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ABSTRACT

Social distancing guidelines put in place to combat COVID-19 resulted in a general education introductory information technology course being taught in a dual teaching environment. Each lesson, some students attended in-person while simultaneously others attended remotely. Students alternated each lesson between in-person and remote attendance. We examined whether there was any difference in performance between in-person and remote attendance using an end-of-lesson quiz. For some students the quiz was announced and for others it was unannounced. Additionally, we measured the subjective experience of students via a survey.

We found that students attending class in-person performed better on end of class quizzes; the difference was small but statistically significant. In-person students also reported paying more attention, being more engaged, and understanding the lesson material better than remote students. Announcing the quiz did not statistically affect performance, although it did improve the subjective experience of in-person students. Finally, when it comes to dual teaching, both students and instructors prefer in-person or remote teaching. Nevertheless, dual teaching may be an effective approach; there was little difference in final course grades between in-person teaching and dual teaching.

CCS CONCEPTS

• **Applied computing** → **E-learning**; **Distance learning**; • **Social and professional topics** → *Information technology education.*

KEYWORDS

emergency remote teaching, remote teaching, online learning, COVID, dual teaching, information technology education, hybrid learning, learning assessment

1 INTRODUCTION

The pandemic caused by the severe acute respiratory syndrome coronavirus 2 (hereafter, COVID-19) disrupted all aspects of daily

life, including education. Classrooms all over the world, from early through post-graduate education, had to adapt to unexpected conditions. To limit the spread of COVID-19, many educational institutions stopped in-person classes and enacted some form of virtual education. Often, unprepared educators found themselves remotely executing lessons designed for in-person learning using videoconferencing technology such as Zoom or Skype.

Eventually, public health organizations, such as the center for disease control and prevention (CDC) put out guidance that people could interact in-person if they wore masks and remained at least six feet apart (also known as maintaining social distance). Educators responded by rearranging classrooms to meet the CDC guidance. In some cases, adhering to the CDC guidance effectively reduced the number of students that could be physically present in a classroom by more than half.

Given classrooms that could hold fewer students, educators had to make tough choices about how to deliver education. One option was to teach classes in-person but reduce enrollment. Another option was to eschew the physical classroom in favor of remotely teaching classes designed for in-person learning. Both choices have benefits and drawbacks. A completely remote environment prevents potential spread of COVID-19 while perhaps reducing the quality of the learning experience. In contrast, a reduced size in-person classroom allows for course delivery as intended, but services fewer students. We explored a third approach we term dual teaching in which simultaneously a portion of the class attends in-person while another portion attends remotely. We used this dual teaching approach in a general education information technology (IT) course. We then measured performance and surveyed attitudes of teachers and students about the remote and in-person aspects of the course. In addition, we studied how end-of-lesson quizzes affected performance and attitudes. Finally, we interviewed select students and instructors to gauge their attitudes about the overall dual teaching approach.

The rest of the paper is organized as follows: Section 2 reviews some of the research on different digitally-based approaches to teaching, especially in comparison with in-person instruction. Section 3 outlines the environment and details the study we conducted. Section 4 presents the results of our study along with some statistical analysis. Section 5 discusses the results of the study. Finally, section 6 concludes the paper.

2 BACKGROUND

Educators have made extensive use of digital technology to aid and enhance teaching. However, there is no generally agreed definition for many approaches and two authors may use the same term to describe two different teaching approaches. Therefore, we define how

we use certain terms. Face-to-face or in-person teaching refers to the traditional teaching approach where the instructor and students are in the same geographical location (e.g., a physical classroom) at the same time [17]. In contrast, online learning is instruction delivered on a digital device [5]. A distinguishing characteristic of online learning, whether synchronous or asynchronous, is that the learning experience is intended from design thru implementation to be delivered via a digital medium [10]. Hybrid learning, also called blended learning is the intentional integration and interleaving of face-to-face and online learning [8]. In hybrid learning, some elements of the class are delivered face-to-face while other elements are delivered online. Finally, COVID-19 inspired a new approach to teaching that is increasingly referred to as emergency remote teaching (ERT) in which instruction or education designed for face-to-face delivery is instead delivered digitally with the intent to return to a face-to-face format once the precipitating emergency has abated [10]. Numerous institutions implemented ERT during the initial response to COVID-19.

To the aforementioned terms, we introduce a new term for clarity, dual teaching. Dual teaching is instruction delivered simultaneously face-to-face to some students and remotely to others. In a similar vein, rotational dual teaching refers to a variation of dual teaching in which students alternate between attending class face-to-face and remotely.

A reason to consider engaging in dual teaching stems from social distancing guidelines. Prior to the guidelines, many schools and universities responded to the pandemic by embracing emergency remote teaching. With the advent of the guidelines, many schools and universities went back to face-to-face instruction. However, in most cases, following social distancing guidelines required adjustments. One common adjustment was to reduce class sizes such that students could maintain social distancing. For example, in our institution, many classrooms designed to hold 18 students were only able to seat nine while maintaining social distancing. Another common adjustment was rotational learning in which classes were split into cohorts with each cohort only attending class on certain days [2, 7]. Of course, the drawback to these adjustments is that either fewer students were taught (due to reduced class enrollment) or students had less interaction with their instructors and each other (due to rotational cohorts). Dual teaching offers a way to address these drawbacks.

There is some reason to believe dual teaching may be effective. Extensive literature exists comparing online and in-person learning at the college level. Interestingly, most studies have found no difference in student performance in online vs in-person learning [3]. For example, a study of 548 students in an environmental science course from 2009-16 found no significant difference in performance between the two modalities [16]. A 2014 study of 67 psychology students in Australia similarly found no significant difference between in-person and online learning, though the study did find that students preferred that classroom activities occur in-person [12]. A study of 64 students enrolled in an online criminology course found no difference in either performance or subjective student evaluation of the course compared to a traditional environment [18]. However, all of the mentioned studies use classes that were designed to be taught online or hybrid.

Interestingly, recent studies comparing in-person learning and emergency remote teaching (ERT) find increased academic performance in ERT conditions compared to in-person [9, 11]. However, one explanation for the counterintuitive results may be that students spent more time studying because the COVID-19 emergency lockdown prevented them from engaging in many activities that might otherwise vie for their time [4]. Additionally, reported academic performance during ERT may be inflated. Some studies find that cheating was likely more prevalent during the pandemic as more testing was done in online environments [1, 6]. Finally, another drawback of ERT may be lower student engagement and participation [11].

Dual teaching may offer a way to educate more students than socially distanced in-person learning. At the same time, it may increase student satisfaction and participation relative to emergency remote teaching.

3 EXPERIMENT

The course used in our study is an introductory information technology course taken by approximately 800 undergraduate students per academic year to satisfy a core STEM requirement. In academic year 2021, we conducted the class using a rotational dual teaching approach in which half the students attended class in-person while wearing face masks while simultaneously the other half attended class remotely. Students alternated each lesson between in-person and remote attendance such that each student attended half the course in-person and half remotely. Remote attendees had a live video and audio feed of the classroom via Microsoft Teams. Remote students also had two-way audio and video contact with the instructor. In addition, lecture slides were shown to remote participants using the Teams screen sharing feature. The same slides were shown simultaneously to the in-person students using a classroom projector system. No changes to the course curriculum were made for the dual teaching environment.

Our institution mandates small classes. No more than 18 students are assigned to a given class period. Further, classrooms are generally designed with this limitation in mind. As a result, the implementation of social distancing policies reduced the classroom capacity by half during the study period. There were never more than 9 students physically present during a class period nor more than 18 students overall (i.e., combined in-person and remote).

For the study, we measured performance and surveyed student attitudes over six lessons. Three of the lessons were on relational databases and the other three lessons were on data mining. During each lesson, the instructor taught as normal. However, at the end of the lesson the students took a short online survey and quiz. The quiz consisted of three questions drawn directly from the material taught during the lesson; individual grades are therefore on a scale of 0-3. In addition to the quiz, student attitudes were surveyed using four questions on a five-point Likert scale. Students self-reported whether they were attending class in-person or remotely. The responses were collected between February 17 and March 18, 2021. Students were given two minutes at the end of class to complete the entire form. Participation was voluntary.

Additionally, we hypothesized that telling students about the assessment at the beginning of class would improve performance.

Therefore, we implemented an intervention where an instructor either announced at the beginning of the lesson that a quiz would occur at the end of the lesson or the instructor surprised students with the quiz at the end of the lesson. We thought informing students of an end of class quiz would cause them to be more engaged during the lesson. Students self-reported whether they knew about the quiz before it was shown to them. Self-reporting was selected over instructor reporting in case a given student heard from students in earlier periods that a quiz was being given that lesson.

Finally, we interviewed select students and instructors at the end of the course to gain their overall impressions about dual teaching. The interviews were informal, and participants were asked their opinion of dual teaching relative to in-person and emergency remote teaching.

4 RESULTS AND ANALYSIS

Over six lessons, 352 students completed the quiz and survey a total of 1,355 times. There was a total of 496 responses from students attending class in-person and 859 responses from students attending virtually. The disparity results from extensive quarantine of students known or suspected to have been exposed to COVID-19 during the time period covered. The exposed students were quarantined for up to two weeks during which time they attended class virtually. However, the quarantines were mostly precautionary, and the overwhelming majority of students experienced no substantial impairment. The authors were provided limited, confidential information about the collective health outcomes of quarantined students and are satisfied that sickness had no direct effect on student performance. Another reason for the disparity is that it required minimal effort for remote students to complete the quiz and survey. They were already in a virtual environment (i.e., Microsoft Teams) and simply needed to click a provided link. The in-person students had to open a browser window and manually enter the link or startup the virtual Teams environment to click the link. The additional effort may have caused some in-person students to opt not to participate. No incentive was given for participation in the study. All statistical tests were done using the stats module of the SciPy Python library.

4.1 Assessment Quiz

On the lessons when students were quizzed, they were asked to answer three general questions drawn from the lesson material. They received one point for each correct answer, resulting in a score between 0 and 3. No incentive was given for a correct answer to a quiz question. As the sample sizes of the in-person and remote groups are of disparate size and have different variances as indicated by the Fligner-Killeen test, Welch's t-Test was used to evaluate the significance of the difference in mean quiz scores rather than Student's t-test (See Table 1). Sample sizes are shown in Table 2.

Overall, we find no statistically significant difference ($p \leq .05$) in performance between the in-person and remote students considered as independent groups. The two groups were further subdivided according to whether they were surprised by the quiz or informed of it at the beginning of class. No significant differences were found.

Table 1 assumes independent samples, but this was not necessarily the case. Students participated in both in-person and remote

Quiz	Mean Score		% Diff.	Welch's t-Test	
	In-person	Remote		t	p-value
Overall	1.75	1.67	4.68	1.39	0.166
Quiz 1	2.40	2.05	15.7	3.66	<.001
Quiz 2	2.41	2.33	3.23	.629	.531
Quiz 3	1.43	1.36	4.65	.570	.569
Quiz 4	.726	.661	9.36	.859	.391
Quiz 5	1.86	1.89	-1.55	-.226	.821
Quiz 6	1.91	1.56	20.6	2.42	.017

Table 1: Average Quiz Score (out of three) for in person and remote groups, with significance test.

Quiz	N	In-Person	Remote
Overall	1355	496	859
Quiz 1	256	113	143
Quiz 2	189	37	152
Quiz 3	267	105	162
Quiz 4	208	84	124
Quiz 5	243	87	156
Quiz 6	192	70	122

Table 2: Sample sizes by quiz

assessments. Although the first quiz was anonymous, subsequent quizzes were not. Therefore, it is possible to examine individual performance on quizzes 2-6 and compare a student's in-person and remote performance. There were 205 students who took at least one each of an in-person and remote quiz. Individual raw scores were replaced with z-scores (distance from mean in standard deviations), generating a mean z-score for in-person and remote assessment quizzes for each of the 205 identifiable students who took a quiz both remote and in-person. This allowed for a pairwise comparison. The results are reported in Table 3.

Mean z-score		Diff.	Paired t-test	
In-person	Remote		t	p-value
.080	-.090	.171	2.27	.024

Table 3: Pairwise comparison of remote and in-person groups quiz results

The pairwise comparison (Table 3) shows a statistically significant 0.17 standard deviation in performance between in-person and remote sessions, suggesting that a given student tended to perform better when a quiz was taken in-person as opposed to remote. Of note, the pairwise comparison excludes Quiz #1 which had the most significant average difference between in-person and remote students (see Table 1), thus suggesting the difference between in-person and remote performance for a given student may be even greater. Announcing the quiz at the beginning of class had no significant effect on performance.

4.2 Survey

In addition to the assessment quiz, students were asked to respond to subjective survey questions about their experience with the lesson using a Likert scale. These prompts were:

(1) I paid attention in class
(2) I understand the material covered
(3) The instructor engaged with me
(4) I engaged with the instructor

Possible responses were, in order, "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Agree" with a value of 1 corresponding to "Strongly Disagree" and a value of 5 corresponding to "Strongly Disagree". Stronger agreement is considered more positive. Respondents are identical to those in Section 4.1. Results for both the in-person and remote group are given in Table 4. Although the Fligner-Killeen test indicated that only for Question 4 did the in-person and remote groups likely have different variances, Welch's t-test was used to find t values because of the disparity in sample sizes. A Mann-Whitney U-test was also conducted for comparison, given the ordinal nature of the survey responses. The results of the Mann-Whitney test (not shown) were similar to Welch's t-test.

Quest.	Mean Score		Diff.	Welch's t-Test	
	In-person	Remote		t	p-value
Q1	3.91	3.55	.355	6.72	<.001
Q2	3.80	3.51	.289	45.65	<.001
Q3	3.96	3.34	.620	11.15	<.001
Q4	3.73	3.05	.684	11.48	<.001

Table 4: Mean survey results with significance test

On every survey question, the students attending in-person responded to the survey questions more positively than the students attending remotely. The largest difference in means occurred on question 4 which asked if a student felt they "engaged" with the instructor.

Quest.	Format	Surprised?		Diff.	Welch's t-Test	
		Yes	No		t	p-value
Q1	Remote	3.48	3.56	.086	1.38	.16
	In-person	3.64	4.04	.394	3.74	<.001
Q2	Remote	3.52	3.49	-.027	-.475	.409
	In-person	3.64	3.88	.247	3.20	.004
Q3	Remote	3.33	3.34	.012	.187	.851
	In-person	3.62	4.09	.466	5.76	<.001
Q4	Remote	2.98	3.10	.124	1.85	.063
	In-person	3.39	3.90	.512	5.81	<.001

Table 5: Impact of Assessment Surprise on Survey Results

We also evaluated whether the assessment quiz being a surprise had any effect on the survey results. As shown in Table 5, surprise had no statistically significant impact on the survey results of remote students. However, informing students of an end of lesson quiz had a significant impact on students attending class in-person. When students knew about the quiz, they responded more positively to all the survey questions.

4.3 Instructor Assessment

In addition to surveying students, we also asked instructors to assess the in-person and remote students. Instructors reported that students who attended remotely were not as attentive or engaged as the in-person students. The instructors noted when they called on remote students they sometimes had to repeat the question or repeatedly state the students name before getting a response. Anecdotally, it seemed the remote students had various distractions vying for their attention. For example, roommates entering and leaving their dorm room or activity occurring outside the room. In addition, without the authoritative presence of an instructor, it seemed students were not always following along with the instruction. Finally, when it came to delivering instruction, teachers reported a tendency to focus on the in-person students. For example, an instructor would tend to direct questions to the in-person students and gauge the effectiveness of instruction based on the in-person responses.

4.4 Dual Teaching Assessment

Several students were interviewed informally after the semester and asked about their experiences with the dual teaching approach. Specifically, they were asked to discuss their preference for dual teaching, in-person instruction, or ERT. Students overwhelmingly indicated dual teaching was the least preferred approach. Most indicated a preference for in-person learning as they felt they learned better with face-to-face instruction. The students found dual teaching inconvenient since, for each lesson, they had to remember or lookup whether they were supposed to attend remotely or in-person. Several students indicated frustration as on at least one occasion they came to class when they were supposed to attend remotely or vice versa. On those occasions, they indicated some measure of being upset when they had to quickly move to the right medium/location to attend class. Despite preferring in-person instruction and attending half the course in-person, given a choice, students stated they would choose ERT over dual teaching. Further research is needed to understand the factors influencing lack of student preference for dual teaching.

Instructor opinion was similar to student opinion regarding dual teaching. Instructors preferred in-person followed by ERT. Dual teaching was the least preferred approach. Instructors felt they could not optimize instruction using a dual teaching approach. For example, class activities like working through problems on a whiteboard or chalkboard which were appropriate for in-person learning were not as useful for remote teaching. Likewise, practices such as having students share their computer screen with the class, which were appropriate for remote teaching, were not as useful for the in-person students.

5 DISCUSSION

For a given lesson, dual teaching effectively splits the class into an in-person portion and an ERT portion. Thus, much of our study may be thought of as a comparison of ERT and in-person teaching. Our findings with regard to ERT are different than others with regards to performance. Unlike others, we did not observe remote students performing better than in-person students. As a group, we saw no difference in quiz performance between in-person and remote

students. However, when we compare a given student's in-person performance against that same student's remote performance, we find that the student performs better when attending class in-person. One reason our results may differ from others is that other studies used final grades as a measure of performance. There are many factors that can influence final grades in an ERT environment. There are negative factors such as increased cheating as well as positive factors such as increased time spent studying. Our study used a quiz given immediately after a lesson with no benefit for cheating and no time to study. The end of lesson quiz also eliminates other confounding and difficult to measure affects such as teacher accommodations due to the pandemic. Thus, we feel our approach may be a better way to evaluate student performance in an ERT environment.

Quizzes have long been a staple of teaching. Among other benefits, quizzes encourage students to complete pre-class assignments such as reading or practice problems [13, 14]. However, there are times that teachers present lesson material without an expectation that students have studied the material prior to class. In such cases, announcing an end of lesson quiz at the beginning of class may encourage students to "pay attention" during class. A previous study found that so-called mastery quizzes, unannounced quizzes given at the beginning and end of a class lecture, led to a marked improvement in retention of key concepts [15]. The quiz at the beginning of class identified important concepts for the students and they were able to hone in on those concepts when presented during the lesson. We took a slightly different approach in which we announced an end of lesson quiz at the beginning of class. Unlike the mastery quiz in which the lesson's key concepts were presented in the beginning of class quiz, we hypothesized that uncertainty on exactly what would be quizzed at the end of class would lead to increased focus throughout the lesson. Indeed, survey results indicate that in-person students were significantly more engaged when they were told they would have a quiz at the end of the lesson. However, it is surprising that announcing the quiz had no impact on the reported engagement of remote students. Further research is needed to understand the reason for this observation.

It should be noted that, although aspects of our study compare the in-person and remote elements of a class, the findings of our study are not necessarily directly applicable to fully remote or fully in-person classes as the class dynamics of those approaches are different than with a dual teaching approach. For example, teachers in our study reported that the shared physical presence of having students in the classroom tended to draw their focus at the expense of students attending remotely. In a fully remote environment, with all the students in the same virtual setting, it is likely that the teacher's feelings of engagement would change. Conversely, it is also possible that perceived engagement with an all in-person class would decrease since this number of students physically present would double.

Year	Approach	Course GPA
AY19	in-person	3.13
AY21	dual	2.99

Table 6: Academic year performance

Finally, although dual teaching was the least preferred approach by both students and instructors, that does not necessarily mean that it is an ineffective approach. While we do not have data for a fully remote version of our course, it is possible to compare performance of the last fully in-person classes with the dual teaching classes. When looking at the overall performance of dual teaching compared with fully in-person, there seems to be little difference in performance. Table 6 shows the final course GPA for students in academic year 2019 and 2021. Academic year 2019 was the last year of data for fully in-person instruction. Academic year 2020 is not shown as it was a mixture of fully in-person, fully remote, and dual teaching.

6 CONCLUSION

Social distancing guidelines associated with COVID-19 caused educational institutions to adjust their classrooms. Most chose to either continue emergency remote teaching or return to in-person teaching but with a reduced number of students in the classroom. We explored a third approach, dual teaching, in which some students attended class in-person while simultaneously other students attend class remotely. Specifically, we engaged in rotational dual teaching in which students alternated every lesson between in-person attendance and remote attendance. We examined the performance and surveyed the perceptions of students when they were remote and when they were in-person. We also surveyed the perceptions of instructors about remote and in-person learning. Finally, we looked at the overall perceptions of dual teaching.

We found students performed better on an end-of-class quiz when taking it in-person rather than remotely. With regards to subjective experience, in-person students responded more positively than remote students to a survey of perceptions about the lesson. In-person students reported paying more attention, being more engaged, and better understanding the lesson material than remote students. Further, announcing a quiz at the beginning of class increased the positive response of in-person students while having no effect on the remote students. Further research is needed to understand why the two groups responded differently to an announced quiz.

Overall, dual teaching is the least preferred teaching approach relative to fully in-person or fully emergency remote teaching. Students reported frustration over alternating between in-person and remote attendance. Likewise, instructors reported difficulty in optimizing instruction for two different audiences. However, though least preferred, there is some indication that dual teaching is effective. Students in a dual teaching environment performed about as well as students in an in-person environment as measured by final course grades.

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REFERENCES

[1] Antonio Balderas and Juan Antonio Caballero-Hernández. 2020. Analysis of Learning Records to Detect Student Cheating on Online Exams: Case Study

during COVID-19 Pandemic. In *Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality*. 752–757.

[2] Molly Borowiak, Fayfay Ning, Justin Pei, Sarah Zhao, Hwai-Ray Tung, and Rick Durrett. 2020. Controlling the spread of COVID-19 on college campuses. *arXiv preprint arXiv:2008.07293* (2020).

[3] Joseph K Cavanaugh and Stephen J Jacquemin. 2015. A large sample comparison of grade based student learning outcomes in online vs. face-to-face courses. *Online Learning* 19, 2 (2015), n2.

[4] Mariana Cernicova-Buca and Gabriel-Mugurel Dragomir. 2021. Romanian Students' Appraisal of the Emergency Remote Assessment due to the COVID-19 Pandemic. *Sustainability* 13, 11 (2021), 6110.

[5] Ruth C Clark and Richard E Mayer. 2016. *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning.* john Wiley & sons.

[6] Ted M Clark, Christopher S Callam, Noel M Paul, Matthew W Stoltzfus, and Daniel Turner. 2020. Testing in the time of COVID-19: A sudden transition to unproctored online exams. *Journal of chemical education* 97, 9 (2020), 3413–3417.

[7] Jarrod S Dennis. 2020. The Effects of Rotational Blended Learning on Course Grades in High School Credit Recovery Math I and English I Courses. (2020).

[8] D Randy Garrison and Heather Kanuka. 2004. Blended learning: Uncovering its transformative potential in higher education. *The internet and higher education* 7, 2 (2004), 95–105.

[9] Teresa Gonzalez, MA De La Rubia, Kajetan Piotr Hincz, M Comas-Lopez, Laia Subirats, Santi Fort, and GM Sacha. 2020. Influence of COVID-19 confinement on students' performance in higher education. *PloS one* 15, 10 (2020), e0239490.

[10] Charles Hodges, Stephanie Moore, Barb Lockee, Torrey Trust, Aaron Bond, et al. 2020. The difference between emergency remote teaching and online learning. *Educause review* 27, 1 (2020), 1–9.

[11] Santiago Iglesias-Pradas, Ángel Hernández-García, Julián Chaparro-Peláez, and José Luis Prieto. 2021. Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study. *Computers in Human Behavior* 119 (2021), 106713.

[12] Nenagh Kemp and Rachel Grieve. 2014. Face-to-face or face-to-screen? Undergraduates' opinions and test performance in classroom vs. online learning. *Frontiers in psychology* 5 (2014), 1278.

[13] Haig Kouyoumdjian. 2004. Influence of unannounced quizzes and cumulative exam on attendance and study behavior. *Teaching of Psychology* 31, 2 (2004), 110–111.

[14] Michael Marcell. 2008. Effectiveness of regular online quizzing in increasing class participation and preparation. *International Journal for the Scholarship of Teaching and Learning* 2, 1 (2008), n1.

[15] Jeffrey S Nevid and Katie Mahon. 2009. Mastery quizzing as a signaling device to cue attention to lecture material. *Teaching of Psychology* 36, 1 (2009), 29–32.

[16] Jasmine Paul and Felicia Jefferson. 2019. A comparative analysis of student performance in an online vs. face-to-face environmental science course from 2009 to 2016. *Frontiers in Computer Science* 1 (2019), 7.

[17] Petrea Redmond. 2011. From face-to-face teaching to online teaching: Pedagogical transitions. In *Proceedings ASCILITE 2011: 28th annual conference of the Australasian Society for Computers in Learning in Tertiary Education: Changing demands, changing directions.* Australasian Society for Computers in Learning in Tertiary Education (ASCILITE), 1050–1060.

[18] Steven Stack. 2015. Learning Outcomes in an online vs traditional course. *International Journal for the Scholarship of Teaching and Learning* 9, 1 (2015), n1.