

Face-to-Face vs. Online Asynchronous Teaching in a Conservation Biology Course

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Abstract

Effective, e-learning environments include a diverse range of pedagogical practices and should focus on active-learning and student-centered pedagogy. Therefore, it should not be the delivery medium, but rather the instructional methods that facilitate proper learning. Courses that incorporate effective instructional methods will support better learning than courses that do not use effective methods, regardless of the mode of delivery. We compared a traditionally taught face-to-face conservation biology course, Biol 4244/5244, for Biology majors to a fully online asynchronous e-learning course designed using essentially the same materials but varying course delivery. The Biol 4244/5244 course is designated by the University of North Carolina at Charlotte as a “writing-intensive course,” where communication is a significant part of the course learning experience. We found no significant differences in learning outcomes, regardless of the method of course delivery. Overall, we feel that this study indicates that online instruction in this type of writing-intensive and evolution-based course is a viable alternative to face-to-face instruction.

Keywords: face-to-face, online, conservation biology, writing-intensive course, evolution-based course

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Science education has rapidly transformed in the digital age, and a large shift in pedagogical approach has occurred over the last 10–20 years. The traditional model, where the lecturer acts as the “sage on the stage,” has become outdated, and is conflict with much of what we know about effective science teaching. Still, many classrooms in higher education rely on a transformative approach to teaching where students attend lectures and earn course grades through in-class participation and examination. An asynchronous online course structure, however, allows students coming from varying backgrounds to review and explore material on their own time, and at their own pace. While deadlines in these courses do exist, the students are largely allowed to complete these assignments as they proceed through the course material on their own. This structure helps place the learning directly in the hands of the student, while shifting the instructor’s role toward being a facilitator. Asynchronous e-learning courses have the potential to capture the benefits of web-based instruction while retaining benefits of traditional classroom instruction, such as direct interactions (Navarro & Shoemaker, 2000; Martin & Bolliger, 2018).

Review of Relevant Literature

In a study of undergraduate students at an American university enrolled in both traditional face-to-face and online courses, students indicated that they preferred online courses to the traditional classroom, indicating that they learned more in these classes, spent more time on these classes, and found these classes to be more difficult yet of higher quality than traditional classes (Hannay & Newvine, 2006). In a comparative study, Paul and Jefferson (2019) examined the differences between traditional and online learning environments and argued that traditional learning environments are (a) bound by location and presence of instructor and student, (b) presented in real time, (c) controlled by an instructor, and (d) are linear in teaching methods. Alternatively, asynchronous online courses are unbound and can be more flexible and dynamic (Paul and Jefferson, 2019).

An asynchronous online course design offers several methods that motivate, challenge and assess students without an instructor having to lead every step of the learning process (Sunal et al., 2003). A well-designed e-learning course has the potential for achieving high levels of learning and understanding, comparable to levels from traditional in-class environments (Byrd-Bredbenner and Bauer, 1991; Zubas et al., 2006; Bernstein, 2013; Nassoura, 2020). Hundreds of comparison studies have shown no differences in learning between e-learning and traditional classrooms (Clark, 1994; Dillon and Gabbard, 1998; Palocsay and Stevens, 2008; Magalhães et al., 2020; Hilton et al., 2021). Bernard et al. (2004) performed a meta-analysis integrating research studies that compared e-learning to learning from traditional classrooms and found no practical differences between e-learning and face-to-face learning. A review of online learning by Tallent-Runnels et al. (2006) found overwhelming evidence that learning in an online environment can be as effective as that in traditional classrooms. However, they found that student learning in an online environment was affected strongly by the quality of the online instruction.

To be effective, e-learning environments should include a diverse range of pedagogical practices and should focus on active learning student-centered pedagogical techniques (Baker, 2003; Browne, 2005; Harris et al., 2020). Therefore, it should not be the delivery medium, but rather the instructional methods that facilitate proper learning. Courses that incorporate effective

instructional methods will support better learning than courses that do not use effective methods, regardless of the mode of delivery (Keengwe and Kidd, 2010; Clark and Mayer, 2016).

Research Questions

We compared a traditionally taught face-to-face conservation biology course, Biol 4244/5244, for Biology majors to a fully online asynchronous e-learning course designed using essentially the same materials but varying course delivery. The Biol 4244/5244 course is designated by the University of North Carolina at Charlotte as a “W” or “writing-intensive course” where communication is a significant part of the course learning experience. In writing intensive courses, students are given frequent opportunities to engage in a variety of informal, low stakes communication assignments and learning activities. Informal writing and speaking opportunities have the explicit purposes of exploring and deepening content area knowledge and developing writing abilities. Students are further required to complete at least one formal communication assignment where students are given formative feedback and an opportunity to revise a significant part of at least one formal communication assignment. For formal writing in W courses, there is a minimum requirement by the university of 2,500 words (approximately 9–10 pages). In Biol 4244/5244, the formal writing assignment is a group-written grant proposal on a chosen conservation related theme. Some of these themes included effects of climate change on species distribution, effects of habitat loss and fragmentation, conservation genetics, endangered species, and the illegal wildlife trade.

To facilitate communication in this course, a peer communication consultant was embedded in the course by the Communication Across the Curriculum (CxC) program. This faculty development program exists to help faculty and departments design curricula that can improve students’ writing and speaking skills. The peer communication consultant is a fellow biology major that has received extensive training in communication methods and meets with students, or in our case student groups, to work on communication and writing-based skills weekly throughout the semester. We compared a variety of learning outcomes, including those related to written communication skills, between students taught using a traditional face-to-face lecture, and students from a newly developed e-learning course in an asynchronous online environment in order to assess which mode of delivery was most effective in promoting learning and written communication in this STEM course.

Methods

Students enrolled in the conservation biology course during spring 2019 (n = 22) were taught using traditional face-to-face lectures, combined with in-class writing activities and in-class work with a peer consultant once per week to help with writing assignments. Students taking the course in fall 2020 (n = 18) participated in a fully asynchronous online course format and were taught using pre-recorded lectures, combined with online discussion boards, online writing activities, and online work with a peer consultant once per week.

Evaluation

Pre- and post-course surveys consisted of 25 questions based on demographics, course learning objectives, and student perceptions about written communication development. Students were first asked a series of questions related to writing-intensive coursework. Questions were related to the following course objectives and measured students’ self-perception of mastery of the objectives:

- (1) Students will locate and access the Atkins library biology research guide where all the online databases for searching literature are located.
- (2) Students will differentiate between an empirical study and a literature review article.
- (3) Students will be able to formulate a scientific hypothesis.
- (4) Students will cite scientific literature using MLA, CSE, or APA formats.
- (5) Students will synthesize data to think creatively about scientific problems.
- (6) Students will locate and access appropriate scientific literature specific to subdisciplines of interest.
- (7) Students will provide and receive useful constructive feedback as part of the peer review process.
- (8) Students will work as a team to solve scientific problems.
- (9) Students will read and interpret scientific literature specific to subdisciplines of interest.
- (10) Students will communicate scientific ideas to non-experts through writing.
- (11) Students will collaborate with a peer communication consultant to improve their writing skills throughout the course.

Students were next asked a series of questions related to conservation biology content. These questions were related to the following course objectives and measured students' self-perception of mastery of the objectives:

- (1) Students will describe the development of the field of conservation biology based on three predominant conservation land ethics.
- (2) Students will explain the significance of conserving ecosystem, species, and genetic diversity.
- (3) Students will differentiate between preservation and conservation.
- (4) Students will describe the main threats to biodiversity.
- (5) Students will describe the significance of the current extinction crisis.
- (6) Students will describe the process of de-extinction.
- (7) Students will describe the effects of global climate change on alterations to water and nutrient cycling.
- (8) Students will describe predicted effects of global climate change on species distributions and phenologies.
- (9) Students will discuss the ethical responsibility of humans in maintaining biodiversity in a sustainable manner.

Statistical Analysis

All test scores were analyzed with inferential statistics using quantitative software, JMP Pro 15. Fisher's exact test was used to accommodate a small sample size. For spring 2019 (face-to-face) and fall 2020 (online) semesters, a statistical analysis was performed to compare the pre- and post-test responses for each question. This analysis was conducted to determine the impact of each teaching delivery method on student understanding for the assessment criteria. To check for the possibility of sample bias, another analysis was conducted to compare responses on the pre-test scores for each delivery method. This step was taken to determine if there was any statistical difference between the groups prior to instruction. Finally, another analysis was performed on each question to compare responses on the post-test scores for each teaching delivery method. This final analysis establishes whether there was a statistically significant

difference between the post-test scores for both groups, which would be an indicator of the relative effectiveness of the two delivery methods.

Additionally, we compared students' overall performance in the course. This comparison included analyzing the average exam scores, final course grade, and performance on a course-long, collaborative writing project. Again, we utilized JMP Pro 15 software to complete the inferential statistical analysis. For each performance area, the numerical score for face-to-face students was compared to that of the online students. A box plot was used to check for the normality of the data. This check indicated that the data are not normally distributed for the three criteria. Therefore, the Wilcoxon Rank Sum, nonparametric test was used to look for a significant difference in the three data sets.

Results

Demographics

UNC Charlotte (UNCC) is an urban research university with over 30,000 students. The undergraduate student population is 57% White, 16% African American, 10% Hispanic, 7% Asian, 5% two or more races, 3% non-resident alien, and the remainder unknown (UNC Charlotte, n.d.). Ninety percent of students enrolled in Biol 4244/5244 were seniors in their last year of undergraduate schooling (n = 20 spring 2019 face-to-face, n = 16 fall 2020 online), while there was only 1 junior in spring and 1 graduate student enrolled in both semesters (Table 1). Twenty-three percent (n = 5) of students enrolled in the course transferred from a junior or community college in spring 2019, while 77% (n = 17) did not (Table 2).

Twenty-eight percent (n = 5) of students in fall 2020 transferred to UNCC from a junior or community college, while 72% (n = 13) did not. Similarly, 23% (n = 5) of students enrolled in Biol 4244/5244 transferred to UNCC from a 4-year college in the spring 2019 course, while 77% (n = 17) did not. Only 11% of students in the course transferred from another 4-year college in the fall 2020 course, while 89% did not (Table 2). Students who transfer from a community college can have different experiences and motivations that might impact their performance (List & Nadasen, 2017). Accordingly, we collected data on possible differences in the students' academic backgrounds in the demographics of our questionnaire to include transfer student information. Assessing the impact of academic background was beyond the scope of our study; however, the data is included in the event it is helpful to other researchers.

Table 1
Summary Data for Students Participating in this Study

Semester taught	Class ranking	n
Spring 2019 (face-to-face)	Junior	1
	Senior	20
	Graduate	1
Fall 2020 (online)	Junior	1
	Senior	16
	Graduate	1

Table 2*Where Students from This Study Came From Prior to UNCC*

Semester taught	Transferred from junior/community college	n
Spring 2019 (face-to-face)	Yes	5
	No	17
Fall 2020 (online)	Yes	5
	No	13
Semester taught	Transferred from 4-year college	n
Spring 2019 (face-to-face)	Yes	5
	No	17
Fall 2020 (online)	Yes	2
	No	16

Qualitative Course Performance—Writing Intensive Survey Questions

There were no significant differences between the modes of course delivery from spring 2019 (face-to-face) and fall 2020 (online asynchronous) for any of the survey questions related to the writing intensive course objectives (Table 3). There was a significant difference between pre-course and post-course answers for both modes of delivery for the following questions, indicating that students increased their confidence throughout the semester (Table 3):

- (1) I know how to access the biology research guide.
- (2) I can differentiate between an empirical and review article.
- (3) How confident are you in your ability to think creatively about scientific problems?
- (4) How confident are you in your ability to choose an appropriate database to search for scientific literature across subdisciplines?

There was a significant difference between pre-course and post-course answers for spring 2019 (face-to-face) for the following questions:

- (1) I am able to write a proper scientific hypothesis.
- (2) How confident are you in your ability to read and interpret scientific literature?
- (3) How confident are you in your ability to communicate scientific ideas through writing?

There was no difference found between pre- and post-course answers in either semester for the following questions, meaning that students did not increase their confidence in these questions throughout the semesters for either mode of course delivery (Table 3):

- (1) Is this a properly written hypothesis: “Does applying fertilizer to plants help them grow?”
- (2) I am able to cite scientific literature within the text of a paper using MLA, CSE, or APA format.
- (3) How confident are you in your ability to give and receive useful constructive feedback as part of the peer review process?

- (4) How confident are you in your ability to work on solving a scientific problem as part of a team?
- (5) How confident are you in your ability to communicate scientific information to a non-expert?
- (6) How likely do you think you are to benefit from working with a peer communication consultant in this course?

Qualitative Course Performance—Conservation Biology Content

There were no significant differences between the modes of course delivery from spring 2019 (face-to-face) and fall 2020 (online asynchronous) for any of the survey questions related to the conservation biology content course objectives (Table 3). We did find a significant difference between pre-course and post-course answers for both semesters for the following questions, indicating that students increased their confidence in the questions throughout the semester (Table 3):

- (1) I am able to describe the development of the field of conservation biology based on the three predominant conservation land ethics.
- (2) I am able to tell the difference between conservation and preservation.
- (3) I am able to describe the main threats to biodiversity.
- (4) I am able to describe the significance of the current extinction crisis.
- (5) I am able to describe the process of de-extinction.
- (6) How confident are you in your ability to accurately describe predicted effects of global climate change on alterations of water and nutrient cycles?
- (7) How confident are you in your ability to accurately describe the predicted effects of global climate change on species distributions and phenologies?
- (8) How confident are you in discussing the ethical responsibility of humans in maintaining biodiversity in a sustainable manner?

There was a significant difference between pre-course and post-course answers for spring 2019 (face-to-face) only for the following question:

- (1) I am able to explain the significance of conserving ecosystem, species, and genetic diversity.

Quantitative Course Performance

A look at the exam average of the face-to-face students and that of the online students indicated no significant difference in their performances. The normal and chi-square approximations for the Wilcoxon test statistic indicated p-values of 0.7642 and 0.7538, respectively. There was also no significant difference in the mean final course grades. The p-value for the normal approximation was 0.3005, and the chi-square was 0.2941. Finally, the analysis of the collaborative project scores indicated no significant difference between the course formats. In this case, the p-values for the normal and chi-square approximations under the Wilcoxon test were 0.0918 and 0.0752, respectively. These scores were further analyzed using the Wilcoxon Exact Test. The two-tailed p-value here was 0.0844, supporting no significant difference in the students' performance on this project.

Table 3

Questions Where Both Groups Showed Improvement from Pre-course to Post-course and There Was No Significant Difference on the Post-course Assessment

Question	Face-to-face Pre vs Post Test	Online Pre vs Post Test	Face-to-face vs. Online Pre tests	Face-to-face vs. Online Post tests
<i>I know how to access the biology research guide.</i>	< 0.0001*	< 0.0114*	0.1468	0.2198
<i>I can differentiate between an empirical and review article.</i>	<0.0001*	<0.0001*	0.9265	1.0000
<i>How confident are you in your ability to think creatively about scientific problems?</i>	0.0079*	0.0433*	0.9542	0.4310
<i>How confident are you in your ability to choose an appropriate database to search for scientific literature across sub-disciplines?</i>	0.0004*	0.0054*	0.7175	0.4977
<i>I am able to describe the development of the field of conservation biology based on three predominant conservation land ethics.</i>	<0.0001*	<0.0001*	1.0000	0.4761
<i>I am able to explain the difference between conservation and preservation.</i>	<0.0001*	<0.0029*	0.2000	1.0000
<i>I am able to describe the main threats to biodiversity.</i>	0.0014*	0.0191*	0.7470	1.0000
<i>I am able to describe the significance of the current extinction crisis.</i>	<0.0001*	0.0076*	0.1098	1.0000
<i>I am able to describe the process of de-extinction.</i>	<0.0001*	<0.0001*	0.1962	1.0000
<i>How confident are you about your ability to accurately describe predicted effects of global climate change on alterations to water and nutrient cycling?</i>	<0.0001*	<0.0001*	0.1224	0.9066
<i>How confident are you about your ability to accurately describe predicted effects of global climate change on species distributions and phenologies?</i>	<0.0001*	0.0012*	0.6191	0.8926
<i>How confident are you in discussing the ethical responsibility of humans in maintaining biodiversity in a sustainable manner?</i>	<0.0001*	0.0112*	0.6248	1.0000

Discussion

University courses may or may not be suitable for online delivery. For writing intensive courses, online delivery often suits the content of the course well, as this type of delivery is primarily text-based (Savenye, 2001). Despite the format of a course as online writing intensive, providing opportunities for student-student interactions and student-faculty interactions through

online discussions and interactive assignments are essential for maintaining learning engagement in the course (Buelow et al., 2018). Martin et al. (2020) noted that participation in online discussion boards and other methods of computer-mediated communication are critical to student's success in online courses. Studies by Kucuk and Richardson (2019) indicated that cognitive presence is significant in maintaining online learning engagement. The structure of our course, including the student-student collaboration on the grant writing project, and student-peer interaction with a peer communication consultant helped maintain students' cognitive presence in online and face-to-face classes. Text-based writing projects, and even peer reviews, can easily be turned in and shared online and students can easily participate in asynchronous discussion posts related to course content.

Our study comparing a face-to-face version of conservation biology, Biol 4244/5244, to an asynchronous online version showed no significant differences between these two modes of course delivery when comparing learning outcomes related to course material and written communication. Both modes of course delivery required the students to work in small groups of 4 to 5 to write a comprehensive grant proposal as their writing intensive assignment for this course. The student performance for both groups indicates that students can work collaboratively to produce an effectively written scientific document, independent of the mode of course delivery. Questions where both groups showed improvement from pre-course to post-course and where there was no significant difference on the post-course assessment indicated that there were no significant differences between face-to-face and online methods of instruction. This was the case for 12 out of the 24 questions, not considering the demographic questions. Interestingly, no communication-related questions fell into this category.

There were several face-to-face survey questions that showed a significant difference from pre-course to post-course and showed no significant difference on the post-course assessment for the two groups. These questions included student confidence in ability to write a proper scientific hypothesis, read and interpret scientific literature, written communication of scientific ideas, and explaining the significance of conserving ecosystem, species, and genetic diversity. This indicates that there are several areas where teaching face-to-face might be more effective than teaching online, especially for communication-based objectives. In a face-to-face environment, we took time to practice a number of these communication-based skills that were possibly not adequately replicated in the online version of the course. It should be noted that although online students did not show improvement in their confidence in these abilities, their performance on the comprehensive grant proposal indicates otherwise. Online and face-to-face students showed increased confidence in their ability to access the biology research guide, to differentiate between an empirical and review article, to think creatively about scientific problems, and to choose an appropriate database to search for scientific literature across subdisciplines.

Research has shown that students who report higher self-efficacy in their ability to use online platforms and self-regulate will perceive greater course effectiveness and are more satisfied with their learning experience (Landrum, 2020). Only one section of our course was offered each of the semesters studied. So, students wanting to take the course were required to enroll in the only format offered. This limited offering meant that students might not have been comfortable with taking an online class. Teaching presence can increase students' emotional

engagement in a course as well as increase students' constructive involvement (Kucuk & Richardson, 2019). Therefore, in future online course offerings, promoting confidence as well as improvement in capability should be a focus.

No conservation biology-related questions resulted in similar responses for both groups on pre-course and post-course assessment, which means that students learned this material by taking the course through both methods of instruction. However, there were several questions related to accessing resources and literature that showed no significant difference before and after taking the course, as well as a number of communication-based questions. Student answers on the pre- and post-test surveys indicate that students entered the class both semesters already having these skills. For example, there was no difference in the pre- and post-test answers for identifying a properly formatted hypothesis or being able to cite literature properly using a common scientific format. The student answers indicated that all 18 of the students surveyed were confident in these skills prior to taking the course in a face-to-face format. Only three students indicated that they may not recognize a properly formatted hypothesis, while only four indicated that they may not be able to properly cite literature prior to taking the online course.

Using quantitative analysis methods, we found no statistically significant difference in students' academic achievement in online and traditional exams. Nor was there a difference in the collaborative grant proposal assignment. This information is a strong indicator of the students' skills. Instead, the questionnaire is an indicator of student confidence in their ability.

There were some methodological weaknesses and limitations to our study. One is the limited comparison of only two classes to each other. We do feel that our study provides an interesting and relevant comparison of a conservation-based face to face and online course. In the future, studies over longer periods of time could add more information to the results we obtained in the present study. Additionally, we recognize that replication of our study could be challenging given the incorporation of a peer communication consultant into the course. While this could be a challenge, it could still be accomplished if others were truly interested in conducting a similar study over a longer period.

Overall, we feel that this study indicates that online instruction in this type of course is a viable alternative to face-to-face instruction. Student performance and confidence are comparable in many (most) of the assessed areas. Improving student confidence is one area that can use some improvement. Martin et al. (2020) suggests the use of a Student Readiness for Online Learning (SROL) survey to determine students' confidence in their ability for online learning. SROL data reflects students' attributes, time management, communication, and technical competencies, all of which have been shown to increase student confidence in online learning. Survey results can be used by students and faculty to assess readiness for online learning and to improve student confidence in online learning. We feel other educators can use information gained in our research to plan and design similar online courses.

Declarations

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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