KENAN FELLOWS PROGRAM FOR TEACHER LEADERSHIP

NC STATE

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Adapting Outdoor Education for Online Learning: A Comparison of Student Experiences in Virtual and In-Person Settings

Dennis Kubasko and Amy Taylor, UNC-Wilmington and Katelyn Higgins, North Brunswick High School

Abstract

This study analyzes a 5-week interdisciplinary summer course designed to serve synchronous face-to-face learners and asynchronous online learners. The online option was first offered in 2020 due to the COVID-19 pandemic. During the course, students explored coastal ecosystem flora and fauna, analyzed local environmental issues, and used these experiences to develop web-based products that feature K-12 integrated lesson plans. The authors collected pre- and post-reflection data from students spanning 2020-2024 and have developed three research questions: (1) Does students' knowledge of science content change when placed in an outdoor face-to-face vs asynchronous online setting? (2) Does students' knowledge of instructional pedagogy change when placed in an outdoor face-to-face vs asynchronous online setting? (3) What qualities and characteristics are more pronounced in student perceptions of outdoor face-to-face vs asynchronous online learning modalities? While there are differences in science content knowledge and instructional pedagogy between face-to-face and asynchronous students, the authors assert that offering both modalities provides students with academic opportunities and perspectives. Based on this data and their own experiences, the authors share a collaborative model that benefits student learning and faculty instructional design when converging modalities, including integrating new mobile technologies.

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

The Island Ecology for Educators (IEE) course is offered as an elective for undergraduate and graduate students during the five-week summer semester (Taylor et al., 2019). It targets two populations of university students: those majoring in science content (i.e., environmental studies, biology, etc.) and pedagogical students majoring in education (elementary, middle, and secondary). Through interactions with resources and experts, students develop readily accessible, web-based materials through engagement with field-based exploration of plants and animals of coastal ecosystems and environmental issues. The IEE course enriches science content knowledge and pedagogical resource development through hands-on, practical outdoor experiences.

The purpose of the course is to (a) provide an overview of the distinct ecosystems found on barrier islands, (b) foster active partnerships by interfacing students with community resources and local experts in science and education, (c) engage in peer-to-peer experiential learning, and (d) explore the use of emerging and emerged forms of technology. The authors assert that designing field-based courses across university departments and involving public stakeholders breaks down the silos that divide academic disciplines and promote interdisciplinary learning. The pedagogical strategies are specifically integrated to enhance students' technology skills and foster critical thinking across content disciplines. The course draws upon 12 years of outdoor education experiences in past course integration.

Due to the global COVID pandemic in 2020 and despite the outdoor nature of the experience, the IEE course was transitioned to an asynchronous online-only modality for university students. Local experts were asked to share their experiences via Zoom meetings in real-time and recorded videos, and peer experiential learning was redesigned to reflect the new online reality. Students accessed course materials using Canvas, and faculty developed pre- and post-assessments to evaluate the impact of the asynchronous online experience on students. The course saw a dramatic increase in enrollment in the summer, and the findings led the instructors to consider hosting students both asynchronously online and face-to-face for the ensuing years (2021-

2024). Ongoing yearly feedback was documented and considered as the course delivery system evolved.

Outdoor Education

Teaching outdoors is becoming increasingly popular for K-12 science classrooms and higher education classes that utilize fieldwork. Outdoor education helps teachers and students conceptualize scientific topics and positively influences students' knowledge, interest, attitude, and motivation (Ayotte-Beaudet et al., 2017). Using fieldwork as a means of education helps students understand theory and provides realistic experiences in subject-specific skills and contexts (Scott et al., 2006). However, teaching methods in outdoor environments differ from traditional classroom approaches, requiring strategies tailored to outdoor settings. Teachers should take a student-centered approach, include active learning opportunities, and connect theory with practical experiences (Jeronen et al., 2016; Kali et al., 2018; Kervinen et al., 2018; Kitchen & Maddison, 2021; Scott et al., 2006).

Despite the benefits, several obstacles can hinder the integration of outdoor teaching, including a lack of confidence and training. These include their lack of confidence and training in outdoor teaching environments and curriculum constraints (Ayotte-Beaudet et al., 2017; Jeronen et al., 2016; Kervinen et al., 2018; Tal & Morag, 2009). Additionally, outdoor teaching presents challenges such as weather unpredictability, classroom management, and time constraints (Ayotte-Beaudet et al., 2017; Jeronen et al., 2016; Kali et al., 2018; Kervinen et al., 2018). Teachers can mitigate these challenges by thoroughly preparing, which could involve conducting risk assessments, identifying high-quality learning outcomes, and anticipating potential barriers (Kitchen & Maddison, 2021). The 2020 pandemic extended unprecedented challenges to face-to-face and outdoor learning, forcing educators to adapt their teaching methods to virtual platforms quickly. This shift required them to reconsider how to engage students, assess learning, and foster a sense of community, connection, and practical application of content in a digital environment.

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Effects of the Pandemic on Higher Education

The pandemic's effect on education has significantly reshaped how instructors and students approach teaching and learning. These changes include the expansion of online and hybrid modalities, issues of equity to technology access, and discipline-specific challenges. As Zhang and Chen (2023) described, online learning has several advantages, such as lower costs, access to a broader range of courses, flexibility, and eliminating of eliminating the ability to eliminate commuting or relocation needs. One study (Stoian et al., 2021) has described how students do not prefer one teaching modality over another; instead, they favor hybrid courses. Even before the 2020 pandemic, Alsaaty et al. (2016) and Tagoe (2012) shared that students are becoming more adept at transitioning to online learning. In many cases, these students prefer blended courses that combine both face-to-face and online learning.

Equity and Access

One realization many learning institutions experienced over the last four years was that not all students may have access to reliable internet connections or the necessary devices at home, which may lead to inequities in learning opportunities (Fatimawati et al., 2024). Online learning with a hybrid or blended format can create a more flexible and dynamic learning environment than solely online learning. Still, research suggests that this type of modality has been shown to exacerbate existing educational disparities, particularly with accessing online resources and participating in synchronous online classes which will only increase the digital divide (Raes, 2022).
Discipline-specific Challenges

In recent years, applied sciences universities have become a significant part of higher education, including subjects in engineering, technology, agriculture and forestry, economics, finance, business administration, design, and nursing (Zhang & Chen, 2023). The curriculum of applied sciences emphasizes practical hands-on skills and, therefore, faces challenges in transitioning the learning environment from face-to-face to online learning (Correia, 2020). In one study (Nguyen & Patel, 2023), dental students found it challenging to learn the necessary content and engage in critical thinking when using an online format. Similarly, science educators have struggled to teach inquiry or laboratory-based lessons online. E-Learning is less well-suited and sometimes less effective for science education, which requires hands-on activities for students to visualize phenomena and concepts (Kustusch, 2016 & O'Brien, 2021). Studies by Alzahrani et al. (2020) and Kaur et al. (2020) have highlighted that online education cannot fully replace in-person classes, particularly in medical education. This is due to the lack of integrated kinesthetic learning, a challenge that applies to most hands-on science courses, such as outdoor environmental studies.

The COVID-19 pandemic has altered the future of digital learning in higher education. It seems to be defined by a combination of online and in-person methods, a focus on more inclusive and equitable access, continuous pedagogical development, and adaptations tailored to specific disciplines that emphasize applied learning. Two studies indicated that there is a preexisting trend of student interest in online learning where approximately 30 percent of students preferred all or most online learning, and 56 percent preferred blended learning formats (Day et al. (2022) & Gierdowski (2019)). Student preferences arise more from the flexibility in instruction modalities that mesh with their personal circumstances (e.g., commuting, employment, desire for immersion) rather than a personal view about the benefits of fully online or face-to-face learning (Guppy et al., 2022).

Research Questions

Given the lack of or limited data on transitioning authentic outdoor education and face-to-face courses to online modalities, it is vital to consider whether student learning can benefit from the convergence of mediums. It is important to investigate potential faculty solutions when designing instructional experiences to help learners when outdoor experiences are restricted or inaccessible. This paper describes a study of students' pre- and post-student perceptions and reflections in asynchronous online modalities vs outdoor learning environments. We answered the following three research questions:

1. Does students' knowledge of science content change when placed in an outdoor face-to-face vs asynchronous online setting?
2. Does students' knowledge of instructional pedagogy change when placed in an outdoor face-to-face vs asynchronous online setting?
3. What qualities and characteristics are more pronounced in student perceptions of outdoor face-to-face vs asynchronous online learning modalities?

The findings of this research have contributed to a collaborative model that enhances student learning and faculty instructional design through integrating new mobile technologies.

Methodology

The IEE course is an elective course taught over a five-week summer semester. The instructors employed two learning modalities in the Island Ecology for Educators (IEE) course: face-to-face and asynchronous online designs. The face-to-face instructional design can be defined as students physically coming to class and participating in many outdoor educational experiences. The asynchronous online instructional design for the IEE course can be defined as students participating at a distance, at their own pace, and engaging with course material at their convenience. All students employed Canvas, a web-based learning management system, to engage with the content.

This study used longitudinal data to investigate student pre- and post-survey responses in the IEE course over five academic years. The IEE course averages 15 students annually and includes graduate and undergraduate students majoring in science and education. It should be noted that a small percentage of students choose not to complete the pre- or post-survey, or both. Those incomplete data sets are removed from the analysis. Completed student responses were separated into face-to-face and asynchronous online student categories and summarized in an Excel sheet. Thirty asynchronous online students and 20 face-to-face students completed both pre- and post-surveys. Enrolled students registered for the IEE course either as a university graduation requirement or as a chosen elective.

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Qualitative data was gathered from closed and open-ended questions about student learning in content, pedagogy, technology integration, and perceptions of learning modalities. The surveys were analyzed for reliability, and then the results were discussed for accuracy of interpretation. The researchers separately coded the survey responses, assigned meaning, and then collaborated to qualify any emergent themes generated across the codes. The themes were determined based on the number of common species, topics, or items mentioned per question. Responses with the same or different mentions of species, topics, and items were highlighted in assorted colors for easy identification. A Microsoft Excel spreadsheet collected all survey responses, codes, and emergent themes.

Results

Data from the Island Ecology for Educators (IEE) course was collected from 2020-2024 through written student survey reflections at the end of the session. Researchers discussed and debated the emergent themes for accurate identification, importance, and application. Patterns within and across 30 asynchronous online and 20 face-to-face respondents were recorded.

Differences in Content Knowledge and Recollection

Flora and Fauna. In the first content survey question analyzed, IEE students were asked to “Describe any terrestrial and/or aquatic flora and fauna of the local barrier islands that you are more knowledgeable about through the assignments and activities featured in this course.” The final reflection prompt analysis found that face-to-face students described substantially more species than asynchronous online students (see Table 1). Face-to-face students cited 74 species names, and asynchronous online students cited 48 species names. It was determined that both face-to-face and asynchronous online students cited 11 of the same species, including sundews, pitcher plants, fox squirrels, painted buntings, blue crabs, and Venus flytraps. Face-to-face students mentioned six contextually relevant key species to the Wilmington area at least three times. However, asynchronous online students did not mention key species. These species include the longleaf pine tree, leatherback sea turtles, cypress trees,

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

prickly pear cactus, red-cockaded woodpeckers, turkey oak trees, and sand live oak trees. While both modalities of students demonstrated growth from pre- to post-test surveys, face-to-face students demonstrated higher content knowledge and recollection of species than asynchronous online students based on the quantity and specificity of species mentioned.

Table 1

Quantity of Citations of Species by Face-to-Face (F2F) and Asynchronous Online Students

Species Cited	Quantity of F2F Citations	Quantity of Asynchronous Online Citations
Longleaf Pine	7	0
Bladderworts	3	1
Sundews	3	4
Pitcher Plants	3	4
Leatherback Sea Turtles	2	0
Painted Buntings	6	1
Fox Squirrels	2	3
Blue Crab	4	2
Cypress Tree	4	0
Prickly Pear Cactus	3	0
Venus Flytrap	3	1

Red-Cockaded Woodpecker	3	0
Turkey Oak	3	0
Sand Live Oak	3	0

Geological and Environmental Issues. In the second content survey question analyzed, IEE students were asked to "Describe any geological aspects, environmental issues, and/or other phenomena affecting barrier islands that you are more knowledgeable about through the assignments and activities featured in this course." The final reflection prompt revealed that face-to-face and asynchronous online students articulated similar topics, with 26 topics identified by face-to-face students and 29 by asynchronous online students (see Table 2). Three topics (fire in longleaf pine ecosystems, coastal storms, and overwash) were only mentioned by asynchronous online students. However, six topics were shared by face-to-face and asynchronous online students, articulating rising sea levels, shoreline erosion, hardened structures, Cape Fear Arch, barrier islands, and human impact. Based on the analysis, there were no appreciable differences in topics mentioned by face-to-face and asynchronous online students.

Table 2

Quantity of Geological and Environmental Issues Cited by F2F and Asynchronous Online Students

Species Cited	**Quantity of F2F Citations**	**Quantity of Asynchronous Online Citations**

Rising sea levels	7	6
Hardened structures	3	4
Erosion	6	10
Barrier islands	4	4
Human impact	3	2
Cape Fear Arch	2	4
Fire in Longleaf Pine Ecosystems	0	3
Coastal storms	0	4
Overwash	0	3

Differences in Knowledge of Pedagogy Instructional Strategies

In the first pedagogical survey question analyzed, IEE students were asked, “In a few sentences, describe any instructional strategies and/or resources that might be useful in teaching science to children, peers, and/or adults. Please reflect upon the strategies learned in Island Ecology.” Both face-to-face and asynchronous online students mentioned hands-on experiences, including field trips, hikes, guest speakers, experiments, and role-playing. However, the most significant difference is that asynchronous online students mentioned the 5E lesson plan format 19 times, whereas face-to-face students only mentioned the 5E lesson plan format twice. This indicates a significant difference in the recollection of instructional strategies. It is also important to note that the 5E lesson plan format was taught in a hybrid classroom with face-to-face students and available asynchronous online Zoom students. The Zoom session was recorded and posted for asynchronous online students who could not be present in synchronous time. This difference indicates that the modalities in teaching instructional

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

strategies are unequal, and asynchronous online students seem to connect with this content more effectively than face-to-face students.

Differences in Technology Literacy

*K-12 Tools***.** In the first technological literacy survey question analyzed, IEE students were asked, "What new technology tools have you discovered as a result of taking Island Ecology for Educators?" It is important to note that this data only includes responses from 2020-2023, as the question was unintentionally omitted from the reflection prompts in 2024. Both face-to-face and asynchronous online students reported discovering tools such as iPads, computers and phones, apps, games, virtual labs, simulations, and virtual reality. However, asynchronous online students uniquely mentioned using GIS and mapping tools. While the differences were minor, the responses suggest that both groups had a similar understanding of technology integration tools for K-12 educators.

Comfort Integrating Technology Tools. In the second technological literacy survey question analyzed, IEE students were asked, "What new technology tools have you discovered as a result of taking Island Ecology for Educators?" When describing their comfort level with integrating their new tools, 30% of face-to-face students (see Figure 1) described themselves as 'very comfortable,' and 41% of asynchronous online students expressed the same level of comfort (see Figure 2). Additionally, 41% of face-to-face students and 45% of asynchronous online students rated themselves as 'comfortable' using technology. Furthermore, 22% of face-to-face students responded that they would feel 'comfortable with more practice,' and 7% of asynchronous online students responded similarly. In both groups, 7% indicated they were uncomfortable using technology integration tools. This data implies that asynchronous online students feel moderately more comfortable using technology integration tools with K-12 children than face-to-face students.

Figure 1

F2F Students' Comfort with Technology

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

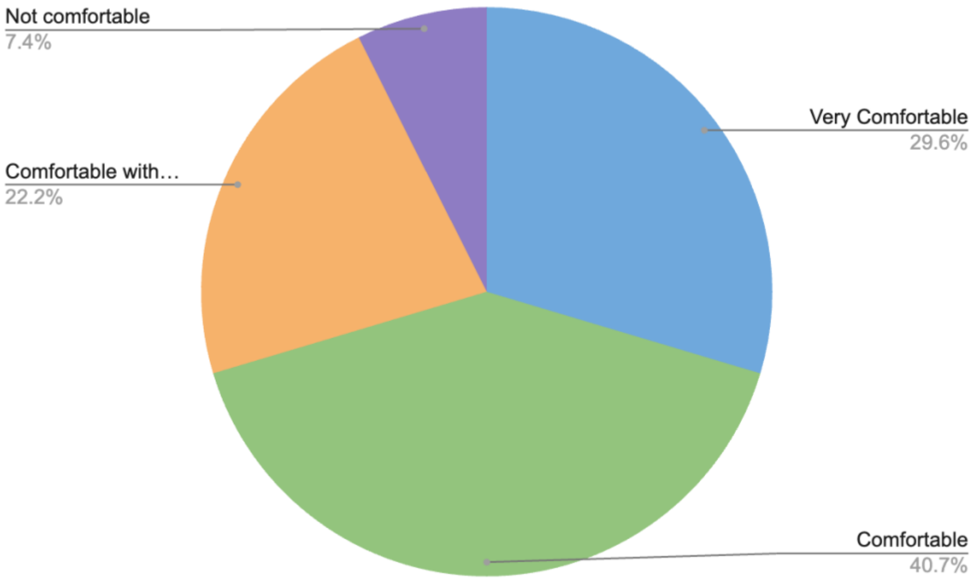
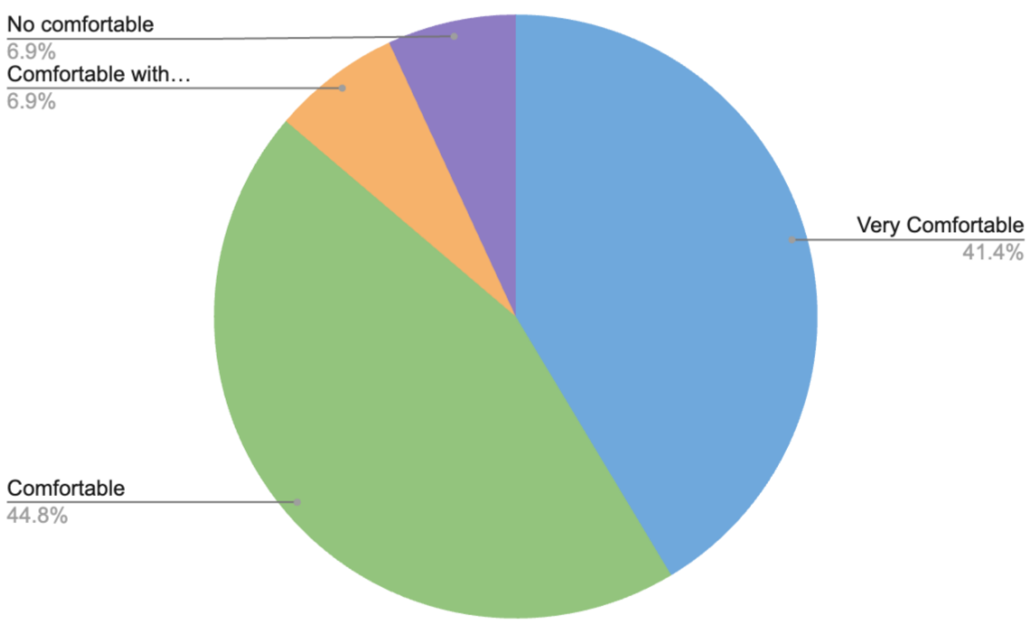


Figure 2

Asynchronous Online Students' Comfort with Technology



Discussion

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

The COVID-19 pandemic has significantly reshaped digital learning in higher education, leading to a new norm where asynchronous online and in-person modalities are blended. This hybrid approach prioritizes inclusivity, equitable access, and continuous innovation in teaching methods, with adaptations that emphasize hands-on learning. In the context of outdoor science education, several questions arise about the impact of this hybrid model on student perceptions and learning outcomes. How does a hybrid learning platform shape students' views, particularly in an outdoor science course? Does their understanding of science content differ when taught in an outdoor face-to-face setting compared to an asynchronous online environment? Additionally, how does instructional pedagogy shift across these modalities? Lastly, what characteristics stand out more in students' perceptions of outdoor face-to-face versus asynchronous online learning experiences? These questions are crucial in understanding the evolving dynamics of teaching an outdoor science education incorporating online learning.

Knowledge of Flora and Fauna

There were conclusive findings based on the descriptive data results and analysis. While both modalities of students demonstrated growth from pre- to post-test surveys, face-to-face students demonstrated higher content knowledge and recollection of species than asynchronous online students based on the quantity and specificity of species mentioned. For instance, one student commented, "North Carolina has some of the widest range of ecosystems that house thousands of species that are important to our environment." The enhanced recollection by face-to-face students may be due to the immersive, hands-on nature of outdoor learning experiences. The ability to directly observe species contributed to a deeper understanding of local flora and fauna. These findings suggest that face-to-face learning environments may be more effective in promoting detailed ecological knowledge, especially for species that require physical interaction or observation.

Geological and Environmental Issues

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Based on the analysis, there were no appreciable differences between geological or environmental topics mentioned by face-to-face and asynchronous online students. The similarity in topic identification suggests that both learning environments effectively conveyed key geological and environmental content. However, the few unique topics mentioned by asynchronous online students reflect a greater emphasis on theoretical knowledge in online settings. The results indicate that while content knowledge in environmental issues may be evenly distributed across modalities, experiential learning in face-to-face settings might enhance students' ability to recall species and local phenomena more effectively.

Differences in Knowledge of Pedagogy

In the post-survey, one student wrote, “I really knew nothing about pedagogy. Taking this class taught me about a whole new realm of science I never really understood.” Students across modalities benefited from the explicit emphasis on methodologies. Face-to-face and asynchronous online students had similar mentions and recollections of pedagogy discussed throughout the class, except for the recall of the 5E lesson plan. Another student noted, “I like the 5E lesson plan. It helps you to create an interesting lesson that will benefit your students and get them interested in what you’re teaching.” The higher recall of the 5E lesson plan by asynchronous online students could be attributed to the accessibility of recorded materials, which provided online students with more opportunities for review. This suggests that asynchronous online modalities reinforce structured instructional strategies through repeated exposure to digital content. The results could indicate that online learning environments may provide an advantage in retaining structured pedagogical frameworks like the 5E lesson plan, while face-to-face environments might be better for hands-on, experiential learning.

Differences in Technology Literacy

The mention of additional technology tools by asynchronous online students may reflect greater emphasis on digital resources in an online learning environment. One

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

student reflected, "The sudden move to digital learning has radically changed the way we teach, but even outside of that, technology in general has changed the way we teach." Asynchronous online students likely had more exposure to and practice with various digital tools throughout the course. These findings suggest that online environments may better equip students with a broader range of technology tools, while face-to-face students focus more on physical interactions with technology during field-based activities.

Comfort Integrating Technology Tools

Asynchronous online students' greater comfort with technology may be due to their frequent interaction with digital tools throughout the course. The data implies that online learning environments facilitate higher levels of comfort with technology integration, possibly because students rely more on these tools. These results suggest that online learning can enhance students' confidence and comfort in using technology tools, potentially due to the increased necessity of technology in their day-to-day learning experience. One student recognized in their post-survey, "I think it [technology] adds another level to any activity, but I don't think it should always be the main focus, as it can sometimes reduce original thinking. On the other hand, I think that it can create a sense of independence, which is great for critical thinking."

Before the pandemic, enrollment in the IEE outdoor education summer course remained steady at or around 13 students for eight consecutive years. However, when we were forced to transition to an online format due to COVID-19 restrictions, we saw a significant spike in enrollment, with twenty-two students. The flexibility and accessibility of the online modality appealed to a broader range of students, and this demand has persisted. Since 2020, we have continued offering a blended course, combining online and face-to-face components. Interestingly, despite offering outdoor classes in person again, more students have expressed interest in the completely asynchronous version of the course. This shift reflects the growing preference for flexible, online learning even

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

in disciplines traditionally associated with hands-on, in-person experiences like outdoor education.

Based on the results, we share a collaborative model that benefits student learning and faculty instructional design when converging modalities, including integrating new mobile technologies.

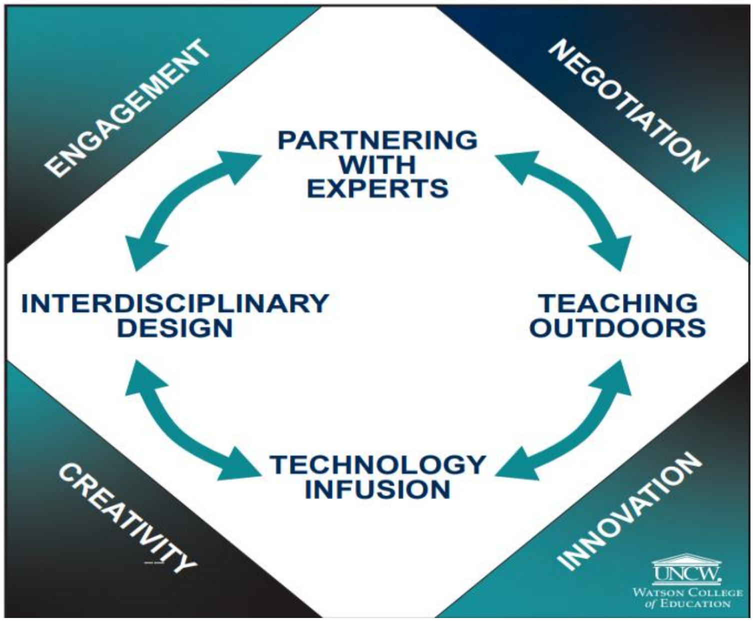
A New Outdoor Education Model

A new outdoor education model was employed to guide this work. The authors believe incorporating the TTIP Teaching Model in designing and delivering outdoor education courses has broad implications for STEM educators (Taylor et al., 2019). The TTIP Teaching Model (see Figure 3) is the framework guiding the teaching of the Island Ecology for Educators (IEE) course. This model has proven to be beneficial in creating an engaging platform for learning and teaching instructional design and environmental education and blends the aspects of teaching outdoors (T), technology inclusion (T), interdisciplinary courses (I), and partnering with experts (P).

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Figure 3

TTIP Teaching Model



As we know, there are benefits to an interdisciplinary cross-listed course that focuses on content application, pedagogical integration, technology infusion, and partnering with experts (Taylor et al., 2019). In practice, employing the TTIP Teaching Model as a framework incorporates best practices for supporting students' learning of environmental education concepts during an outdoor field experience. In the case of this reported study, we can report and summarize the data using this framework as a lens. One of the many challenges to STEM education lies in the successful intersection of themes across the distinct disciplines of science, technology, engineering, and mathematics (Bybee, 2013). As STEM literacy becomes an increasingly important outcome for our nation, the authors assert that the TTIP Teaching Model presents readers with one contextual framework for future interdisciplinary interventions. The model can lead to engaging, innovative, creative, and negotiated learning opportunities in curricular design and integration (see Figure 3).

As we analyze and assign meaning to the study results, we do so using the framework of the TTIP Teaching Model. We observe four strategies inside the diamond:

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

interdisciplinary design, partnering with experts, teaching outdoors, and technology infusion. While the authors recognize challenges in isolating each strategy from the others, rationalizing the influence is worth the discussion. For instance, we have consistently recognized the importance and value of teaching island ecology content outdoors as an important learning strategy. The results demonstrate that face-to-face students show more sophisticated content knowledge acquisition and recollection of flora and fauna species than when compared to asynchronous online students. While both students showed growth in their recall of island ecology content, it is evident that one population of students benefited more from outdoor education strategies.

Data interpretation leads us to assert the importance of the interdisciplinary design strategy of the curriculum. We observed students in both modalities benefiting and growing in their knowledge of instructional pedagogy. As students come to the island ecology course from different areas of expertise, content (EVS, Biology), and pedagogy (education), it can be inferred that after the class, all students had similar recollections of instructional design. This was a success! The one difference we observed in the two populations was with lesson planning: asynchronous online students benefited more from this aspect of the Canvas modules. We found this interesting but not altogether unexpected. When forced to move instruction completely online for all students, the authors designed the course with best practices, robust instructional design, and online methodologies. The following year, students were given a modality choice. Since face-to-face enrolled students had direct access to the instructors, they benefited from more informal conversations and face-to-face instruction with their instructors daily. That was not the case for asynchronous online students. They deeply depended on the technology infusion strategy efforts found in Canvas for their learning. Students were evaluated on their lesson plan submission for all four major assignments. The 5-E lesson plan template and the online learning materials that support its acquisition became critical to asynchronous online student success.

Both population modalities demonstrated growth when the differences in technology literacy are considered. The findings suggest that online environments may

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

better equip students with a broader range of technology tools, while face-to-face students focus more on physical interactions with technology during field-based activities. The importance of each strategy in the TTIP Teaching Model when supporting the other three strategies demonstrates the model's power. These results reinforce the importance of increased attention to technology infusion strategies when paired with authentic interdisciplinary design.

Concentrated efforts to contribute to real-world learning opportunities in environmental and sustainability education are critical for the next generation of students and their education. Modeling, project, and service-based learning, as well as internships providing a pathway to literacy, are but a few examples that demonstrate content optimism (Dale & Newman, 2005). The key challenge in attaining content literacy is that many teachers struggle to regularly integrate environmental issues or sustainability education into the science or general curriculum (Jones et al., 2010). Methods courses vary across pre-service teacher programs, and there is a gap in understanding the relationship between curriculum and instruction and how this impacts the teaching and learning of environmental topics. The authors have observed several beneficial outcomes of teaching an island ecology course for future educators and have shared recommendations for designing similar STEM courses focusing on content application, pedagogical application, technology infusion, and partnerships utilizing the TTIP Teaching Model.

The benefits framed by this TTIP Teaching Model include:

- Gained awareness of the variety of professional opportunities in pursuing a career in formal and informal science education and, in some cases, actual successful career moves for our students.
- Supported partnerships with local agencies and scientific experts.
- Partners in public service projects with environmental education and stewardship goals.

- Sustained collaboration among college faculty from different programs and disciplines, such as education, biology, environmental science, geology, and computer science.
- Teaching about nature while being in nature.
- Increased knowledge of various forms of technology and how to teach with those tools.
- Experience with creating engaging K-12 science lesson plans.
- Development of web pages and mobile applications.

In conclusion, this study highlights the effectiveness of the TTIP Teaching Model in enhancing student learning across both face-to-face and asynchronous online modalities. While face-to-face students benefited from hands-on outdoor experiences, asynchronous online students gained stronger proficiency with digital tools and instructional frameworks. Both groups showed growth in science content knowledge and pedagogical understanding, though each modality offered unique strengths. Integrating interdisciplinary design, technology, and expert partnerships within the TTIP framework demonstrates a promising approach to future STEM education, particularly in fields requiring theoretical knowledge and experiential learning.

Acknowledgment

This article is based upon work supported by the ETEAL Applied Learning Strategic Initiative Award at the University of North Carolina Wilmington. Any opinions, findings, conclusions, or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of the university. We are grateful to former IEE students for their contributions to the project through data collection and analysis.

References

Alsaaty, F., Carter, E., Abrahams, D., & Alshameri, F. (2016). Traditional versus online learning in institutions of higher education: Minority business students' perceptions. *Business Management Research, 5*(31). DOI: https://doi.org/10.5430/bmr.v5n2p31

Ayotte-Beaudet, J.P., Potvin, P., Lapierre, H. G., & Glackin, M. (2017). Teaching and learning science outdoors in schools' immediate surroundings at K-12 levels: A meta-synthesis. *EURASIA Journal of Mathematics, Science and Technology Education*, *13*(8). https://doi.org/10.12973/eurasia.2017.00833a

Alzahrani, S.B., Alrusayes, A.A., and Aldossary, M.S. (2020). Impact of COVID-19 pandemic on dental education, research, and students. *International Journal of Health Sciences and Research*, Vol. 10 No. 6, 207-212.

Bybee, R. W. (2013). The case for STEM education: challenges and opportunities. Arlington, Virginia: National Science Teachers Association.

Correia, A.P. (2020). Healing the Digital Divide During the COVID-19 Pandemic. *Quarterly Review of Distance Education*, 21,13–21.

Dale, A., & Newman, L. (2005). Sustainable development, education, and literacy. *International Journal of Sustainability in Higher Education, 6*(4), 351-362.

Day, T., Chung, C., Doolittle, W., Housel, J., & McDaniel, P. (2022). Beyond COVID Chaos: What Post Secondary Educators Learned from the Online Pivot. *The Professional Geographer, 75*(1), 14-30. https://doi.org/10.1080/00330124.2022.2081225

Fatimawati, I., Badiozaman, A., Ling, V., & Ng, A. (2024). University Students' Experiences and Reflection on Their Transition to HyFlex Learning during Post-Covid times. *Journal of Educational Technology Systems*, *52*(4), 448–470. https://doi.org/10.1177/00472395231226407

Gierdowski, D. C. (2019). 2019 study of undergraduate students and information technology. Research report, EDUCAUSE, Boulder, CO. Accessed August 26, 2024. https://library.educause.edu/resources/2019/10/2019-study-of-undergraduate-students-and-information-technology

Guppy, N., Verpoorten, D., Boud, D., Lin, L., & Bartolic, S. (2022). The post-COVID-19 future of digital learning in higher education: Views from educators, students, and other professionals in six countries. *British Journal of Educational Technology,* 53, 1750–1765. https://doi.org/10.1111/bjet.13212

Jeronen, E., Palmberg, I., & Yli-Panula, E. (2016). Teaching methods in biology education and sustainability education including outdoor education for promoting sustainability—a literature review. *Education Sciences*, 7(1), 1. https://doi.org/10.3390/educsci7010001

Jones, P., Selby, D., & Sterling, S. (editors) (2010). *Sustainability Education: Perspectives and Practice across Higher Education*, New York: Earthscan.

Kali, Y., Levy, K., Levin-Peled, R., & Tal, T. (2018). Supporting Outdoor Inquiry Learning (soil): Teachers as designers of mobile-assisted seamless learning. British *Journal of Educational Technology*, 49(6), 1145–1161. https://doi.org/10.1111/bjet.12698

Kaur, N., Dwivedi, D., Arora, J., & Gandhi, A. (2020). Study of the effectiveness of e-learning to conventional teaching in medical undergraduates amid COVID-19 pandemic. *National Journal of Physiology, Pharmacy, and Pharmacology*, 10(7), 563-567.

Kervinen, A., Uitto, A., & Juuti, K. (2018). How fieldwork-oriented biology teachers establish formal outdoor education practices. *Journal of Biological Education*, *54*(2), 115–128. https://doi.org/10.1080/00219266.2018.1546762

Kitchen, R., & Maddison, J. (2021). A fieldwork toolkit for early career geography teachers. *Teaching Geography*, *46*(1), 17–20. https://www.proquest.com/scholarly-journals/fieldwork-toolkit-early-career-geography-teachers/docview/2522192776/se-2

Kustusch, M. (2016). Assessing the impact of representational and contextual problem features on student use of right-hand rules. *Physical Review Physics Education Research*, 12. https://doi.org/10.1103/PhysRevPhysEducRes.12.010102

Nguyen, V., & Patel, T. (2023). Influence of the COVID-19 pandemic on Learning Preferences and perspectives of Generation Y and Z Students in dental Education. *International Journal of Dental Hygiene*, 21, 487-494. DOI: 10.1111/idh.12602

O'Brien, D. (2021). A guide for incorporating e-teaching of physics in a post-COVID world. *American Journal of Physics*, *89*(4). https://doi.org/10.1119/10.0002437

Pandya, B., Patterson, L., Khaimah, R., & Cho, B. (2022). Pedagogical transitions experienced by higher education faculty members – "Pre-Covid to Covid." *Journal of Applied Research in Higher Education*, *14*(3), 987-1006. DOI:10.1108/JARHE-01-2021-0028

Raes, A. (2022). Exploring student and teacher experiences in hybrid learning environments: Does presence matter? *Postdigital Science and Education*, *4*(1), 138–159. DOI:10.1007/s42438-021-00274-0

Journal of Interdisciplinary Teacher Leadership 2025, Vol. 8, No. 1, pp. 60-83

Scott, I., Fuller, I., & Gaskin, S. (2006). Life without fieldwork: Some lecturers' perceptions of geography and environmental science fieldwork. *Journal of Geography in Higher Education*, *30*(1), 161–171. https://doi.org/10.1080/03098260500499832

Stoian, C., Fărcașiu, M., & Stanici, M. (2021). E-Learning vs. Face-To-Face Learning: Analyzing Students' Preferences and Behaviors. *Sustainability*; Basel, 13(8). https://doi.org/10.3390/su13084381

Tagoe, M. (2012). Students' perceptions on incorporating e-learning into teaching and learning at the University of Ghana. *International Journal of Educational Development Using Information Communication Technology*, 8, 91–103.

Taylor, A., & Kubasko, D. (2019). Island Ecology for Educators: The intersection of ecosystems content, coastal environmental education, and technology In S. Schroth (Ed.), *Handbook of Research on Building STEM Skills through Environmental Education.* Hershey, PA: IGI Global.

Taylor, A., & Kubasko, D. (2019). Island Ecology for Educators: An interdisciplinary course bridging science and education through interactive community partnerships. *Journal of College Science Teaching*, *49*(1), 24-30.

Zhang, Y., & Chen, X. (2023). Students' Perceptions of Online Learning in the Post-COVID Era: A Focused Case from the Universities of Applied Sciences in China. *Sustainability*, *15*(2), 946. https://doi.org/10.3390/su15020946