Engagement in the Undergraduate Science Course: Lessons Learned about Participation and Distraction from the Remote Classroom

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Abstract

The COVID-19 pandemic has left very little unaltered, education included. Institutions encountered an almost immediate transition to remote learning to prevent disease transmission. Because most students and instructors alike were unfamiliar with remote learning, challenges quickly arose and have unfortunately lingered longer than most had hoped. In this study, we investigated the effects of remote learning on student engagement and perceived success in face-to-face undergraduate science courses from both the student and instructor perspectives. We attempted to identify the major distractors as well as strategies which increased engagement for students. Analysis revealed that students were less likely to engage in their remote science classroom when compared to their previous face-to-face classrooms with no significant differences in perceived engagement or success between class standing or age of the students. Students identified the strongest remote classroom diversions as other distractions on the internet and mental health issues. The most engaging factors in the remote classroom were instructor enthusiasm and questions presented by the instructor. From the instructor perspective, they found it more difficult to connect with students and found students engaged less in group discussion in remote courses when compared to their face-to-face in courses. Our data reveal differences in engagement and perceived success from the student and instructor perspective in remote science courses which were offered previously in a face-to-face format. Lessons learned from this study will not only assist in improving future remote courses but will assist in student engagement in the undergraduate science classroom overall. https://doi.org/10.21692/haps.2023.004

Key words: remote learning, active learning, engagement, success

Introduction

COVID-19 changed almost every aspect of human life, including education. The almost immediate change in course delivery format has greatly impacted both educators and students. Due to social distancing guidelines, classroom capacities were greatly reduced while the pandemic forced most to engage in remote learning on videoconferencing applications like Zoom. While some have been greatly impacted by this new format, leading to a decline in academic performance, others have found benefit in the ease of use and flexibility. Regardless of the preferred format, this new remote delivery method has impacted engagement and understanding, particularly in undergraduate science classrooms which were traditionally taught face-to-face. We aimed to study both quantitatively and qualitatively from teacher and student perspectives.

In the remote learning environment, it can be challenging for students to stay engaged in the classroom and motivated throughout the semester. Students in face-to-face classrooms had higher rates of motivation when compared to students in remote classrooms (Raes et al. 2020). In addition, students in face-to-face classrooms received higher in-class quiz scores than those in virtual classrooms (Raes et al. 2020). Students were asked to reflect on their top concerns regarding remote learning. Those ranking highest were demotivation, access to reliable internet, access to technology, and influence of the home environment (de Souza et al. 2020). More specifically, STEM students reported higher dissatisfaction with remote learning during the pandemic when compared to their non-STEM peers (Barber et al. 2021). Of particular importance, first-generation students and under-represented minority students felt they had less time to focus on schoolwork with higher expectations in the home and other responsibilities (Barber et al. 2021). While some issues that arose during remote pandemic learning were obvious such as internet connectivity and functioning issues, other issues such as communication challenges between instructors and students were more nuanced (Katz et al. 2021). It is important to note, however, that challenges such as communication and

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discrepancy between under-represented minority students existed in remote learning before the pandemic, and the pandemic may have exacerbated these issues. Overall, it is clear from emerging studies that remote learning poses serious challenges for educators, particularly in motivating and connecting with students (Daniels et al. 2021; Petillion and McNeil 2020; Wester et al. 2021).

Less research has been published on science-specific curriculum and the impact of remote learning on these face-to-face courses, especially labs. Graduate medical students from 13 medical schools felt that certain clinical aspects were not achievable via virtual learning and had subsequent concerns about preparedness in their field (Alsoufi et al. 2020). Undergraduate microbiology students attended labs offered in both remote and in-person formats. While students found remote activities convenient, an overwhelming majority of students desired a hands-on component to the lab (Brockman et al. 2020). This data suggests that even if pandemic remote learning ceases, educators should maintain invested in best strategies for remote learning engagement as it may provide an important modality, in part, for future students.

While many students have been previously accustomed to remote learning, particularly non-traditional students, the pivot to online learning was abrupt and disruptive to many. Students were required to engage in a format that they would not have likely chosen for themselves. First-time remote students during the pandemic revealed that they felt there was less flexibility in their remote courses alongside a heavier workload (Trout 2020). Concerns were not the same for all courses. These students found that remote learning worked well for general education classes but not for core courses in their major (Trout 2020). Of particular importance, these students felt that difficulty in communication and lack of interaction have negative effects on their motivation in the remote courses (Trout 2020). This highlights a particular concern for engagement in science courses.

While the pandemic and disruptive learning will not last forever, remote and online learning will continue. According to the National Center for Education Statistics, in Fall 2018, over 6 million students had enrolled in at least one distance education course at degree-granting postsecondary institutions, which had increased from previous years (U.S. Department of Education 2019). In Fall 2019, this number rose to over 7 million students and with the pandemic, Fall 2020 remote course enrollment jumped to over 14 million (U.S. Department of Education 2021). This necessitates the need to better understand engagement in the remote classroom from both the student and instructor standpoint, which likely lead to perceived and actual academic success. As online enrollment and interruptions may continue, lessons learned from this study not only guide success in the remote classroom, but in the face-to-face classroom as well.

Materials and Methods

Data Collection and IRB Approval

We conducted two surveys from February to April 2021. These self-administered surveys were completed by using an online software (Qualtrics, Provo, UT) following informed consent. The surveys were distributed via email link to either students or instructors participating in undergraduate core biology, chemistry, or physics courses involved in remote learning which were previously offered in-person. The survey contained Likert scale, ranking, demographic, and open-ended questions. The survey did not collect any identifying data to ensure participant confidentiality. Surveys responses were removed from participants who did not verify via questionnaire that they enrolled in one of the described courses above. This project was approved by the Webster University Institutional Review Board (IRB approval number SP2129) and informed consent was obtained from all participants.

Statistical Analysis

Data was collected through Qualtrics (Qualtrics, Provo, UT). We used descriptive statistics, particularly frequencies and percentages, to examine mean participant responses. For ranking data, we utilized the mode response and reported percentages. In addition, we compared group means via one-way ANOVA utilizing IBM SPSS Statistics.

Results

Basic Student Demographics

We sought to describe student perceptions towards remote learning in undergraduate biology, chemistry, and physics courses. We received 36 surveys which met our exclusion criteria (enrolled in Essentials of Biology I/II, Anatomy and Physiology I/II, General Chemistry I/II, or General Physics I/II courses in Fall 2020 or Spring 2021 that met remotely on Zoom). Participants were predominately upperclassman and between 18-25 years old (Table 1).

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Class Standing	Percent Response (n)	Age	Percent Response (n)
Freshman	8.3% (3)	18-25	97.2% (35)
Sophomore	27.8% (10)	26-33	2.8% (1)
Junior	30.6% (11)	34-41	0% (0)
Senior	33.3% (12)	42+	0% (0)

***Table 1**. Student survey demographics describing class standing and age. n=36*

Association of Engagement in Remote Undergraduate Science Classrooms with Age or Class Standing

We surveyed students to determine their perceived engagement in undergraduate science courses which were held remotely when compared to their previous face-to-face experiences. When participants were questioned how likely they were to respond to their instructors' questions in the remote classrooms we found that most students (63.9%) felt less likely to respond when compared to a face-to-face setting (Table 2). When we compared responses by class standing, we found no statistical difference in responses between groups, thus class-standing had no determination on whether students were more or less likely to respond *(p=0.510, data not shown*). When participants were questioned how likely they were to ask for help or clarification in the remote classrooms we found that most students (55.6%) felt less likely to ask for help/clarification when compared to a face-to-face setting (Table 2). Similarly to the response question, we found no statistical difference in responses from different classes *(p=0.585, data not shown*). Group discussions have been utilized to improve connection and engagement in the remote classroom, thus we asked participants how likely they were to participate in group discussions in the remote classrooms when compared to a face-to-face classroom. We found the majority of students (72.2%) felt less likely to participate when compared to a face-to-face setting (Table 2). In addition to questioning the likelihood of their actions, we directly asked how engaged students felt in these remote classrooms. We found that the majority of students felt less engaged (83.3%) in the remote classroom when compared to their face-to-face classroom engagement (Table 2). It has been suggested that increased engagement can result in increased success. While we did not measure assessment scores, we did ask the students about perceived success. Interestingly, a large number of students (44.4%) felt about the same when comparing their perceived success in the remote vs the face-to-face classroom. Still, a large number of students (38.9%) felt less successful in the remote classrooms (Table 2). When comparing class standing for their perceived engagement and success survey items, we observed no statistical difference between the remote and face-to-face classroom *(p=0.146, p=0.230 respectively, data not shown*).

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Survey Item	Less Likely (1)	About the Same (2)	More Likely (3)	Mean (±SD)
How likely are you to respond to your instructor in the remote classroom when compared to the traditional classroom?	63.9%	27.8%	8.3%	1.4 (±0.7)
How likely are you to ask for clarification in the remote classroom when compared to the traditional classroom?	55.6%	33.3%	11.1%	1.6 (±0.7)
How likely are you to participate in group discussion in the remote classroom when compared to the traditional classroom?	72.2%	25.0%	2.8%	1.3 (±0.5)
How likely are you to be engaged in the remote classroom when compared to the traditional classroom?	83.3%	8.3%	8.3%	1.3 (±0.6)
How likely are you feel successful in the remote classroom when compared to the traditional classroom?	38.9%	44.4%	16.7%	1.8 (±0.7)

***Table 2**. Student survey addressing perceptions on engagement and success in the remote undergraduate science classroom when compared to face-to-face classrooms. n=36*

Student Ranking of Distractors and Promotors of Engagement

We were interested in exactly why engagement was lower in remote classrooms when compared to in person science courses. We implemented a question which had participants rank their greatest distractors in the remote science classroom (Figure 1). We found that 46% of students felt that other distractions on the internet were the major contributing distractor in remote classrooms (Figure 1). The next major contributing factor was stress, anxiety, and/or other mental health concerns (28%). The mode response was "Other Distractions on the Internet" (Figure 1).

Factors which ranked lowest on the scale and thus not likely to play a role in decreased engagement were the lack of authority or personal accountability (29%) in remote classrooms, other people in the learning area (17%), other obligations outside of the course (11%), and interestingly stress, anxiety, and/or other mental health concerns (14%) (Figure 2). While many reported mental health concerns as a major distractor, others felt that it played no role at all. Interestingly, it was the most polarized response, being high in both the highest and lowest ranked distractor (Figure 1-2). The mode for this least likely contributing factor to distraction was "Lack of Authority or Personal Accountability" (Figure 2).

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Most Likely Factor Contributing to Distraction

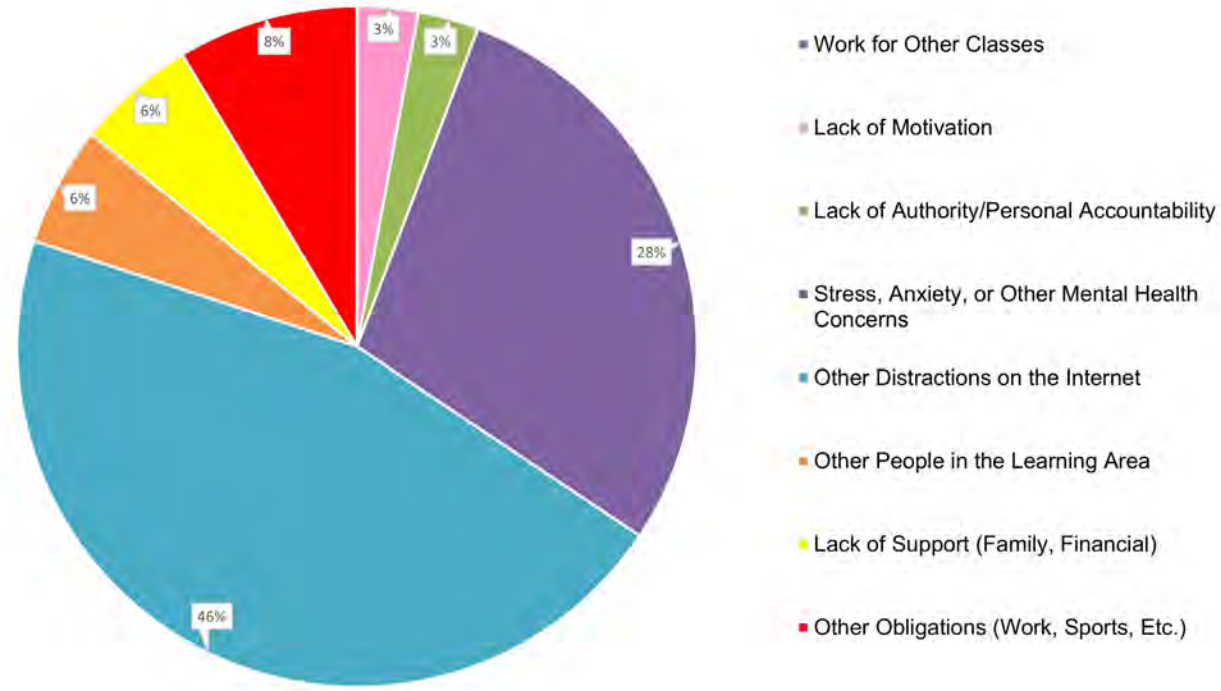

***Figure 1**. Student survey of the largest distractors in the remote undergraduate science classroom when compared to face-to-face classrooms. n=35*

Least Likely Factor Contributing to Distraction

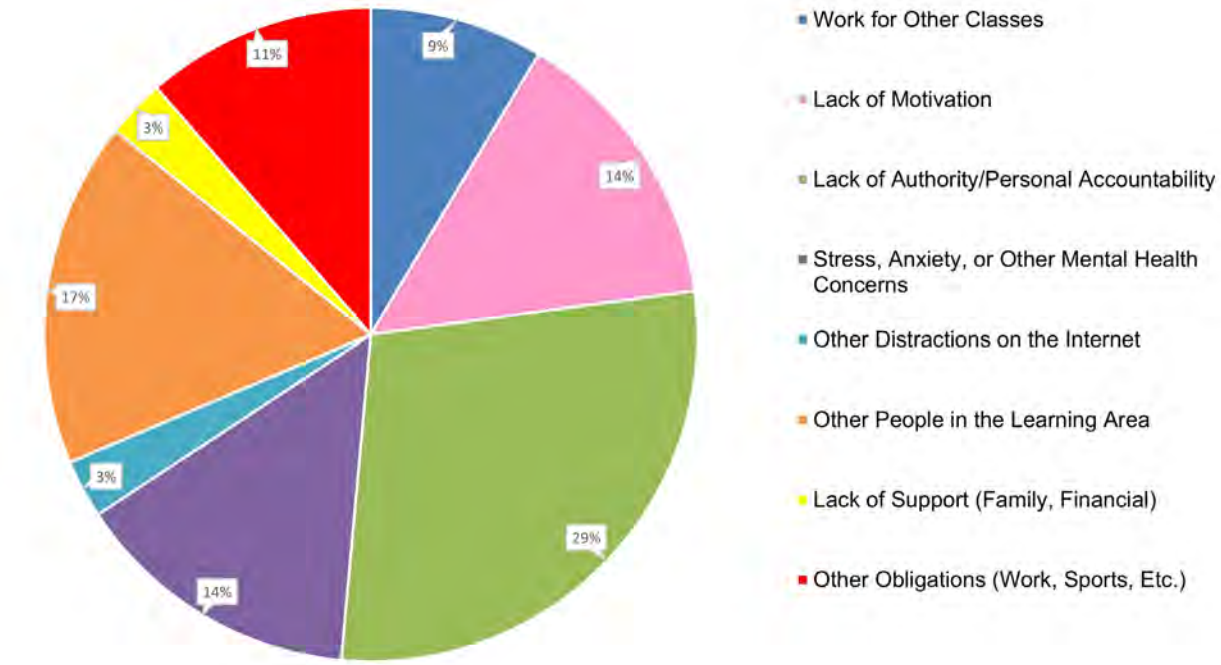

***Figure 2**. Student survey of the least likely distractors in the remote undergraduate science classroom when compared to face-to-face classrooms. n=35*

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We also implemented a ranking survey question which focused on the largest promoting factors for engagement (Figure 3). We found the most likely factors contributing to student engagement in the remote science classroom were instructor enthusiasm/passion (46%) and questions asked by the instructor (27%) (Figure 3). The mode response for greatest promoter of engagement was "Instructor Enthusiasm/Passion" (Figure 3). The least effective strategies for were much more variable. They included the requirement by the instructor to engage (24%), breakout rooms (15%), and instructor passion (21%) ranking least likely to contribute to engagement (Figure 4). Again, instructor passion was one response that was polarizing; however it was two times more likely to be considered a contributing factor to engagement (Figures 3 and 4). The mode for least likely factor to contribute to remote classroom engagement was "requirement by the instructor" to engage such as keeping the camera on or participating in a response (Figure 4).

An open response question asked students if there were any factors which strongly contributed or hindered their success in their remote science courses. While no common themes emerged, students mentioned that flexibility and the ability to better manage time contributed to success while factors such as excessive screentime, additional coursework, and lack of teacher engagement hindered their success. We also asked students for their suggestions for future remote learning. A common theme was the request for increased engagement from the instructor, specifically asking for more group discussions, games, breakout rooms, and communication.

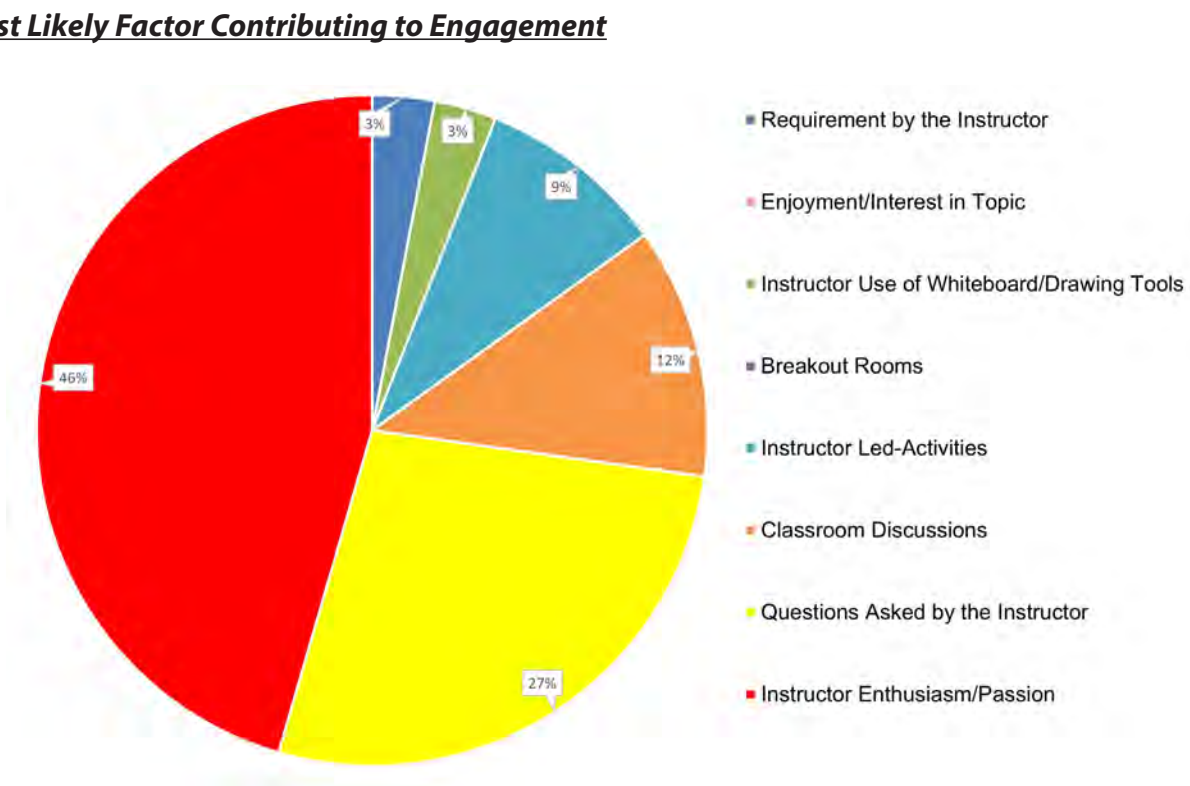

***Figure 3**. Student survey of the greatest promotors of engagement in the remote undergraduate science classroom when compared to face-to-face classrooms. n=33*

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Least Likely Factor Contributing to Engagement

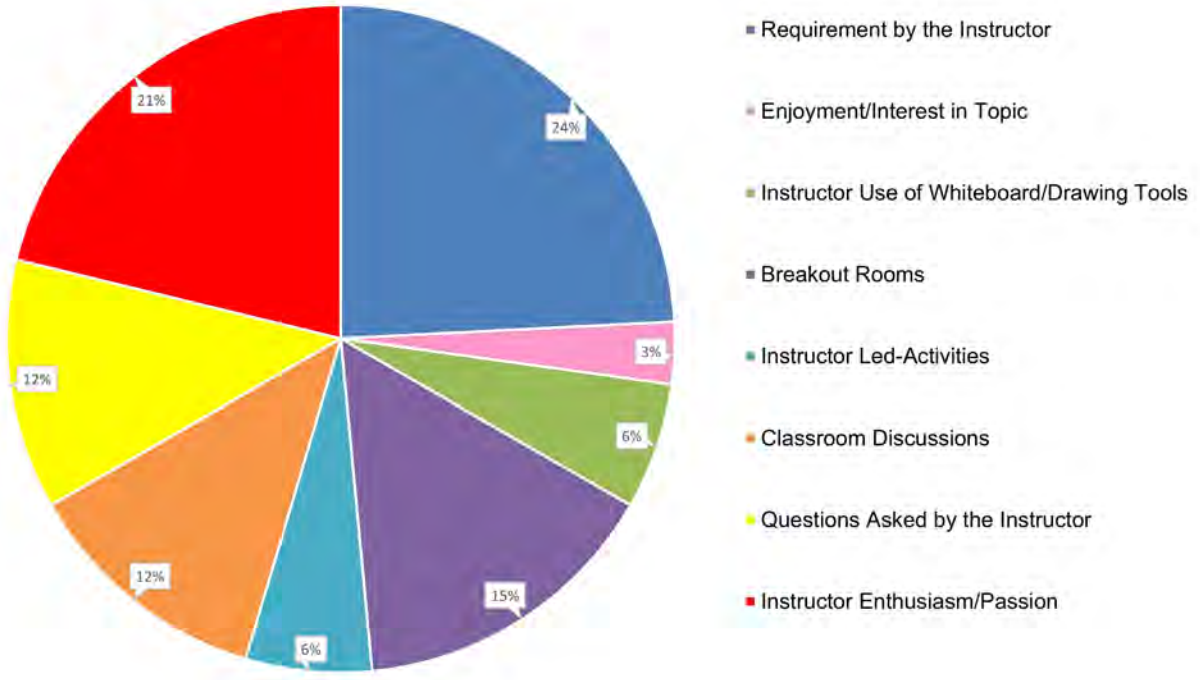

Figure 4*. Student survey of the factors least likely to increase engagement in the remote undergraduate science classroom when compared to face-to-face classrooms. n=33*

Basic Instructor Demographics

We surveyed the instructors of these undergraduate science courses to gain an understanding of their experience (Table 3). Forty-four percent of instructors had never taught an online course and 89% had never taught a hybrid course (n=9). Many of our courses were run hybrid in the sense that the lecture was held remotely while the lab was held in person at reduced capacity with social distancing. For this reason, we asked about the experience for both modalities. The majority of instructors had 6 years or more teaching experience (89%) (Table 3).

Experience in Remote/Online Teaching	Response (n)	Experience in Hybrid Teaching	Response (n)	Overall Teaching Experience	Response (n)
No	4	No	8	1-5 years	1
Yes	5	Yes	1	6-10 years	4
				11-15 years	2
				16+ years	2

Table 3*. Instructor survey demographics describing remote, hybrid, and overall teaching experience. n=9*

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Regarding the instructor perceptions of the remote classroom, there was no consistent response in the enjoyment of the modality as some seemed to enjoy the experience while others did not. Overall, instructors found it more difficult to connect with students (55%). They also reported that students either performed the same (44%) or worse (44%) in the remote classroom and engaged less in questions provided (67%) and group discussions (78%).

An open response question asked instructors if there were any factors that strongly contributed to or hindered their classroom management skills. While no common theme emerged, answers cited various issues such as their own unpredictable childcare and difficulty connecting with students. We also asked instructors if they felt students were able to achieve success in their science courses in the hybrid/remote learning environments in the same way they had in their own previous face-to-face courses. Again, no common themes emerged but response included that it may depended on their student's own motivation or independence as well as the type of assessment given. Other open response questions included instructors' recommendations on courses which would or would not work well remotely, what suggestions they have for improvement to remote science courses, and if they gained any additional skills during their time remote teaching. Overall, instructors felt that remote learning did not work well for laboratory courses and improvements could include additional preparation time, better training for the remote format, and soliciting students for their recommendations. While there was no major theme for skills gained during remote teaching, individuals reported increased proficiency with technology and active learning strategies.

Discussion

Undergraduate science courses are often taught in the face-to-face format, yet the COVID-19 pandemic forced most into a remote learning environment. In this study, we investigated the effects of remote learning on student engagement and perceived success in face-to-face undergraduate science courses from both the student and instructor perspectives. Science courses which are particularly challenging and considered gateway STEM courses were chosen for this study (undergraduate biology, chemistry, physics) (Freeman et al. 2011). Analysis revealed that students were less likely to engage by asking questions, responding to their instructor, or participate in group discussion in their remote science classroom when compared to their previous face-to-face classrooms. Despite the lack of engagement, many felt their success was about the same (44.4%). This warrants further research to investigate perceived success versus academic performance in the classroom and further delineating what

Survey Item	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean (±SD)
I enjoyed teaching a remote/hybrid.	1	3	1	3	1	3.0 (±1.3)
I found it more difficult to connect with students when compared to a traditional setting.	0	2	1	1	5	4.0 (±1.3)
Students engaged more in group discussion in the remote classroom.	6	1	0	2	0	1.8 (±1.3)
Students asked for more help in the remote classroom.	3	2	2	2	0	2.3 (±1.2)
Student performed stronger academically in the remote classroom.	1	3	4	0	1	2.7 (±1.1)
Students engaged more in the questions provided in the remote classroom.	4	2	0	3	0	2.2 (±1.4)

Table 4*. Instructor survey addressing perceptions on engagement and success in the remote undergraduate science classroom when compared to face-to-face classrooms. n=9*

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defines success from the student standpoint. In addition, further studies should investigate if course enjoyment plays a role in student success.

We investigated which factors were most impactful in contributing to decreased engagement and report that other distractions on the internet and stress, anxiety, and other mental health issues were the highest reported. While some students did not feel that mental health factors contributed to their disengagement, it's important to focus on the high number that did. In addition, an open response question addressing suggestions for improvement in the remote classroom recommended that instructors have a better understanding of the emotional concerns and strains of students. Considering instructors reported having a more difficult time connecting with students in the classroom, this is an area to highlight for future study. Future studies should explore this high-ranking contributing factor and investigate the implementation of support strategies to reduce this student concern. Perhaps surprising, class-standing and age of the students did not make a difference in the responses. It would seem likely that upperclassman, due to previous experience in college classrooms, would have been more likely to engage in group discussions, ask questions and feel more successful than underclassman, however, this was not true.

We also wanted to focus on what could improve student engagement in the remote classroom. We found the highest-ranking factors for engagement were instructor enthusiasm and questions asked by the instructor during class. The emphasis that remote students placed on instructor enthusiasm is interesting and suggests that students have some sort of emotional need or preferred personality type for their remote instructors. Their response indicates that enthusiastic individuals may fare better in remote teaching settings, yet this is likely a nuanced situation and further studies should investigate which specific "enthusiastic" behaviors in the remote classroom are leading promotors of engagement.

Students felt that the requirement by the instructor for students to engage was ineffective. The open response question which asked students for factors which would contribute to their success also revealed this common theme of increased engagement from the instructor. Students suggested increased instructor enthusiasm as well more engagement via the incorporation of group discussion, games, and other active learning strategies would support their success. Some responses noted that the remote learning format increased their workload and suggested that extended time on assessments would be beneficial.

From the instructor standpoint, they found it more difficult to connect with students in the remote classroom. They felt that students were less engaged in group discussion and classroom questions when compared to the face-to-face classroom. Overall themes from the instructors' open responses were that the depth of understanding was lacking in the remote classroom, as well as their own personal training in the format. They felt that students who would succeed in a face-to-face classroom would succeed in a remote classroom, but those who lacked motivation in a face-to-face classroom would fare even worse remotely. Instructors had mixed feelings on the enjoyment of teaching remote or hybrid courses. However, a common theme emerged from an open response question where instructors would not recommend a remote learning format for laboratory classes specifically. They felt these types of courses were important to keep face-to-face and did not translate well in the remote setting.

Overall, we found that undergraduate students were less likely to engage in the remote science classrooms when compared to face-to-face instruction, independent of class standing and age. Students felt that instructor enthusiasm was the major contributing factor for engagement in the remote classroom. Similarly, remote instructors felt that students engaged less in group discussion and found it harder to connect with students when compared to their face-to-face classrooms. While many undergraduate science courses have moved back into the face-to-face classroom space, we cannot ignore the increased demand for online learning, potential for future interruptions in face-to-face learning, and the declining undergraduate college course enrollment. While this study had limitations such as small sample size of both students and instructors, any information which can help instructors increase student engagement and success in the undergraduate science classroom is valuable.

About the Authors

Dr. Shannon Kispert is an assistant professor in the Department of Biological Sciences at Webster University. She primarily teaches undergraduate human anatomy and physiology. Carson Gross, BS, is a graduate of Webster University whose undergraduate research focused on pedagogy in the remote classroom.

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