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Natural Sciences Education

ORIGINAL ARTICLE

Undergraduate Education

Student-focused, career-driven exploration in natural history museums through experiential education and mentorship: A model to intentionally increase the racial and ethnic diversity of students

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Abstract

Being immersed in the processes of research can develop undergraduate students' science identities and support their persistence in pursuing science careers. However, it can be difficult for students to find opportunities for engaging in authentic scientific research. The professional staff and scientific objects in natural history museums provide such an opportunity that can create relationships through which both undergraduate students and museums benefit. Students require authentic practical experiences to better understand their academic fields and career trajectories, and museums require assistance curating and managing collections. This can be accomplished through mentorship, training, and research experience in a formal course. At the University of Florida, I developed and taught a course titled "Introduction to Natural History" that engaged students in projects in museum collections. Discussion sessions replaced lectures by introducing topics such as the concept of research, distinction between predictions and hypotheses, understanding of the nature of science, and how to conduct literature reviews. In 2019 and 2020, students completed a pre- and postcourse survey to gauge their understanding of science and their anticipated career trajectory. My results demonstrate that mentorship and authentic experiential science opportunities using museum collections enable students to realize a passion, sense of purpose, and better understanding of science and careers in science.

Abbreviations: INH, introduction to natural history; NHCs, natural history collections; NHMs, natural history museums; STEM, science, technology, engineering, and mathematics.

1 | INTRODUCTION

Many people are familiar with the public face of natural history museums (NHMs) due to their encounters with public programs and exhibits that include specimens or objects such as the fully assembled *Tyrannosaurus rex* skeleton at the Smithsonian Institution's National Museum of Natural History (Wu, 2018). Fewer are aware of the natural history collections (NHCs) used primarily in research and their potential to be used in education by students and scientists (Humphrey, 1992). NHCs have traditionally been used to show physical characteristics of species in upper level "ology" courses (Hilton et al., 2021; Castro et al., 2022). Given the variety of careers within museums, NHCs can be used as a tool to provide undergraduate students access to research experiences and skill development in preparation for careers in or adjacent to science fields (Connors et al., 2021; Ellwood et al., 2020).

There is potential to broaden the diversity (Table 1) of people working in science, technology, engineering, and mathematics (STEM) by exposing and engaging historically underrepresented and marginalized (Table 1) students to various fields of science and helping them to develop their science identities (Carpi et al., 2017; Chen et al., 2021; Wong, 2015). There is, and has been, inequitable access to and participation in science courses and careers, especially for structurally marginalized (Table 1) students (Women, 2020). All students should have opportunities to gain practical experiences beyond content knowledge to help develop their critical thinking and 21st-Century workplace skills. Women and people of color continue to be underrepresented in STEM careers (Buck et al., 2020; Estrada et al., 2016; Ong et al., 2011, 2018; Wilkins-Yel et al., 2019; Women, 2020) often due to exclusionary norms and practices (Graham et al., 2022; Mosley, Hargons, et al., 2021; Rangel et al., 2021). Additionally, the social justice awareness of the Black Lives Matter movement and emergence of "Black in X" (i.e., Black in Marine Science, Black in Natural History Museums) groups (Langin, 2020), in part due to racist confrontations such as that which Christian Cooper experienced while birding in New York City, illustrates a need for intentional inclusion of people most marginalized in STEM. Experiential learning with intentional mentorship is a component that can be used to combat gatekeeping (Gaslewski et al., 2012) and feelings of lack of belonging in STEM (Arnold et al., 2020; Brockman, 2021; Derricks & Skaquaptewa, 2021; Rangel et al., 2021; Rockinson-Szapkiw et al., 2021; Wilkins-Yel et al., 2022 as well as encourage engagement in science (Rodenbusch et al., 2016).

I developed a model of undergraduate involvement in NHC-based projects (Figure 1) through which the next generation of scientists can be trained and prepared for a diversity of science careers (Burdick, 2012). This type of authentic science training has the potential to increase students' motivation and interest in science (Hunter et al., 2007; Smith et al., 2021) and to develop their science identities (Mraz-Craig et al., 2018). This in turn can lead to increased retention of undergraduate students in science (Brabec et al., 2018; Chen et al., 2021; Kier et al., 2014; Nagda et al., 1998). This is particularly true for students from marginalized groups (Table 1) because it addresses the significant hurdle of connecting to and finding mentors in science (Ginther et al., 2011; Graham et al., 2022; Farmer, 2003; Hurd & Sellers, 2013; Morzinski & Fisher, 2002; Rasheem et al., 2018; Ely & Thomas, 2001). Moreover, the use of NHCs in formal education can provide students with necessary experience to ensure that they maintain and grow their scientific interests (Rodenbusch et al., 2016; Smith et al., 2021).

Core Ideas

- Independent, hands-on research experiences in natural history collections inspired future careers in science.
- Students developed scientific skillsets and gained "real" science experience while networking with scientists.
- Mentorship motivated students and allowed development of their science identities.

1.1 | Understanding NHCs

Taken as a whole, the world's NHCs contain more than a billion specimens that have been collected over the past 200 years and that provide a resource for scientists to understand the past and present biodiversity and cultures (Drew, 2011; Funk, 2018; Meineke et al., 2019; Nelson & Ellis, 2019; Powers et al., 2014). NHCs are like libraries whose books are carefully cataloged unique specimens and objects that can be used to create a wealth of knowledge. Data from these specimens are a vital resource for understanding our world and for making connections to the past and the future. Variation in traits of specimens collected over time can illustrate the impact of changing climates, and we can also assess changing distributions of native and invasive species and their pathogens (Daru et al., 2018; Ellsworth, 2016; Greeney et al., 2018; Leonhardt et al., 2019; Mothes et al., 2019; Pietras & Kolanowska, 2019). Changes in animal and plant populations can be mapped in relation to human activities to understand our impact and develop strategies for conservation (Sikes et al., 2017). Recent efforts using new genomics and imaging technologies allow even further uses of collections (Butcher et al., 2021; Hedrick et al., 2020). The value of NHCs for training early career scholars has been previously recognized through the U.S. National Science Foundation's (NSF) funding awards for Interdisciplinary Research using Biological Collections via the Postdoctoral Research Fellowship in Biology program (Miller et al., 2020). This program helped to create mentors steeped in NHCs that can later train undergraduate students.

NHCs offer rich opportunities for science learning and can be used to introduce undergraduate students to research (Bakker et al., 2020; Cook et al., 2014; Hiller et al., 2017; McLean et al., 2016). The physical resources and digital data associated with NHCs can be used by students in activities that build their competence to tackle global problems (Cook et al., 2014). Experiential, inquiry-based learning is a distinct advantage of having access to NHCs. For example, instead of learning animal or plant identification or anatomy solely via a lecture or textbook, students can physically interact with specimens and digital or printed 3D models for a more hands-on experience (Alzen et al., 2018; Hilton et al., 2021). Students also gain key 21st-Century skills (Trilling & Fadel, 2009), such as oral and written communications, critical thinking and problem solving, professionalism and work ethic, teamwork and collaboration, working in diverse teams, applying technology, and leadership and project management.

1.2 | Rationale for the introduction to natural history course model

An introduction to natural history (INH) course can be designed to engage students in inquiry-based museum projects that helps them to understand how scientific knowledge is generated. These experiences have the power to transform students' perceptions of how the world works and how we are inextricably linked to the natural world, while also accentuating the important role that museums play in our understanding our world (National Academics of Sciences, Engineering and Medicine, 2021). Though "cookbook" labs have merit by providing students with some experience following a predetermined method (Spell et al., 2014), these often do not allow students to develop skills such as hypothesis generation, experimental design, data collection, data analysis, scientific communication, problem solving, or tolerance. These skills are needed to fuel students' interest in science during this critical point in their academic careers (Brabec et al., 2018).

The model of the INH course can be applied across multiple spaces including departmental green houses, university farms, extension programs, libraries and archives, government research facilities, and other places where staff members and graduate students can build mutualistic relationships with undergraduate students (Ernst et al., 2014; Kobulnicky et al., 2016; Mullen, 2020; Skjevik et al., 2020; Van Vliet et al., 2013). Connecting students to mentors and potential role models also supports engaging students from marginalized backgrounds (Table 1) in science (Farmer, 2003; Hurd & Sellers, 2013; Rasheem et al., 2018; Zappo, 1998). In addition to semester-long opportunities, this model has been applied to short-term opportunities (e.g., conferences or internships) that encourage students to explore STEM fields at different stages in their careers (Corwin et al., 2015; Harrison et al., 2011; Mraz-Craig et al., 2018; Phillips, 2020, 2021; Sorensen et al., 2018) and longer projects such as summer internship programs (e.g., Phillips, 2021). This paper outlines the model of an undergraduate INH course that uses authentic experiential opportunities in NHCs coupled with mentorship to help develop students' science identities. Through pre- and postcourse surveys, I explore how students' understanding of science and careers in science changed because of their experiences in this INH course. I also explore the potential of this course model to intentionally increase the racial and ethnic diversity of students engaged in and retained in science. In this work, I aim to answer two questions: What experiences should be provided to students to facilitate learning using NHCs? How can students represent what is known already in their scientific fields to give personal meaning to these experiences?

2 | MATERIALS AND METHODS

2.1 | Overview of experience

I developed the course primarily for undergraduate students at all levels in their academic program. This course was taught at the University of Florida (UF) in the spring semester of 2018 (20 undergraduate students), 2019 (33 undergraduate students), and 2020 (12 undergraduate students and three undergraduate mentors who previously took the course). I was particularly interested in engaging students in their first or second year of college. In the third iteration of the course, a graduate student from the Museum Studies program also enrolled in the course. The course was offered via the Department of Biology (BSC 2930, ZOO 4926 and BOT 4935) and Anthropology (ANT 3930). The different course designations were designed intentionally to include (1) seniors and juniors (ZOO 4926, BOT 4935) wanting to explore opportunities for potential future careers, (2) freshman and sophomores (BSC 2930) who were early in their academic journey with more time to develop their career goals using the experiences in the course, and (3) students from both science and nonscience backgrounds (ANT 3930). As a result of the wide diversity of careers within and adjacent to museum, offering and making the course accessible to a variety of students provided an opportunity for students to build skillsets to inform and

TABLE 1 Definitions of terms used within the article that often confer different meanings based on usage.

Term	Definition	Resources
Diversity	Diversity is a term that refers to the variety of different perspectives represented on a team. While diversity is related to race and social justice issues, they are facets of a larger conversation. The term represents a broad range of experiences, including gender, sex, socioeconomic background, upbringing, religion, education, sexual orientation, ethnicity, neurodiversity, and life experience.	Cooks-Campbell (2021)
Experiential learning	Learning by doing. Experiential learning exists when a personally responsible participant cognitively, affectively, and behaviorally processes knowledge, skills, and/or attitudes in a learning situation characterized by a high level of active involvement.	Dewey and Dewey (1915); Hoover and Whitehead (1975)
Marginalized	Groups that are and have been confined to a lower status in society due to the unfair structures created by society. Such a group is denied involvement in mainstream economic, political, cultural, and social activities, resulting in inequitable outcomes. Use “structurally marginalized” communities and/or populations to be very clear that this a result of unfair and unjust systems. Instead of using terms like “disadvantaged,” “underprivileged,” and/or “vulnerable” to describe communities that have been structurally marginalized, consider using “disinvested” and/or “underresourced.”	Drake and Rose (2018); Evans-Winters (2019); BUMC (2021)
Historically underrepresented	This term refers to groups that have been denied access and/or suffered past institutional discrimination in the United States and, according to the Census and other federal measuring tools, includes African Americans, Asian Americans, Hispanics or Chicanos/Latinos, and Native Americans. This is revealed by an imbalance in the representation of different groups in common pursuits such as education, jobs, and housing, resulting in marginalization for some groups and individuals and not for others, relative to the number of individuals who are members of the population involved. Other groups in the United States have been marginalized and are currently underrepresented. These groups may include but are not limited to other ethnicities, adult learners, veterans, people with disabilities, lesbian, gay, bisexual, and transgender individuals, different religious groups, and different economic backgrounds.	Drake and Rose (2018); Office of Equity, Vitality & Inclusion Boston University School of Medicine, Boston Medical Center & Boston University Medical Group (2021)

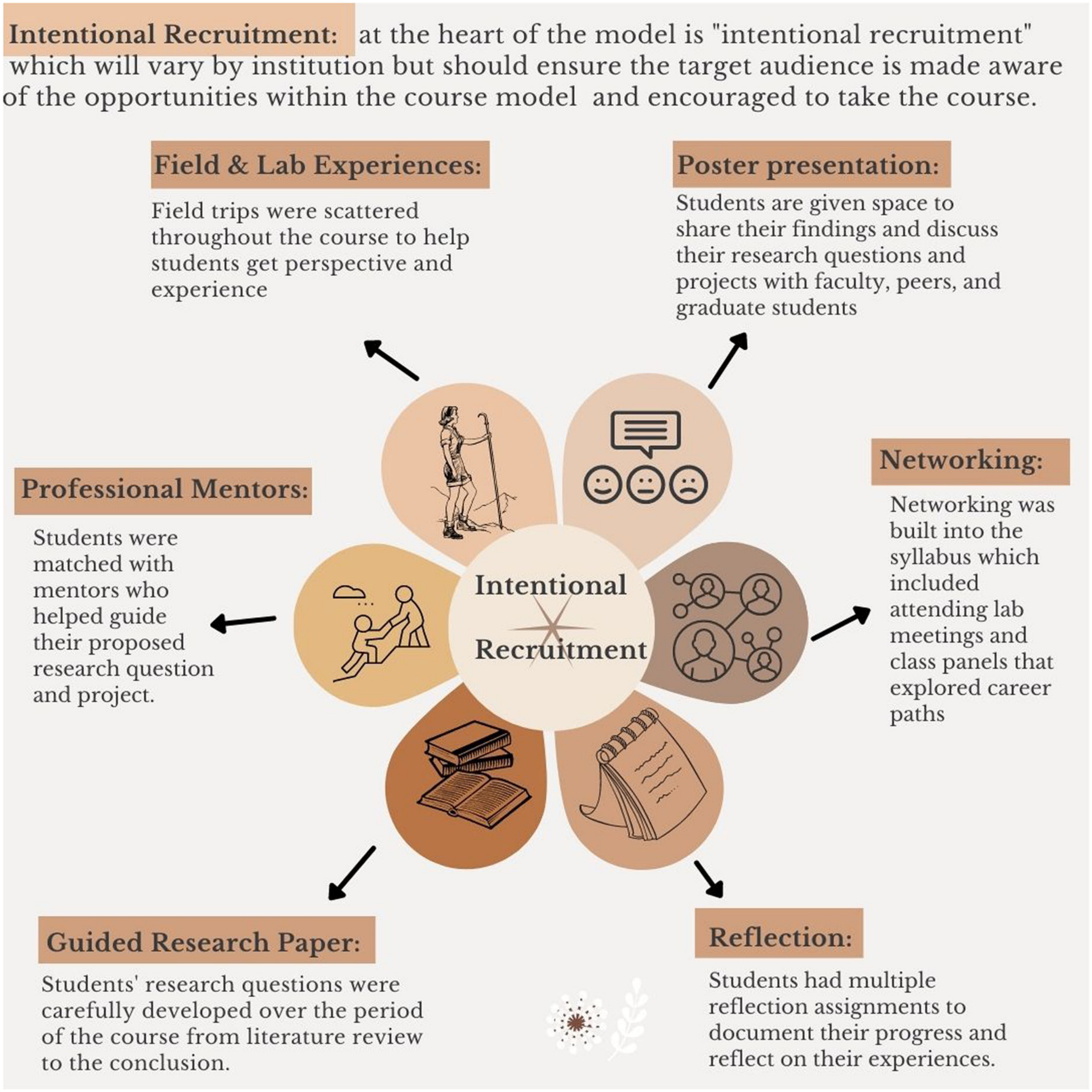

FIGURE 1 Introduction to Natural History course model components. Figure credit: Alnycea Blackwell, CC BY-NC Adania Flemming and Alnycea Blackwell.

assist with career planning (Clawson, 1985; Harris & Lee, 2019).

Students enrolled in the course belonged to four different colleges and were pursuing 13 different degrees including science and nonscience. As such, it was important to ensure students understood the nature of science as they engaged in their research projects. The concept of "doing science" was discussed with students by exploring the nature of science. Some relevant aspects discussed include "science is a way of knowing and there are values and beliefs inherent to the development of scientific knowledge" (Lederman et al., 1998), "science is a human endeavor and people of all ages, socioeconomic levels, races, sexes and nationalities engage in the enterprise" (Weinburgh, 2003), and "the development of scientific knowledge involves human creativity and human subjectivity" (Crowther et al., 2005). To that extent, students understood that there are many methods of "doing science", not just one "Scientific Method" (Crowther et al., 2005), and that our current best explanation of the natural world falls within the limitations of our observations. Similar to Pringle's (2020) emphasis of moving K-12 students away from rote memorization, emphasis was placed on students examining phenomena, generating evidence-based claims and providing explanations. Therefore, as students engaged in their research projects within the NHCs, we discussed, for example, how a process as simple as sorting and identifying specimens was one step in potentially describing a new species or understanding the distribution of a species. Students were asked to make observations while curating specimens which informed their reading of scientific peer-reviewed literature. This then informed their research projects and the hypotheses that they developed and tested during the course. This was all woven into the course paper and presented at the end of the course in a scientific poster.

All of the collections-based experiences occurred in the Florida Museum of Natural History at UF. The potential mentors, which consisted of graduate students, museum faculty, and staff (e.g., collection managers or collection technicians), were required to attend a mentoring session prior to the course to develop skills and best practices for successful mentoring (McMorris et al., 2018; Raposa et al., 2017, 2021). This session outlined the aim of the course and the role of the mentors, including the difference between a typical volunteer and the INH students. It emphasized the need for mentors to facilitate students' learning experience in line with what is needed from STEM mentors: psychosocial support (e.g., listening, offering advice, asking questions) and helping their mentees develop a sense of belonging and content knowledge in STEM (Graham et al., 2022; Rangel et al., 2021).

The course structure was divided into three main modules: pre-research experience, during research experience, and postresearch experience. This fit into the framework of a weekly 3-h lab and 1-h class discussion (Supporting Information 2). During the pre-research experience, students were introduced to NHCs as "libraries of life" and potential mentors via a presentation from the museum director and tours of several museum collections. During the research experience, students were paired with a mentor (graduate student or collections staff) with whom they worked for the 7 weeks of the research project. Mentors were required to submit potential projects and once paired, mentors and mentees either adjusted these projects, created new projects, or worked on the originally proposed projects. Regardless of the option chosen, students were required to develop their own research question. Their mentors directed students as they generated a research question from the literature review while engaging in their research project in the collections (Table 2). Because some research questions developed required more time than the course allowed, some students produced a proposal in lieu of a completed research project. However, they were able to obtain comparable experience to their peers who brought their research projects to completion by working within NHCs. Situated learning theory posits that knowledge is acquired "in situ" and a student's learning is constructed by their social (or cultural) habits and circles (Donaldson et al., 2020; Lave & Wenger, 1991). Thus, in addition to experiential learning opportunities in the class students also had both optional (e.g., paleontological excavations or an ichthyological collecting trip) and required (e.g., a class BioBlitz) experiences that allowed them to situate their learning experiences. During the postresearch experience, having completed their research projects, students presented their work to their peers and academic department that was scheduled during the last 3-h lab session.

2.1.1 | Pre-research experience

During the first 4–5 weeks of the course, students were introduced to NHCs via class discussions and tours of the collections. In the first week of the course, students completed a presurvey (Table 3) followed by a guest lecture from the museum director. For the discussion with the director, students were assigned to read the museum annual report and strategic plan to gain a "birds' eye" perspective of the museum. This activity also situated students within the museum by allowing them to have access to the structure and policies guiding the museum (Figure 2). Students then had a longer discussion during a 3-h lab period in which I provided a deeper introduction to the museum and discussed how the course required students to be involved in their learning process. For this class discussion, students were assigned readings and peer-reviewed literature about the importance of NHCs specimens and the science that they enable.

During the lab period (3-h lab) in the second week of class, students toured three to four collections (Table 4), spending 30 min in each collection. At the end of the tours, a 20-min "speed-networking" session allowed students to meet and engage in dialogue with potential mentors and ask additional questions about the collections and potential projects. Students were encouraged to research potential mentors and to set up additional meetings before choosing a mentor. The class discussions during this second week focused on preparing students for their research projects, with topics such as "what is research," "hypothesis vs predictions," "citation, citation management, and literature review," "broader impacts in science," and "understanding the importance of applied versus basic science."

2.1.2 | Research experience

Before the research experience, students noted their preference for mentors (via a survey in which they ranked and provided rationales for the preferences) and were then paired with a mentor who guided students as they completed a research project. After each 3-h lab period, students submitted a journal entry about their experience and progress (Table 5). At the end of the second lab period, students determined their research project topic. At the end of the third period, they completed an annotated bibliography using peer-reviewed literature on their selected topic. At that time, they were required to schedule a meeting with their respective teaching assistants (TAs) to discuss their topic and develop hypotheses to

TABLE 2 Examples of projects students completed in the class.

Student no.	Project title	Skills gains	Collection/lab	INH course year
1	The implications of digitization and CT scans on museum curation and educational outreach	CT scanning, 3D-imaging, sectioning, and segmenting 3D-data to study morphological traits, using the statistical software R to analyze the shape of parietal bones	Herpetology/Digital Imaging Lab	2019
5	Understanding diversity of species in Ecuador and testing the species hypothesis theory using four specimens from Ecuador, and two from Brazil	Butterfly curation and dissection, scientific illustrations using camera lucida, examination of reproductive anatomy, DNA data sequencing, and calculating maximum likelihood trees for sequences of data	Lepidoptera	2019
8	Use morphological observations of museum specimens to create a key for quick and accurate identification of crocodilian skulls down to the level of genus or species	Morphometric analysis, creating a dichotomous key using established standard measurements	Herpetology	2019
10	The use of human fingernails as tools to create impressions in Carrabelle Punctate Pottery	Sorting and cleaning pottery shards, identifying and distinguish shard impressions, using a digital microscope	Florida Archaeology	2019
11	Reimaging museum collections: a workflow for two-dimension specimen imaging of Centrarchidae	Imaging software experience (Adobe Photoshop and Illustrator), 2D specimen imaging, photo-editing in Adobe Lightroom	Ichthyology/Digital Imaging lab	2019
15	To what extent did the colonization of humans on the Eleuthera island approximately 4830 years ago impact the native snail species?	Sorting and identifying snails using a microscope, learning Microsoft software, comparing snail shell morphology from varying timelines (colonization periods), imaging snails	Invertebrate Zoology	2019
24	Comparing microfossils at the Montbrook fossil site	Sorting microfossils, picking microfossils (using a microscope to pick very small fossils out of a matrix), first time using a microscope	Vertebrate Paleontology	2020
25	Geographic distribution and ploidy in *Rhexia*	Using flow cytometry, identifying ploidy level, botanic field work and plant identification, analyzing flow cytometry results using FCS Express	Botany/Molecular Systematics	2020
26	Does reproductive anatomy support a single species of *Tropidophora tricarinata* in eastern rainforests as claimed by Fischer-Piette et al. (1994), or multiple species as they were originally described?	Scientific illustration using camera lucida, identifying reproductive structures of snails, measuring shells, analyzing geographic data, analyzing genetic data, building competence using Adobe Photoshop and Illustrator for processing images	Invertebrate Zoology	2020
27	Susceptibility of captive waterfowl to *Aspergillosis*	Bird curation and taxidermy (skeleton, tissue sample and a spread wing), identifying and analyzing fungal infections in birds, analyzing and graphing data	Ornithology	2020
30	Cause-specific mortality of Florida panthers	Mammal curation, databasing using specify, literature searches for species with different names, identifying morphological indications of animal death (skull damage), organizing data, specimen identification including sex of panthers from skulls	Mammalogy	2020

Abbreviation: INH, Introduction to Natural History.

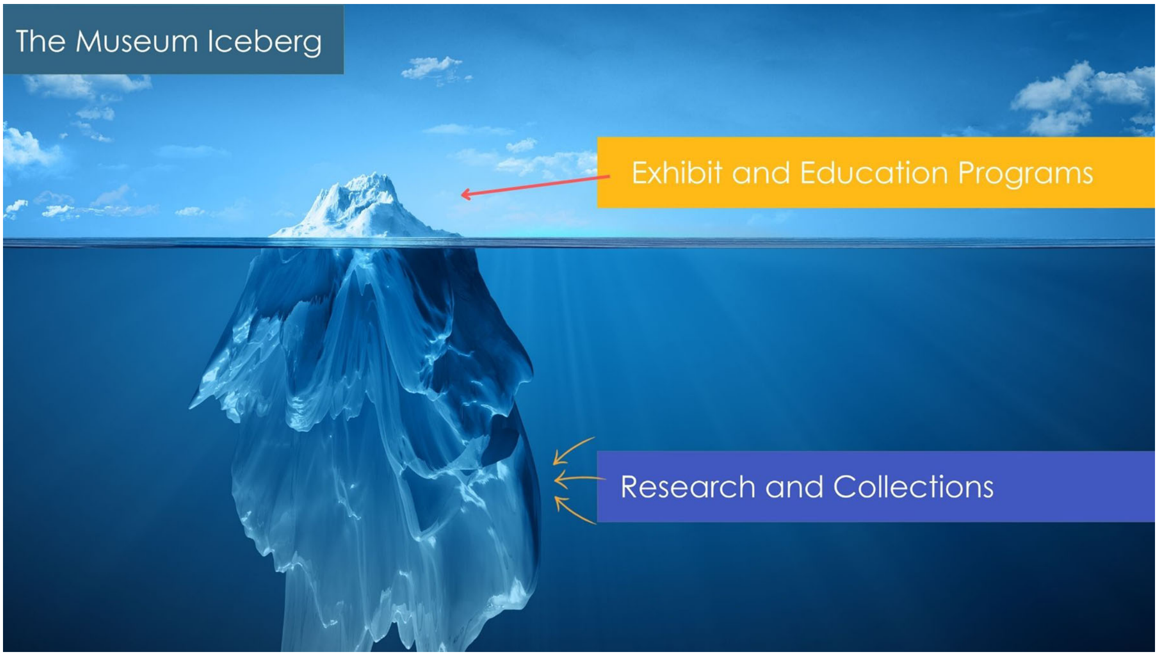

FIGURE 2 Image used as an analogy to indicate the research collections, though often hidden from the public eye, are significant. For the course model outlined, it provides students with opportunities for career development. Figure credit: Alnycea Blackwell, CC Adimas/Adobe Stock.

be explored in their research projects. At the end of the fourth lab period, they submitted a proposal of their research project. During the next lab period, students participated in a BioBlitz on campus, which is the exploration and documentation of biodiversity in an area over a short period of time (Baker et al., 2014; Lundmark, 2003; Rokop et al., 2022). This event was designed for students to engage and network with scientists and participate in a similar process to the one that brought specimens and objects into the collections. At the end of the fifth lab period, students submitted and engaged in a peer-review of both a project outline and an introduction. A paper draft was due at the end of their sixth week in the collection, and students were assigned paper drafts to peer-review. They then had a seventh lab period during which they completed their research projects.

During class discussion, they continued to develop skills and experience relevant to their projects and careers in science. These included discussions on "use of collections in digitization," "introduction to systematics," "science communication," and "how to write an abstract." These also included a panel discussion with graduate students and other museum professionals, and a class session where they received feedback on drafts of their posters. Before each assignment was due, students received feedback (from the TAs, the professor and on occasion, their peers) on their previously submitted assignment. Meetings were scheduled as needed to follow up with students who needed additional assistance. Each assignment had a pedagogical justification (Table 5) which were based on a combination of constructivism and situated learning theory. The aim was to provide authentic learning through experiential opportunities. Students were involved in academic and career-relevant settings where they could showcase their learned concepts and experiences (from organizing data through a citation manager, to critiquing and receiving feedback, and finally presenting their work; Donaldson et al., 2020).

2.1.3 | Postresearch experience

During the postresearch experience, students presented their work to their peers and academic department (i.e., biology and anthropology) via a poster presentation in the last lab period. The peer-reviewed draft of their course paper was due at that time. The final paper was due as an end-of-term exam and students used peer feedback to revise their paper. Before the final class discussion, students submitted a reflection of the course. Students were asked to include their views of the value of a university-based museum, the course, and any suggestions to improve the course for future iterations. In the final class discussion, students provided feedback for the class after they completed their post survey (Table 3).

2.2 | Addressing the research questions

I used the pre- and postsurveys to determine what experiences helped students to learn using NHCs ("What experiences should be provided to students to facilitate learning using NHCs?") and how their prior knowledge gave meaning to these experiences ("How can students represent what is known already in their scientific fields to give personal

TABLE 3 Pre- and postsurvey questions given to students prior to and after taking the Introduction to Natural History class.

Presurvey questions	Postsurvey questions	Purpose
What is your concept of science?	What is your concept of science?	To compare their understanding of science and the nature of science after taking the course
What is your concept of museum scientist?	What is your concept of museum scientist?	To provide a baseline understanding for their differentiation of a museum scientist and careers in museums before and after taking the course
What contributed to your concepts of both of these?	What contributed to your concepts of both of these?	To tap into what students, consider their prior knowledge, before and after taking the course.
What are your learning goals for the course?	What learning goals did you achieve while taking the course?	To understand students' interest for taking the course, and the extent to which their learning goals were achieved during the course
What are your learning goals for the course, post discussion (after collaboration- that is after discussing the course outline in class)?	Did you accomplish any learning goals that were not part of your initial goals?	To understand the level at which they understood the course while questioning if their learning goals changed after the instructor discussed the class outline, and if there were any unintended learning goals achieved after taking the course
What is your current career trajectory?	What is your current career trajectory?	To get a baseline for their career trajectory at the beginning and end of the course

meaning to these experiences?") (Table 3; Supporting Information 1). Learning for this course was centered on students' understanding of science and their ability to do science, taking into consideration the nature of science. To address the first question, students were asked about the changes in their concepts of science and museum scientists. To address the second question, they were asked what contributed to their understanding. The differences in their responses to these questions before and after taking the course were qualitatively analyzed to assess whether the course components and experiences influenced these concepts. Using thematic analysis for their outlined learning goals before and after they took the course allowed me to understand which experiences were essential to students if there was influence. Changes in career trajectory after taking this course for a semester also allowed me to gain insight on the impact of the experiential nature of the course, described in more detail below.

Instructors administered both a pre- and postcourse survey to evaluate how students' understanding of science and career aspirations evolved over the period of a semester in the INH course. Students were given at minimum of 30 min to provide substantive responses to the questions. Each student was assigned a number to deidentify their responses to the questions and remove biases while coding the data. Participant data were first organized in a spreadsheet using a phronetic iterative approach (Tracy, 2019). During this step, participants' pre- and postcourse surveys were coded and thematized. To code the surveys, I documented snippets of their responses to the questions in Table 3 related to the research questions. These snippets became codes and during focused and repeated review of their responses, I discerned emerging patterns and themes across the 32 students. Some of the emerging themes were networking (i.e., making connections), experience (i.e., more and better experience with scientific techniques), and careers (i.e., discovering and learning more about careers). Data were further analyzed in NVIVO (QSR International Pty Ltd., 2018, NVivo, Version 12). During this time, the data were organized into cases, which allowed the analysis to look across and within participants to find patterns in the data.

The University of Florida Institutional Review Board (IRB) approved student assessments for the second and third iteration of the course (UF IRB no 201900803); no surveys were conducted in the first year (2018).

3 | RESULTS

3.1 | IRB participants

There were 32 students who were IRB participants in the INH course. Their demographic information is provided in Figure 3.

TABLE 4 Example of a typical lab tour schedule.

Date: January 16th collection tours		
Time	**Group 1**	**Group 2**
2:00–2:30 p.m.	Molecular Systematics Lab	Mammalogy Collection
	Transition	
2:40–3:10 p.m.	Mammalogy Collection	Molecular Systematics Lab
	Transition	
3:20–3:50 p.m.	Invertebrate Zoology Collection	Invertebrate Paleontology Collection
	Transition	
4:00–4:30 p.m.	Invertebrate Paleontology Collection	Invertebrate Zoology Collection
	Transition to seminar room	
4:35–4:55 p.m.	Debrief with mentors, speed networking session	

TABLE 5 Class assignments for the Introduction to Natural History (INH) course. The timeline of assignments reflects the "process paper" students complete based on their research projects.

Assignment	Date due	Pedagogical justification
Post question about the syllabus	Thurs., Jan. 9	Student accountability
Collection reflection	Wed., Jan. 22	Student reflections
Collection reflection	Wed., Jan. 29	Student reflections
Citation manager download	Wed., Jan. 30	Skillset building
Collection reflection	Wed., Feb. 5	Student reflections
Collection of choice due	Fri., Feb. 7	Student agency in choosing a project
Class readings	Multiple	Skills development, reviewing primary literature
Journal entry	Multiple	Student reflections
Collection reflection	Wed., Feb. 12	Student reflections
Potential paper topic	Thurs., Feb. 20	Process paper, part 1
Paper annotated bibliography	Thurs., Feb. 27	Process paper, part 2
Paper proposal due	Thurs., Mar. 12	Process paper, part 3
Paper introduction and outline	Thurs., Mar. 19	Process paper part 4
Field experience reflection	Tues., Mar. 24	Student reflections
One question from video	Thurs., Mar. 26	Prepare for panel sessions
Paper Abstract due	Thurs., Mar. 26	Process paper, part 5
Peer review of outline and intro	Thurs., Mar. 26	Process paper, part 6; experience critiquing and providing feedback
Paper draft due	Thurs., April 2	Process paper, part 7
Poster draft due (in class)	Thurs., April 9	Process paper, part 8; translating paper onto a poster to communicate their findings.
Peer review of draft due	Thurs., April 16	Process paper, part 9; peer review
Lab meeting or interview Reflection	Thurs., April 16	Skills development and networking
Final posters due	Thurs., April 17/23	Oral presentation
Final paper due	Wed., April 23	Process paper, part 10
Evaluation assignment	Thurs., April 30	Student reflections

3.2 | Course iterations

There were three iterations of the course that varied in design based on students' feedback and evaluations of previous offerings. The first iteration was informed by student feedback during an introductory biology course (informal class discussions) because tours of the NHCs were part of their typical lab experiences. In class discussions, these students noted

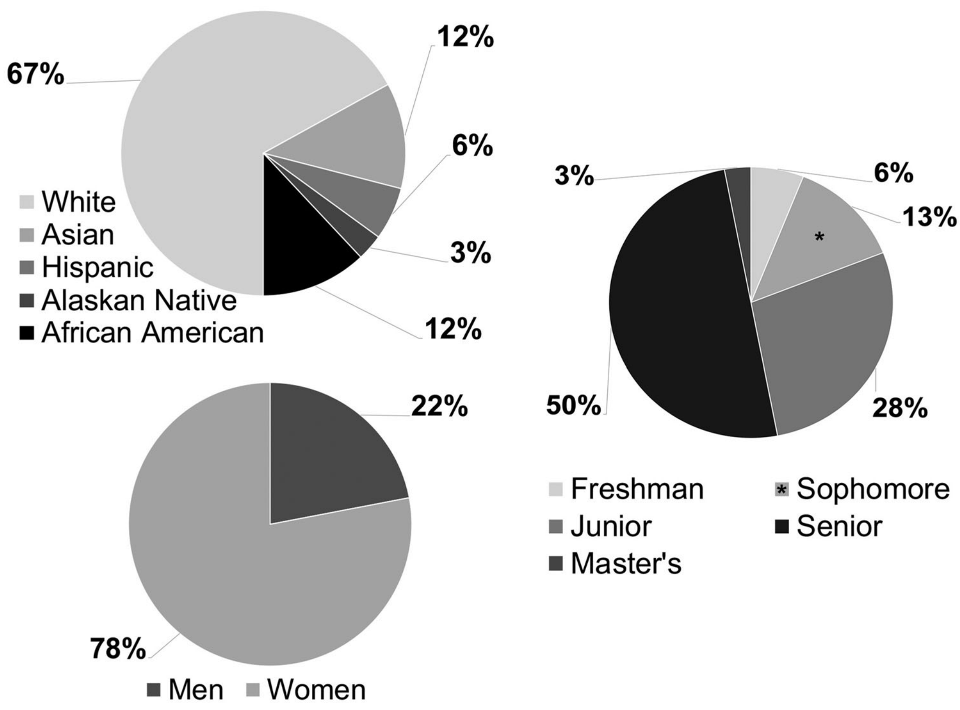

FIGURE 3 Sex ratio, academic level, and race and ethnicity of the 32 students who were Institutional Review Board (IRB) participants in the introduction to natural history course.

the importance of interacting with "real scientists" who were "just people" and learning not just about the science but the importance of all the dead specimens they worked with. Students were especially excited for the experiential learning opportunities such as familiarization with various taxonomic groups through observation and manipulation of specimens versus the more monotonous internet search results their peers presented to them. As such, the first INH course iteration was designed to be an immersive experience for students focused on leveraging mentor/mentee relationships and developing students' science identities. The first iteration was taught over a 14-week period, 2 h per week. The students spent 7 weeks working on a project of their choice in the NHCs after being introduced to each collection over three lab periods. Students had two discussion classes with their instructors. One was an introductory class at the beginning of the semester and the second was a mid-semester class discussion check-in. Students also completed weekly journal entries to reflect on their experiences and provide documentation that the instructors used to follow students' progress.

INH student feedback from an end of semester class discussion and written class reflections resulted in changes to the first iteration of the course. The changes were designed to amplify aspects of the course that students found useful. For example, during the first course iteration, some students were invited to participate in field experiences with their mentors outside of class hours and reported positively on the impact to their research project. During the class discussion, it was clear all the students were interested in having this experience as well as more time outside of lectures to interact with peers. They were also very intrigued by the career trajectories of many of the curators and professional staff with which they interacted with. For the second iteration, the course was taught over a 15-week period and increased from two-credit hours to three-credit hours associated with twice per week meetings that incorporated both a class discussion (1 h) and a lab (2 h). This allowed students to engage in research more fully in the collections and have time to interact with each other (Table 6). Field experiences (e.g., BioBlitz, optional field excursions) and opportunities for networking (e.g., in-class panels, attending lab meetings of museum faculty) were folded into the class discussion and lab, as explained below in the course model. Intentional advertisement was also done through emails and university programs that provide support for diverse (i.e., race, gender, ability, neurodiversity) students on campus.

Feedback from INH students as well as their mentors resulted in further changes to the existing course model. In the third iteration, the course was expanded from three-credit hours to four-credit hours, which enabled students to spend 3 h in the collections each week. Based on reviews from the students and their mentors, a 2-h period each week was insufficient to develop projects. "Near peer" TAs were added to the course; these students took the course previously and provided feedback to students while gaining a different skillset as a peer instructor (Akinla et al., 2018; Azman et al., 2021; Tobin & Tippins, 1993; Zaniewski & Reinholz, 2016). Each student

TABLE 6 Class outline and topics discussed by week for the introduction to natural history museums course.

Week	Topic	Objective	Discussion (Lecture)	Lab	Task
1	Introduction to natural history museums (NHMs)	Students will be introduced students to NHMs.	Guest presentation from museum director introducing NHMs.	Discussion of class outline and assignments. Deeper dive into the use and function of NHMs.	Complete pre-survey. Read: museum annual report and strategic plan; Kemp (2017, Introduction)
2	What is research? What is the nature of science?	Through analysis of peer review literature, students will understand the premise and processes involved in scientific research as well as what the nature of science.	Discuss the processes involved in scientific research. Discuss peer review literature on nature of science and scientific research.	First set of collection tours: this will showcase three different collections in neontology and paleontology, and a molecular genetics lab used in collection-based research.	Read: Crowther et al. (2005); McPherson (2001); Kemp (2017, Ch. 23).
3	Digitization in collections	Students will gain an understanding of digitization practices and their applications within NHMs.	Introduction to specify database, iDigBio, and digitizing collection.	Second set of collection tours: this will showcase three additional collections in anthropology and neontology while highlighting the various digitization efforts used within these collections.	Read: Hedrick et al. (2020); Lubar (2017) First Collection Reflection due.
4	Citations, citation management, and literature review	Students will learn how to conduct a literature review and use citation management software as a tool for analyzing peer-reviewed literature.	Hands on workshop with science librarian on how to search for peer-reviewed literature and incorporate references using citation management software.	Third set of collection tours: this will showcase four additional neontology and paleontology collections.	Create Mendeley account. Review guide created by science librarian. Second Collection Reflection due.
5	Basic versus applied research	Students will differentiate between applied and basic science within context of NHMs.	Discussion activity where students denote the type of science and its applications, including the broader impacts of this science.	Fourth set of collection tours: this will showcase several Lepidoptera collections and the museum's Exhibits and Public Programs.	Collection of choice due for student projects. Third Collection Reflection due.
6	Collection projects	Using the skillsets discussed in previous lectures, we will discuss the creation of students' projects for the course.	We will discuss a peer-reviewed paper on the nature of science and its messiness. We will also discuss expectations for the collection project which will be developed into a class paper and presented via a poster.	First intensive collection session with mentors based on students selected project of choice.	Fourth Collection Reflection due. Journal Entry due. Read: Taber (2018, Ch. 8); Suarez and Tsutsui (2004)
7	Uses of collections, part 1	Students interpret and discuss the use of collections.	Discussion on the uses of collections and the relevance of museum specimens, with emphasis on their role in developing and answering scientific questions.	Second intensive collection session with mentors based on students selected project of choice.	Schedule student meeting with TAs. Journal Entry due. Read: Lubar (2017, Ch. 7)

(Continues)

TABLE 6 (Continued)

Week	Topic	Objective	Discussion (Lecture)	Lab	Task
8	Uses of collections, part 2	Students interpret and discuss the use of collections. Systematics will be woven into this discussion by a guest lecturer.	Short seminar on systematics, followed by a discussion of the uses of collections and the relevance of taxonomic names.	Third Intensive collection session with mentors based on students selected project of choice.	Project Topic due. Journal Entry due. Schedule half-hour student meeting with instructor.
9	Science communication	Students will learn how to apply scientific knowledge to relevant audiences.	Students will participate in a panel of various science educators who will discuss mediums used to engage public audiences in science.	Fourth intensive collection session with mentors based on students selected project of choice.	Proposal for paper due. Journal Entry due.
10	History of NHMs	Students will learn how to design their projects in the present while crediting contributions from the past	During class we will review and discuss an assigned peer-reviewed paper which discusses the role of historic figures in NHMs.	BioBlitz: We will explore and document biodiversity on campus with scientists at UF.	Paper Outline and Introduction due.
11	How to make a poster and abstract writing	Students will create abstracts for their projects and outline the components of a poster.	We will discuss the important components of an abstract and critique poster outlines using past scientific posters.	Fifth intensive collection session with mentors based on students selected project of choice.	Paper Abstract due. Peer Review Outline due. Journal Entry due.
12	Careers in museums, part 1 (graduate student panel)	Students will meet with graduate students to differentiate between the types of academic degrees, and potential career paths related to NHMs.	Student will engage in conversation with a diverse (varying fields in museums, sex, race, career interest) group of graduate students.	Sixth intensive collection session with mentors based on students selected project of choice.	Paper draft due. Peer review assigned after submission. Journal Entry due.
13	Poster preparation	Students will critique and provide critiques for their peers to help improve their poster design and presentation.	Students will present their posters within class and receive peer feedback to make changes for the final poster presentation	Seventh intensive collection session with mentors based on students selected project of choice.	Laptop required for in class poster peer review (breakout rooms used if online) Journal Entry due.
14	Careers in museums, part 2 (staff and faculty panel) poster session	Students will meet with faculty and staff to differentiate between the types of academic degrees, and potential career paths related to NHMs.	Student will engage in conversation with a diverse (varying fields in museums, sex, race, career paths) group of faculty and staff.	Students will participate in a poster presentation where they will share their research experience with their peers as well as faculty and staff at UF.	Peer review of paper draft due. Final poster due.
15	Class evaluation	Students will evaluate their experience in the INH course.	Through an in-class discussion, students will evaluate their experience in the INH course.	Reading Day (no class)	Final paper due week 16 during finals week.

was matched with two of three TAs and required to discuss with them their work in the collections and their proposed research topic, including the hypothesis that they derived from their literature review. Students were also required to complete peer reviews. Class discussions were added that focused on gaining skillsets such as completing a literature review and discussing what research entailed. Marginalized students on campus were also directly emailed and encouraged to sign up for the course.

In addition to these planned changes, the course moved to a virtual space because of the COVID-19 pandemic. Students had already spent 3 weeks working on their projects in collections, which was sufficient time for most to develop their research projects. However, changes were made based on individual research projects and needs. That is, many mentors provided students with digitized collection data, or students used the existing collection databases to complete their research projects. The few that did not have sufficient data for analysis instead completed extensive research proposals. Other main components relevant to the success of the course are outlined below.

3.3 | Resulting course model

The INH model contains several components that allowed me to situate students in their learning (Figure 1) (Donaldson et al., 2020; Lave & Wenger, 1991). This model allowed students to be introduced to collections and research in a nuanced manner that was focused on career development. Components of the course model that were essential for the various course iterations based on student feedback and reflections during and after taking the course are presented as bullets within the components.

1. Field and lab experiences: Students were first introduced to the scope of possible research through tours of collections. Field trips were scattered throughout the course, including an annual class BioBlitz and optional trips to other collecting sites.
   - Discussion classes (2019, 2020): To complement their lab experiences, students engaged in classes discussions to discuss various aspects of doing research and science, including how to communicate the science with a broad audience, how to write a paper, and how to interrogate and discuss scientific literature. For most of these classes, the classroom was arranged in a circle or square to allow students to engage in the dialogue and actively participate in hands-on sessions. Major topics and areas of study in museums were also addressed such as digitization, systematics, and science communication (Table 6).
   - Bioblitzes (2019, 2020): Students explored biodiversity on campus during one of their 3-h lab periods with a diverse (i.e., age, sex, field of study, race, and ethnicity) group of scientists (Figure 4). Given that students were working on different types of collections (biodiversity, archaeological, and paleontological), this field-based activity gave students an opportunity to participate in aspects of the process that brought biodiversity specimens or objects to the collections. Students were given an option to focus on specific taxonomic groups based on their interest. Students learned techniques for collecting different types of organisms and some of the procedures for preserving these as voucher specimens.
   - Optional field experiences (2019, 2020): Situated learning emphasizes authentic activity and enculturation so that learning activities can be accessible to all members within a social and learning structure (Brown et al., 1989; Donaldson et al., 2020; Lave & Wenger, 1991). Thus, students were provided opportunities to conduct field work with scientists based on their interest, or simply to try a different experience (e.g., ichthyological collecting trips or paleontological excavations).
2. Professional mentors: Students were matched with mentors who guided their proposed research question and related project based on the students' interests. Students had agency in choosing their mentor based on their interests and interactions during collections tours and the following speed-networking session. Their mentor was the museum staff, faculty, or graduate student with whom students conducted a museum research project while developing their own hypotheses based on their observations and review of published work. They also had near-peer mentors to who provided guidance and support as well.
   - Graduate and professional panel (2019, 2020): A panel allowed students to talk to a diverse (i.e., age, sex, field of study, parental status, race, and ethnicity) group of scientists and learn about their career pathways, interests in their field, and their guiding principles. At the end of the panels, in their weekly journals and in their class reflections, students noted the importance of this experience in seeing different professions within the museum and learning about the different paths that the scientists had taken to their current positions.
   - "Near peer" TAs (2020): These students took the course previously and provided students feedback while gaining a different skillset as a peer instructor (Akinla et al., 2018; Azman et al., 2021; Zaniewski & Reinholz, 2016). Students were matched with two of three TAs in the course and required to discuss with them their proposed research topic and the hypothesis that they derived from their literature review and projects in the collections.

FIGURE 4 Group picture of Introduction to Natural History students, museum scientists, and Life Discovery conference teachers who participated in the BioBlitz 2019. Photo credit: Jeff Gage.

3. Guided writing paper: Unlike many end-of-term papers, students' research questions were carefully developed throughout the course, beginning with their initial literature review. They received feedback from their instructors and peers as they developed their scientific paper based on their research projects. This allowed students to develop writing skills pertinent to any career field. This was undertaken as "process writing" in contrast to the "product writing" typically used in undergraduate education (Tariq & Khan, 2021).
   - Citation manger and lit review training (2020): Lectures on citation management and literature reviews were added to the syllabus. A science librarian walked students through important aspects in obtaining and organizing peer-reviewed literature, tasks with which many students struggled in previous years.
4. Poster presentation: Students were given space to share their findings and discuss their research questions and projects with faculty, peers, and graduate students across the Departments of Biology and Anthropology as well as the Florida Museum of Natural History.
5. Networking: Multiple forms of networking were built into the syllabus, including attending lab meetings and class panels that explored career paths in and across biodiversity (e.g., ichthyology, botany, and mammalogy), paleontological, and archaeological fields.
   - Lab meeting (2020): Students were required to attend a lab meeting for the faculty curator with which their project was associated or interview a member of that faculty's lab (other than their direct mentor). The aim was to help students better understand academic research, including developing ideas, sharing procedures and thoughts, developing collaborations, and providing feedback.
   - Peer review (2020): To help students build social networks with their peers and cultivate a sense of ownership in their developing skill sets, they were required to give peer-feedback on research papers and posters.
6. Reflection: Students had multiple reflection assignments, including a weekly journal to document their progress and reflect on their experiences. They also completed reflections on their tours of collections and the course overall. This was designed to help students situate their learning experiences in line with their prior experiences (Donaldson et al., 2020; Lave & Wenger, 1991; Nolan, 2008; Quinton & Smallbone, 2010). These reflections were crucial in allowing changes to be made to the various iterations of the course.

TABLE 7 Themes that emerged from learning goals students noted as important in the pre- and postsurvey.

Themes	Pre-survey students (%)	Post-survey students (%)	Change (%)
Skills and experience	100	100	0
Networking	41	31	-9
Career	41	53	13
Grad school	34	66	31
Professional school	28	28	0
Writing Skills	22	31	9
Research	19	44	25
Mentoring	6	3	-3
Science communication	6	19	13
Gap year	6	25	19

7. Intentional student recruitment: I incorporated intentional recruitment of marginalized students in science (Table 1) by directly providing them with details about the upcoming course through programs such as the Office of Academic Support and the University of Florida Office for Graduate Diversity Initiatives. I also directly advertised to these students through email prior to opening the course for enrollment. I also determined how students had heard of the course and ensured they understood that the course model was atypical. This prevented students from enrolling during early enrollment and gave time for freshmen, sophomores, and other students to register for the course.

3.4 | Addressing the research questions

The thematized results from the pre- and postsurvey for 32 students (Table 7) from 2019 and 2020 indicated that students' learning goals were focused on developing scientific skillsets and gaining "real" science experience while networking with scientists. In the presurvey administered in the first-class period, all students noted a strong need to develop skills and experience in science. Some of the students noted specific skills that they felt could be gained based on the course syllabus. Twenty-two percent of students were interested in improving their scientific writing skills, 6% in improving their scientific communication, whereas 19% were interested in gaining research skills related to their careers of interest. Forty-one percent of students wanted to gain a better understanding of careers in science through the class experience, though almost all of the students implied having this as an underlying goal of the course by their reference to careers in their qualitative data submission. Forty-one percent of students were interested in the networking opportunities that the class provided, while 6% of students were interested in mentoring as a result of networking. Thirty-four percent of the students were interested in attending graduate school after finishing their undergraduate degree, whereas 25% students planned to attend professional school (e.g., dental, medical, or law). Another 34% of students had a career in mind but did not mention graduate or professional school as the pathway to their career of interest, and 6% were undecided about career options. Therefore, in thinking about what experiences should be provided to students to facilitate learning using NHCs, students should be provided with experiential opportunities to allow them time to develop skills while engaging in science alongside scientists.

In the postsurvey, all students felt that they had successfully developed their desired scientific skills and experience. Thirty-one percent explicitly emphasized the importance of the writing skills that they developed. For example, one student noted "The class places an unusual emphasis on providing a large amount of feedback to improve your scientific writing. This seems to be often overlooked in many science classes presumably since the focus is on content of what you are saying and not how you are saying it, however, if you cannot communicate your findings the value of them is greatly diminished. This feedback is essential to improving our communication (e.g., research paper, poster presentation, etc.)." Another 44% explicitly articulated the importance of the research skills they developed. For example, one student noted "One unanticipated goal I realized was how to conduct research almost on my own. I have only ever conducted research under the direction of an instructor who already knew what the outcomes of my research would be. This course taught me how to do these things myself, review literature to develop a hypothesis, test the hypothesis, analyze the results… ." Sixty-six percent of the students noted that they planned to attend graduate school after completing their undergraduate degrees (a 10% increase from the pre-course survey), whereas 28% (no change from the pre-survey) planned to attend professional school and the remaining 6% hoped to continue their projects and get more experience to further inform their trajectory to their careers of interest. Twenty-five percent of the students were considering taking a gap year before pursuing either graduate or professional school.

Their qualitative responses to the pre- and postsurvey questions helped to address how the students represent what is already known as part of giving meaning to their experience. Students post-survey results indicated their understanding of science, the nature of science and being a scientist was impacted by formal (e.g., K-19 classes) and informal (e.g., mentoring, visiting a museum) learning opportunities. The need for experience in science was common for all students despite their academic level in college. The opportunity to develop a research project—based on their experiential work in collections and review of the literature—was of paramount importance to all students. Students discussed the value of having the scaffolded experience, such as process versus product writing, which gave them agency as their science identities were developing while building competence (Tariq & Khan, 2021). They were able to reflect on their experiences doing science and develop their ideas using feedback from their peers and their instructors, without being told what they ought to do or the result they ought to find. Discussing the failure of results was as important as discussing successful outcomes and allowed students to better understand the nature of science. Students also used their experience doing science to make changes in majors or career trajectories to incorporate new or developed interest in STEM. For example, one student shared the following:

> The science I was taught in school was strict with a focus on the medical field. I chose to pursuit scientific illustration and began my college career at UF as an art major … Through the course, I became a bird study skin preparator. After about 3 weeks, I earned a paid job as a skeletal preparator at the offsite laboratory. Due to this course and the opportunities that it has brought me, my entire career path has transformed. I even changed majors and plan on attending graduate school so I can become a museum professional.

4 | DISCUSSION

4.1 | Addressing the research questions

Based on the pre- and postsurvey results, the data indicate that experiential learning opportunities (Figure 1; Tables 1 and 7) were considered the type of experiences students should be provided to facilitate learning using NHCs. Students should be exposed to science with them positioned as scientists instead of passive consumers of the "scientific process," which occurs when students participate in cookbook labs. Student feedback from my course model (Figure 1) illustrates that 21st-Century skills were gained through the paper and the poster based on their course research project. The research projects included processes such as sorting and identifying specimens, conducting DNA extractions, databasing, georeferencing specimens, segmenting CT-scanned specimens using computer software, and conducting statistical analyses (Table 2). Students also built their professionalism and work ethic through multiple networking opportunities, including interacting with their mentors and other colleagues.

4.2 | Potential of the INH course

Through mentorship and this experiential education opportunity, students found a passion in or gained a better understanding of STEM fields. Therefore, more specific, guided, mentorship courses need to be created to engage students, including those from marginalized backgrounds (Table 1) in STEM. As educators, we must understand that students are not empty vessels to be filled but can contribute to the production of scientific knowledge, especially within models such as the INH course (Dangerfield, 2018; Kazempour et al., 2012; Lee et al., 2015; Lightman & Sadler, 1993; Sawyer, 2006; Sheridan & Mungai, 2021). The importance of providing opportunities to fuel students' passion and curiosity in natural history is detailed in the case study of an undergraduate field-based course (Ernst et al., 2014). Additionally, the professionals within NHCs can help spark students' curiosity in science while expanding their minds on career trajectories.

As repositories of biodiversity, archaeological, and paleontological data, there is a wide range of careers associated with NHCs (e.g., ichthyologists, mammologists, botanists, paleontologists, anthropologists, science writers, graphic designers, educators, and development officers). There are also individuals working at different levels including faculty (principal investigators), lab technicians, collection technicians, collection managers, and graduate students. Many of these professionals had varied interests and meandering paths that led to their current positions. However, they developed skillsets along the way that are essential to their current roles within museums.

There have been many methods employed to provide students with experience in their fields. These include apprenticeship-based undergraduate research experiences, which are often highly competitive (Bangera & Brownell, 2014; Linn et al., 2015), as well as course-based undergraduate research experiences (CUREs) that offer authentic experiences based on a specific topic (Auchincloss et al., 2014; Bangera & Brownell, 2014; Corwin et al., 2015; Flaherty et al., 2017; Goodwin, 2021; Smith et al., 2021). The INH model represents a hybrid version of CUREs, which provides students with agency alongside mentorship to develop and explore a variety of scientific questions on different topics, while also being situated in their learning. Like other resources (e.g., other departmental green houses, university farms, extension programs, libraries, archives, and government research facilities), NHCs can be used to prepare students for careers after their undergraduate degrees. There is great potential for higher retention of students, particularly those from marginalized backgrounds (Table 1), to gain a better appreciation for science using the INH model as it removes many of the barriers to students' success in research (Arnold et al., 2020; Boles & Whelan, 2017; Espiritu et al., 2021; Graham et al., 2022; Grosser et al., 1996; Mosley, McNeil-Young, et al., 2021; Mottet, 2019; Wilkins-Yel et al., 2019).

4.3 | A final look at the utility of NHCs

The results of this study illustrate that NHCs can serve as a training opportunity for undergraduate students, though they have been underused in this way. The 20th Century marked a challenging time for NHMs during which many NHCs around the world struggled to remain relevant to the public despite their importance to scientific research (Bradley et al., 2014; Dalton, 2003; De Angeli & O'Neill, 2020; Nowogrodzki, 2016; Pearce & Simpson, 2011). The first two decades of the 21st Century were marked by a massive mobilization of biodiversity data. For example, in the United States, the digitization of collections supported by the US National Science Foundation's Advancing Digitization of Biodiversity Collections program led to an accelerated usage and new values for NHCs (Nelson & Ellis, 2019). The aggregation of digitized NHC data has transformed studies of biodiversity through the expanded access to specimens and associated data. These unlocked "new data" provide more opportunities for students to work with NHCs professionals through authentic learning experiences to inform their academic careers, as well as other careers such as in bioinformatics and computer sciences. The structured nature of the INH course also benefited the mentors who gained experience in mentoring students from diverse backgrounds (i.e., race, sex, level of college experience, and level of research experience). The model developed and used in this course should be considered and utilized to engage undergraduate students from different diverse backgrounds (race and ethnicity, sex, level of college experience, and level of research experience) in their academic journeys, while positioning them for success after they graduate.

AUTHOR CONTRIBUTIONS

Adania D. C. Flemming : Conceptualization; Data curation; Formal analysis; Methodology; Project administration; Resources; Writing – original draft; Writing – review and editing.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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