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TRANSITIONING FIELD COURSES IN PLANT IDENTIFICATION TO REMOTE INSTRUCTION: AN ANALYSIS

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TO REMOTE INSTRUCTION:
AN ANALYSIS

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ABSTRACT

An analysis of methods and practices in online instruction of hands-on plant identification skills illustrates the efficacy of teaching techniques utilized in collegiate plant materials courses during the COVID-19 pandemic. The implementation of safety precautions across the globe necessitated distance learning and hybrid distance learning in response. Questionnaires were distributed to instructors and students of courses in biology, botany, ecology, environmental and wildlife science with focus on plant materials science. Course strategies most effective in pandemic learning include setting up a strong foundation in communicating with students pertaining to course structure and technological proficiency while providing students with independent project opportunities to identify plants and return to the course to report independent progress. Most frequent methods and most effective methods utilized in course development and delivery were determined through matrix table, multiple-selection, and Likert scale analysis. Results document the unique pandemic experience and illuminate the clearest path to optimization of the teaching and learning of hands-on plant identification courses in the digital age across natural science disciplines.

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I. INTRODUCTION

Toward the end of the year 2019, the coronavirus pandemic began to sweep across the globe. By March of 2020, it had reached the United States of America and rules of lockdown and quarantine were put in place to mitigate the spread of disease. Schools at all levels of education nationwide were required to close promptly and shift to online learning. Even traditional hands-on courses in outdoor environments were restructured for remote instruction. "Across the world, universities and research institutes have shut down. As with other subjects, courses critical to the training of conservation biologists … are being cancelled or moved online. In practice, this means that professors with little prior online teaching experience are now teaching students with little experience in online learning" (Bates, et al., 2020) and students of these applied sciences would "miss the practical hands-on experiences gained through labs and field courses" as these activities were surmised to be unable to resume until the global shutdown had lifted (Bates, et al., 2020). A vast majority of instructors had no precedent for this experience, and the success of online field-based courses had not been widely measured nor standardized. The purpose of this study is to gather information from the variety of experiences that professors and students of plant materials science and related botany courses have cultivated and to provide guidance in best practices for educational institutions to implement in to maximize student success as society increasingly utilizes digital teaching and learning.

As a graduate teaching assistant working with a group of educators to redevelop multiple plant materials courses for online delivery at the University of Rhode Island, I began investigating the niche of remotely delivered plant identification knowledge. Each instructor independently has approached the distance learning challenge with individual solutions in response to the rapid transition of field courses in plant identification to remote instruction and modified their approach in the subsequent semesters of continued COVID restriction. It is notable to preface that although the world has experienced pandemics in the past, this is the first time in human history in which society has had the ability to undertake widespread distance learning via the world-wide web. Technological advancements and their availability now allow for long-distance communication, while modern health and safety recommendations have stressed isolation in response to the pandemic, and a worldwide focus now exists to ensure and promote the rights of individual people of all ages to have access to education. These societal components have enabled distance-learning on a grand scale. The intent of this research is to demonstrate that hands-on outdoor plant identification courses are achievable even through a digital learning experience. I propose that remote courses built with a variety of flexible components encouraging students to experience outdoor environments while supporting student's academic, emotional, and social needs increases information retention in learners and overall satisfaction with the course experience for both instructors and students. I hypothesize that a mixture of instructional course components and high instructor preparedness improves student preparedness and engagement, and that high levels of student engagement have a positive correlation with high student skill acquisition. In addition, I propose that instructor satisfaction with the course experience directly relates to student success in terms of increased understanding, overall course grade, and satisfaction with the course experience. It is expected that plant identification skills specifically introduced by instructors yields student confidence in those skills, to be verified with the percentage of correlated instructor and student responses for each skill. It is also expected that instructor perspectives of student engagement are in accordance with self-reported student engagement. Modal majority results of Likert scale-of-agreement data are to be confirmed, where possible, with two-tailed Mann-Whitney U-testing. Based on a review of literature, the assumption is made that the intersection of course delivery strategies preferred by instructors and students provides the greatest benefits in optimizing the transfer of knowledge, measured by confirmation of the hypotheses.

1.1 Online education

Online learning has been around for nearly four decades, but the subjects most often supported are based overwhelmingly in traditional classroom instruction (Hansen, 2001). Between the year 1900 and 1930, radio and television were first used “to deliver educational content” (Hansen, 2001). The development of the “World Wide Web back in 1989” serves as the foundation for our ability to now utilize “interactive audio or video-conferencing, pre-recorded instructional videos, webcasts… or computer-based systems delivered over the internet” to pursue distance learning (Williams van Rooij and Zirkle, 2016). Caliksan and colleagues (2017) prefaces one study by describing the process of rapid technological advancement within the past twenty years enabling distance learning and its incorporation into the “traditional” or most common learning model leading to increased temporal and spatial flexibility for students enrolled in these courses. In subjects such as computer science, mathematics, language, literature, social studies and history, instructors can present information such that students assimilate in very similar ways whether in an in-person or "digital" classroom. This traditional classroom format has the potential to translate well to distance-learning initiatives in higher education, where students already familiar with the subjects and types of learning methods provided by the K-12 (kindergarten through twelfth grade) school system can adapt readily to further their education using mostly, or entirely, online learning tools. The online environment has the potential to allow students to assimilate knowledge at an individualized learning pace and attend courses from anywhere across the globe. Distance-learning, remote learning, "Open University" education, "Massive Open Online Courses" and related terminology are used to describe the online "classroom" learning environment (Arnfalk, et al. 2016). In-person or face-to-face teaching and learning refers to instructor and student presence in the physical learning environment and is contrasted with synchronous learning conducted in real-time through audiovisual digital devices within a specified schedule and asynchronous learning which provides learning materials to students to view and review independently without strictly scheduled lessons, but by set deadlines within the framework of the course (Caffarella and Ratcliff Daffron, 2013).

In many cases worldwide distance learning has been an excellent avenue for education. In Spain, the Open University of Catalonia "is a university that develops its entire teaching by means of a virtual campus (www.uoc.edu) and through virtual learning environments, especially with asynchronous written communication networks" as well as synchronous and asynchronous means for learning and discussions and uses the internet to provide access to information, materials, and assess student learning (Badia, et al., 2014). A Brazilian example describes distance learning as a means of connecting students with access to high-quality education at a low cost to feasibly reach a wider population. Distance learning from individual student computers reduces commuting costs but almost exactly balances overall energy and resource consumption (Agostinho, et al., 2017). However, there are trade-offs, and the distribution of these costs can disproportionately affect low-income students (Markowitz, 2020). This past year a California survey during spring of 2020 reported that students from low-income backgrounds have felt excessive strain due to the pandemic (Markowitz, 2020). Three-fourths of these students worried about being able to finish their programs on time, or at all, and overlying these changes over half of the students reporting that they felt they would not be able to maintain financial security to cover regular costs of living, particularly if the pandemic persisted (Markowitz, 2020). Accessibility of technology particularly for low-income students is an important factor in student success, and in many parts of the world students are only able to attend remote classes from mobile devices such as cell phones (Caffarella and Ratcliff Daffron, 2013; Caliksan, et al., 2017). Boroowa (2020) discusses predictive learning analytics to identify students at risk of low success in online courses, noting that instructors use their personal judgment in making the decision to reach out to struggling students. In online courses, students experiencing difficulties have low participation in course activities, may not turn in assignments and assessments, and may not log on for online sessions. Instructor awareness of their students' needs as individual people is necessary to help them succeed in any type of classroom, and a baseline of clear communication is crucial to ensuring student success.

While sources of knowledge used by distance education programs tend to differ from traditional classroom textbook resources, the flow of information is nearly the same (Agostinho, et al., 2017). Many universities provide centralized web platforms to organize course materials and accept assignment and assessment submissions as basic portfolio tools to grade student work and keep a record of course completion. Ireland implemented a nationwide "ePortfolio" system for schools to collect and save student work throughout their educational careers, serving as a long-term asynchronous interface (Brown, et al., 2018). The most effective use of ePortfolios occurred when the curriculum included learning how to use and interact with the ePortfolios, and the study recommended that administrators implementing digital portfolio systems must remain involved in their use to best meet the needs of learners (Brown, et al., 2018). Web platforms also can be used as an avenue for communication between students and instructors through blog-style posts, chat rooms, and virtual synchronous audiovisual office hours (Brown, et al., 2018). Lectures can be videotaped to be embedded in course websites, providing students with a means of accessing course material outside of class time (Brown, et al., 2018). These functions have been used for the past decade by instructors at the college level as a greater understanding of accessibility and student needs has been incorporated into the course-construction process, whether courses were offered locally or remotely (Brown, et al., 2018). Bender and Hill (2016) discussed the challenges of teaching remotely and contrasted these challenges with the benefits of flexibility gained in online learning environments. “Web-based applications (such as Google docs) that allow students to generate content and share it with their peers may be used, for example, to allow students to collaborate in the creation of a research proposal…. the inclusion of other social media may also be of benefit in teaching qualitative methods online” (Bender and Hill, 2016). Other “platforms include Blackboard, Canvas, D2L, Moodle, and SaP3” (Dieli, 2020). While the specific web tools mentioned may become obsolete in the coming years as new technology is introduced, the necessity to provide academic avenues of communication between instructors and students remains constant. Additional aspects of online learning that have undergone changes from traditional classrooms include online teaching roles, which are “especially relevant in virtual universities, because these universities often have had to rethink face-to-face teaching roles to adapt it to teach in virtual learning environments … new teaching roles have emerged, not derived from the traditional face-to-face teacher functions” (Badia, et al., 2014). Professors also reported difficulty in gauging how much and how well students have learned in the pandemic teaching environment. Bender and Hill (2016) noted it may “be challenging to assess students’ mastery of concepts and skills” in remote learning, as instruction through videos is often one-sided and students do not necessarily receive corrective feedback on their performance of course activities. Bender and colleagues (2016) posit that courses that are not face-to-face limit instructor interpretation of nonverbal cues from students that instructors are trained to interpret as part of classroom instruction, and as a result teaching approaches and assessment strategies such as exams and quizzes must be altered to maintain clarity and connectivity. While assessing student learning outcomes determines the effectiveness of course elements, student success in courses can be difficult to determine, as many factors are involved. Educational leaders often use testing data when making decisions about implementation of strategies that hopefully will improve student success (Yennie, 2020). Williams van Rooij and Zirkle (2016) measured success as grades exceeding 60% on quizzes, but other studies used course satisfaction and short and long-term learner information retention as measures of success (Bender and Hill, 2016; Dieli, 2020), where short-term learning growth is measured using pre- and post- testing (Yennie, 2020), and long-term learning growth is achieved by students carrying skills learned in the course experience forward by months or years in professional capacity in the workplace (*Report to Congress II. The National Environmental Education Advisory Council*, 2001; Kallas, et al., 2015; Alonso, J.M., et al., 2018).

1.2 Botanical education

Botanical identification has a long-standing history within the field of education. In the 1800s, medical students in Scotland "were expected to possess a broad knowledge of general science to become successful practitioners and this required practical work in the dissecting room, the laboratory, the museum and the hospital. Accordingly, these study places were furnished with equipment that would help students 'to know facts and not words, things and not mere statements of things'" in hands-on learning using physical models of specimens - in this case made of papier-mâché (Olszewski, 2011). Olzsewski (2011) continues:

> "Vegetable physiology was taught to aspiring physicians with the aim of improving identification skills related to vegetable drugs and herbs in the medicinal cabinet. The active method of taxonomic botany, both identifying and classifying plant specimens, was most advantageous in this medical framework."

Botanical instructors at the time used techniques referred to as "new botany" which energized previously mundane lectures by incorporating botanical illustration to extend the lifespan of observation of ephemeral and seasonal plant structures, using reusable, oversized, visually appealing models that allowed many students to see simultaneously, small structures in greater detail, and presenting pertinent and interesting topics such as carnivorous plants, herbal remedies and comestible plant products (Olszewski, 2011). Previously, botany was taught with plant parts "labelled with markers and students were expected to identify them by sight" (Olszewski, 2011). By the late nineteenth century dissection of specimens or models came into popularity and "The Royal Commission of 1878 recognized this new direction and concluded 'Lectures, however good and however well illustrated by experiments and illustrations, and reading, however extensive, cannot give the student that reality, precision and fullness of knowledge which he obtains by making an experiment or a dissection, or studying a specimen for himself'" (Olszewski, 2011). This outlook has influenced the hands-on components of botanical teachings ever since.

At the University of Rhode Island, plant identification skills are taught in courses with a variety of foci. Landscape Plants II (LAR/PLS 354) is a springtime identification course that teaches students how to identify common plants in already-established landscapes, as well as new varieties being introduced into the landscape trade. One instructor and two teaching assistants introduce students to plant materials including woody gymnosperms and angiosperm trees and shrubs. Course content is region-specific to New England, and students are shown landscape uses of plants in terms of design considerations with respect to buildings and other plants based on mature height and width, sun and shade tolerance, winter hardiness, soil moisture and drainage, salt tolerance and “Integrated Pest Management” (IPM) concerns. Students observe visual characteristics and learn to cross-compare size, form, color, and texture as well as foliage arrangement and detailed characteristics to distinguish closely related species and cultivated varieties. Students practice the recollection of family, genus, species, variety, and cultivar names. The in-person class is traditionally held twice per week with class walks around outdoor managed landscapes on-campus. The first class day is an hour and fifteen minutes long, and the second day each week is two hours and forty-five minutes. Each class introduces about fifteen to twenty plants and short quizzes of ten plants are held once a week during the longer class period that cover the cumulative knowledge of plants covered up to the week before. At the end of the semester students are tested on information retention by means of oral exams walking through public spaces within residential neighborhoods. Students work in pairs and each take turns working individually and together to identify fifty landscape plants that were learned during the semester. The exam is held over the course of an hour and a half or less and students receive the highest score for responding immediately with confidence in their verdict. Referring to notes, asking for hints, or guessing incorrectly decreases the score earned on each plant.

Field Botany and Taxonomy (BIO 323) is a similar course focused on the flora of Rhode Island. The fall course covers three hundred plant species within sixty-seven families over the course of fourteen weeks. Twice weekly meetings cover about twenty plants per week and quiz on ten of the species each week. Unlike the landscape plants course, the sessions are each three hours and forty-five minutes long to allow for field work. One instructor and two teaching assistants transport twenty-five students in vans to field trip sites off-campus representing different natural habitats such as salt marshes, freshwater ponds, and upland woodland habitats. For the quizzes, students recall family, genus and species names of these “wild” plants. In class, students are shown how to identify plants as individual species within their physical environmental context, presented with the genus, species, and family name of each plant to follow on the “trip sheet” list of plants and their descriptions to be learned during that class period. Students also take notes in the field as they listen and watching to learn information and collect samples of plants to be pressed. Learners are instructed to recognize overall growth habit and close-up details including shapes of leaves and leaf margins, counting the number of structures present and noting colors and patterns compared to other plants. Scent is used as an important identification feature, typically through “scratching and sniffing” of bark and leaves as well as smelling flowers, tactile and visual textures and tasting of edible species. Comparing and contrasting plant characteristics in nature and in their herbarium collections side-by-side facilitates viewing clear similarities and differences between plants. The use of dichotomous and random-access keys is taught using guidebooks in forb, grass, tree and shrub, fern, and moss identification, most frequently using *Newcomb's Wildflower Guide* by Lawrence Newcomb and Gordon Morrison; *A Field Guide to Trees and Shrubs* by George Petrides and Roger Tory Peterson; Northeast Ferns by Steve Chadde; and *Grasses, Sedges and Rushes* by Lauren Brown and Ted Elliman, along with Grasses of the Northeast: *A Manual of the Grasses of New England and Adjacent New York* by Dennis Magee; *Mosses of the Northern Forest* by Jerry Jenkins; and *Common Mosses of the Northeast and Appalachians* by Karl B. McKnight, et al. During the class students work in pairs or small groups to collect, press, and dry samples of each species. One field trip takes the class to the Brown University Herbarium to see how herbarium collections are professionally developed and maintained. When frost and cold force the class indoors students learn how to use the larger plant manuals and are trained in the use of dissecting microscopes to key out grasses, sedges and rushes. Dissecting and compound microscopes are employed to study bryophytes (such as mosses and liverworts) and students team up to complete "moss map" projects to become familiar with bryophyte species that coincide on particular substrates, giving an in-person group PowerPoint presentation to describe their moss habitats. The semester ends with trips outside to learn how to key trees and shrubs using winter twig and bark characteristics such as buds, bud arrangement, leaf scars, pith, lenticels and other features. Weekly average seat time hours for students are about seven and a half class-time hours plus about five hours of self-study for a total of twelve and a half hours dedicated to the class (Brown and Maynard, 2021). Pre-COVID field botany sessions were both in-person experiences, and following the summer and fall 2020 pandemic experience, a small group of botany students returned to the field for the summer session in 2021. Even in ordinary, pre-pandemic semesters, different safety considerations are taken into account during different parts of the year as students in the in-person fall class are required to wear neon orange vests and to stay together in groups while hiking during hunting season. Summer students are more likely to experience the hazards of strong sun and high air temperature. Safety skills covered in the in-person versions of the course include instruction in the identification of poison ivy and poison sumac, and staying alert for more mild plant irritants, as well as being absolutely certain about the identification of a plant prior to eating it. The class has an off-campus final exam in a nearby natural management area identifying approximately one-hundred plants, with students traveling in staggered in groups along a trail loop as the instructor tags plants to be identified and teaching assistants collect the tags as the last students finished examining each living specimen.

1.3 Online botanical education and learning tools

Given their strongly hands-on nature, plant identification courses were considered poorly suited for online education prior to the onset of the coronavirus pandemic. The history of environmental education incorporating digital strategies begins with lesson plans designed for elementary education. The Environmental Education Collection: A Review of Resources for Educators (1998) guided teachers in building lifelong environmentally conscious knowledge and skills. As of 2005, nearly twenty percent of grants to develop environmental programming were awarded at the collegiate level. At the time it was recommended "that Congress update the National Environmental Education Act for the 21st century to reflect the growth and maturation of the environmental education profession" through legislation that provided and enforced high standards with tools for measuring the effectiveness of environmental education programs. The intent was to continue "to improve the quality, accessibility, and dissemination of environmental education materials and programs" (Setting the Standard, Measuring Results, Celebrating Successes: A Report to Congress on the Status of Environmental Education in the United States, 2005). The United States of America was only one of many countries aiming to improve environmental knowledge. "Ecological education became especially important at the beginning of the 21st century because ecological problems revealed a global character and nobody could solve them without forming ecological culture, ecological responsibility and skills in the sphere of ecology. Ecological education constructs the knowledge about the environment, about causes and consequences of ecological catastrophes, ecological safety, and concepts of the place of a man in nature. These questions are of vital importance in the modern stage of human existence … up-to-date level of ecological consciousness for the most part of the Earth's population is extremely low" (Kallas, et al., 2015) and as such it is necessary to continue educate the citizens of earth for the benefit of humankind and for the planet itself. Ecological field courses teach students how to make observations about the natural world, memorize information, and navigate pathways to discover new information within the context of the natural sciences**.** Typically, these courses are taught, very literally, “in the field,” through a combination of observational or hands-on learning techniques and traditional classroom instruction. An Indonesian study from September 2013 to April 2014 showed that critical thinking in environmental and natural science topics could be developed using online tutorial activities. Twenty-eight out of 124 students in the study were able to access the online curriculum and reflected this ability in the outcome of the course. “The ability to think critically [is] expected to be owned by both students who study through face to face as well as online” (Rahayu and Sapriati, 2018). The aforementioned study collected student opinions pertaining to online open educational resources, with reflections falling into a Likert spectrum: “The materials are interesting 38% strongly agree, 54% agree, 8% strongly disagree; The materials challenge the students to find other resources from OER; 69% strongly agree, 31% agree; The materials help students to express scientific ideas 46% strongly agree, 54% agree; The materials could improve skills in finding and validating information sources 54% strongly agree, 38% agree, 8% disagree” (Rahayu and Sapriati, 2018). Another study by Durumus and Yapiciolgu (2015) described a project educating teachers of environmental sciences to teach skills that stressed “observing components of nature with their senses, observing living and unliving entities in their habitats and reflecting … on theoretical knowledge of nature as it relates to practical real-world knowledge of ecology” (Durumus and Yapicioglu, 2015). Among the educators were thirty-five individuals involved in college or university level education (Durumus and Yapicioglu, 2015). The program was held in a valley with rich biodiversity, and the group was trained to apply concepts from nineteen different activities that they would then be responsible for teaching to their own students (Durumus and Yapicioglu, 2015). Opinion-based feedback was received following the program regarding the benefits participants yielded from the study and ways they incorporated the program experience into their teaching practices (Durumus and Yapicioglu, 2015). Feedback fell into categories describing student interest, motivation, confidence, classification skills, sharing knowledge and improving awareness among the people in their lives and developing a love of nature (Durumus and Yapicioglu, 2015). These categories partly informed the development of survey questions for the current study. In determining the most frequently used methods of teaching plant identification skills, a study surveying two hundred and fifty undergraduates examined learners' abilities to navigate through plant identification keys (Lopes, 2011)**.** The utility of keys to engage students "at the organism level," rather than microscopically or in terms of interior structure, was assessed as students were asked to use different types of illustrative and descriptive glossaries and conventional and interactive dichotomous keys (Lopes, 2011). Students proceeded to follow the series of choices constituting keying steps to identify external plant structures needed to deduce the correct identities of sample plants, and then were asked to reflect on the ease of use of each guide (Lopes, 2011). College student participants rated the keys as "fully efficient" for student learning - the highest mark within the given Likert range (Lopes, 2011). The "Interactive Dichotomous Keys" improved undergraduate student learning from approximately fifty-four percent success in plant identification to seventy percent only one year later, and eighty percent success the following year (Lopes, 2011).

In recent years, instructors have incorporated some online learning tools, however, as the digitization of herbarium specimens and the online availability of research papers and identification guides and websites has increased. “Open educational resources (OER) consist of digitized materials offered freely and openly for educators, students and self-learners to use and re-use for teaching, learning and research” (Rahayu and Sapriati, 2018). Similarly, “Massive online open courses (MOOCs) have been used to improve the effectiveness of teaching and learning. Moreover, MOOCs have global influence, allowing students of different ages, nationalities, backgrounds, abilities, and interests to participate” (Hsiao, et al., 2018). “Environmental Management” in “Open University” course delivery refers to the general availability of remote learning resources, such as “online access, allowing tutors to work synchronously with groups of students outside of class time, and observing the changes in individual and collaborative work performed in courses instructed by means of synchronous and asynchronous methods (Bell, et al., 2017). Asynchronous methods are defined as a learning strategy where “students and professors do not need to be logged onto the Internet at the same time” (Hansen, 2001). Data from an article by Flannery and colleagues (2013) reflected on the popularity of distance learning in the late 1990’s and early 2000’s and projected an increase in distance learning due to increased accessibility and cost effectiveness and questioned whether online distance learning could be as successful as classroom learning. One student felt as if they learned more, “I have to do more research on my own, which is helping me understand things better. I’m not just taking some professor’s lecture at face value” (Flannery, et al., 2013). New types of technologies, citizen science projects, and other interactive digital learning experiences have been utilized more than ever before in the learning process. Ahmad and colleagues (2012) discussed virtual laboratory technology used in high school curricula that covered the same concepts as traditional hands-on lab exercises while reducing overall cost of laboratory materials and allowing students to visualize biological structures and processes. Similar digital learning tools can be adapted easily to teach college students hands-on skills outside of an on-campus laboratory setting. Alonso and colleagues (2018) describe hands-on chemistry laboratories being effectively supplemented by virtual lab activities, using simulations of concepts covered in the in-person lab to reinforce lessons. In plant identification courses, a common hands-on laboratory component is the collection of plant specimens (Kallas, et al., 2015). The origins of preserved plant collections, or herbaria, are described along with recent efforts to make plant specimens readily available online.

> "Herbaria are collections of preserved plant[s] specimens, some of which date back to the 16th century. They are essential to botanical research, especially in systematics. They can also be important historical documents. The collections of Lewis and Clark, Carolus Linnaeus, and Charles Darwin, to name a few, are primary sources for the study of these individuals' work. Now many of these herbarium specimens are being scanned and the images are freely available on the web …. The JSTOR Plant Science Project makes available electronically about 2 million plant specimens, many historically significant, as well as the entire runs of important plant journals. In addition … links to social media can bring the history of botany to 21st century students" (Flannery, et al., 2013).

One such social media group titled “Botany Education in the 21st Century” (https://www.facebook.com/groups/1056168897735912) has become a significant resource for botany educators forced online during the COVID-19 pandemic to share teaching resources, including information on herbaria. Herbarium digitization allows students to learn directly from plant collections. Rather than visiting an herbarium collection, plant specimens and features of these plants can be observed online. Students can compare plants that they have encountered with these samples and see how these materials have been preserved, without excessive handling or risk of damage to the original specimens. “Collecting specimens is a major part of what biologists have done in the past and what they do today…. teachers need to be curators of such data collections so students can understand the valuable information available in them (Siemens, 2008). Digital specimens are also available through websites such as the Consortium of Northeastern Herbaria (https://portal.neherbaria.org/portal/), which provides digital access to participating collegiate and other botanical collections across northeastern North America and eastern Canada. A 2019 project analyzed the development of an application, or “app”, titled the “Probabilistic Vegetation Key,” which used statistical probability to determine the identity of a plant (Chytrý and Tichý, 2019). Botanists informed the statistical selection and the technology replicated the ability to narrow down potential selections of plant characteristics to the most likely choice (Chytrý and Tichý, 2019). This app is an example of a learning and teaching tool that allows people to identify plants and engage with field botany material using computers and mobile devices (Chytrý and Tichý, 2019). Other apps and online resources include “iNaturalist” (https://www.inaturalist.org) and the associated app “Seek”, “GoBotany” (https://gobotany.nativeplanttrust.org), “bPlant” (https://bplant.org) and others that continually improve with the contribution of citizen scientist participants volunteering photographs and location data to add to comprehensive botanical knowledge (Brown, 2019). Other resources include the Integrated Taxonomic Information System or “ITIS” (https://itis.gov), the United States Department of Agriculture’s Plant List of Accepted Nomenclature, Taxonomy and Symbols or “USDA PLANTS” Database (https://plants.usda.gov) and Biota of North America Program or “BONAP” (http://bonap.net). Each of these resources provides information on the current accepted names of plant taxa, native ranges, and geographic distribution of plant species that can be shared with students.

1.4 Social-emotional considerations of teaching during the pandemic

At the start of the pandemic, educators struggled to translate rapidly and effectively the physical elements of field coursework to online platforms, and students and instructors alike continued to cope emotionally and psychologically with the transition to remote learning and societal isolation in different ways as individuals reported symptoms of high stress due to adjustments required by safety measures of the pandemic. Most students in plant science and ecology disciplines experienced online learning for the first time, with the adjustment to online learning arriving among plethora other concerns occupying students’ minds including job security, physical health and safety, and maintaining good mental health. The first week of online synchronous teaching during the pandemic “was assumed to be the most burdened and stressful week of the transition” (Besser, et al., 2020). Although off to an uncertain start, student learning was not necessarily compromised by this situation. The switch to online education presented an opportunity to cater to different learning styles and expand the scope of course material as digital communication increases the accessibility of information (Bender and Hill, 2016; Hsiao, et al., 2018).

During COVID, web tools and learning platforms have become particularly important in the adaptation of all courses for distance education. The pandemic-driven transition to online learning has occurred in all disciplines across all student age groups, and at all learning levels. To address typical classroom learning strategies, an organization titled "Fierce Education" (https://www.fierceeducation.com) brings together virtual information for instructors to access on best practices in digital instruction. A Fierce Education guide has been published to help educators keep students focused and engaged. This guide recommends that students stay organized using a schedule or spreadsheet to keep track of assignment due dates and maintain a resource of online links to easily access class materials (Bresnick, 2020). In addition, setting a schedule and sticking to the schedule are important, particularly in courses utilizing synchronous lectures, as well as setting aside regularly scheduled times to view asynchronous lecture materials and not trying to multitask as distractions in the home-learning environment can be prevalent (Bresnick, 2020). Creating a conducive study space at home is an alternative to traveling to a study location such as a library - particularly as travel was restricted due to shelter-in-place and quarantine regulations (Bresnick, 2020). Decorating the space to simulate the typical study environment helps students to focus (Bresnick, 2020) and instructors can guide students in creating optimal study spaces and obtaining computer and internet access, textbooks, and other learning equipment needed to participate in class (Bell, et al., 2017). Mandating both synchronous and asynchronous communication among students and between instructors and students and offering synchronous office hours and help through email and messages keeps students connected with the course and with other people (Bresnick, 2020). The main goal of this guide is to provide a structured learning environment outside of a classroom.

Mental and emotional health is vastly important and directly tied to physical health and influences academic success. Markowitz (2020) states that almost all students surveyed had experienced a class cancellation for the remainder of the semester, with most remaining classes moving to virtual learning (Markowitz, 2020). Two-thirds of all students surveyed reported higher stress levels and concern with developing or worsening anxiety and depression, and one-third of students expressed concern about developing issues with substance abuse as they attempted to deal with the stresses of living through the pandemic (Markowitz, 2020). The emotional dialogue among academic instructors has revealed reluctance to using digital teaching methods once the pandemic subsides, despite many benefits provided by online learning. According to Boroowa and colleagues (2020), the "Technology Acceptance Model by Davis, Bagozzi, and Warshaw (1989) is based on the well-established theory of Planned Behaviour (Ajzen, 1991), and states that the intention to use technology is influenced by two factors: (a) Perceived Usefulness… and (b) Perceived Ease of Use" with respect to the application of a particular technology in the course curriculum. The current dialogue resembles that of instructors interviewed by Hansen (2001) near the beginning of digital learning - the last two years of the 1990s - when “cyber courses” began to be offered at universities across the United States of America, with 41.5% of American households possessing internet access by the year 2000 (Hansen, 2001). Although distance learning was touted as beneficial for the schedules of working adults, members of the military and residents of rural areas far from universities (Hanson, 2001; Choi, et al., 2018), some instructors predicted, incorrectly, that it would be a short-term fad, unsustainable and inferior to traditional classroom learning (Hansen, 2001). The initial transition to mandatory remote teaching left little time to prepare and adjust, and not everyone had a successful experience. However, there are now many excellent online learning tools available. According to Hsiao and colleagues (2018), it can be expected that instructors utilizing flipped teaching models with “perceived self-efficacy” may continue to use some of these strategies even after it is no longer required. Results of research from Badia and colleagues (2014) illustrated that only about sixty of 965 surveyed instructors taught general science courses in the open university online system that could have included biological topics, a small portion of the total population of instructors. Most instructors taught social sciences and engineering courses (Badia, et al., 2014). About half of the total instructors had between three- and ten-years’ experience teaching online, and about one-third of the instructors were only teaching remote courses at the time of the survey (Badia, et al., 2014). Badia and colleagues (2014) concluded that instructor age, field of specialization, time devoted to online teaching, and degree of perceived importance of online teaching roles interplay to affect instructor ability “to promote learners’ collaboration in virtual learning environments."

Social fulfillment is an important part of human life (Hansen, 2001), and the experience of being in nature as part of a group compels many like-minded people to take field ecology courses. In-person there are opportunities for spur-of-the-moment sharing of advice and knowledge by professors. The camaraderie of venturing out as a group does not immediately translate to teaching a course as an individualized online learning experience, and instructors and students are likely to feel left out of the original social experience (Bates, 2020). Even with synchronous group projects and video meetings, digital learning has a very different social aspect from in-person instruction (Hansen, et al., 2001; Bell, et al., 2017). However, Hansen (2001) also reported that as of the early 2000s, online courses were not seen as isolating by the instructors or students who participated in them, and they felt they were able to get to know one another more in-depth than they would have been able to in an in-person course setting. The end goal of teaching is learning, and digital instruction during the pandemic had to accomplish this objective while maintaining student and instructor safety. The isolation that occurred was only with respect to pandemic safety practices, and although disappointing for many instructors and students, foregoing social aspects in daily life and disrupting the typical social college experience in the short term was a small price to pay to maintain student and instructor safety. There are, in fact, many ways to maintain social connections through remote instruction and the digital campus can serve as a close substitute for in-person interaction (Hansen, 2001; Bender and Hill, 2016). The unprecedented fatigue now experienced by "traditional" college students relative to their school, work and family responsibilities is very similar to the ordinary experience of “non-traditional” college students. At the beginning of the pandemic all students were cut off from the typical campus social experience, and students needed to balance at-home self-guided learning with personal obligations in the same way non-traditional students do. “[N]on-traditional learners” are typically older adult learners, pursuing undergraduate degree courses and the challenges they face in “Distance Education”- administered courses, noting elements of “personality, mutuality, emotionality and formality” as important considerations (Choi, et al., 2018). Brockett (2015) states that non-traditional learners, in particular, bring more personal experience to every learning scenario, and instructors should facilitate the ability for those learners to utilize and share their experiences. Towards the end of spring 2020 and continuing into subsequent semesters, online synchronous students have developed fatigue due to spending large amounts of time for almost all coursework on synchronous videoconferences and asynchronous computer activities. Students and instructors of University of Rhode Island courses using the videochat service “Zoom” and other videoconferencing platforms have reported what is now known as “Zoom Fatigue” according to the interviews with professors (2020) and dialogue among students. The change in learning structure and schedule structure along with other concerns exacerbated mental health issues and contributed to higher rates of disengagement from course participation. Balancing synchronous, asynchronous, and in-person elements when possible is important to attain social fulfillment while not exhausting learners and educators, which can diminish motivation and subsequently diminish long-term learning retention. Learning retention increases in all learners when practical applications and personal experiences connect students with the learning experience. Most students during the pandemic, who would have been traditional classroom learners, participated in courses as "non-traditional" students, making it even more important to improve understanding by relating personal experiences to course content (Brockett, 2015; Choi, et al., 2018; deGroot, et al. 2018). Pedagogy is defined as teaching approaches that are used to instruct children, while andragogy typically describes teaching adults (Brockett, 2015; Choi, et al., 2018; deGroot, et al. 2018). Both terms are used interchangeably when referring to the general college student population which intersects these two life stages. Student approaches to learning are taken into consideration when designing how to engage students in course material and when finding the best ways to provide students with feedback and communication. Arnfalk and coworkers (2015) used a series of five quizzes each worth one-tenth of the final grade, a peer-assessed assignment worth two-fifths, and a forum participation grade worth one-tenth, for a total of one hundred percent of the course grade, stressing forum participation as an important piece of the student learning experience. Instructor "telepresence" - providing feedback in asynchronous forum participation - is a crucial modern course component (Bender and Hill, 2016). Current research reflects strategies for success for virtual learners using "Predictive Learning Analytics" (PLA), and data assessing 170,000 students analyzed the readiness of higher educational institutions to embrace change, particularly with respect to virtual learning, reaching a conclusion similar to that found in analyzing the ePortfolio system in Ireland. "It has been consistently found that uptake of new innovations needs to be supposed from both a senior management level as well as from the ‘shop floor’” (Boroowa, et al., 2020). The data shows the frequency of student access to Open University resources between 2015 and 2017 reflected as weekly percentages, with PLA aiming to determine patterns of students “at-risk” for failure to address issues before they become too difficult to rectify (Boroowa, et al., 2020). In accordance with Boroowa (2020), Caffarella and Ratcliff Daffron (2013) and Patokina (2020) state that successful program planning involves taking the “stakeholders” into account. Stakeholders are the individuals invested in the success of a course or program, including instructors, learners, and various levels of the organization, surrounding community and other entities who will benefit from the success of the program and its learners (Caffarella and Ratcliff Daffron, 2013). The first three semesters of University of Rhode Island student stakeholders taking the newly- online versions of their courses expressed initial hesitation with online plant identification because students that enroll in a course in-person often have different expectations for themselves and the course than a student initially enrolling in an online class**.** Learners often must overcome a very common mental roadblock by understanding that an in-person learner can become a successful online learner, as was the case on a very large scale with first-time online students in the spring of 2020. This apprehension is common, however, so students should be taught that it is not a concrete obstacle, as critical thinking in environmental and natural resource sciences can certainly be developed using online tutorial activities (Rahayu and Sapriati, 2018). In this regard, maintaining motivation to complete coursework in a timely fashion and understanding how to navigate a course’s online platform are essential components to student success in this regard (Caffarella and Ratcliff Daffron, 2013) as students develop a general skill set in how to be online students, in order to do well in the variety of courses they are taking. Instructors play a key role in this process, as they must convey clear expectations at the start of the course that students are expected to respond to regular communications (Hansen, 2001) and to know when to participate in course assignments and activities – the remedy to a communication issue reported in interviews with professors reflecting upon the COVID-19 teaching experience. The pandemic has also brought health to the direct attention of the public, and this consideration can no longer be omitted from building a positive course experience. As such, instructors must remain aware of the general whereabouts of students as they complete remotely sanctioned class activities to ensure safety and general well-being as best as possible from a distance and understand that distractions and home situations may cause difficulty for a student's learning progress. Instructor compassion and flexibility have been important social elements that maintain student engagement in online courses, by reducing apprehension and improving student motivation especially for students new to online learning which includes - as a result of the pandemic - a greater number of students than ever before.

1.5 Pandemic practices in online plant identification education

In the spring of 2020, the global coronavirus shutdown coincided with the beginning of spring break at the University of Rhode Island, which was then extended by one week so that instructors might adapt their courses for online instruction. The University's web platform at the time was "Sakai" (https://www.sakailms.org), which supported assignment submission and grading functions as well as sharing information about lessons with the students. Web platforms such as Sakai are also referred to as learning management systems, computer applications designed as tools to keep students invested in the course material (Dieli, 2020). Landscape Plants II had been taught before, during and after the COVID-19 shutdown. Dispersed across the region and unable to meet in-person, we provided our students with our best substitute on short notice. Basic lesson descriptions and resources posted for each Sakai unit were expanded into modules of learning that focused on different plant families. Resuming with the plants we intended to teach prior to the shutdown, we recorded two videos per plant, the first for teaching identification characteristics and stories for each plant, and the second showing only the features of the plant as a quiz video. Using “Techsmith Relay/Knowmia,” (https://www.techsmith.com) we were able to caption videos and create links to embed within class web pages and quizzes. Every module included a unique creative project as well. For example, asking students to create cross-comparison charts for five different species within Ericaceae, the Heath family, and designing a small landscape placing six species of their choice from the Cupressaceae, or cypress family, from a list of plants taught. With the COVID shutdown continuing, the summer 2020 offering of Field Botany and Taxonomy became a five-week long asynchronous learning experience presented to eighteen students. Regularly weekly deadlines were presented in the form of to-do lists within lesson pages referred to as “modules” on the University’s new learning management system, “Brightspace” (https://brightspace.uri.edu) (Brown and Maynard, 2021). Previously trained in the use of Sakai, instructors and teaching assistants were required to undertake additional training to learn the new system, which would facilitate the submission of assignments, posting of grades and forum discussions. My advising professor along with one other instructor and myself as the teaching assistant spent many hours developing and administering the course. The instructors and TA communicated with students using email and text, and office hours were held upon request by phone call and video chat. Due to COVID-19 shutdowns, most students were living off-campus, and several were attending virtual class from out of state. Our redesigned “flipped” course allowed students to continue receiving practical experience in plant identification, learning by reading about plant terminology, groups of plants and ecological communities characterized by plant species, reviewing information with short multiple-choice quizzes, and then exploring the natural world to find the type of plants that were the focus of that week’s lesson. Modules included understanding basic botany concepts and terminology and then learning wildflowers, trees and shrubs, grasses, ferns and fern allies including club mosses and horsetails. Students were expected to key out plants while in the field. The keys used included Newcomb’s Wildflower Guide, Petrides’ Trees & Shrubs, and Northeast Ferns. GoBotany’s simple, full, and dichotomous keys also were used, and students learned to utilize all of these keys as a resource to identify plants based on a series of descriptive choices. In addition, the Consortium of Northeast Herbaria was used as a reference to cross-check the identification of plants as students created their own digital “vouchers.” Students learned sixteen plants weekly, about four plants each day, making a voucher for each plant. One voucher each week was developed further into a presentation with extra information and shared through a discussion function within Brightspace. Students were required to read and respond to at least two other presentations, thus maintaining student interactions even in an entirely asynchronous learning environment. We learned through trial and error that students needed to submit three specific types of clear photographs in their vouchers: a "big picture" image providing a context for overall size, growth habit, and location near other species; a mid-distance picture providing details such as branch arrangement, bark texture, and presence of flowers or fruiting structures; and a close-up image showing details of foliage, branch, and flower morphology, color, markings, texture and other identification clues. Students also posted these images to a class "project" on iNaturalist and helped to verify each other's identifications. iNaturalist was also used to conduct a vegetation survey capstone project towards the end of the course, after students' keying skills were well developed. The vegetation survey required students to find a relatively unmanaged natural landscape spanning more than one natural community type, if possible, and walk a straight line transect, stopping to identify species every five steps and recording and photographing the first twenty plant species observed. A proposal was submitted in advance delineating two potential study areas with proposed transects and Global Positioning System (GPS), coordinates. The final project report included the actual transect used following any changes, images and descriptions of the natural community based on the plant life present, and uploaded images with GPS coordinates in iNaturalist so that the class transects were visible as "pinned locations" on a digital map. Throughout the course assignments were due by the end of the week, typically on Sunday nights. Each module had a "to-do" list showing all the assignments the students were responsible for that week. It served as a checklist with assignment pages hyperlinked to the to-do list so that students could access the online activities using more than one digital pathway. To succeed in the course, students were expected to view the emails and course announcements - listed on the course "home" page and automatically sent by email - to know when to check the course website and when to participate in activities and complete assignments. Vouchers, blog posts, presentations and projects were graded individually by the instructors and teaching assistants, but multiple-choice quizzes were set up to be graded automatically and have randomized question orders generated for each student. Brightspace records the amount of time students spend accessing online course materials, however with online field botany, much of the classwork was spent outdoors, away from the computer, and many activities on the web could be downloaded in a matter of seconds. As a result, the amount of time recorded by Brightspace did not reflect actual student work time and could not be used to assess student participation. Participation grades relied upon assignments submitted rather than consistent periods of time logged in to the course website. At the end of the course, I composed a questionnaire to ask the students about their course experience, within which students stated they typically spent two to six hours per week working through the module while four to eight additional hours per week were used to explore the outdoors, ranging from a minimum of six to a maximum of fourteen hours total, with an average of ten hours per week equating to 140 seat time hours spent on the course over the semester. During the summer course, most students did not have other class obligations, but many had jobs and personal obligations, particularly with keeping safe and healthy during the active pandemic-related shutdowns. Over the five-week summer course, students with greater availability were more easily able to spend closer to seventy hours focusing on the course material, while learners with busier schedules may have limited course work closer to thirty hours. In contrast, fall semester students had to balance full course loads as well as jobs, personal obligations and keeping themselves safe during the pandemic. The fall course had originally expected students to spend 180 seat time hours on a four-credit course over a 14-week semester, but when the online version of the course was shortened to eleven weeks the seat time hours became closer to that of a three-credit course, at about 135 seat time hours. Using knowledge gained from the development of the summer session, two instructors and three teaching assistants developed and managed the fall Field Botany and Taxonomy course for fifty online students. The longer fall term allowed the addition of a moss unit and more-detailed lessons in grasses, ferns, and fern allies, along with weekly multiple-choice vocabulary quizzes. Twenty-one of fifty students reflected that a pre-filmed “moss camp” video touring the moss species of the University of Rhode Island Kingston campus’ North Woods was a beneficial and engaging element of the course. Instructors and students determined early in fall semester that four weekly vouchers needed to be reduced to two vouchers and one presentation as a blog post each week and students remained responsible for replying to their classmates’ plant presentations. Fifty-four percent of students described the process of starting out with twice as many vouchers to be a good approach to the learning curve of preparing the vouchers so that it felt much easier when the number was reduced. The voucher experience balanced out due to the course being more than twice the length of the summer session. With the change in safety precautions as regular COVID testing became available, the course was able to hold weekly in-person recitations on-campus of small groups of one to five students to review keying and identification skills. A third of the students were able to attend the sessions, and another third stated that they felt they would have benefited from the practicums but were unable to attend due to work schedules, other coursework, living too far from campus, or being in a high-risk group for COVID-19. In both the summer and fall courses, the instructors and teaching assistants made audiovisual guides showing students how to use iNaturalist and create vouchers for each plant type. At the very beginning of the courses, each teaching team member introduced themselves via a description and image in the first "Start Here" module, and students then completed an introductory blog post introducing themselves and composing a fun scientific name to represent their personalities. For each class, this asynchronous "icebreaker" activity was the first instance in which students interacted with one another and the instructors.

> "As the course[s] unfolded, we found that the switch to the online format had created new learning opportunities. Students continued hands-on learning with greater independence. Resources designed for the course could be reused by students time and again, and we improved accessibility by captioning videos and narrating PowerPoints. Several students completed classwork from out of state, adding to the diversity of plants that the class found. The asynchronous schedule allowed students with personal or work obligations to participate fully. While our students all reflected that the course was time-intensive, they enjoyed the motivation to spend more time outdoors each week" (Brown and Maynard, 2021).

1.6 Survey development

The format of the surveys developed for this study was modeled after precedent studies in multiple disciplines. Social science surveys pertaining to online education possess an extraordinarily wide range of participants, from 100 to 170,000, with typical sample sizes between 100 to 1,000 participants. One study utilized an anonymous online questionnaire to ask 965 higher education instructors of the "virtual campus" of the Open University of Catalonia about their perspectives and experiences in online teaching (Badia, et al. 2014). Data was collected over the course of four months from November 2011 to February 2012, distributing questionnaires to be answered anonymously by course instructors (Badia, et al. 2014). The total number of respondents was less than half of the approximate 2,100 instructors within the system (Badia, et al. 2014). Demographic information included academic education, field of specialization, experience with online instruction, level of teaching, and time devoted to online teaching compared to face-to-face (Badia, et al. 2014). Of the survey respondents "56.2% were men, and 43.8% were women, and their average age at the end of 2012 was 42.7 years" with a standard deviation of 7.61 (Badia, et. al., 2014). An Israeli study observing effects on instructor stress during the first week of the coronavirus pandemic distributed online questionnaires to 1,400 instructors at fourteen universities, receiving 313 responses, with almost exactly 50% of responses each being female and male (Besser, et al. 2020). Caliksan and colleagues (2017) surveyed 107 students at a single university about their general satisfaction participating in distance learning. Statistics showed nearly a 2:1 ratio of satisfaction to dissatisfaction in preference of accessing courses through mobile devices, as students were able to complete coursework even in remote locations that otherwise did not have infrastructure supporting consistent internet access (Caliksan, et al., 2017). de Groot and colleagues (2019) asked "adult distance students" about the benefits of various learning strategies, noting that different learner age categories use learning resources differently. This study assessed a sample of 4,945 students enrolled in courses at the Open University of the Netherlands between August 2012 and August 2013, with 50 questions "to assess 9 learning" strategies consisting of scale-of-agreement questions rather than multiple choice, short answer, or other methods (de Groot, et al., 2019). Using a range of five choices was a tactic employed by Badia and colleagues (2014) as well, using "strongly disagree" to "strongly agree" as the scale-of-agreement. A fourth study surveyed 169 university instructors to determine motivation for using flipped course models, a technique approached by instructors to provide self-directed learning (Hsiao, et al., 2018). "Students are first exposed to new material outside class, usually via reading or video lessons prepared by the teachers; class time is then devoted to the harder task of assimilating new material" (Hsiao, et al., 2018). The study was conducted in response to a gap in information noted by the research team, as previous studies only inquired of student perspectives on flipped teaching, and this study sought to capture the voices of the instructors that implement this form of instruction (Hsiao, et al., 2018). Precedents collected in a dissertation titled "Success Stories: Community College Teachers Using Technology to Engage Online Students" state that online course enrollment increases while student "persistence and course grades are significantly lower" compared to in-person courses, but students who are engaged in the course material retain more information from the course compared to students who are disinterested, treating engagement as a learning motivator and information retention as a direct measurement of student success (Dieli, 2020). "The research shows that for students to be engaged in the learning process, teachers must use best practices and select the appropriate [teaching] tool for the appropriate purpose" (Dieli, 2020). The current survey would not need to include demographic information already collected by previous similar studies in online education but would need to ask about teaching tactics from both instructor and student perspectives by means of scale-of-agreement inquiry. In analyzing the variety of teaching methods used by instructors, I chose to correlate the teaching tactics used with the satisfaction of instructors and students and confidence in student retention of learning outcomes. Satisfaction and confidence consist of a conglomeration of variables including academic, emotional and social accommodations, and the survey sought to find out the type of flexibility provided by remote teaching of field courses and how instructors incorporated student exploration of the out-of-doors as part of an online curriculum. Courses considered for this study included field botany, wetland ecology, ornithology, herpetology, natural resources, and entomology courses at universities (Kallas, et al., 2015; Alonso, J. M., et al., 2018), as well as a variety of continuing education courses and among programs such as the Master Gardeners and other adult learning programs applicable for Continuing Education Units or continuing education credits. To focus the study, only courses with large plant identification components taught to undergraduate students at the collegiate level would be considered. During survey development, a consideration was made to include post-testing of course knowledge retained by students at different intervals of time following course participation, however the surveys could not extensively summarize specific knowledge within the wide breadth of course topics. Instead, instructors and students reported and provided opinion-based feedback.

II. Methodology

For this thesis project a set of questionnaires were developed to critically assess teaching and learning techniques in practical plant identification courses, created not only from studies in other disciplines but also from my perspective and the challenges observed in communication from instructors to their students. Following the format of a study by Patokina (2020), as an informal preliminary study I conducted synchronous online interviews of seven University of Rhode Island instructors of six different courses to ask about their experiences following the onset of the pandemic and the challenges and benefits experienced relative to pre-pandemic teaching. Their subjects included wetland science, soil science, herpetology, entomology, and similar ecological courses. The interviews asked about typical class size prior to the pandemic compared to current class size during the fall semester of 2020, as well as the number of students that have disengaged or unenrolled by the end of each version of the course. Answers reflected that most courses had one instructor, between one and two teaching assistants, and held class remotely with much smaller in-person lab sections compared to previous semesters or provided kits and supplies for students to complete independent self-directed lab activities. Class sessions were typically held for 50 minutes to one hour twice a week. Most instructors stated that they and their students spent more time planning and participating in the course than usual, and that it was difficult to gauge student engagement in the course. Five of six courses had an average of thirty students with a class portion taught synchronously for an average of one hour twice per week. One course had over one hundred students led by one professor and one teaching assistant. Every course used the university's Brightspace platform to organize and present course material and collect student work. Each instructor organized their courses differently within the websites, but most embedded readings within the course website, eliminating the need to purchase a textbook in all but one course. Supplementary videos used within online lesson modules were typically between five and ten minutes long and mostly were sourced from materials developed by other instructors and found on "YouTube" (https://www.youtube.com). Most instructors had attempted to film their own course materials the previous semester and found that while it was helpful to have all the course information saved in the event it was needed, low filming quality and the excessive amount of time needed to film all of the course material in the field was not worth the effort. Occasional use of longer videos filmed by the current course instructors and their previous students was the most rewarding use of this teaching tactic. Instructors each had a different grading system that held students accountable for course material in different ways, employing creative and fun assignments that relied on the students' engagement in the process rather than the outcome, asking students to incorporate personal perspectives in reflecting upon scientific answers. Personalized assignment prompts mitigated plagiarism, which had been a common issue with traditional question and answer approaches. A study on open education by Rahayu and Sapriati (2018) found that students used word-for-word quotes in non-cited open note answers rather than paraphrasing the concepts presented. Although several instructors were unaware of helpful tools within the online platforms that other instructors were using to address identical purposes, each instructor overcame their challenges by identifying multiple ways to achieve the use of online blackboards, color-coded grading, and sharing links to web resources with students. As the semester continued, instructors noted absences due to students and their families dealing with the coronavirus as well as heightened stress in navigating the pandemic, along with general disengagement and reduced motivation that was slightly higher than pre-COVID semesters, with an average of 15% to 20% of students disengaging from courses compared to the typical 10%, and between 2% and 5% of students unable to participate at any given time due to having the coronavirus or being quarantined, isolated, or sheltered-in-place, a commonplace occurrence during the pandemic. Besser and colleagues (2020) describes the immense amount of stress citizens of the world experienced during this time:

> "… one of the most notable stressors concerning the COVID-19 pandemic is the tremendous disruption it has caused for daily life. The consequences of the COVID-19 pandemic around the world (eg, the number of individuals who have died from the illness or been incapacitated by it; the number of individuals who have been infected by the coronavirus which causes COVID-19; the global economic consequences of the pandemic) as well as the various responses to the pandemic (eg, social distancing practices, travel restrictions, stay-at-home orders; community curfews and mandatory quarantines) are unprecedented experiences for many individuals. The psychological stress associated with the COVID-19 pandemic is likely to be

> exacerbated for those individuals who were already feeling somewhat overwhelmed by the stressors in their lives. This type of increased stress can also be followed by anxiety-related behaviors such as sleep disturbances, and an overall lower perceived state of health. These behaviors may, in turn, affect workload stress related to the need to teach from home and online synchronous teaching arrangements."

Personal experience as a teaching assistant developing and delivering hybrid asynchronous, synchronous, and in-person course content for ten courses over the course of the past two years also informed the development of the survey questions. Interactions with students about the methods that functioned well and less well manifested in the creation of a set of end-of-semester survey questions summarizing their experiences. The most frequent student recollections were incorporated into the surveys developed for this study, as well as thought-provoking statements provided by students that broadened the possibilities of questions to be included. Eighty students from three different plant identification course sections at the University of Rhode Island provided feedback at the end of spring (18 students), summer (18 students) and fall (50 students) 2020 semesters, remarking that not only were they tackling new course material, but at the same time learning how to take online courses (Appendix A: Case Study).

The current study consists of two sets of online surveys developed using the "Qualtrics XM" survey platform. Responsible Conduct of Research (RCR) and Institutional

Review Board (IRB) certification were obtained prior to the distribution of the surveys. Participation was voluntary and no private information was collected or disclosed with exception of instructor email addresses needed to enable the anonymous distribution of the student surveys. Email addresses provided were separated from the instructor's answers to remove bias but used to keep track of student survey-takers from the same course. Participants were required to be above the age of 18 and submit informed consent. Internet access and sufficient time to complete the survey was needed. The first fourteen-question survey was distributed to instructors and required approximately fifteen minutes. The second seven-question survey was distributed to their students and took about five minutes to complete. Answers were collected anonymously, consisting of matrix-table and Likert scale questions providing levels of agreement and asking about the nature of assignment and assessment types used. Blank spaces were provided for instructors to add remaining details, and university and course titles were collected to discover the quantity of course types and the locations of participating collegiate institutions. Remote distribution of the survey minimized cost and maximized participant safety during the coronavirus pandemic. Compensation for participation in the study involves sharing the results of the survey findings with participating professors. No compensation was provided to student participants other than the knowledge that their responses would help students succeed in future. Scale-of-agreement survey questions were phrased to compare current (during COVID) and previous (pre-COVID) course delivery methods and components. Results are expected to represent the teaching techniques of the larger population of plant science instructors. The first survey observed instructor experiences with teaching methods and course goals the instructors had for their students. The second asked students their preferred learning methods and which goals they felt were most confidently accomplished. Both surveys addressed student motivation, engagement, and overall success. Surveys addressed elements of course development and delivery to students falling into four major categories: course composition, preparedness, engagement, and skill acquisition.

2.1 Limitations and biases

Limitations of this study include the opinion-based nature of the survey responses, subject to human error. The surveys assume that instructors and students accurately recall details of their course experiences and recognize the language used in the surveys to answer appropriately. Other survey limitations include ambiguity in qualitative thought of potential participants regarding whether a particular course taught falls under the specific description of the study, which, as reflected in emailed apologies from instructors, reduced the available data for the primary survey. Access to technology and timeframes in which to respond to the recruitment email communication influenced participation. Selection error applies, as respondents of an online survey about online education have online experience, and instructors who did not teach online courses did not respond to the survey about the COVID teaching experience. The beginning of the survey asked if instructors had decided not to teach as a result of the pandemic, and most respondents did not select this option. Sampling bias is suggested as those instructors who may have chosen not to teach in a mandated digital course environment may have been less likely to participate in a survey that is also online. The study was conducted under the assumption that following the worldwide pandemic, instructors will continue to offer remote components of field courses as a form of progress in the digital age and in response to increased societal safety measures. The study was distributed to over 270 professors and departments of biological, environmental and plant sciences at United States of America-affiliated land grant colleges, universities, and other institutions with similar programs, and the subset that replied is the population surveyed. Thirty-nine instructors specified that the survey criteria did not match the course that they teach or submitted surveys with entirely blank results. Of student respondents, nine submitted blank surveys that required omission. A subset of forty instructor and twenty-nine student responses comprised the final total of sixty-nine utilizable survey responses. Of student responses, five individuals represent a control group of pre-pandemic students, providing the ability to compare longer-term retention of skills and confidence in knowledge of course material. A larger response rate of instructors and students was initially expected, however the response rate achieved was within the range of precedent studies analyzed. Due to the long Institutional Review Board application process and limitations of the Qualtrics survey program, the timing of survey distribution was postponed from the end of spring semester 2020 until the beginning of spring semester 2021, and instructors had between February 1 and March 15, 2021, in which to respond while student responses were collected only between March 15 and April 5, 2021. Students reflecting on pre-COVID and spring COVID course experiences may have taken into consideration pandemic course experiences when answering, changing how they may have answered if the survey had been given in spring semester of 2020. It is the hope that following the pandemic, studies such as this one will continue to be conducted and can be distributed both online and in-person, removing initial biases and encouraging further participation. Sampling bias also exists among student respondents as students most invested in - or most agitated by - a course may be the most likely to be motivated to provide feedback. In addition, the survey was not distributed from an anonymous email address, and as such the individuals with personal investment in the courses at the University of Rhode Island comprised a larger subset of the sample size compared to courses from other universities. In terms of survey composition, the number of questions of importance could have been reduced to fewer than 123 sub-questions within the fourteen instructor questions. Rather than varying question types as suggested by the Qualtrics survey software to include yes-or-no, short answer, and scale-of-agreement questions, reducing survey length and using entirely one question type would improve the ability to cross-compare questions through statistical analysis.

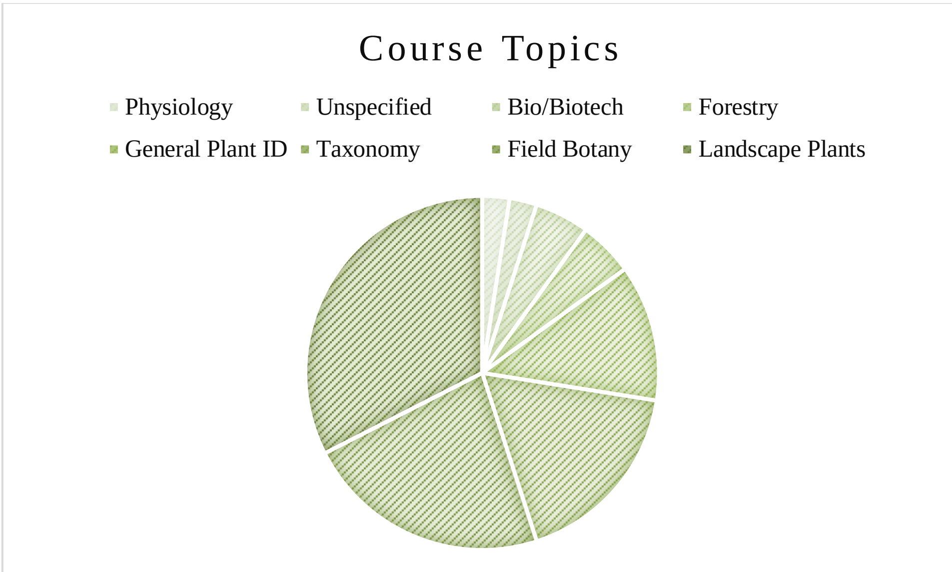
III. Results

Each study focused on four core topics: skill acquisition, student engagement, course components and delivery methods, and instructor and student preparedness. Of 276 instructors contacted, applicable responses totaled forty individuals for a 15% response rate. Of those instructors, five distributed the survey to students of their courses, and 29 students responded. Based on previous instructor interviews, student response rate is 0.04% of an estimated 8,280 students in 276 courses. Five of the student questionnaires returned formed a control group of students reflecting on pre-pandemic course experiences, with the remaining twenty-four describing their course experience during the pandemic. Thirty-three of the instructors represented U.S.-affiliated land-grant educational institutions, while seven were not land-grant schools.

Figure 1.0. Survey respondent participation map

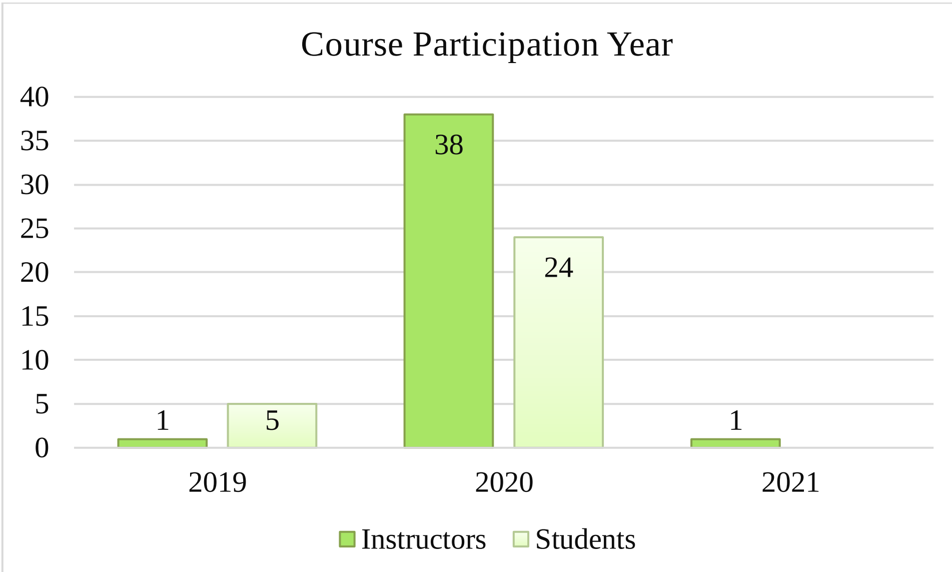
Instructors answered both for multiple and singular courses, with fifty-one course titles specified. Figure 1.1 shows course types and plant materials covered.

Figure 1.1. Course topics taught by instructor respondents



Of 40 total courses, most focused on landscape plant identification, with the second largest group focusing on field botany and wild plants, followed by taxonomy and plant diversity. Although not specifically asked in the questionnaire, instructors provided insight into the average number of plant families and species within those families that their courses covered. Five instructors reporting on one or more courses each resulted in an average of thirty plant families containing two hundred species. Twenty-three courses covered both herbaceous and woody plant material, while five covered only woody plants and two specifically covered only herbaceous plants. Four courses covering herbaceous plants included coverage of grass plants. Three classes covering woody plants included winter bud identification. Ten courses did not specify the type of plant materials covered.

Figure 1.2. Course participation year



Pre-COVID courses taught in 2019, during-COVID courses taught in 2020, and one course was planning for spring 2021 but had not yet implemented the course. Three instructors responded only for spring 2020, one specifically for summer, three for both spring and summer, nine for fall only, and twenty-three did not specify the semester within that year. Three spring 2019 and two fall 2019 students comprised the pre-COVID responses, while five spring 2020, two summer 2020, thirteen fall 2020, and four unspecified 2020 students comprised the remaining student responses. Instructors that discussed only spring 2020 courses had taught the first portion of their class in-person and subsequently had very little preparation time to adjust to online teaching. Instructors of summer and fall 2020 courses had more planning time to adapt lessons for online teaching that adhered to pandemic safety protocols. Of the latter, those who experienced the former were able to incorporate some of the previous semester’s successful strategies into their teaching. Within the pre-covid student sample, three were spring 2019 and two were fall 2019 students.

Within the surveys, six question types used different scoring systems (Table 1.0).

Table 1.0. Survey data interpretation key

Rank	Confidence	Compared to previous courses	Number of times	Duration	Course Delivery
0	N/A	N/A	0 times	5 minutes	
1	Not learned	Much less	1-5 times	10-30 minutes	In-Person (I)
2	Not confident	Less	6-10 times	50-75 minutes	Synchronously (S)
3	Somewhat confident	Same	11-15 times	75+ minutes	Asynchronously (A)
4	Confident	More	16-20 times	Untimed	
5	Very confident	Much more	21+ times		

The first question type was a simple "yes" or "no" question whose percentages are of the total number of instructors. The remaining question types are categorical ranks including the level of student confidence in skills, instructor and student perspectives comparing current course experience to previous courses, number of times course components were employed during a semester, duration in minutes of course activities including class sessions, assignments and assessments, and course delivery methods used separated into in-person, synchronous and asynchronous delivery. Likert and multiple-choice percentages are derived by dividing out of the number of responses per question rather than the total number of instructors. Each question was assigned a code abbreviating the question content, and codes are split among four question categories. The number of responses per code were compared between students during COVID and students prior to COVID, as well as two groups of instructors: those whose students had provided survey responses, and those whose students had not. As the survey sample size was small, these groups were separated to determine whether they would accurately represent the larger population of instructors of similar courses nationwide. For each code, the response percentage at each rank revealed coinciding modal majority and level of agreement between respondent groups. In example, code "51T+" refers to the frequency with which tests with fifty-one questions or more were used during the specified semester. Instructors showed modal majority percentage of using tests with this question quantity length zero times. with 60% of instructors who had provided student responses and 53% of instructors whose students had not responded to the subsequent survey sharing the result with a difference only seven percent. Summarized tables convert the modal majority percentage into qualitative descriptions. "Yes" or "no" results are given as the percentage of instructors that said their course did include those elements. All percentage questions are summarized in three main groups of 0-32% (low), 33-66% (medium), and 67-100% (high). Likert scale-of-agreement data instead describes the percentage of total responses for that question, split among each rank. Rather than one-way analysis of variance, t-tests, chi-square tests, and other parametric analyses, this qualitative survey data is best analyzed nonparametrically (Badia, et al., 2014). Unlike the multiple principal component analysis, Bartlett's test, Cronbach's alpha, or Pearson's rank correlation and Spearman's rho biserial correlation also conducted by Badia and colleagues (2014), the small amount of statistically sampleable nonparametric information in this study better lends itself to selective Mann-Whitney U-testing. In the case of the current study, questions were not all composed as Likert inquiries, and as such the percentages and ranks with the smallest distance between both student and both instructor subgroups (Appendix B: Tables 2.3, 2.4, 2.5, 2.6) show the most potential for representing the much larger course participant population. With a larger data set, Kruskall-Wallace testing would be able to describe the survey results in more detail. Citations are provided in each table for survey questions derived from precedent studies. All other questions are based on considerations noted in the synchronous instructor interviews (Amador, J., Couret, J., Floyd, C., Gold, A., Karraker, N., Paton, P., and M. Peach) and from end of semester student course reflection questionnaires. Mann-Whitney U-testing is used to determine if the significance of results reported by pre- and during- COVID students would be representative of the larger population of students in plant identification courses. Test values were calculated using Microsoft Excel spreadsheet formula functions. Due to the small survey sample size, Mann-Whitney U-testing requires the use of a critical value. Using a table of critical values with a p-value of 0.10 and two-tailed test criteria, the U-statistic for each Likert question comparison between pre- and during COVID students was identified to determine the likelihood of the pandemic's effects upon elements of the student course experience. Similarly, the questions in which instructor and student Likert responses were compared were also able to be tested using this method to discover whether teaching strategies affected the student course experience. In the event that the U-statistic is less than or equal to the critical value, the null hypothesis is not rejected, and the pandemic is shown to have affected the student course experience. When the U-statistic is greater than the critical value, the null hypothesis *is* rejected, and the pandemic is shown to have had no significant effect on student experience for the given question code.

Skill Acquisition:

Mastery of skills taught by plant identification courses was assessed by students of courses during and before the pandemic. Codes represent each skill description, and similarities are compared using the highest percentages per ranked score, or modal majorities, as well as Mann-Whitney U-test comparisons. Table 1.1 lists question criteria for student skill acquisition alphabetized by associated abbreviations. Modes of closest similarity between instructors whose students did and did not respond to surveys include BIO, DES, DRA, ECO, HPHY, LAN, and TER as skills prospectively most applicable to larger sample sizes. Codes with the most similar responses between pre- and during-pandemic students include DES, DRA, ECO, GEO, HDIG, LAN, NAM, NAT, ONL, SENS2 (texture), SENS3 (scent), TAX2, TAX3 and TCH. Eleven questions demonstrated direct correlation between skills taught and skills acquired at a concurrent level of student aptitude. Five skills are subsets of other skills and two skills without equivalent instructor responses are omitted from the calculation. Three skills taught by a lower percentage of instructors was touted with higher confidence by a higher percentage of students. Of the remaining skills, three skills taught by most instructors (between 67 and 100%) yielded a student score of “somewhat confident.” The two remaining skills were taught by between 33 and 66% of instructors, and one yielded a score of “not confident” while the other student score produced was “not learned." Of the twenty-seven skills surveyed, students during COVID reported confidence as strong or stronger in ten skills compared to their pre-COVID counterparts. Student knowledge of provenance and geographic ranges of plant species was higher during the pandemic, and between 33 to 66% of instructors covered this skill. The same percentage class of instructors had students recognize natural communities of plants as part of the curriculum during COVID. Students during COVID had a similar, slightly higher confidence at "somewhat confident" compared to their pre-pandemic peers. Table 1.2 shows the modal majority of student confidence in skills prior to (blue) and during (green) COVID-19, with equal confidence bolded in black. The correlation between instructors teaching each skill during COVID as also displayed as three percentage levels. Some skills were voted equally at more than one level of confidence by students.

Table 1.1. Skill acquisition code definitions

Code	**Definition**
BIO	General plant biology including anatomy and physiology
CUL	Cultivation, care, maintenance and harvest techniques of live plant materials
DES	Designing of landscapes and understanding siting, spacing, and biotic and abiotic stressor susceptibility
DES2	Advising others on growing condition requirements of plants (Bloom, et al., 1956).
DIS	Dissection of plant parts to learn anatomy and understand reproduction (Olszewski, 2011).
DRA	Drawing of plant parts to understand plant anatomy and plant species identification (Olszewski, 2011).
ECO	Understanding ecosystem interactions between multiple plant species and other organisms (Kallas, et al., 2015).
GEO	Learning provenance and geographic range of plant species (Flannery, 2013).
HDIG	Creation of digital herbarium collections (Flannery, 2013).
HIS	Learning historical, comestible, medicinal, irritant and toxic properties of plants (Olszewski, 2011).
HPHY	Pressing plants to create physical herbarium collections (Flannery, 2013).
IDO	Understanding the process of plant identification *Continued…*

Table 1.1. Skill acquisition code definitions (continued)

Code	Definition
KEY	Navigating field guides, random access keys and dichotomous keys to identify plants (Lopes, 2011).
LAN	Distinguishing between unmanaged, naturalistic and managed landscapes and landscape plants of each
NAM	Learning binomial nomenclature and meanings of scientific names
NAT	Recognizing natural communities of plants
ONL	Using digital, online plant identification apps, keys and websites (Chytrý and Tichý, 2019).
OUT	Experiencing the out-of-doors to understand a plant's context in physical environments
POP	Conducting vegetation population surveys, studies and inventory projects (Chytrý and Tichý, 2019).
SENS1	Learning visual characteristics of plants and how other senses are used (Durumus and Yapicioglu, 2015; Flannery, 2013).
SENS2	Learning textural characteristics of plants (Durumus and Yapicioglu, 2015).
SENS3	Learning scent and taste-based characteristics of plants (Durumus and Yapicioglu, 2015).
TAX1	Learning family characteristics
TAX2	Learning genus and species characteristics
TAX3	Learning relationships and differences between major groups of plants (i.e. gymnosperms & angiosperms, monocots & dicots)
TCH	Ability to teach others about the plants they had learned in class (Bloom, et al., 1956).
TER	Learn botanical terms and plant anatomical structures

Table 1.2. Skill acquisition results**

	Modal Majority of Student Confidence				
Frequency of Skills Taught	**Not learned**	**Not confident**	**Somewhat confident**	**Confident**	**Very confident**
None	DES2		**IDO,** TCH	DES2, TCH	IDO, TCH
Low 0-32%	CUL, **HDIG,** HPHY, POP	DRA, ECO	BIO, DRA, ECO, POP	BIO	**BIO**, CUL, HDIG, HPHY
Medium 33-66%	HIS	DES, GEO, NAT, TAX1, TAX2	DIS, GEO, HIS, **LAN, NAT,** TAX2, **TAX3**	KEY, LAN, TAX2, TAX3	**DES,** DIS, KEY, TAX1
High 67-100%		SENS3	NAM, OUT, SENS2, **TER**	NAM, ONL, **SENS1,** SENS2	NAM, **ONL,** OUT, SENS1, SENS2, SENS3

*Key:

Blue- modal majority showing greater student confidence in skill acquisition prior to COVID-19

Green- modal majority showing greater student confidence in skill acquisition during COVID-19

Bold black- equal modal majorities in student skill confidence for a code before and during COVID-19

**Note: The intersection of medium to high instructor coverage of skills intersects with medium to high student confidence in the greatest number of different skills.

In comparison, Mann-Whitney U-test results show thirteen codes less than or equal to the critical value at 90 percent confidence (α=0.10), demonstrating that the pandemic did affect levels of student confidence in acquisition of certain skills. Critical values are listed first in each numerical comparison, showing the greatest distinction first as reduction in confidence of student skill acquisition with experiencing time outdoors (OUT 28>0), followed by using scent (SENS3 28>9) identifying plants by texture (SENS2 30>16), teaching other people about plants learned (TCH 30>19), learning scientific names (NAM 30>21), cultivating live plant materials (CUL 26>18), using identification keys (KEY 29>24), and learning genus and species characteristics (TAX2 30>29) Levels of student confidence remained the same for learning evolutionary relationships of plant groups (TAX3 30>16) and understanding the plant identification process (IDO 30>25) as also shown in the chart of modal majorities. An increase in student confidence in skill acquisition was seen in identifying plants by visual characteristics (SENS1 30>12), learning plant biological concepts (BIO 26>21), and completing landscape design and plant selection projects (DES (29 = 29). Test results also describe fourteen codes with selected U-statistics exceeding the critical value, in which the null hypothesis is rejected and significant overlap is detected between pre- and during-pandemic students, shown in order from least to greatest difference between critical value and U-statistic: DES2 (29<30,) DRA (26<30), HDIG

(26<32), TAX1 (28<34), DIS (25<32), GEO (30<37), LAN (30<38), TER (30<38), ECO (29<38), ONL (30<39), HPHY (25<35), POP (28<39), HIS (26<39), NAT (29<45). The results of the Mann-Whitney U-test show low probability of representing a larger sample size of respondents with statistical significance. In example, although LAN, NAT and HDIG modal majority ranks overlap between student subgroups, the responses would not necessarily overlap given a greater number of respondents.

Engagement:

Student and instructor engagement in courses was assessed by how well social and emotional criteria were met. Table 1.3 displays the definitions of question code abbreviations. Codes with the strongest modal majority responses among instructors are as follows: DIFF, DIVRS, INSPRT, LOTS, POS, and PRTC. Codes with the most similar responses between student groups before and during COVID are as follows: DIVRS, FSAF, and PRTC. Table 1.4 compares levels of student engagement before and during the pandemic along with instructor perspectives of instructor and student engagement. Between one and two-thirds of professors expressed that they would be willing to use the same course model again with some changes, as they were less satisfied with the experience provided to students compared to courses in past. Students during COVID felt that they had received more support from instructors compared to previous experiences, although students prior to the pandemic stated similarly that they felt much more supported in hands-on plant identification courses compared to previous experiences. Instructors described a modal average of the same amount of support from colleagues and administrators.

Table 1.3. Course engagement code definitions

Code	Definition
AGN	Use current course model again
APPR	Student apprehension at start of course (Bender and Hill, 2016).
DIFF	Course content difficulty
DIVRS	Diversity and cultural representation (Patokina, 2020).
FSAF	Feeling of safety (Patokina, 2020).
FUN	Creativity and humor encouraged in student assignments (Brockett, 2015).
FUN2	Creativity and humor used to engage students' attention (Brockett, 2015).
INSPRT	Emotional support instructors received from colleagues (Miceli, 2018).
KCL	Whether students got to know classmates (Hansen, 2001).
KIN	Whether students got to know instructors (Hansen, 2001).
LOTS	Improvement of student understanding of course concepts by the end of the semester (Yennie, 2020).
LOV	Student development of a love of plants
MENS	Instructor motivation to ensure student well-being (Patokina, 2020).
MOT	Student motivation to succeed (Snyder Elliott, 2007).
MTCH	Instructor motivation to teach (Snyder Elliott, 2007).
OFF	Office hours attended (Bender and Hill, 2016).
OVR	Students overwhelmed with stress
POS	Positivity of experience
PRTC	Student participation
SATISF	Instructor satisfaction with the course
SHR	Student communication about non-course concerns interfering with course success (Patokina, 2020).
SHR2	Students seeking help (Patokina, 2020).
SPRT	Emotional support students received from instructors (Bender and Hill, 2016: Patokina, 2020).
STRS	Instructors overwhelmed with stress (Besser, et al., 2020).
TECH	Regular technology checks to ensure accessibility of course components for students
TIM	Student seat time hours spent on the course
WEL	Student overall average course grades

Table 1.4. Course engagement results

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
AGN	N/A	N/A	Medium
APPR	Same	More	N/A
DIFF	Same	More	Same
DIVRS	More, Much more	Same	High
FSAF	Much more	Same	N/A
FUN	Same, Much more	More	Same
FUN2	N/A	N/A	High *Continued…*

Table 1.4. Course engagement results (continued)

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
INSPRT	N/A	N/A	Same
KCL	More	Same	N/A
KIN	Much more	Much more	N/A
LOTS	Much more	Much more	Same
LOV	Much more	Much more	Low
MENS	N/A	N/A	More
MOT	Much more	Same	Same
MTCH	N/A	N/A	Same
OFF	Less, More	Same	Same
OVR	Same	Less	Same
POS	Much more	Much more	Same
PRTC	More, Much more	Same	Same
SATISF	N/A	N/A	Less
SHR	Same as	Same as	High
SHR2	Much more	Same	Same
SPRT	Much more	More	N/A
STRS	N/A	N/A	Much more
TECH	N/A	N/A	Medium
TIM	Less	More	Less
WEL	Much more	Much more	Same

Mann-Whitney U-test results of students before and during the pandemic express significant differences in student apprehension at the start of the course (APPR 13<31). Statistically significant criteria include students feeling as though they were able to get to know their classmates (KCL 29>6) and instructors (KIN 29>7), improvement of student understanding by the end of the semester (LOTS 29>10), student motivation to learn (MOT 29>12), students having an overall positive course experience (POS 29>14), students feeling supported in their course experience (SPRT 29>14), increasing student appreciation and love for plants (LOV 29>10), students seeking help from instructors (SHR2 29>18), course design to support student diversity (DIVRS 26>16), student feeling of safety during the course (FSAF 29>19), student participation in the course (PRTC 29>21) and how well the students did in terms of average grades (WEL 29>26). The results of modal majority comparisons indicate KCL, MOT, SPRT, SHR2, DIVRS, FSAF, PRTC show a minute reduction in student course satisfaction overall, while course codes KIN, LOTS, LOV, POS and WEL did not change and remained mostly high for both pre- and during- pandemic student groups. Modal majority of both instructor and student responses described student participation and instructor ability to support a diverse student body as the most consistent elements of student engagement.

Course Components:

The characterization of components of plant identification courses during COVID describes virtual classroom, assessments and assignments used by instructors. Question code definitions are shown in Table 1.5. As shown in Table 1.6, codes with the most similar responses between both instructor groups are as follows: 51T+, ASM, HAND, IND, NSYNC, NTA, QUZ, TXP. Codes with the most similar responses between student groups before and during COVID are as follows: 11Q+, 51T+, ASM, CHK, DISC, FLX, PINS, QUZ, SAMLV, SUPVID, TPC, TXTRD.

Table 1.5. Course component code definitions

Code	**Definition**
10Q-	Frequency per semester of quizzes with ten questions or fewer
11Q+	Frequency per semester of quizzes with eleven questions or more
50T-	Frequency per semester of exams with fifty questions or fewer *Continued…*

Table 1.5. Course component code definitions (continued)

51T+	Frequency per semester of exams with fifty-one questions or more
ASM	Course delivery method of assignment submissions (Brown, et al., 2018).
AUD	Audio recordings added to text and presentations (Williams van Rooij and Zirkle, 2016).
CAP	Videos with subtitle captions (Williams van Rooij and Zirkle, 2016).
CHK	Checklists and regular announcements provided to students (Bresnick, 2020).
CLS	Closed-note assessments (Rahayu and Sapriati, 2018).
DISC	Course delivery method of class discussions (Bender and Hill, 2016).
EXAM	Duration in minutes of exams
EXC	Extra credit
EXT	Extensions on assignments and assessments
FLX	Instructor flexibility (Bender and Hill, 2016; Miceli, 2018).
GRP	Group projects (Choi, et al., 2018).
HAND	Hands-on skills
HRDV	Hours of course development (Snyder Elliott, 2007).
HRINST	Hours of instruction (Snyder Elliott, 2007).
IND	Independent projects (Choi, et al., 2018).
LEC	Duration in minutes of lectures
LECL	Lecture length compared to previous semesters
LRN	Students were asked about learning style at start of course (Bender and Hill, 2016).
MOB	Multiple versions of activities to ensure accessibility, in particular mobility concerns due to COVID
MTG	Frequency per semester of lecture sessions
MTINS	Course delivery method of instructor initially meeting students (Bender and Hill, 2016).
NASY	Number of asynchronous components
NIN	Number of in-person components
NINDV	Number of instructors to develop the course
NINST	Number of instructors
NONL	Number of course websites (Brown, et al., 2018).
NSTU	Number of students enrolled
NSYNC	Number of synchronous components
NTA	Number of teaching assistants
OBS	Number of obstacles instructors faced in communicating concepts to students
ONRD	Online readings
OPN	Open-note assessments (Rahayu and Sapriati, 2018).
PART	Course delivery method of participation grade (Arnfalk, et al., 2015; Dieli, 2020).
PCLS	Presenting projects to the class (Dieli, 2020).
PINS	Presenting projects to the instructors (Dieli, 2020).
QUIZ	Duration in minutes of quizzes
QUZ	Course delivery method of quizzes
RESB	Resubmission of assignments and assessments
RESB2	Resubmissions by a particular deadline
SAMCT	Working with cut plant samples
SAMLV	Working with live plants
STYL	Designed assignments for multiple learning styles (Bender and Hill, 2016).
SUPVID	Duration in minutes of supplementary videos
TPC	Course units organized by topic (Ahmad, et al., 2012). *Continued…*

Table 1.5. Course component code definitions (continued)

TXP	Required purchase of textbooks
TXTRD	Required readings in textbooks, digital texts or online
VID	Frequency per semester of asynchronous lecture videos
VID/DEM	Benefit of instructional video demonstrations or demonstrations of activities (Ahmad, et al., 2012).
VID/LEC	Benefit of lecture videos or lectures
WKL	Regularly scheduled weekly activities
WKP	Course units organized by week
WRI	Writing prompt assignments

Table 1.6. Course component results

Code	**Students Pre-COVID (n=5)**	**Students During COVID (n=24)**	**Instructors (n=40)**
10Q-	High	High	1-5 times
11Q+	Low	Low	0 times
50T-	High	Medium	1-5 times
51T+	0 times preferred	0 times preferred	0 times
ASM	Asynchronous	Asynchronous	Asynchronous
AUD	Low	Medium	N/A
CAP	Medium	Low	N/A
CHK	Medium	Medium	High
CLS	Medium	Low	N/A
DISC	In-Person	In-Person	Synchronous
EXAM	N/A	N/A	50-75 minutes
EXC	High	Medium	Medium
EXT	N/A	N/A	High
FLX	High	High	N/A
GRP	Medium	Low	0 times
HAND	High	High	Same
HRDV	N/A	N/A	Much more
HRINST	N/A	N/A	Same
IND	Medium	High	1-5 times
LEC	N/A	N/A	50-75 minutes
LECL	N/A	N/A	Same
LRN	N/A	N/A	Low
MOB	N/A	N/A	Medium
MTG	N/A	N/A	21 times or more
MTINS	In-person	In-person	Synchronous
NASY	N/A	N/A	Much more
NIN	N/A	N/A	Much less
NINDV	N/A	N/A	Same *Continued…*

Table 1.6. Course component results (continued)

NINST	N/A	N/A	Same
NONL	N/A	N/A	Same
NSTU	N/A	N/A	Same
NSYNC	N/A	N/A	Same
NTA	N/A	N/A	Same
OBS	N/A	N/A	More
ONRD	Medium	Low	N/A
OPN	High	Medium	Medium
PART	In-Person	In-Person	Synchronous
PCLS	In-Person	In-Person	Synchronous
PINS	In-Person	In-Person	Asynchronous
QUIZ	N/A	N/A	10-30 minutes
QUZ	In-Person, Asynchronous	Asynchronous	Asynchronous
RESB	High	Medium	Low
RESB2	N/A	N/A	Low
SAMCT	High	Medium	N/A
SAMLV	High	High	N/A
STYL	N/A	N/A	High
SUPVID	Medium	Medium	5 mins, 10-30 mins
TPC	Low	Low	Medium
TXP	N/A	N/A	Medium
TXTRD	Medium	Medium	Medium
VID	N/A	N/A	0 times
VID/DEM	Medium	Medium	N/A
VID/LEC	Low	Medium	N/A
WKL	Medium	High	N/A
WKP	Medium	Medium	Medium
WRI	N/A	N/A	Low

Most courses were held synchronously, with each course session meeting for 50 to 75 minutes about two to three times per week, as indicated by most course meetings occurring 21 or more times per semester. The duration and frequency of lectures did not change compared to courses prior to the pandemic. Exams were typically 50 questions or fewer, given asynchronously and utilizing the same amount of time as one class period. Most instructors administered these exams as open-note assessments between one and five times per semester. Likewise, open-note quizzes consisted of ten or fewer questions were administered asynchronously between one and five times during the semester. Quizzes took between ten and thirty minutes to complete. Most courses accepted asynchronous exam, quiz and assignment submissions, and students both during and before the pandemic preferred asynchronous submissions. Before COVID, 60% of students perceived a benefit from closed-note exams and quizzes, while only 8% perceived benefit during COVID. Individual projects were assigned between one and five times per semester and were perceived as much more beneficial than group projects during COVID. Most courses did not use group projects at all, decreasing the use of collaborative projects during COVID. Between 33% and 67% of students prior to COVID benefited from individual and group projects each. Most courses overall used synchronous lecture attendance to grade participation. Most students overall preferred that in-person participation determine the participation grade. All students preferred to give presentations to the class in person, however due to pandemic safety practices most projects were submitted asynchronously with associated presentations given to the class synchronously. Most courses held discussions synchronously, while most students overall would have preferred holding discussions in-person. During COVID, nearly half (46%) of the students reported lectures or lecture videos were helpful, while only half that percentage reported the same prior to COVID. Between one-third and two-thirds of students during (42%), and before (60%), COVID found video demonstrations or demonstrations of course activities to be helpful. Supplementary videos were reported to range from between five to thirty minutes long. Students mostly preferred the shorter videos. Most courses did not require students to purchase textbooks. Instructors generally incorporated readings of relevant print or online book chapters and other web resources. Students pre-COVID felt that readings were more beneficial than did students during COVID. Most courses did not use long writing assignments. Most students during and before covid (79% and 80%, respectively,) appreciated the flexibility of instructors to adapt course materials. Between one-third and two-thirds of instructors offered extensions, although most courses did not offer extra credit. Most students during COVID and all students before COVID perceived extra credit opportunities to be beneficial. Most courses did not have a particular deadline for resubmitting assignments and did not offer students a chance to resubmit assignments, however 50% of the students during COVID reported that assignment resubmissions were beneficial. In comparison, 80% of students before COVID expressed that assignment resubmissions were beneficial. Students preferred in-person activities utilizing hands-on components. Most courses incorporated the same amount of student demonstration of hands-on skills compared to previous courses, and students found hands-on activities very helpful during COVID as well as beforehand. Prior to COVID, 100% of students perceived benefit from working with live plants and plant samples, and 92% of students perceived the same during COVID. Prior to COVID, 100% of students perceived benefit from working with cut plant samples. During COVID, between one and two-thirds of students (46%) perceived this benefit. Overall most instructors spent many more hours planning and developing their current course curriculum compared to developing past courses and spent the same quantity of hours instructing as they had during pre-COVID courses. Generally, courses had the same number of instructors and teaching assistants developing and delivering the course, and the same number of students enrolled compared to previous semesters. Most courses used the same number of course websites compared to previous courses. Most instructors encountered more obstacles in conveying information to students compared to previous courses. Most instructors introduced themselves to students through synchronous means at the start of the semester, while most students in both groups preferred to meet instructors in-person. Most instructors did not ask students to reflect on prior knowledge or learning style at the start of the course, however most students felt that they arrived with the same level of prerequisite knowledge on the subject as in previous semesters. Most courses catered to multiple learning styles on the one hand, but on the other did not provide multiple versions of activities to ensure that students with limited mobility or the inability to travel could complete assignments. Sixty-five percent of instructors provided checklists and announcements to keep students on track, and 100% of instructors in the subgroup with student respondents provided these reminders of student responsibilities. Sixty-five percent of instructors provided checklists for students to keep track of assignments, and 60% of students before COVID and 58% of students during COVID stated that they consistently relied on these reminders. Regularly scheduled weekly activities were helpful for most students during COVID, and helpful for between one and two-thirds of students before COVID. Between one and two-thirds of instructors organized course website pages by week, and over two-thirds of the instructor subgroup did so, and between one and two-thirds of students overall perceived this as beneficial. Between one and two-thirds of courses organized course information by topic and students before and during COVID reflected that this was not particularly helpful.

Preparation:

Prerequisite student experience, instructor preparation and guidance given to students at the start of the course were expected foundations of student success. Table 1.7 defines course preparation abbreviations. Table 1.8 shows similarities between question codes. Questions with the most similar responses between both instructor groups include FRM2: guiding students in standard formatting, and FTCH: instructor proficiency in technology at the start of the pandemic. Codes with the most similar responses between student groups before and during COVID are as follows FTCH, FUN, PRQ, PRV and UND.

Table 1.7. Course preparation code definitions

Code	Definition
COND	Guidance and proficiency in learning in a conducive study environment
FRM	Guidance and proficiency in formatting assignments
FRM2	Guidance and proficiency in the importance of standardized formatting
FTCH	Instructor technological proficiency on short-notice in response to COVID-19
KIT	Provision of kits, materials, textbooks, technology to students
NAV	Guidance in navigating the course and associated learning management systems (Caffarella and Ratcliff Daffron, 2013; Hsiao, et al., 2018).
PRONL	Previous online student course experience (Hsiao, et al., 2018).
PRQ	Prerequisite student knowledge of subject (de Koning, et al., 2020).
PRV	Previous course experience in the subject (de Koning, et al., 2020).
SAF	Guidance and proficiency in plant and pandemic safety precautions
SYL	Guidance in navigating course syllabus
TRN	Instructor training in digital education (Williams van Rooij and Zirkle, 2016; Hsiao, et al., 2018)
UND	Student understanding of concepts introduced (Yennie, 2020).

Table 1.8. Course preparation results

Code	Student Subset A (Pre-COVID)	Student Subset B (Correlated)	Total Instructor response (n=40)
COND	High	High	Medium
FRM	High	High	Medium
FRM2	N/A	N/A	Low
FTCH	High	High	Medium
KIT	High	High	Medium
NAV	Medium	High	High
PRONL	Low	High	N/A
PRQ	Medium	Medium	N/A
PRV	Medium	High	Same
SAF	Medium	High	Medium
SYL	Low	High	High
TRN	N/A	N/A	More
UND	High	High	N/A

Course preparation was similar among pre- and during-COVID courses. Creating a conducive study space, learning to format assignments, feeling that instructors were technologically equipped to transition to online teaching on short notice, and understanding of course concepts were very similar between the two sets of students. Learners before and during the pandemic were able to access necessary course technology and learning materials. During the pandemic, materials were sent home for student use in the form of kits of class and laboratory supplies. As expected, students during COVID-19 had more experience with online courses, although the quantity of prerequisite courses completed was the same as before. Instructors reported that they received more training to be able to administer online courses, and students during COVID reported a much higher understanding of how to interpret the course syllabus and navigate the course websites and online resources compared to previous experiences. Students felt safer taking the courses during COVID than they had during previous courses, as instructors conscientiously planned for student safety during the pandemic.

IV. Discussion

The most effective teaching methods used for plant identification instruction include course components, social fulfillment and emotional engagement strategies that achieved a level of student performance, the same as or better than “staple” strategies used successfully year-after-year. Effectiveness was measured by student success - most students being inspired by, engaging in, and learning from the course (Bender and Hill, 2016), comprised of criteria including overall grades, student growth from the start to the end of the semester, and student and instructor satisfaction. Several instructors and students provided commentary in addition to direct survey question responses. The consensus among instructors was that the abrupt transition to online instruction in the middle of spring semester 2020 was difficult, with a short timeframe in which to introduce new teaching options before pursuing the chosen method for the remainder of the semester. The most common method of attempting to teach plant identification that first semester involved using videos and two-dimensional images. This strategy took about twice as long to develop and implement compared to previous lesson plans, and many lesson goals were omitted and expectations of students lowered. It was difficult to prioritize memorization and spelling of plant names while providing asynchronous and open-note multiple choice assessments. While all the instructors surveyed would have preferred teaching plant identification in the field as they had in the past, by summer and fall semester, those instructors who had more time to devise lesson plans were able to opt for more creative solutions, often resulting in a self-directed learning approach in which students still could engage with live and cut plant materials. In the case of instructors that thought to send kits of twigs to students, they discovered and provided this learning opportunity early in the pandemic and continued to distribute kits. Instructors who did not find off-screen solutions in an otherwise virtual curriculum continued to struggle through methods that they felt were the best options available, remaining distraught and dissatisfied. The instructors that did opt for off-screen strategies within the virtual curriculum found it suitable and much more satisfying, accomplishing many of the goals that they intended for students in their original pre-COVID courses including allowing students to explore plants as a sensory experience and maintaining student interest in the course material. Additionally, instructors with years of background experience in teaching technology and online instruction felt less overwhelmed and better able to plan courses no matter the course delivery method used, as course delivery methods included asynchronous components as hybrid setups combined with synchronous and in-person elements. Students most appreciated spending time with live plants and experiencing practical creative projects that allowed them to engage in-depth with the course material.

Reflecting upon the collective experience of instructors and students within the current study, I expected that four question categories would sequentially interplay with one another to describe the elements of courses surveyed. I surmised that instructor preparedness combined with course composition would influence student preparedness and engagement, resulting in the level of success of student skill acquisition. Comparison questions of Likert data meant to be beneficial should rank three, four or five, representing a course at the same level or better than previous course experiences or previous student confidence. Comparisons reflecting detrimental information should rank one or two, representing the most negative qualitative information. Additionally, ranks given by students during the pandemic should achieve the same qualitative score or better than ranks given by pre-pandemic students. High satisfaction and high student grades may be used to identify other beneficial course components. Comparing instructors with student respondents, the sample size of 69 total participants was not necessarily statistically representative of the larger population of educators and students of these courses. However, subgroups were compared to each larger group to identify potential significance that may be translated into estimations applicable to the larger population. Percent-highest modes were compared between all instructors and all during-COVID students, the subgroup of instructors directly correlated with all during-COVID student respondents, and the during-COVID students with the pre-COVID student control group. The small sample size yields a larger margin of error, necessitating the use of a 0.10 confidence level (90% confidence) rather than the standard 0.05 (95% confidence) for larger sample sizes of larger populations. Mann-Whitney U-tests using two-tailed significance tests were utilized to perform the analysis (Besser, et. al. 2020). It was notable to discover that the percentage of courses using live plant samples remained nearly identical before (100%) and during (92%) the pandemic. The use of live plant samples indicates that although remote, instructors tasked students with exploring their natural surroundings and identifying plants independently as they learned new information through the course. The students had some confidence in understanding plants in their outdoor contexts, were confident in keying exercises using print and online resources, and mostly identified plants by visual characteristics. Students reflected an even higher confidence in sight-identification compared to pre-COVID learners, who had somewhat higher confidence in identification by texture and scent characteristics of plants. It is apparent that the shift in instructional methods altered self-assessed student strength in identification tactics. While providing self-directed hands-on activities for students to complete, instructors also had the ability to focus on teaching concepts that support plant identification knowledge, including learning more about where plants grow in nature and how plant ecosystems are characterized. The most similar responses found between both student groups described no significant change in the use of online plant identification apps, keys and websites as students stated having very high confidence in this ability (ONL), nor any difference between learning botanical terms and anatomical structures as students stated having intermediate confidence before and after the pandemic began (TER). During COVID, students felt they were able to get to know their classmates to about the same degree as in previous courses, and their instructors much more than in previous courses. This is somewhat surprising as it was expected that students in mostly synchronous online courses with mostly individual activities would not have the opportunity to meet and collaborate with peers. However, course discussions and presentations were used to keep students connected with instructors and with one another. Instructors stated that their courses during COVID had fewer in-person elements, the same quantity of synchronous components, and a more asynchronous components compared to previous course offerings. This information is affected by the timing of response collection, as multiple respondents had offered online synchronous courses in the spring of 2020 and the number of synchronous components was expected to be much lower beforehand. As a result, students came into fall semester courses with more online course knowledge than in previous semesters. The preliminary questionnaires and interviews of students from semesters prior indicate that the number of students with strong online backgrounds had previously been much lower. Before COVID, 40% of students reported captions added to audio recordings were a helpful course component and 20% of students benefited from audio recordings added to text presentations. Preference appears to have switched during the pandemic, with only 13% of students during COVID needing the addition of captions and 42% needing audio recordings. Although the percentages for this particular response are low, that does not discount their benefit for the students who responded that these were helpful elements of course design. Incorporating as many accessibility aspects into course design as possible is considered an important modern pedagogy practice that provides benefit to subgroups of learners with varied learning styles. Asynchronous open-note assignments and assessments with options to resubmit for a better grade reduces stressors that would be present for in-person timed activities, as students can fit the block of time that the task takes more easily into their schedule. Many instructors during COVID reported assisting students with learning how to begin their courses and gather materials, and whether students had prerequisite knowledge or not, the communicative effort put forth by instructors resulted in most students feeling well-equipped to participate at the start of the semester. One hundred percent of the instructor subgroup did build accommodations into their courses, and this is the subset correlated with all during-COVID student responses and is thus reflective of those accommodations. Shared trends before and during COVID include codes KIN, LOTS, LOV, POS, SHR and WEL indicating that students felt they were able to get to know their instructors more than in previous courses, learned more than in previous courses they had taken, developed a high love and appreciation for plants, had a highly positive experience, sought help from instructors when there were factors that affected their ability to succeed in the course, and obtained good grades, doing well in the course overall. These shared items appear to be characteristic of plant identification courses in general rather than specific to the pre- or during COVID student experience. The efforts that instructors made to connect with students during the pandemic reduced their overall level of stress specifically related to the course, even when other factors were affecting the students' lives.

Modal majority data showed specific strong trends within the group of instructors who distributed the survey to their students and within the associated student responses. Most instructors held class, discussions, quizzes and presentations synchronously. Classes were held more than twenty-one times per semester, about two to three times per week. Student participation was dependent upon synchronous attendance. Assignments were submitted asynchronously. The lecture period and asynchronous exams were 50 to 75 minutes long, about the same length as before COVID and tests of fifty questions or fewer were between 50 and 75 minutes long and given one to five times per semester. Quizzes of ten questions or less were between 10 and 30 minutes long and given between one and ten times during the semester. Independent projects were given between one and five times. Instructors had more training in developing online courses than before and spent many more hours developing their synchronous courses, containing more course websites and much more asynchronous elements than previous course experiences that they had created. Although instructors reported much more stress than before and encountered more obstacles in conveying information to students, they were more and much more motivated to teach and to ensure student safety and well-being. Students felt safer compared to previous course experiences as instructors worked to put clear safety precautions in place during COVID-19. Most instructors also built their courses to support student diversity, and most students felt about as supported in diversity as they had in previous course experiences even during the pandemic. Instructors were able to incorporate into student assignments the same amount of fun, or more, to engage student attention and drive student motivation, and students reported having more fun compared to other classes. Although instructors surmised that students would be overwhelmed with stress due to the pandemic, students were generally less stressed than in previous courses. While instructors expected the learner experience to be the same or more positive, students found it much more positive. Similarly, instructors generally felt that students learned the same amount as in previous courses they had taught, while students felt they learned much more compared to previous courses they had taken. Students spent the same amount of seat time hours completing course-related work and utilized office hours the same amount as in previous courses, and instructors reported that student grades were about the same as in previous semesters, while students reported that their grades were much better compared to previous course experiences. The number of enrolled students was generally the same during COVID as in pre-COVID courses. To improve communication, all instructors provided checklists for students, helped students to navigate the course website, took student learning styles into consideration and designed multiple versions of activities to improve accessibility. Instructors were very clear in helping students navigate the course website, course syllabus and proper formatting of assignments. Nearly half of the students relied on the checklists, the organization of the course and course website by week, and regularly scheduled weekly activities. Most students were able to obtain materials and technology needed to succeed in the course and to create a conducive study space without any instructor assistance. Students appreciated the ability to submit extra credit including assignment resubmissions and valued the flexibility of instructors to adapt the course as needed throughout the semester. Students felt that they got to know their instructor more than in previous courses. Students felt confident and somewhat confident in identifying plants using visual characteristics, and somewhat confident in understanding geographic range and provenance of plants and understanding plants outdoors in the context of their environments. Students were also somewhat confident in learning relationships and differences between major groups of plants such as gymnosperms and angiosperms, and monocots and dicots. These students felt that they had complete and thorough understanding of the course material by the end of the course, and were very confident in knowledge of plant biology, somewhat confident in understanding the overall process of plant identification, recognizing natural communities of plants, distinguishing between natural, managed, and unmanaged landscapes, practicing cultivation and care of live plants, and relying on texture as an identification characteristic. Depending on the course type and goals for each course, courses that covered keying skills yielded students with high confidence in these abilities. Students valued being able to work with live plants and to attain hands-on experience during the pandemic. Most students answering for fall 2020 courses had taken online courses the semester before, and most students felt proficient in plant and pandemic safety precautions.

This study documented the rapid technological adaptation of plant identification courses to remote learning during the coronavirus pandemic, providing insights into methods commonly used and most frequently appreciated by instructors and learners alike. Some of the tested criteria were statistically confirmed to be representative of larger test populations of plant identification course students, despite small sample sizes. The study used four categories to categorize aspects of the general plant identification course experience. It was hypothesized that a mixture of instructional course components and high instructor preparedness would improve student preparedness and engagement, and that high student engagement levels would have a positive correlation with high student skill acquisition. Skills covered by instructors and summarized by students supports the hypothesis that most of the skills introduced by instructors produce students confident in those skills. Some exceptions showed both greater confidence in skills instructors may not have specifically intended as major course goals, as well as lesser confidence in some skills that were introduced but were covered more effectively in pre-COVID learning environments. It was also expected that instructor perspectives of student engagement would be in accordance with self-reported student engagement. General trends showed high student engagement with medium student-reported skill acquisition levels rather than the highest possible skill acquisition. In addition, it was proposed that instructor satisfaction with course experience would directly relate to student success in terms of increased understanding, overall course grade, and satisfaction with the course experience. While visible on a small scale, not enough survey data was obtained to verify this trend for the overall population of course instructors of plant identification courses. It was also assumed that the intersection of course delivery strategies preferred by instructors and students would provide the greatest benefits in optimizing the transfer of knowledge. Instructors employed clear communication strategies that kept students engaged and able to confidently participate in the course material despite the surrounding social and emotional factors of the coronavirus pandemic.

Following my analysis of survey results it is apparent that a larger sample size of instructors and students would have strengthened the interpretation of data as a representation of the overall population of plant identification course instructors and learners. Few questions could be analyzed using the Mann-Whitney U-test due to the original setup of question types within the survey, and the pre-COVID student subgroup and student-correlated instructor subgroup sample sizes were too small to represent, with certainty, most potential answers of the larger plant identification course participant population. Questions had been re-worded to best inquire of instructor and student experiences, but this changed the interpretation of questions by respondents and added bias. A uniform question format would allow for better statistical comparisons. Other questions asking specific types of assignments in the field would have led to a greater understanding of hands-on activity implementation and achievement of course goals. There is much yet to be discovered about the transition of hands-on courses to online, remote learning, particularly the information retention of students of hands-on plant identification courses over time. I recommend that future studies follow these strategies to remedy the experimental design and improve data analysis. Results of the surveys best show the methods instructors utilized most during the period of COVID-19 and which methods students preferred in the learning experience. The surveys illustrate the consensus between instructors and students about most effective strategies of online and hybrid learning in hands-on botanical collegiate classes. Table 1.9 shows the optimal use of course components in online and hybrid remote plant identification courses as offered by instructors and preferred by students, contributing to student engagement and skill acquisition.

Table 1.9. Optimal course structure as determined by survey results

Component	**Delivery method**	**Duration**	**Frequency**	**Details**
Class	Synchronous	50-75 minutes	2-3 times weekly	Participation grade
Videos	Asynchronous	5-30 minutes	N/A	N/A
Exams	Asynchronous	50-75 minutes	1-5 times per semester	Open-note, 50 questions or fewer
Quizzes	Asynchronous	10-30 minutes	1-5 times per semester	Open-note, 10 questions or fewer *Continued…*

Table 1.9. Optimal course structure as determined by survey results (continued)

Component	Delivery method	Duration	Frequency	Details
Assignments	Asynchronous submissions, synchronous presentations	N/A	1-5 times per semester	Individual projects, discussion posts, short personalized creative and fun writing assignments
Hands-on	Asynchronous	N/A	N/A	Off-screen self-directed outdoor activities, distribute kits
Readings	Asynchronous	N/A	N/A	Online, textbook purchase not required

Mann-Whitney U-testing has shown statistically that instructors can maintain the level of student confidence in certain skills between in-person and online courses:

- Learning evolutionary relationships of plant groups (monocots and dicots, gymnosperms and angiosperms) - MWU: TAX3 30>16; Distribution of highest confidence pre-COVID: 40% somewhat confident, 40% confident, 20% very confident; Distribution of highest confidence during COVID: 33% somewhat confident, 25% confident, 4% very confident.
- Understanding the overall process of plant identification - MWU: IDO 30>25; Distribution of highest confidence pre-COVID: 40% somewhat confident, 20% confident, 40% very confident; Distribution of highest confidence during COVID: 33% somewhat confident, 21% confident, 21% very confident.

Mann-Whitney U-testing also has shown statistically that instructors can increase the level of student confidence in the acquisition of certain skills between in-person and online courses:

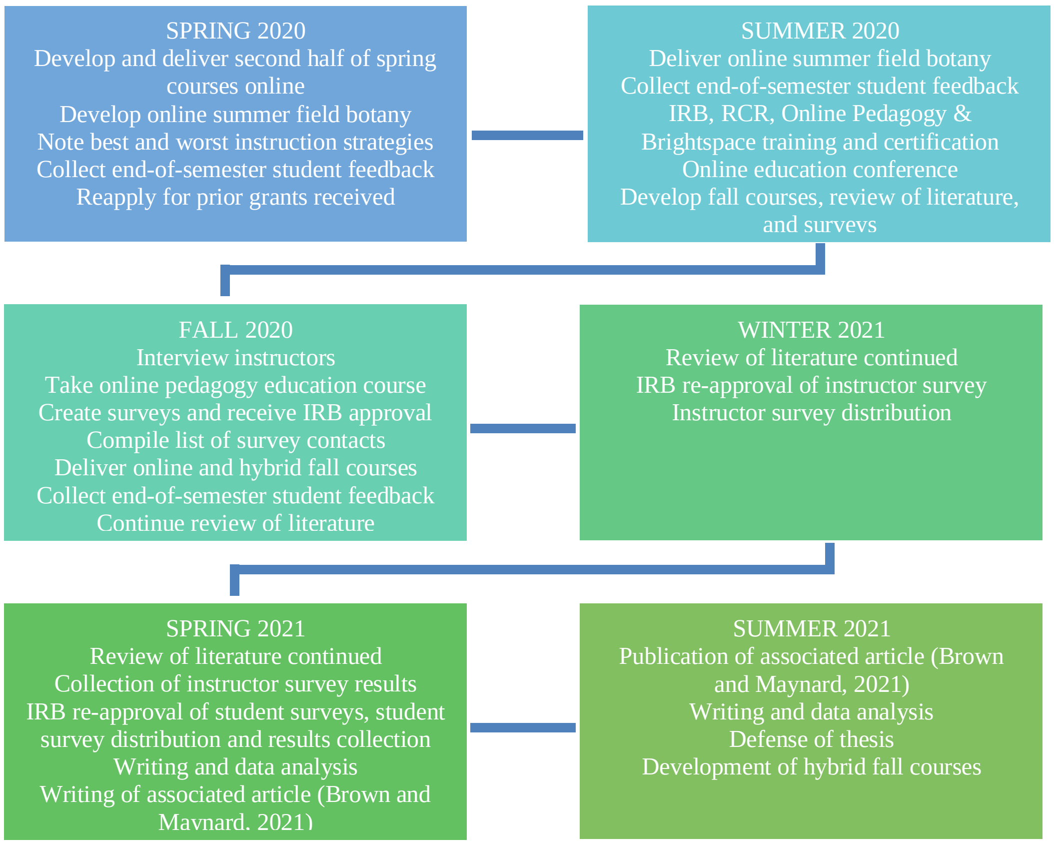
- Identifying plants by visual characteristics - MWU: SENS1 30>12; Distribution of highest confidence pre-COVID: 0% somewhat confident, 60% confident, 40% very confident; Distribution of highest confidence during COVID: 33% somewhat confident, 33% confident, 17% very confident.
- Learning plant biological concepts - MWU: BIO 26>21; Distribution of highest confidence pre-COVID: 40% somewhat confident, 20% confident, 40% very confident; Distribution of highest confidence during COVID: 25% somewhat confident, 25% confident, 13% very confident.
- Designing landscapes and practicing plant selection and siting - MWU: DES 29 = 29; Distribution of highest confidence pre-COVID: 0% somewhat confident, 20% confident, 40% very confident; Distribution of highest confidence during COVID: 21% somewhat confident, 33% confident, 4% very confident.

Following these guidelines for optimal course structure should help to reduce the stressful and excessive quantity of course development hours experienced as instructors were testing new strategies during the pandemic, improving the instructor and student experience from the start of course development. Preparation included instructors receiving training in online teaching, guiding students through navigating the course website and syllabus, providing kits of materials for course activities and designing course activities with student safety in mind. Organizing course material by week on the course website, scheduling activities and due dates to occur regularly, and providing checklists for students to keep track of assignment completion are beneficial strategies. Based on frequency and duration of course components, it can be extrapolated that assignments were used to build knowledge through active, hands-on work with plants, creative design projects, and pertinent readings. Primarily online readings that include lessons in terminology, taxonomic relationships, basic botany, and keying exercises should continue to be offered as these skills are readily acquired in remote plant identification courses. Low-stakes assessments in the form of quizzes and tests were used to reinforce the knowledge being built. Recommendations from previous interview and case study responses include using optional practice quizzes to encourage memorization. Creative assignments using humor maintain student engagement and motivation by developing a love of plants while allowing students to incorporate personal experiences and knowledge into their own course experiences. Holding synchronous class sessions with all other activities being asynchronous is the most effective strategy employed during the pandemic. Further recommendations from instructor interviews and previous experiences suggest that establishing clear expectations for student participation at the start of the course including when to check email, check course websites for messages, and to complete self-scheduled asynchronous assignments and activities as early in the week as possible are all beneficial complements to the main course delivery strategies. In an online course it is important to mandate synchronous attendance for class and to offer synchronous office hours, encouraging asynchronous communication and maintaining regular deadlines to respond to email and course web platform messages. Even if a course is mostly asynchronous, requiring attendance for synchronous office hours on a regular weekly basis helps to guide students and holds learners responsible for that week's goals, translating the structured schedule of in-person classes to an online hybrid format. Instructors achieved the best success when opting not to limit learning plants to two-dimensional screens but by adapting the course experience to include self-directed plant exploration of physical plant materials with virtual communications and exercises to introduce and reinforce the lessons that the instructors intended the students to accomplish. Working hands-on with plants within the structure of a flexible online course that balances synchronous and asynchronous elements is therefore an effective way to learn plant identification, and instructors have profoundly realized that it does not have to occur in a traditional classroom setting to be a fulfilling and successful experience.

V. Appendices

Appendix A: Survey development process

Figure 2.0. Workflow of survey development



Case study: University of Rhode Island Field Botany Student Feedback

Of fifty Field Botany and Taxonomy students, forty-eight provided responses.

- 100% of students expect to use their new skills for work, school, or just for fun.
- 98% are more confident in identifying new plants and also feel they will be able to recognize the plants they learned in the future.

Continued…

- 94% felt great or good about the course overall and remarked that they had an overall positive experience.
- 75% are satisfied with the number of plants learned. 16% of students wanted to learn more plants, for a total of 91% of students who appreciated learning a larger number of plants.
- 73% of students appreciated the clear and straightforward organization of the course website, particularly with the to-do lists explaining exactly what to expect of the course each week. The same percentage of students thought the course was good or great despite the circumstances of having to learn remotely.
- 71% of students really appreciated the prompt, consistent communication with professors and teaching assistants.
- 65% checked the to-do list at the start of the week or as soon as the module became available, writing down what they needed to do and scheduling regular times to do the assignments each week.
- 63% hoped for more in-person guidance.
- 48% thought the online version of the course was harder than it would have been in-person.
- 46% really appreciated having this class as a change of pace from other online courses, as spending time exploring the outdoors was "a breath of fresh air"
- 42% said they would benefit from more video lectures made by the current course instructors to introduce each unit's plant type as well as videos showing how to use keys at the beginning of the course, explaining vocab terms on plant structures, and

Continued…

introducing Rhode Island natural communities. The same percentage of students expressed that they missed face-to-face learning in the field and had been nervous or disappointed at first when they heard the course was going to be online.

- 40% of students made the effort to get everything done as close to the start of the week as possible. Students also benefited from taking extra photos and samples, making sure they were high-quality, and keeping them labeled and organized.
- 33% of students agreed that the course was time intensive. Some students expressed that they spent entire days completing vouchers for the class. The optimal solution is to provide students with guidance on exactly how much time to spend finding plants, creating vouchers, and working on each assignment type.
- 29% each thought the course was about as easy or slightly harder than other four-credit courses, stating that the material itself was easy but very time-consuming.

Challenges which arose during the summer course guided the instructors and TAs in developing a smoother execution of the fall course offering. Details that seemed obvious when presented in-person were found to be lost in translation when students were conducted course activities independently and as such needed to be conveyed to the students in new ways. For instance, although we shared readings with students, such as “Plant blindness is a real thing: why it’s a real problem too” by Angelique Kritzinger, and other resources introducing the concepts of plant identification and collection, our students still suffered initial “plant blindness,” the inability to distinguish the general greenery of lawns and trees and shrubbery around them into the individual species of plants present. Plant blindness initially resulted in extra time spent driving to parks to find plants they could have found in their lawns or neighborhood medians. The first pictures taken by several students unknowingly included enough species in the background to suffice for their next several assignments. We provided resources to train students in plant collection safety, warning them not to touch poison ivy, poison sumac, or stinging nettle; being aware of biting and stinging insects; and using care in using sharp objects to cut plant samples. We did our best to ensure student safety from a distance. We found that summer students had a difficult learning curve with botanical terminology, and we addressed this in the fall with weekly plant terminology quizzes to better familiarize students with the terms used in their field guides. Working on their own, students needed help distinguishing between managed landscapes and wild spaces (only "wild" plants were covered in their guides), landscape plants and plants encroaching upon landscapes. We also found that we had to clarify that the students had to key out plants while in the field and pay attention to characteristics like the undersides of leaves, buds, pith, and leaf and bundle scars. Only one out of fifty students during the entire fall semester considered taking a photograph of the underside of a leaf as an identification characteristic without being prompted. We held students responsible for understanding how plants fit into their ecosystem contexts. For many, this only sank in towards the end of the semester when they undertook their vegetation surveys, which overlapped more than one habitat. In fall, we provided students in COVID quarantine with what we referred to as "contingency samples" with multiple images and written descriptions of plant. We also had students in different regions, including one identifying sidewalk plants in the middle of New York City. We had to provide sample information for students who couldn't find less-common plant types such as clubmosses. The iNaturalist app offers suggestions if prompted and we found that, at first, some students accepted these as accurate identifications without further effort, even if they were incorrect. On average each student confidently learned 50 plants. However, by creating a class "project" in iNaturalist we over 300 different plant species, exceeding the number of plants we covered during pre-COVID semesters. As in previous in-person versions of the course we observed that students spent the first two weeks struggling with keying and then moved forward with ease. Because the new "flipped" focus was on keying skills, not memorization we found that students weren't memorizing plant names, and we did not cover as many plant families. One student said they only recalled scientific names by the end of the semester, a few said they only remembered common names, and several were relieved they didn't have to memorize names but focused on learning details about the plants. To engage and motivate the students, we created fun examples and incorporated puns, jokes, stories, and our own written voices into the language of the course web pages, and the students noticed and enjoyed when we incorporated a sense of humor. Students enjoyed using discussion posts to swap plant-finding adventure stories with genuine excitement. We found that, under the circumstances, the discussion blog was a reasonably good substitute for human interaction, allowing instructor feedback and student conversation to occur without coordinating participants' schedules. Some students preferred being able to go back and re-listen to and re-watch videos and use the captions to learn, and others who said they would have preferred hands-on and outdoor learning were surprised to find that they also benefited from self-directed and self-paced learning. The online format provided greater flexibility in adapting the course to students in different regions and ecosystems. Students learned self-sufficiency and became more confident in the process of identification as a translatable skill. They now know how to find the resources to identify any type of plant anywhere in the world. A discussion of transfer of training - the process of applying learned knowledge in a practical work setting - asserted that only 10 to 15% of knowledge from the learning process is typically transferred to the workplace (Jane Northup citation: https://files.eric.ed.gov/fulltext/ED590264.pdf), however the goal of any course is to maximize information retention. There is "concern about attrition and retention rates in online courses versus face-to-face courses" due to "lack of: student engagement online, sound online pedagogy, faculty preparedness for online teaching, student preparedness for online learning, and institutional technology infrastructure and policy gaps" (Williams van Rooij and Zirkle, 2016). However, field botany and similar hands-on courses teach practical skills and require students to use those skills on a daily basis throughout the semester, taking those skills with them in their future work lives. At the end of the semester, 100% of students said they would strive to continue using the skills they had learned for work, school, or fun in the future and described that they had already begun to excitedly share their new knowledge with anyone who would listen and immediately using their knowledge in work, internships, other courses and at home with family and friends. In Bloom's Taxonomy of educational skills (Bloom, et al. 1956), teaching information to others is a higher-level step in the learning process, indicating that the students are really taking what they learned with them. "Our most significant concern - other than fears about keeping ourselves and our students safe from COVID-19 - was that we would not be able to provide our students with the quintessential field botany course experience" (Brown and Maynard, 2021). We were unable to point out plants and provide guidance in-person to achieve the same clarity in the transfer of knowledge the way it had been conducted for so long. Online instruction was certainly different than the previous teaching methodology, but in the end we felt we were able to achieve the same goals in different ways – by giving our students confidence in identifying plants.

Appendix B: Survey results collection

Table 2.0. Survey respondent university participation

LOCATION	REGION	COLLEGIATE INSTITUTION
AL	East	Auburn University
DE	East	University of Delaware
KY	East	University of Kentucky
MA	East	Stonehill College
NC	East	Campbell University
NC	East	University of North Carolina at Chapel Hill
NY	East	Barnard College
NY	East	Cornell University
PA	East	Penn State University
RI	East	University of Rhode Island
SC	East	Clemson University
SC	East	University of South Carolina Upstate
TN	East	Tennessee State University
TN	East	The University of Tennessee
VA	East	Virginia Tech
VT	East	University of Vermont
IA	Midwest	Iowa State University
KS	Midwest	University of Kansas
MI	Midwest	Michigan State University
MI	Midwest	University of Michigan Biological Station
NE	Midwest	University of Nebraska - Lincoln
OH	Midwest	Central State University, Dept Agricultural Sciences
OH	Midwest	The Ohio State University
OH	Midwest	Walsh University
WI	Midwest	University of WI-Madison
AK	West	University of Alaska – Fairbanks
CA	West	University of California, Riverside
FSM	West	College of Micronesia - Federated States of Micronesia
ID	West	University of Idaho
NV	West	University of Nevada, Reno
OR	West	Oregon State University

Table 2.1. Instructor survey question titles and types

Q1.	Informed consent form
Q2.	Collegiate institution & Course title(s) (short answer)
Q3.	Email address to be contacted for student survey (short answer)
Q4.	Choose all components learned in your course (multiple checkboxes)
Q5.	Describe skills, other important course components, & creative projects (short answer)
Q6.	During introductory period, I guided students in… (Y/N or N/A)
Q7.	Course delivery method (In-person, Synchronous, Asynchronous or N/A)
Q8.	Compare students to those in previous versions of course (Likert: 1. Much less than previous versions 2. Less than 3. Equal to 4. More than 5. Much more than)
Q9.	Describe aspects of social awareness in your course model (Y/N or N/A)
Q10.	Frequency of times activities used in course per semester. (0, 1-5, 6-10, 11-15, 16-20, 21+)
Q11.	Duration in minutes of each course component (5, 10-30, 50-75, 75+, untimed)
Q12.	Compare design to previous versions of course (Likert: 1. Much less than previous versions 2. Less than 3. Equal to 4. More than 5. Much more than)
Q13.	Describe your experience with this course model (Y/N or N/A)
Q14.	Additional comments (short answer)

Table 2.2. Student survey question titles and types

Q1.	Informed consent form
Q2.	Describe your level of confidence with each skill learned in your course. (Likert: N/A, Not learned, Not confident, Somewhat confident, Confident, Very confident)
Q3.	Describe your course experience (Y/N or N/A)
Q4.	Select your preferences for each course component. Preferences refer to the course method that works best for you [In-person, Synchronously online (i.e. live video class)
Q5.	COMPARED to other course experiences I have had: (N/A, Much less than other courses, Less than other courses, About the same as other courses, More than other courses, Much more than other courses)
Q6.	Which course components were the most helpful in your course?
Q7.	Name your favorite project, activity, assignment, or one thing that stood out to you from this course experience!

Results percentage tables

In Tables 2.3 through 2.6, Likert scale responses are given as the percent for the modal majority rank, followed by the rank designation for the given response type. Following a semicolon, the percentage of responses for each rank are given. Comparisons to previous courses or pertaining to level of confidence in student skills refer to ranks 1,2,3,4,5 in order from smallest to largest (Table 1.0). In example, “40% 3; 0, 10, 40, 30, 20%” refers to no responses for the first rank, 10% of responses for the second rank, 40% of responses for the third rank (specified as the highest modal majority of ranks prior to the semicolon,) 30% of responses for the fourth rank, and 20% for the fifth rank. In the case of multiple modal majority ranks, a comma is placed between the ranks following the percentage. For instance, if both rank three has 40% of responses and rank four also has 40%, a comma will separate the ranks in the modal majority: “40% 3, 4.” Question ranks are similarly provided for frequency questions (0x, 1-5x, 6-10x, 11-15x, 16-20x, 21+x) with “x” representing the number of times a particular course element is used, and duration in minutes given for 5, 10-30, 50-75, 75+, and untimed numbers of minutes (Table 1.0). Only three ranks are used for course delivery methods, with “I” representing “in-person,” “S” representing “synchronous,” and “A” representing “asynchronous” course delivery methods (Table 1.0). Yes or no questions are shown with “Y” representing “yes.” “N/A,” or “not applicable,” refers to questions that were not asked in the student survey or instructor survey, and as a result, were not answered (Table 1.0).

Table 2.3. Skill acquisition results percentages

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
BIO	40% 3, 5; 0, 0, 40, 20, 40%	25% 4, 5; 8, 17, 25, 25, 13%	05% Y
CUL	40% 5; 0,20,20,20,40%	25% 1; 25,21,17,17,8%	20% Y
DES	40% 2,5; 0,40,0,20,40%	33% 4- 21,17,21,33,4%	38% Y
DES2	60% 4; 0,40,0,60,0%	33% 2; 13,33,25,17,8%	N/A
DIS	40% 5; 20,20,20,0,40%	29% 3; 21,17,29,13,0%	38% Y
DRA	40% 3; 20,0,40,20,20%	38% 2; 21,38,4,17,8%	30% Y
ECO	40% 3; 0,20,40,20,20%	38% 2; 17,38,13,29,0%	23% Y
GEO	40% 2; 0,40,20,20,20%	38% 3; 8,29,38,21,4%	55% Y
HDIG	40% 1,4; 40,0,0,40,20%	33% 1; 33,13,17,13,13%	25% Y
HIS	60% 3; 0,40,60,0,0%	33% 1; 33,29,13,8,0%	45% Y
HPHY	60% 5; 20,0,0,20,60%	46% 1; 46,0,17,17,4%	20% Y
IDO	40% 3,5; 0,0,40,20,40%	33% 3; 0,25,33,21,21%	N/A
KEY	80% 5; 0,0,0,20,80%	33% 4; 21,8,13,33,21%	50% Y
LAN	40% 3,4; 0,0,40,40,20%	38% 3; 4,8,38,21,29%	35% Y
NAM	40% 4,5; 0,20,0,40,40%	42% 3; 8,21,42,21,8%	90% Y
NAT	40% 2,3; 0,40,40,20,0%	33% 3; 17,29,33,13,4%	38% Y
ONL	40% 4,5; 0,20,0,40,40%	38% 5; 8,4,17,33,38%	68% Y
OUT	100% 5; 0,0,0,0,100%	38% 3; 4,17,38,4,29%	78% Y
POP	60% 3; 0,40,60,0,0%	38% 1; 38,17,8,21,8%	01% Y
SENS1 (VISUAL)	60% 4; 0,0,0,60,40%	33% 4,5; 4,13,33,33,17%	75% Y
SENS2 (TEXTURE)	40% 4,5; 20,0,0,40,40%	38% 3; 25,25,38,4,8%	75% Y
SENS3 (SCENT)	60% 4; 0,20,20,60,0%	50% 2; 25,50,8,4,4%	75% Y
TAX1	40% 4; 20,0,20,40,20%	29% 2; 8,29,21,21,13%	60% Y
TAX2	40% 3,4; 0,20,40,40,0%	42% 2; 4,42,29,17,8%	60% Y
TAX3	40% 3,4; 0,0,40,40,20%	33% 3; 13,25,33,25,4%	60% Y
TCH	40% 4,5; 0,0,20,40,40%	42% 3; 8,13,42,17,21%	N/A
TER	60% 3; 0,0,60,20,20%	29% 3; 0,25,29,25,21%	95% Y

Table 2.4. Engagement results percentages

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
AGN	N/A	N/A	38% Y
APPR	20% 3; 0, 20, 20, 20, 0%	33% 4; 4, 8, 29, 33, 21%	N/A
DIFF	80% 3; 0, 0, 80, 20, 0%	42% 4; 0, 17, 29, 42, 8%	55% 3; 0,20,55,12.5, 2.5%
DIVRS	40% 4,5; 0,0,20,40,40%	46% 3; 8,8,46,4,21%	88% Y
FSAF	60% 5; 0,0,20,20,60%	50% 3; 0,4,50,4,38%	N/A
FUN	40% 3,5; 0,0,40,20,40%	50% 4; 8,8,4,50,25%	55% 3; 2.5,2.5,55,20,0%
FUN2	N/A	N/A	70% Y
INSPRT	N/A	N/A	48% 3; 16,10,48,19,6%
KCL	60% 4; 0,0,0,60,40%	42% 3; 21,4,42,21,8%	N/A
KIN	80% 5; 0,0,0,20,80%	29% 5; 17,4,25,21,29%	N/A
LOTS	80% 5; 0,0,0,20,80%	42% 5; 4,4,29,17,42%	47% 3; 6,29,47,12,6%
LOV	80% 5; 0,0,20,0,80%	38% 5; 8,8,17,25,38%	05% Y
MENS	N/A	N/A	39% 4; 0,6,27,39,27%
MOT	60% 5s; 0,0,0,40,60%	38% 3; 0,13,38,21,25%	60% 3; 0,20,60,14,6%
MTCH	N/A	N/A	47% 3; 3,3,47,28,19%
OFF	40% 2,4; 0,40,20,40,0%	29% 3; 17,25,29,21,4%	44% 3; 19,28,44,9,0%
OVR	60% 3; 40,0,60,0,0%	38% 2; 8,38,33,8,8%	51% 3; 6,29,51,14,0%
POS	80% 5; 0,0,20,0,80%	42% 5; 4,0,33,17,42%	43% 3; 3,17,43,31,6%
PRTC	40% 4,5; 0,0,20,40,40	33% 3; 8,8,33,25,21%	38% 3; 5,36,38,8,13%
SATISF	N/A	N/A	37% 2; 7,37,13,33,10%
SHR	60% 3; 20,0,60,0,20%	29% 3; 17,25,29,17,0%	70% Y
SHR2	60% 5; 0,0,20,20,60%	29% 3; 0,17,29,25,25%	38% 3; 6,35,38,18,3%
SPRT	60% 5; 0,0,0,40,60%	33% 4; 13,4,17,33,29%	N/A
STRS	N/A	N/A	45% 5; 0,3,9,42,45%
TECH	N/A	N/A	50% Y
TIM	60% 2; 0,60,20,20,0%	38% 4; 4,25,21,38,13%	44% 2; 6,44,41,6,3%
WEL	60% 5; 0,0,40,0,60%	38% 5; 0,8,33,17,38%	55% 3; 0,9,55,36,0%

Table 2.5. Components results percentages

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
10Q-	80% Y	67% Y	38% 1-5x; 12,38,24,18,6,3%
11Q+	20% Y	17% Y	36% 0x; 36,27,18,15,3%
50T-	80% Y	38% Y	64% 1-5x; 30,64,6,0,0,0%
51T+	0% Y	0% Y	71% 0x; 71,29,0,0,0,0%
ASM	57% Asynchronous; 43% I, 0% S, 57% A	57% Asynchronous; 23% I, 20% S, 57% A	70% Asynchronous; 9% I, 21% S, 70% A
AUD	20% Y	42% Y	N/A
CAP	40% Y	13% Y	N/A
CHK	60% Y	58% Y	78% Y
CLS	60% Y	8% Y	N/A
DISC	67% In-person; 67% I, 17% S,17% A	61% In-person; 61% I, 23% S, 16% A	44% Synchronous; 30% I, 44% S, 26% A
EXAM	N/A	N/A	61% 50-75 minutes; 0,3,0,61,13,23%
EXC	100% Y	63% Y	40% Y
EXT	N/A	N/A	73% Y
FLX	80% Y	79% Y	N/A
GRP	60% Y	13% Y	74% 0x; 74,26,0,0,0%
HAND	100% Y	71% Y	39% 3; 13,26,39,19,3%
HRDV	N/A	N/A	56% 5; 0,0,9,34,56%
HRINST	N/A	N/A	41% 3; 6,13,41,22,19%
IND	60% Y	71% Y	66% 1-5x; 17,66,9,9,0,0%
LEC	N/A	N/A	56% 50-75 minutes; 3,14,3,56,22,3%
LECL	N/A	N/A	62% 3; 7,28,62,3,0%
LRN	N/A	N/A	25% Y
MOB	N/A	N/A	48% Y
MTG	N/A	N/A	50% 21+ x; 6,3,12,12,18,50%
MTINS	100% In-Person; 100% I, 0% S, 0% A	82% In-Person; 82% I, 11% S, 7% A	47% Synchronous; 31% I, 47% S, 22% A
NASY	N/A	N/A	42% 5; 3,0,19,35,42%
NIN	N/A	N/A	75% 1; 75,17,8,0,0%
NINDV	N/A	N/A	69% 3; 3,6,69,16,6% *Continued…*

Table 2.5. Components results percentages (continued)

Code	Students Pre-COVID (n=5)	Students During COVID (n=24)	Instructors (n=40)
NINST	N/A	N/A	84% 3; 3,0,84,13,0%
NONL	N/A	N/A	60% 3; 0,3,60,30,7%
NSTU	N/A	N/A	54% 3; 3,23,54,11,9%
NSYNC	N/A	N/A	41% 3; 19,19,41,11,11%
NTA	N/A	N/A	54% 3; 5,14,54,14,14%
OBS	N/A	N/A	38% 4; 0,3,19,38,27%
ONRD	40% Y	13% Y	N/A
OPN	80% Y	54% Y	55% Y
PART	83% In-Person; 83% I, 17% S, 0% A	63% In-Person; 63% I, 17% S, 20% A	38% Synchronous; 26% I, 38% S, 36% A
PCLS	57% In-Person; 57% I, 29% S, 14% A	45% In-Person- 45% I, 31% S, 24% A	48% Synchronous- 12% I, 48% S, 40% A
PINS	57% In-Person; 57% I, 29% S, 14% A	48% In-Person; 48% I, 28% S, 24% A	51% Asynchronous; 14% I, 35% S, 51% A
QUIZ	N/A	N/A	67% 10-30 minutes; 3,67,0,18,3,9%
QUZ	50% In-Person, Asynchronous; 50% I, 0% S, 50% A	46% Asynchronous; 36% I, 18% S, 46% A	42% Asynchronous; 29% I, 29% S, 42% A
RESB	80% Y	50% Y	30% Y
RESB2	N/A	N/A	23% Y
SAMCT	100% Y	46% Y	N/A
SAMLV	100% Y	92% Y	N/A
STYL	N/A	N/A	80% Y
SUPVID	40% Y	46% Y	38% 5 minutes, 10-30 minutes; 38,38,0,12,4,8%
TPC	20% Y	29% Y	48% Y
TXP	N/A	N/A	33% Y
TXTRD	40% Y	42% Y	60% Y
VID	N/A	N/A	23% 0x; 23,19,16,13,10,19%
VID/DEM	60% Y	42% Y	N/A
VID/LEC	20% Y	46% Y	N/A
WKL	40% Y	67% Y	N/A
WKP	60% Y	46% Y	60% Y *Continued…*

Table 2.5. Components results percentages (continued)

Code	**Students Pre-COVID (n=5)**	**Students During COVID (n=24)**	**Instructors (n=40)**
WRI	N/A	N/A	15% Y

Table 2.6. Preparation results percentages

Code	**Students Pre-COVID (n=5)**	**Students During COVID (n=24)**	**Instructors (n=40)**
COND	100% Y	83% Y	38% Y
FRM	80% Y	96% Y	43% Y
FRM2	N/A	N/A	23% Y
FTCH	100% Y	92% Y	58% Y
KIT	100% Y	83% Y	50% Y
NAV	60% Y	88% Y	85% Y
PRONL	20% Y	71% Y	N/A
PRQ	60% Y	63% Y	N/A
PRV	60% Y	67% Y	92% 3; 0,6,92,3,0%
SAF	60% Y	92% Y	53% Y
SYL	20% Y	100% Y	78% Y
TRN	N/A	N/A	40% 4; 3,23,23,40,10%
UND	100% Y	100% Y	N/A

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