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An Interdisciplinary Approach to Experiential Learning in Cyberbiosecurity and Agriculture Through Workforce Development

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An Interdisciplinary Approach to Experiential Learning in Cyberbiosecurity and Agriculture Through Workforce Development

Abstract

Cyberbiosecurity and workforce development in agriculture and the life sciences (ALS) is a growing area of need in the curriculum in higher education. Students that pursue majors related to ALS often do not include training in cyber-related concepts or expose the 'hidden curriculum' of seeking internships and jobs. Exposing students through workforce development training and hands-on engagement with industry professionals can provide learning opportunities to bridge the two and is an area of growth and demand as the workforce evolves. The objectives of this work were 1) to learn key concepts in cybersecurity, including data security, visualization, and analysis, to name a few, through class activities and engagement with professional partners and 2) to understand what knowledge students gained from participating in the course could transfer over for when they enter the workforce. Three themes emerged from the study where students, through direct engagement with industry partners, gained more insight about the industry applicable to their studies; they established work environment expectations for entering internships and official job placements and established ways in which the workforce development training informed their future careers.

Keywords

cyberbiosecurity, experiential learning, workforce development, interdisciplinary

Cover Page Footnote

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In Memoriam of Dr. Susan Duncan, associate director of Virginia Agricultural Experiment Station and director of the Center for Advanced Innovation in Agriculture

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Abstract— ***Cyberbiosecurity and workforce development in agriculture and the life sciences (ALS) is a growing area of need in the curriculum in higher education. Students who pursue majors related to ALS often do not include training in cyber-related concepts or expose the 'hidden curriculum' of seeking internships and jobs. Exposing students to workforce development training and hands-on engagement with industry professionals can provide learning opportunities to bridge the two and is an area of growth and demand as the workforce evolves. The objectives of this work were 1) to learn key concepts in cybersecurity, including data security, visualization, and analysis, to name a few, through class activities and engagement with professional partners and 2) to understand how students applied the knowledge gained from participating in the classroom prepared them for their internship experience. This paper does not discuss the course's internship portion but focuses on the student's experiences and takeaways from participating. Three themes emerged from the study where students gained industry knowledge; they were able to establish internship expectations and establish ways in which the workforce development training informed their future careers.***

Keywords— cybersecurity, agriculture, experiential learning, workforce development, interdisciplinary,

I. INTRODUCTION

Technologies and technology utilization in the food, agriculture, and life sciences have drastically advanced in the past decade, creating new gaps in how we adapt to the evolving landscape in food and agriculture. As technologies advance in the food and agriculture systems, data information is limited in how it is exchanged across sectors, resulting in opportunities for potential data security risks and challenges. The advanced expansion of technologies, information, and communication technologies has influenced today's agricultural structure, development, processes, and procedures (Angyalos et al., 2021). This study was not intended to present new or novel discoveries but instead add to the body of literature related to the focus of cyberbiosecurity in food and agriculture. Additionally, this study proposes and emphasizes the need for developing educational resources to support cross-training experiential learning courses for undergraduate students in the data sciences and food and agriculture studies. This study utilizes a case study model to develop and implement an experiential learning-focused undergraduate course entitled "Integrating Cybersecurity & Agricultural Innovation" that integrates and engages early-career undergraduate students interested in learning and pursuing careers in cyberbiosecurity by engaging students from data sciences and food and agricultural studies. Murch et al. (2018) define cyberbiosecurity as "developing an understanding of the vulnerabilities to unwanted surveillance, intrusions, malicious and harmful activities which can occur within or at the interfaces of led life science, cyber, cyber-physical, supply chain and infrastructure systems, and developing and instituting measures to prevent, protect against, mitigate, investigate, and attribute such threats as it pertains to security, competitiveness, and resilience."

With the growing workforce due to the high advancement of technologies in cybersecurity in the food and agricultural field, gaps are present in the training and development processes and programs for individuals to enter the field. There is a growing need for individuals in the domain (agriculture, food, and life sciences) to be more prepared and versed in topics related to data and cybersecurity. The interconnectivity of many technologies within farm production, farm facilities, extraction, and data exchange amongst vendors and suppliers can become an open portal to unattended and unprotected information networks (Drape et al., 2021). Preparing for future cyber threats is particularly important, considering the number of industries that utilize different forms of technology (Peccoud et al., 2018; Cooper, 2015). Studies show that graduates from cyber studies should possess the necessary soft skills, critical thinking, and capabilities to solve problems, transferable skills needed in the workforce (Jones et al., 2018, as cited in Payne et al., 2020). Therefore, it is essential to consider workforce development and training of students to enter the field as the food and agriculture industry continues to evolve.

Higher education can intentionally integrate the fields of data sciences and life sciences to attract, train, and equip students that need to be more knowledgeable of the opportunities in cybersecurity that exist in food and agriculture-related careers. With the demand for cybersecurity professionals, colleges and universities must work to improve the practices surrounding data sciences in agriculture and food sciences for the upcoming generation of workforce-ready individuals (Payne et al., 2021). Training and development in data sciences and information technology is a typical program study (Richardson et al., 2019). However, fewer colleges and universities offer interdisciplinary fields of study in the data sciences and life sciences as a joint discipline (Tsado, 2019). Also, because this field is a newer concept in higher education, there is a lack of traditional training and certification programs/courses accessible, which creates barriers to educating individuals pursuing post-secondary school for potential employment as a professional in the cyberbiosecurity field (Drape et al., 2021). This course integrated the Kolb (2015) experiential learning model to provide opportunities for students to engage, collaborate, generalize, and practice what they learned throughout the course.

Institutions need to be swifter in their ability to respond to the changes in the needs of potential employers of graduates. Developing courses is arguably one of the most valuable ways to adapt and evolve more efficiently to meet these needs. In addition, higher education has the resources to develop interdisciplinary fields of studies in agriculture, life science, and data science. Building courses that address these gaps is critical in developing the educational resources needed for higher education to develop programs that train students through the workforce interested in cyberbiosecurity and empower students to think more critically about data sciences in an applied setting (Tsado, 2019). Three research questions guided the study:

1. What new knowledge did students gain from interactions with the course lessons, materials, and guest speakers?

2. What workforce development knowledge and skills do undergraduate students enrolled in the course need to enter the workforce?

3. What do undergraduate students in the experiential learning course want to learn more about career preparation?

II. EXPERIENTIAL LEARNING IN CYBERBIOSECURITY COURSES

Much education and cybersecurity research has focused on specific aims for cybersecurity students (Payne et al., 2021). Agricultural systems continue to evolve and adopt increasingly sophisticated technologies. For example, smart technologies and smart farm adoption carry downstream risks to food buyers (Drape et al., 2021). The consequence of doing so increases cybersecurity threats and potential risks to the food supply chain. However, only some studies examine this increasingly important intersection between agriculture, life sciences, and cybersecurity. Though biosecurity and cybersecurity have many areas of discovery, the interrelationship between the two is increasingly gaining interest (Murch et al., 2018). As technologies continue to develop, there becomes an even greater demand for more training and development programs for individuals interested in pursuing careers in the cyberbiosecurity field. According to researchers, there needs to be more training in the field. This can lead to the destruction and misuse of high-value information and the exploitation of security systems that can significantly impact the food system (Richardson et al., 2019).

There needs to be more awareness and understanding of concepts related to cyberbiosecurity and its potential impact on the food and agricultural system. However, in fields like information technology, training and curricula are well-established through traditional educational platforms (Richardson et al., 2019). Additionally, many professionals obtain their educational experience and training through informal hands-on experiences, primarily on the job site as official employees. Considerably this is also true for the cyberbiosecurity workforce. Training in biosecurity has also varied with the multiple education resources and structures used to train professionals (Tsado, 2019). Specifically, training programs and organizations predominantly use educational resources such as active learning, formal and informal classroom settings, and web-based and online modules (Richardson et al., 2019). It is critical to recognize that along with educational resources, training, and curricula development in the information and technology field, the cyberbiosecurity life sciences educational resources and training are established by the industry training program and organizations for employees through hands-on job training as well (Richardson et al., 2019). As it relates to the development of this course, similar efforts were developed and succeeded at Virginia Tech, the Integrated Security Education and Research Center (ISERC). This program integrated the science, business, liberal arts, and engineering fields to curate more integrated student experiences (VT Pamplin College of Business, 2023). However, gaps still lie in research to address the need and development of training programs and curricula at the university level in the interdisciplinary field of cyberbiosecurity food and agriculture.

Despite the clear need for more cyberbiosecurity experts, undergraduate and graduate-level education to train and develop students still needs attention and improvement to address this dearth of education (Tsado, 2019). As part of the proposed course, students are introduced to cyberbiosecurity as a concept, examining various issues at the intersection of cybersecurity and agriculture (Drape et al., 2021). In addition, students are also exposed to career pathways in cyberbiosecurity.

A. *Experiential Learning*

Experiential learning is a set of tools and techniques that students can learn and engage in interactive activities and experiences of hands-on and engaging experiences (Kolb, 2015). Kolb (1984) considers experiential learning to be learning and obtaining knowledge cultivated through experiences, perception, and cognitive behavior (as cited in Fai Ng et al., 2018). Experiential learning offers how students can reference experiences from the outside world in their own words, thoughts, and emotions

(Yardley, 2012). In his work, David Kolb prompted experiential learning that influenced John Dewey's scholarship (Miettinen, as cited in Fai Ng et al., 2019). Experiential learning brings a new meaning to hands-on learning (Mazurkewicz, 2012). It also encompasses a more holistic approach to how students learn in the classroom. Creating a space where students can explore situations, create discoveries, and learn and engage in environments outside the typical classroom fosters a space to develop their thinking and ideas (Fai Ng et al., 2018).

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Within the 4-stage cycle of the model, the study utilizes the first two steps, first establishing the *concrete experience* (Kolb, 2015). During the *concrete experience* phase, learners enter a brand-new experience or interpret a prior experience in a new way (Konak et al., 2013). Because the course encompassed agriculture, food sciences, and data sciences students, each student was entering a new learning experience. Students were introduced to their disciplines from an integrated lens. Learning about the Cyberbiosecurity industry by engaging with peers from other disciplines and professionals from the workforce. The *reflective observation* was next in the 4-stage cycle used in this study. *Reflective observation* is the process of students reflecting on their experiences, comparing those experiences to past experiences, and reflecting with peers (Moseley et al., 2020). Students conducted reflective observations throughout the course, contributing to the data collection. Students reflected on their knowledge before the course, their knowledge gained, potential interest throughout the course, and finally, their reflection and analysis after completion.

Before the development of this course, no department at Virginia Tech offered an interdisciplinary, experiential learning course in cyberbiosecurity. This course, however, integrated data science, food and agriculture, and industry partners in a novel learning experience. The instructor accomplished this by integrating various levels of expertise, working with university career development personnel and external industry partners to develop partnerships and learning experiences for students to carry beyond the formal classroom setting.

III. METHODS

Course Description

This undergraduate course provided an interdisciplinary, experiential-learning-based background and exposure to working on and completing a team project in cyberbiosecurity in agriculture and the life sciences. These projects, a capstone, were designed for students to learn about cyberbiosecurity and how their agricultural and data science knowledge could provide employment opportunities related to the cyberbiosecurity field. This course sought to provide knowledge and training on cyberbiosecurity, issues with online data and security, how we might protect our biological data, and partner with the industry to learn how they protect their data. The course offered the opportunity of an optional paid internship if the student wanted to participate during the summer.

The course also taught critical thinking and problem solving, professional presentations, and writing skills in the context of completing the capstone project. Students would use these skills to complete the capstone project and present their work in person to industry partners and classmates. The course introduces cyberbiosecurity as a concept, examines various issues at the intersection of cybersecurity and agriculture, and exposes students to career pathways in cyberbiosecurity. (Table 1) displays the 12 topics discussed over the semester. Students also contributed to developing the weekly topics they wanted to understand more of from the course instructors, university personnel, and industry partners. Having students participate in the course development allowed students to develop an investment of interest based on their understanding of individual professional needs and support.

TABLE I.

WEEK	***COURSE TOPICS***
WEEK 1	“Introduction to Cyberbiosecurity”
WEEK 2	“The Enterprise of Cyberbiosecurity”
WEEK 3	“Food System Vulnerabilities”
WEEK 4	“Data-driven Farming”
WEEK 5	“Data and Agricultural Research”
WEEK 6	“Ag Industry and Big Data”
WEEK 7	“Data Control and Ownership”
WEEK 8	“Ethics of Data Control and Ownership”
WEEK 9	“Capstone Prep-Visualizing Data”
WEEK 10	“Capstone Prep- Communicating Science”
WEEK 11	“Exploring Internships and Careers”
WEEK 12	“Capstone Presentations”

[a.] Table 1: Weekly Course Topics

[b.] Figure Caption

Figure Labels: Table 1 shows the 12 weeks and course topics we taught throughout the semester. Based on student feedback and topics from university and industry partners, they all contributed to the content discussed each week.

A. Participants

This course consisted of 10 students, nine undergraduate students and one graduate student, as part of a case study design with a convenience sample of students (Kivunja, 2015). The class consisted of students from the data sciences and food and agriculture. There were no prerequisites for the course, and students did not have to have interdisciplinary experience or background in both fields of study. The course was advertised broadly across undergraduate channels and through academic advisors, colleagues interested in the subject areas, and the College of Agriculture and Life Sciences. Students enrolled in the course based on interest, creating a more random sample of students (Cooksey & McDonald, 2011). Each student was unique in their prior knowledge of cybersecurity and data science. The course was a one-credit class taught once a week in both an in-person and hybrid online format and offered during the Spring 2022 semester.

B. Data Collection and Coding

The project team advertised the course through Virginia

Tech's College of Agriculture and Life Sciences and the data science department. The information was openly distributed to these colleges' staff, faculty, and students. The course was open to any undergraduate early-career-focused student eligible to participate. The course did not require any prerequisites for students to participate. Any content and class material taught in the course did not require students to have prior knowledge of the course or coursework. Students could participate or withdraw at any time without penalty to their grades or participation in the course.

The course integrated inclusive pedagogy practices that ensured each felt a sense of belonging and that their social and academic needs were being met (Morina, 2020). The instructors assigned weekly reflections at the end of each class. Additionally, students also received prompts to share their thoughts. These reflections included topics related to agriculture, cyberbiosecurity, the course in general, guest speaker feedback, input on upcoming class topics, and reactions from the teaching dialogue and activities (See Table 1). The purpose of these was twofold. One was to intentionally glean feedback from gauging student learning and comfort with the material. The second was for program planning to design content for students' perceived needs. The course was taught alternately by the instructor, teaching assistant, workforce/career development professionals, and Cybersecurity-related professionals throughout the semester. Diversifying the various speakers throughout the course allowed students to engage and be more comfortable with partners and learn through social interactions, which provided the necessary workforce development training for their future career paths.

The data collected from this course consisted of reflection questions following each class meeting. The responses consisted of tailored reactions from students and their experiences in the course. The data also consisted of 12 weeks of responses, focusing on different aspects of the course and content. The responses were initially grouped by the subject to understand what percentage of the class covered workforce development, the interdisciplinary field of cyberbiosecurity, and potential subjects.

As part of the coding process, *in vivo* was conducted to determine what meaningful patterns were emerging to make up sub-categories of data based on the conversation and other audio-based recordings and by-products collected using Atlas.ti (Charmaz, 2006). *In vivo,* coding is a type or category of qualitative data analysis that uses participants' words to summarize or analyze the data (Manning, 2017). *In vivo,* coding defines patterns in the data and arranges the data in a systematic order (Saldana, 2021). The data was first open-coded, categorized into major themes, and then focused coding, identifying any repeating patterns, and understanding the multi-layer meaning. (Creswell et.al., 2007). The resulting codes were more direct and began explaining more significant data segments related to perceptions of cyberbiosecurity. Focused coding helped determine the adequacy of the *in vivo* codes (Charmaz, 2014). By comparing data to data, concentrated codes assisted the researcher in grouping like codes and refining them into more significant categories. Focused coding expedited the *in vivo* coding and helped to condense and reorganize what was found in the first coding round (Charmaz, 2006).

Axial coding was conducted as the final step of the coding process, helping the researchers bring all the data together and determine themes based on the research questions (Corbin & Strauss, 2008). The development of the codebook emphasized the action-oriented nature of language in which participants discussed experiences of being a participant in cyberbiosecurity from their viewpoint (Roth, 2008). The codebook was developed around critical areas using constructs from work presented in the literature review and taking the coding scheme. The quotes in this work were presented as is without any changes. To avoid monotonous reading, the present article has not included all the quotes (Anderson, 2010). Only those quotes that best reflect the themes or the findings have been outlined here. The comprehensive data set could be provided upon request from the corresponding author.

IV. Results

Three themes emerged from the data. They were: 1) Students developed industry networks and academic engagement, 2) Students established career expectations and aspirations, and 3) Workforce training and development were most important for students to succeed in future career placement. The results of the experiential learning course consist of an overview and analysis of the workforce development training in cyberbiosecurity and how those skills transfer into the workforce. Over the semester, students engaged in several hands-on activities and engaged conversations with departments within the university, partners outside of the university, and their peers. In addition, following each class meeting, students were asked to answer reflection questions in an open-answer format to capture the participants' responses to their personal experiences of what they took from each class meeting.

The reflections guided students' thinking about their experiences from that day in class. With guidance from the professor, students had the autonomy to guide their thinking and learning experiences through the course. Considering the students are the next generation of the workforce, many would take on internships while others go directly into jobs; it was only appropriate for them to guide the class in a direction they felt would be most beneficial for their future experiences in the field. In addition, the interplay between students across disciplines would force each student and area to focus on communicating effectively with the other. This is essential for careers in cyberbiosecurity within food supply chains, technology adoption, and efficiencies in food and agriculture.

A. Themes

Theme One: Developing Industry Network and Academic Engagement

Throughout the course, students had the opportunity to engage directly with professionals from the field of cyberbiosecurity. Students could ask direct questions and engage in enriching conversations with these professionals, from internal university partners to external corporate partners and organizations. The course strongly focused on workforce development and the industry field of cyberbiosecurity; industry partners such as Deloitte, John Deere, small business start-ups, and government agencies could engage students from a day-to-day operational aspect cyberbiosecurity from a field focus lens. Theme 1 focused on the knowledge gained from the partners who visited during the semester. The students expressed their ability to connect their current areas of interest and studies to some of the topics shared in the guest speaker visits.

With students coming from both primarily the computer data sciences and agriculture and life sciences, although their current work in the classroom was not directly related to the content in which they learned in class, the concepts of how they saw themselves in the field, and their idea of how closely related they are to the cyberbiosecurity fields were present. Before the study, students had very little understanding of cybersecurity/data sciences and the field of food and agriculture as an interdisciplinary field which we refer to as cyberbiosecurity, from the guest speakers and activities that they participated in as it relates to the industry allowed them now to see these two areas as an interdisciplinary field. Students responded:

> "Food systems interconnect with more of life than we thought. I learned a lot about how much data was involved in agriculture and how integrated it is into our daily life."

Considering the course integrates two disciplines into one, students were exposed to more knowledge on how cyberbiosecurity in food and agriculture is interconnected. Additionally, because it is a growing field, it is essential for those entering this discipline that people are aware of. Students acknowledged this by stating:

> "The thing that stood out to me was how the speaker talked about understanding how the fields were so interconnected and to make sure to understand that when going into the industry."

In addition, students learning about how the disciplines work concurrently, industry partners expressed the need for more training and development programs to equip the next generation of professionals for the workforce. Students also expressed the importance of these training programs by stating:

> "I like that he mentioned we should train people to go into the field of cyberbiosecurity, considering that many people are unaware of how cyberbiosecurity is super important, myself included."

Industry partners also provided inside knowledge and perspectives on the various risk related to the interdisciplinary field of cyberbiosecurity in food and agriculture. Finally, students asked what resonated more in understanding cyber risk in the agriculture and life sciences. Students responded:

> "The slide showing the different areas that handle different aspects of security and cyber threats was beneficial for understanding cyber risk with life sciences. In addition, it was exciting when they tried to locate which area one of the students works in with his collaboration with Deloitte."

Another student added:

> "The reading and discussing the different aspects such as the technology that goes into all the food and forcing myself to think about the vulnerabilities of the food system."

Theme Two: Career Aspirations and Expectations

Theme two focused on students' expectations and aspirations of what they needed to be most efficient and effective when entering the workforce. Although the course focused on cyberbiosecurity as a field of work and industry, there was also space for students to explore the idea of internships and jobs throughout the semester. Before taking this course, students had not participated in internships or worked in areas related to their studies. A vital goal of the course was to create educational resources and experiences that would assist students in their career journeys. Reflection questions following each class meeting would highlight hypothetical resources, skills, tools, or support students need to succeed in their internships. Based on the workshop led by an industry partner, students were asked how they think they fit into the cyberbiosecurity industry; one respondent wrote:

> "I enjoy data analytics and know how important that is for all fields, including agriculture and bio. Food systems and food chain as a food science major, which is closely related to more of the agriculture and life science or bio side of the industry."

Based on students' engagement with industry partners, students were able to identify ways they saw themselves contributing to the cyberbiosecurity field, stating:

> "Drinking water security. One small mishap and the drink supply for millions of people can be on the line. I would like to help fix that issue."

Another student added:

> "When it comes to healthcare, a lot of personal data is liable to be stolen, so I think I would be in that area."

Allowing students to establish their wants and needs to be efficient and effective when they enter the workforce allowed them to develop more clarity and confidence in their expectations for themselves, potential supervisors, and the work environment. Students addressed what makes an ideal internship. One student stated:

> "I hope to have support from my work team and supervisor about my daily needs and expectations."

Additionally, students who were entering internships found that having a clear understanding of the scope of the hiring process for entering an official full-time role by stating:

> “I think understanding the employment timeline helps enter an internship or job. Generally, there is a schedule for the hiring process, which is useful to know, especially for finding a job after college."

Lastly, as students engaged with industry professionals throughout the course, they also learned about the day-to-day duties and operations of those roles. Part of the workforce development training component of the course is allowing students to think critically about going into the workforce and identify what they need to do in a role. One student stated:

> "I want to learn how these companies function daily and what it would look like to enter that field.”

Theme Three: Workforce Development Preparation

The third theme focuses on students' takeaways from the course as it relates to areas they found they wanted to learn more about in workforce development, takeaways from the guest speakers who discussed topics of general workforce development tools, and how those workforce development skills transfer over into the workforce. Throughout the course, students could contribute their perspectives to the conversation through the lens of which field they studied. So, although they were sharing knowledge across disciplines and making sense of their contribution and position in the cyberbiosecurity field, they all had one thing in common. Their common ground was their need to learn more about the general functions of navigating the workforce. Many students understood the importance of having resumes, proficient interviewing skills, communication skills, and the ability to network. Still, they all were similar in their desire to learn more about developing those skills best. As discussed earlier in the paper, students curated the topics throughout the course. With that, students expressed greater interest in workforce preparation than in gaining technical as part of their experience in the course. One student expressed:

> "How do you include other skills not directly related to the job?"

Workforce development is a critical component of the course. Students were able to ask questions from industry partners directly about their work environment and experiences, aside from the technical skills needed to do the job. A student shared one takeaway:

> "I think the best advice was at the end when they talked about her background in finance but how she was willing to learn anything that Deloitte needed, and now she has a job she never thought she would have."

Additionally, as part of the engagement of industry professionals, students also engaged with one another in creating, revising, and editing moc resumes. However, they also took it further to engage with one another, reviewing and providing feedback and exchanging resumes for form or peer engagement and experiential learning while strengthening their professional documents. One student noted:

> "Resumes are tough and working on cover letters and maybe what to expect with big internships would help me learn more about what to expect applying for jobs.”

A part of the experiential learning model for the course was where students engaged and collaborated to explore topics, activities, and discussions around workforce development. This structure allowed students to build collaborative partnerships amongst each other and guest professionals. At the start of the course, instructors asked students what they wanted to gain from their workforce experience; a respondent wrote that they wanted to learn more professionally to communicate and develop their teamwork skills.

DISCUSSION, RECCOMENDATIONS, AND CONCLUSION

This work aimed to understand the students' perceptions of cyberbiosecurity course content, their skill development, and the workforce development skills they thought would be necessary for their future internships or post-graduation jobs. The research questions used to guide the outcome areas were 1.) What new knowledge did students gain from interactions with the Integrating Cybersecurity and Agricultural Innovation experiential learning course lessons, materials, and guest speakers? 2.) What workforce development knowledge and skills do undergraduate students enrolled in the Integrating Cybersecurity and Agricultural Innovation experiential learning need for entering the workforce? and 3.) What do undergraduate students in the Integrating Cybersecurity and Agricultural Innovation experiential learning course want to learn more about career preparation?

The three themes indicated that students developed their industry network and academic engagement, career aspirations, and expectations and could identify the value of workforce development training.

Theme One: Developing Industry Knowledge and Academic Engagement

The class exposed students to various concepts in cyberbiosecurity and workforce development skills, including built-in reflections each time the class met. Intentionally designing the course this way enabled the students to reflect on what they had just learned. A limitation of this was the inability to ask students to reflect meaningfully after the class ended, which is one hallmark of experiential learning (Kolb, 1984). Many responses were derived from responses to the proposed research questions. We answered research question one, which asks what knowledge was gained from participating in the course; students expressed, “It was most helpful to have discussions that helped hear others' opinions and experiences from a professional point of view.” Learning from industry professionals worked to break the imaginary gatekeeping of the industry from the students. Many students had questions about how to apply for jobs and what the cyber-based components of the jobs would be, and it helped to see students identify with those careers. It helped solidify the desire for a concrete experience (Sugarman, 1985).

Theme Two: Career Aspirations and Expectations

Career preparation was a significant course component. Many of the student's first formal introduction to workforce development training, additionally, in an interdisciplinary field such as cyberbiosecurity in food and agriculture. Throughout the course, instructors offered students relevant questions that would prompt their thinking and understanding of their potential needs and expectations to succeed on a job. Through engagement with professionals who visited the class throughout the semester, students could establish job expectations and aspirations that would foster a thriving work environment and experience. Research question two addresses what skills students found most essential to have a successful internship experience; data showed that students thought "Having clear guidance and understanding of the day-to-day functions of the organization and supervisory support" were valuable contributions to the internship experience.

Theme Three: Workforce Development

Throughout the course, students engaged with professionals from the university's internal entities and outside the university with professional partners. Though the internal and external partners engaged with students on content specific to their background within cyberbiosecurity, workforce development training was consistent amongst each partner. Discussions on soft skills, resume building, interview etiquette, submitting applications, requesting recommendation letters, communicating in the workplace, and resources to find jobs were all topics the course explored throughout the semester. Reflection questions administered throughout the course encompassed questions around workforce development topics they felt they needed more development in, the tools they gained from engaging with partners, or potential workforce development topics they were interested in learning more about for future lessons in the course (Kolb, 2015). For example, research question three addresses what students learned to be most transferable for the workforce; students expressed, "Resume building, internship performance, and effective communication skills in the workplace were the most important tools needed to enhance their all-around development for entering the workforce."

B. Limitations

The course was a one-time semester-taught pilot course specifically designed for the grant. In addition, the sample size for the study was significantly low for a qualitative study. The planning and preparation of when the course was offered and how it was marketed across the university can be improved for future practice by offering the course during the fall semester and bringing a coordinator on to assist with the communication between departments and partners. Because Cyberbiosecurity is a new topic across universities and industries, promoting the course with more intention and personnel support could assist with increasing enrollment. Another limitation of this study was in designing the questionnaire. There should be a consistent format in the structure of reflection questions for future practices. If the reflection questions following each class meeting consist of two questions, question one should reflect "what you learned," and question two should reflect "what do you want to know?" Consistency in formulating the reflection question will increase the rigor and consistency in measuring students' growth and knowledge in the course.

C. Recommendations for Research

The research includes future data collection to gauge student knowledge in workforce development or cybersecurity-specific assessments. The university that offered this course has yet to have an interdisciplinary area of study in cyberbiosecurity. Therefore, understanding student experience in an interdisciplinary course would be beneficial in refining and offering new classes meant for a diverse student group. Further research could better understand student motivation to seek knowledge in cyberbiosecurity topics in agriculture and the life sciences. Although this study does not discuss the internship portion of this course, future work could examine the internship experience.

D. Recommendations for Practitioners

Recommendations for practitioners seeking to integrate cyberbiosecurity into their classes include involving industry partners and professionals in the planning stages of the course. Hence, they all have the same prior knowledge of the specific topics in the course to design a more cohesive course. Recruiting students should be intentional, targeting programs specific to data sciences, agriculture, and life science areas of study. This will allow students to engage with partners to strengthen their understanding of the topics for the class. Finally, recommendations suggest that students co-create some aspects of the course, providing input on assessments, speakers, and topics for discussion based on their interests. Providing autonomy will engage students and encourage their participation. Internships are a significant component of this experiential learning course; coordinating with partners on potential internships should occur during the fall semester to secure internship placements for the upcoming semester.

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