport with students (Glazier, 2021). Normalizing these types of approaches so that teaching is associated with evidence-based strategies for learning rather than prioritizing content transmission is necessary, but that requires a transformational change in the way colleges and universities, in addition to instructors, view teaching and learning (Henderson et al., 2011). The Association of American Universities (n.d.) developed a framework for systemic

change intended to guide institutions in creating *sustainable* change that encourages effective educational practices in STEM. The framework includes guidance geared toward what people at multiple levels (institution, administration, department, and faculty) can learn and demonstrate about the effectiveness of evidence-based STEM teaching practices. This approach focuses on changing a culture rather than simply changing policies or practices. Deep change of this kind is needed to support such a shift in teaching practices.

Conclusion

Although online courses have been a part of academia for nearly 30 years, they are still perceived as something "other" or "different," sometimes even "less than" face-to-face courses. The faculty in this study viewed online courses in relation or comparison to face-to-face courses, with the ideal being an in-person setting.

This study indicates that there is still work to do in order to improve undergraduate STEM education, particularly in the online environment. Despite their beliefs about what it meant to be a good teacher and what good instruction was, the faculty in this study approached teaching online as presenting pre-made content. Notions of faculty presence and social presence (Arbaugh et al., 2007; Garrison et al., 2000, 2010), both necessary components of a CoI, were not considered. The instructors established paradigmatic and practical assumptions about what it meant to be a good teacher (Brookfield, 2017), but those assumptions and practices did not play out in their online courses. Instead, they viewed teaching in the online environment as presenting pre-made content and instruction as making sure students completed work.

The faculty interviewed for this study viewed online courses as "not regular class[es]" and teaching those classes as "not teaching per se." Each of the instructors had assumptions about what a classroom was and about good instruction, but even for instructors who taught online for multiple years, those assumptions remained grounded in the face-to-face environment. Work remains to change the way we think about what it means not only to teach undergraduate STEM courses but to teach them in an engaging way in an online environment. As Koehler and Mishra (2009) indicated in their work on the TPACK framework, "teaching is a complicated practice that requires an interweaving of many kinds of specialized knowledge" (p. 61). That knowledge must be discussed, shared, and implemented.

The shift to online courses at the onset of COVID-19 disrupted higher education and could trigger a trend to continue to put more undergraduate STEM courses online. More research is needed about how instructors approach teaching asynchronously in this environment and how feelings about teaching online have changed after this experience.

Acknowledgements We thank the faculty members who participated in the interviews and allowed us to examine their courses. We also thank Pamela Eddy for comments on an early draft.

Author's Contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Regina Garza Mitchell, Brian Horvitz, Whitney DeCamp, Megan Grunert Kowalski, and Cherrelle Singleton. The first draft of the manuscript was written by Regina

Garza Mitchell and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding This material is based upon work supported by the National Science Foundation under Grant No. 1712065.

Declarations

Non-financial Interests The lead author, Regina L. Garza Mitchell, is an Editorial Review Board member for the journal.

Ethics This project received Human Subjects Institutional Review Board approval #17-10-39 from Western Michigan University.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

Apkarian, N., Henderson, C., Stains, M., Raker, J., Johnson, E., & Dancy, M. (2021). What really impacts the use of active learning in undergraduate STEM education? Results from a national survey of chemistry, mathematics, and physics instructors. *PLoS One*, *16*(2), e0247544. https://doi.org/10.1371/journal.pone.0247544.

Arbaugh, J. B., Cleveland-Innes, M., Diaz, S. R., Garrison, D. R., Ice, P., Richardson, J. C., & Swan, K. P. (2008). Developing a community of inquiry instrument: Testing a measure of the community of inquiry framework using a multi-institutional sample. *Internet and Higher Education*, *11*(3–4), 133–136. https://doi.org/10.1016/j.iheduc.2008.06.003.

Association of American Universities (2017). *Progress Toward Achieving Systemic Change: A Five-Year Status Report on the AAU Undergraduate STEM Education Initiative*. https://www.aau.edu/sites/default/files/AAU-Files/STEM-Education-Initiative/STEM-Status-Report.pdf.

Association of American Universities. (n.d.). Framework for systemic change in undergraduate STEM teaching and learning. https://www.aau.edu/education-service/undergraduate-education/undergraduate-stem-education-initiative/stem-framework.

Barkley, E. F., & Major, C. H. (2022). *Engaged teaching: A handbook for college faculty*. The K. Patricia Cross Academy.

Brookfield, S. (2017). *Becoming a critically reflective teacher* (2nd ed.). John Wiley & Sons, Inc.

Dancy, M. H., & Henderson, C. (2005, September 21). Beyond the individual instructor: Systemic constraints in the implementation of research-informed practices. *AIP Conference Proceedings 790*, 113. https://doi.org/10.1063/1.2084714.

DeCamp, W., Horvitz, B., Mitchell, G., Kowalske, R. L., M. G., & Singleton, C. (2022). Development of a self-report instrument for measuring online teaching practices and discussion facilitation. *PLOS ONE*, 17(10), e0275880.

Dolan, E. L., Elliott, S. L., Henderson, C., Curran-Everett, D., John, S., K., & Ortiz, P. A. (2018). Evaluating discipline-based education research for promotion and tenure. *Innovative Higher Education*, *43*(1), 31–39. https://doi.org/10.1007/s10755-017-9406-y.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111.

Garrison, D. R., & Arbaugh, J. B. (2007). Researching the community of inquiry framework: Review, issues, and future directions. *The Internet and Higher Education*, *10*(3), 157–172. https://doi.org/10.1016/j.iheduc.2007.04.001.

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education model. *The Internet and Higher Education*, *2*(2–3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6.

Garrison, D. R., Anderson, T., & Archer, W. (2010). The first decade of the community of inquiry framework: A retrospective. *Internet and Higher Education*, *13*(1), 5–9. https://doi.org/10.1016/j.iheduc.2009.10.003.

Garza Mitchell, R. L. (2009). Online education and change. *Community College Review*, *37*(1), 81–101. https://doi.org/10.1177/0091552109338731.

Gehrke, S., & Kezar, A. (2015). Unbundling the faculty role in higher education: Utilizing historical, theoretical, and empirical frameworks to inform future research. In M. B. Paulsen (Ed.), *Higher Education Handbook of Theory and Research, 30* (pp. 93–150). Springer.

Glazier, R. (2021). *Connecting in the online classroom: Building rapport between teachers and students*. Johns Hopkins University Press.

Harrington, C., & Zakrajsek, T. D. (2017). *Dynamic lecturing: Research-based strategies to enhance lecture effectiveness*. Stylus Publishing.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature. *Journal of Research in Science Teaching*, *48*(8), 952–984. https://doi.org/10.1002/tea.20439.

Horvitz, B. S., & Zinser, R. (2011). Identifying the state of online instruction in National Science Foundation funded technical education programs at community colleges. *International Journal of Instructional Technology and Distance Learning*, *8*(12), 33–44. https://itdl.org/Journal/Dec_11/Dec_11.pdf#page=37.

Horvitz, B., DeCamp, W., Kowalske, M. G., & Mitchell, G. (2021). R. L. Online Observation Protocol Sheet. Retrieved from: https://scholarworks.wmich.edu/instruments_teaching/1/.

Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education: What is "enhanced" and how do we know? A critical literature review. *Learning Media and Teaching*, *39*(1), 6–36. https://doi.org/10.1080/17439884.2013.770404.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.

Koh, J. H. L. (2020). Three approaches for supporting faculty technological pedagogical content knowledge (TPACK) creation through instructional consultation. *British Journal of Educational Technology*, *51*(6), 2529–2543. https://doi.org/10.1111/bjet.12930.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. SAGE Publications.

Major, C. H. (2015). *Teaching online: A guide to theory, research, and practice*. Johns Hopkins University Press.

Major, C., & McDonald, E. (2021). Developing instructor TPACK: A research review and narrative synthesis. *Journal of Higher Education Policy and Leadership Studies*, *2*(2), 51–67. https://doi.org/10.29252/johepal.2.2.51.

Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). Jossey-Bass.

Miles, M. B., Huberman, M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). SAGE Publications.

Miller, E. R., Smith, T. L., Slakey, L., & Fairweather, J. (2021). *Framework for systemic change in undergraduate STEM teaching and learning*https://www.aau.edu/sites/default/files/STEM%20Scholarship/AAU_Framework.pdf.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x.

Pratt, D. D., Smulders, D., & Associates (2016). *Five perspectives on teaching: Mapping a plurality of the good* (2nd ed.). Krieger Publishing Company.

President's Council of Advisors on Science and Technology (2012). *Engage to Excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_2-25-12.pdf.

Ravanal Moreno, E., Cabello, V. M., López-Cortés, F., & Amórtegui Cedeño, E. (2021). The reflective practice as a tool for making tacit knowledge explicit. *Reflective Practice*, *22*(4), 515–530. https://doi.org/10.1080/14623943.2021.1930527.

Saldaña, J. (2021). *The coding manual for qualitative researchers* (4th ed.). SAGE Publications.

Saldaña, J., & Omasta, M. (2022). *Qualitative research: Analyzing life* (2nd ed.). SAGE Publications.

Seaman, J. E., & Seaman, J. (n.d.). *Distance education state almanac 2019*https://www.bayviewanalytics.com/distance.html.

Seaman, J. E., Allen, I. E., & Seaman, J. (2018). *Grade increase: Tracking distance education in the United States*https://www.bayviewanalytics.com/reports/gradeincrease.pdf.

Seaman, J., Allen, I. E., & Ralph, N. (2021). *Teaching online: STEM education in the time of COVID*. Bay View Analytics. https://www.bayviewanalytics.com/reports/stem_education_in_the_time_of_covid.pdf

Shea, P., Richardson, J., & Swan, K. (2022). Building bridges to expand the Community of Inquiry framework for online learning. *Educational Psychologist*, *57*(3), 148–161. https://doi.org/10.1080/00461520.2022.2089989

Singer, S., Nielsen, N. R., & Schweingruber (Eds.). (2012). *Discipline-based education research: Understanding and improving learning in undergraduate science and engineering*. National Academies Press. http://www.nap.edu/catalog/13362/discipline-based-education-research-understanding-and-improving-learning-in-undergraduate.

Smith, V. (2010). Essential tasks and skills for online community college faculty. *New Directions for Community Colleges*, *150*, 43–55. https://doi.org/10.1002/cc.404.

Stains, M., Harshman, J., Barker, M. K., Chasteen, S. V., Cole, R., DeChenne-Peters, S. E., Eagan, M. K. Jr., Esson, J. M., Knight, J. K., Laski, F. A., Levis-Fitzgerald, M., Lee, C. J., Lo, S. M., McDonnell, L. M., McKay, T. A., Michelotti, N., Musgrove, A., Palmer, M. S., Plank, K. M., & Young, A. M. (2018). Anatomy of STEM teaching in north american universities. *Science*, *359*(6383), 1468–1470. https://doi.org/10.1126/science.aap8892.

Tracy, S. J. (2010). Qualitative quality. *Qualitative Inquiry*, *16*(10), 837–851. https://doi.org/10.1177/1077800410383121

Walton Radford, A., & Weko, T. (2011). *Learning at a distance: Undergraduate enrollment in distance education courses and degree programs (NCES 2012 – 154)*. United States Department of Education.

Wilson, E. C., & Berge, Z. L. (2023, February). Educational experience and instructional design effectiveness within the community of inquiry framework. *International Review of Research in Open and Distributed Learning*, *24*(1), 159–174. https://doi.org/10.19173/irrodl.v24i1.6751.

Yik, B. J., Raker, J. R., Apkarian, N., Stains, M., Henderson, C., Dancy, M. H., & Johnson, E. (2022). Evaluating the impact of malleable factors on percent time lecturing in gateway chemistry, mathematics, and physics courses. *International Journal of STEM Education*, *9*(15), https://doi.org/10.1186/s40594-022-00333-3.