Impact of a Cybersecurity Work-Related Course on Students' Career Thoughts and Attitudes: A PISCES Course Evaluation

Dr. Marcia Combs
Cybersecurity Management
Murray State University
Murray, KY, United States
mcombs@murrystate.edu
0000-0001-6052-3602

Dr. Randall Joyce
Cybersecurity and Network Management
Murray State University
Murray, KY, United State
rjoyce@murraystate.edu
0000-0002-1573-7051

Mr. Cain Bynum
Cybersecurity Management Graduate Program
Murray State University
Murray, Kentucky, USA
cainbynum@aol.com
0009-0004-9189-5459

***Abstract*—This article proposes a research study conducted at Murray State University Cybersecurity and Network Management program to investigate the impact of work-related experiential learning on college students' career thoughts and attitudes within the context of cybersecurity career development. The Cybersecurity and Network Management program introduced the CNM 518 course based on the Public Infrastructure Security Cyber Education System (PISCES) project that offers practical, hands-on experiences. The proposed research project slated for Spring 2024, aims to assess how this work-related experiential learning influences students' career thoughts and attitudes, using the Career Thoughts Inventory as a measurement tool. This research project emphasizes the importance of reflective learning within CNM 518 and aims to contribute empirical evidence on the impact of work-related experiential learning on students' career thoughts and how such learning experiences positively influence the career decision-making processes and, subsequently, the broader field of cybersecurity education.**

Keywords—PISCES, Career Development, Work-Related Experiential Learning, Cybersecurity, Security Operation Center

I. INTRODUCTION

Murray State University, situated in western Kentucky, is a mid-sized public institution. As of October 2022, had a total enrollment of 9,489 students, spanning both undergraduate and graduate programs [1]. One of MSU's notable programs is Cybersecurity and Network Management (CNM), previously recognized as Telecommunication and Systems Management (TSM), which was established in 1998. This program holds the status of being a Murray State University Program of Distinction. Since its inception, the CNM program has been dedicated to teaching knowledge and skills in the field of cybersecurity. The CNM program, situated within the School of Engineering, is a 120-credit program available in both online and on-campus formats. The core courses in the CNM program encompass a broad range of cybersecurity subjects, including but not limited to Internet of Things, Digital Forensics, Incident Response, Threat Hunting, and Security Operations. The CNM program offers students numerous experiential learning opportunities such as internships, study abroad, and problem-based learning. Experiential Learning Theory (ETL) is defined as the process whereby knowledge is created through the combination of grasping and transforming experience often ETL is referred to as learning through actions and discovery [2, 3]. In the field of cybersecurity using experiential learning to teach the skills cybersecurity professionals need to do their job efficiently and adequately is critical in addressing the workforce gap and producing quality professionals.

A. Work-Related Experiential Learning in Cybersecurity

In the spring of 2023, the CNM program introduced both on-campus and online sections of the CNM 518 Threat Hunting and Security Operations course. CNM 518 is a work-related experiential learning course where students delve into the various stages of addressing a cybersecurity incident within a security operations center, encompassing both technical and managerial responsibilities. Proficiencies acquired in this course encompass understanding the origins of a breach, pinpointing compromised systems, implementing containment measures, and proactively identifying additional breaches. Furthermore, this course introduces students to industry-standard incident response tools and methodologies, with a particular emphasis on log analysis, network examination, and forensic techniques.

Historically, experiential learning in cybersecurity has taken the form of case-studies, capture-the-flag activities, and interactive games, all aimed at actively engaging and fostering students' interest in the field [3-6]. CNM 518 deviates from the conventional approach to cybersecurity experiential learning by integrating a pedagogical work-related design built upon the foundation of the Public Infrastructure Security Cyber Education System (PISCES) project. PISCES offers students a practical, work-related experiential learning opportunity with the aim equipping the next generation of cybersecurity analysts with practical and experiential knowledge, facilitated through a unique collaboration with the company Critical Insight [7, 8]. Together, they have developed a network monitoring solution tailored for small communities, municipalities, and modest-sized healthcare agencies. This solution empowers students to monitor segments of network traffic, enabling

them to identify anomalies and potential indicators of compromise [9]. Amid the escalating frequency of cyberattacks and the persistent shortage of cybersecurity professionals, the imperative of offering experiential learning experiences cannot be overstated.

As the CNM 518 course was specifically designed to align with the PISCES project, the adoption of an Experiential Learning (ETL) model became essential to fully leverage the hands-on learning opportunities within the course. The course modules were meticulously crafted using the Kolb learning cycle approach, a methodology that has demonstrated success in other cybersecurity programs [3, 4, 6].

The Kolb learning cycle approach encompasses four sequential stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation [4, 10, 11]. With this approach, the course modules were structured to immerse students in the role of a cybersecurity analyst, allowing them to cultivate their proficiency with the tools and analytical capabilities essential to the field. Within each module, a novel analyst or threat-hunting skills or tool was introduced and briefly showcased. Subsequently, students were tasked with independently replicating the demonstrated activities within their own learning environments. Supplementary resources, including readings and tutorials, were provided to augment the content covered during demonstrations and lectures. Armed with freshly acquired knowledge and skills, students were encouraged to further test their skills in the PISCES environment, exploring its intricacies and pushing the boundaries of what they could uncover. Each module in the course facilitated students in traversing all four stages of the learning cycle, a process visually depicted in Fig. 1.

The course spanned a duration of 16 weeks, involving two-hour and fifteen-minute sessions each week. The initial PISCES student Spring 2023 cohort consisted of nine participants with 22% female and 68% male. As the course neared its conclusion, students were encouraged to participate in an evaluation process where they provided qualitative feedback on both the faculty and the course itself. The following is some of the feedback from the students.

"The course allowed me to work with tools that I have never used before, being able to use them and do multiple things was really cool."

"The lab assignments and walkthroughs really helped with the courses and being able to create the dashboards and visualizations helped with my learning."

"More hands-on activities in the PISCES will help get more used to using Elastic."

CNM 518 is scheduled for another offering in the spring of 2024. In an effort to align it more closely with Kolb's experiential learning theory [11], the following adjustments will be added with the goal of creating positive attitudes toward the student's skill set in the PISCES environment while encouraging growth in the field.

- Adding new reflection assignments to the modules to help students identify negative thoughts about labs in PISCES.
- Adding on-demand recordings of PISCES Lab walkthroughs with the lab assignments.
- Create group work PISCES lab assignments.

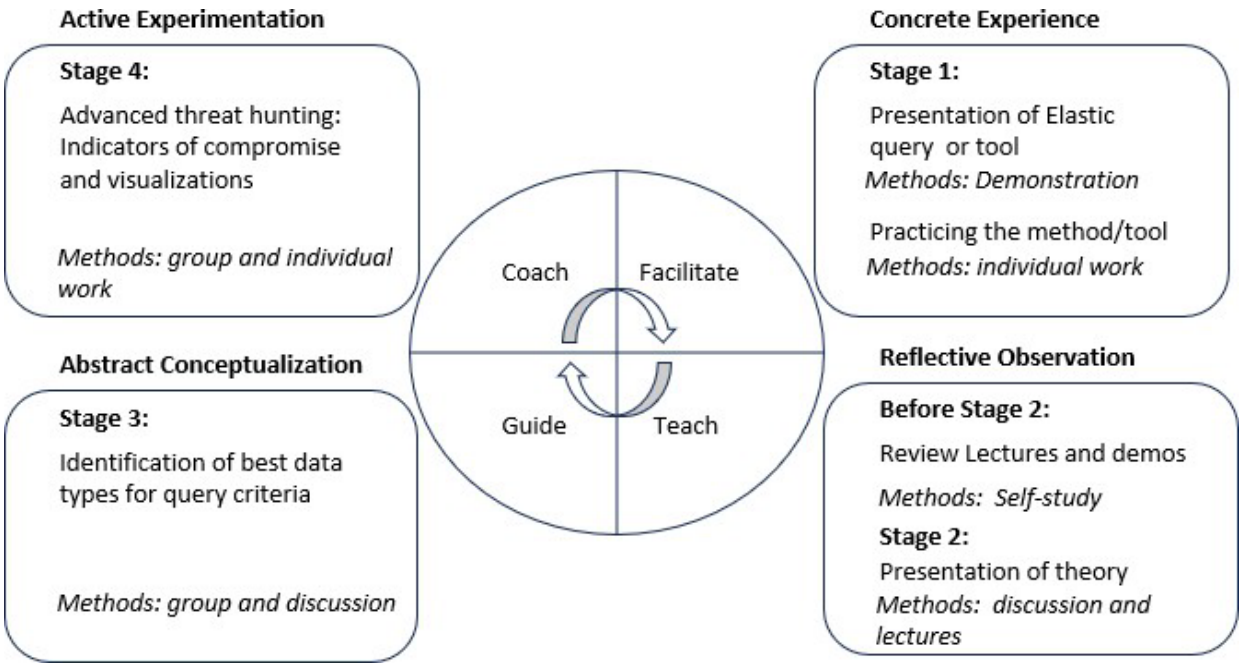

Fig. 1. Kolb's Learning Cycle

CNM 518 reflective question assignments are based on the Career Thoughts Inventory (CTI) workbook schema "to identify, challenge, and alter any negative career thoughts and then follow up with action" [12]. Example reflection question is listed below:

- Reflect on your PISCES lab assignment XX. Were there moments when you encountered negative thoughts or self-doubt about your abilities or decisions? Can you describe these thoughts and the specific situations that triggered them?
- Think about how you addressed the negative career thoughts during the PISCES lab assignment XX. How did you challenge these thoughts, and what strategies did you use to improve your decision-making abilities? Share any instances where you overcame self-doubt and made a well-informed decision.
- Describe an example where you transformed a negative thought into a positive action during the PISCES lab assignment XX. How did this positive action contribute to your overall experience and outcomes? Additionally, discuss how you made effective use of support from colleagues, mentors, or peers to enhance your learning and decision-making.

By engaging in this project, students gain invaluable experience in using industry-standard tools and working with substantial volumes of data within a security operations center environment. This hands-on exposure prepares them effectively for their future careers in the cybersecurity field [8, 9]. In the realm of cybersecurity, gaining practical, hands-on experience is pivotal in preparing students for the workforce and fostering their deep engagement and cybersecurity career development.

The CNM program offers students another experiential learning course. CNM 411 is a problem-based experiential learning course that covers the technical and pragmatic aspects of network design, operations, and management. Serving as the culmination of the undergraduate Cybersecurity and Network Management program, this course explores and applies technologies, tools, and methodologies relevant to network managers. The curriculum covers critical aspects such as efficiency, performance, reliability, risk management, disaster recovery, and security. The course involves a substantial network design project and the examination of a real-world case study for assessment and practical application.

B. Cybersecurity and Career Development

As Murray State University's CNM program advances and broadens its range of experiential learning courses, particularly emphasizing their dedication to work-related courses, a fundamental question arises: What impact do these work-related courses have on students' career development?

Career development spans a person's lifetime beginning in childhood and continues to retirement and is defined as "a concept designed to capture the dynamic, changing nature of career or work behavior" [13]. Life-span career developmental theorist, Dan Super, defined five life and career developmental stages, growth (age 0-14), exploration (age 15-24), establishment (age 25-44), maintenance (age 45-64), and decline (age 65+) [14]. Traditional college students fall within the exploration stage of Super's Life Rainbow where emerging adults [15] are developing vocational self-concepts that reflect their occupation preference and ability level [13]. According to the Cognitive Information Processing (CIP) Theory, vocational self-concept is situated within both the executive processing domain and the knowledge domain. The executive knowledge domain centers on metacognitions, including aspects like self-talk and self-awareness. In contrast, the knowledge domain concentrates on self-knowledge (employment preferences) and occupational knowledge (education and training) [16].

CNM 518 was first introduced in the spring of 2023 with a modest enrollment of nine students. While this represents a relatively small sample size, it serves as the basis for collecting data to explore the course's impact on student career development based on the CIP executive knowledge domain. This paper proposes a new 2024 study to explore the connection between work-related experiential learning CNM 518 and its impact on CIP executive processing domain, with a focus on assessing students' career thoughts and attitudes. The primary objective of the proposed research project is to examine how work-related experiential learning influences students' career thoughts and attitudes, utilizing the Career Thoughts Inventory (CTI) [12] as a measurement tool. The proposed research seeks to gain insights into the potential impact of work-related experiential learning on career-related cognitive patterns and contribute valuable knowledge to the fields of education and career development.

The outline for the remaining sections of the articles includes a review of career development and work-related experiential learning literature, an overview of the proposed research methodology, and conclusion.

II. LITERATURE REVIEW

In the realm of exploring the connection between work-based experiential learning and students' attitudes toward making career decisions, there is a lack of comprehensive research. A 2013 study [17] examined the effect of an agricultural project-based and work-based learning experience on undergraduate participants vocation identity, career decision self-efficacy and career maturity. Vocational identity reflects an individual's sense of their goals, interests, skills, and confidence in making career choices [18]. Career decision self-efficacy is the individual's belief they can successfully complete tasks in making career choices [19] while career maturity is the degree individuals are prepared to make vocational decisions [20]. The findings of this project-based and work-based learning experience helped define students' career interests and career goals and suggests the experience had a positive effect on vocational identity and career decision self-efficacy but no measurable impact on career maturity. This study was grounded in the

constructivist theory and did not delve into students' beliefs and attitude responses regarding career development.

Orthogonal research includes career development based on early career income and workplace promotion. 2023 study investigated the relationship between work-based learning and students' early career income [21]. Using a dataset from the National Centre of Education Statistic (NCES), found high school students who participated in at least one work-based learning such as job shadowing, community service, cooperative education, internships could expect a 7% higher income than those who did not participate in work-based learning. In 1986 a five-year longitude study [22] found a positive correlation in an experiential learning business management simulation game. In the game the participants' participants' performance was connected to the participants workplace promotion rates and career satisfaction in the game.

Another research project in experiential learning demonstrated study abroad had a positive effect on students' vocational identity and career decision-making [23]. The study revealed that studying abroad significantly impacted college students' self-knowledge, which, in turn, played a pivotal role in shaping their career options. However, it's important to note that this study did not address the issue of students' career related negative self-talk, attitudes, or beliefs.

A study [24] investigating the relationship of mindfulness on decision-making styles, negative career thoughts, and vocational identity suggest that individuals higher in mindfulness and those with thinking-based and internal decision-making styles experience fewer negative career thoughts and higher levels of vocational identity. Mindfulness like the CIP theory executive domain emphasizes how negative career thoughts affect the career decision making process [25]. This study aligns with the intended purpose of the proposed research project in terms of examining participants' thoughts and attitudes. However, it's worth noting that this study focused on teaching mindfulness within a career counseling context, rather than within an experiential learning context.

There seems to be a noticeable gap in research, particularly regarding the intersection of work-related experiential learning and college students' self-talk, attitudes, and beliefs in career development. Consequently, the primary aim of this proposed research project is to explore the relationship between the PISCES work-related experiential learning experience and college students' attitudes toward career development.

III. PROPOSED METHODOLOGY

This research project proposes a control group study to assess and compare the CTI scores of two distinct groups. The experimental group (Group A) will participate in a senior level work-related experiential learning course (CNM 518) while the control group (Group B) will participate in a senior level problem-based experiential learning course (CNM 411).

As discussed earlier, CNM 518 Threat Hunting and Security Operations Center Management is a work-related experiential learning course where students delve into the various stages of addressing a cybersecurity incident within a security operations center, encompassing both technical and managerial responsibilities. CNM 518 is built upon the foundation of the PISCES project, offering students a practical, work-related experiential learning opportunity. CNM 411 is problem-based experiential learning course that covers the technical and pragmatic aspects of network design, operations, and management. Serving as the culmination of the undergraduate Cybersecurity and Network Management program, this course explores and applies technologies, tools, and methodologies relevant to network managers. The curriculum covers critical aspects such as efficiency, performance, reliability, risk management, disaster recovery, and security.

The Career Thoughts Inventory (CTI) [12] has been shown to be a reliable and valid measure of career related negative thoughts, beliefs, attitude and dysfunctional thinking for adults, college students, and high school students. The CTI is a 48-item self-administered assessment that provides a total score (CTI Total Score) as well as scores for three construct scales: Decision Making Confusion (DMC), Commitment Anxiety (CA), and External Conflict (EC). Individuals with higher CTI Total Scores are less likely to have a clear perception of their career goals, less likely to be informed about occupation and uncertain about career choice. College students with higher CTI Total Scores are less decisive and are prone to feelings of depression. The three constructs reflect the individual's inability to make a career decision due to overwhelming negative thoughts (DMC), inability to make a commitment to a specific career (CA), inability to balance the importance of their own self-perceptions and the input from others (EC). The CTI uses a Likert scale with responses ranging from "strongly disagree" (0) to "strongly agree" (3) and the total score can range from 0 to 144. The CTI can be administered in 7 to 15 minutes and can be scored in 5 to 10 minutes.

The hypothesis statements for the research project are as follows:

- H0: There is no significant difference in Career Thoughts Inventory (CTI) scores between students who participate in work-related experiential learning (Group A) and those who do not (Group B).
- H1: There is a significant difference in Career Thoughts Inventory (CTI) scores between students who participate in work-related experiential learning (Group A) and those who do not (Group B).

It is expected that both the sample size for each group will be less than 30, therefore a Mann-Whitney U test will be employed to analyze and compare the distributions of CTI scores, allowing us to either accept or reject the null hypothesis.

If U statistic $\leqslant$ critical U value, the null hypothesis (H0) will be rejected meaning there is a significant difference in

CTI scores between the two groups. If U statistic > critical U value, the null hypothesis is accepted meaning there is no significant difference in CTI scores between the two groups.

This research project is tentatively set for Spring 2024 with data collection of students' CTI scores pre and post CNM 518 and 411 course completions. CNM 411 students who have completed CNM 518 are excluded from the research. The CTI instrument will be delivered either hardcopy/paper or electronic, depending on copyright approval. An IRB proposal will be submitted to Murray State University IRB committee for review and approval prior to Spring 2024.

IV. CONCLUSION

In conclusion, the CNM 518 course through PISCES offers students a valuable opportunity for self-growth and confidence in their career pathway through the completion of practical labs in PISCES and reflection assignments. These assignments encourage students to identify, challenge, and transform negative career thoughts into positive actions, ultimately enhancing their decision-making skills and overall learning experience. Furthermore, this research project, set for Spring 2024, aims to provide empirical evidence regarding the impact of work-related experiential learning on students' career thoughts and decision-making. By comparing CTI scores between Group A (CNM 518 participants) and Group B (CNM 411 participants), the study seeks to test the hypothesis that work-related experiential learning positively influences students' career thoughts. The Mann-Whitney U test will be employed to analyze and compare the distributions of CTI scores, allowing us to either accept or reject the null hypothesis. In summary, this research project not only highlights the importance of reflective learning within CNM 518 but also contributes to the broader understanding of how experiential learning can positively influence students' career thoughts and decision-making processes. The results of this study will provide valuable insights for both educators and students in the field of cybersecurity and digital forensics and the impact of the PISCES project.

REFERENCES

[1] *Murray State Student Data*. 2023 [cited 2023 September 12]; Available from: https://murraystate.edu/about/administration/Provost/institutional-effectiveness/OfficeOfInstitutionalResearch/MSUStudentData.aspx.

[2] Kolb, D.A., *Experience as the source of learning and development*. Upper Saddle River: Prentice Hall, 1984.

[3] Rege, A. *Multidisciplinary experiential learning for holistic cybersecurity education, research and evaluation*. in *2015 USENIX Summit on Gaming, Games, and Gamification in Security Education (3GSE 15)*. 2015.

[4] Melnikovas, A., et al. *Teaching pentesting to social sciences students using experiential learning techniques to improve attitudes towards possible cybersecurity careers*. in *European conference on cyber warfare and security: Proceedings of the 22nd European conference on cyber warfare and security*. 2023. Academic Conferences International Limited. https://doi.org/10.34190/eccws.22.1.1145

[5] Rege, A., K. Williams, and A. Mendlein. *An experiential learning cybersecurity project for multiple STEM undergraduates*. in *2019 IEEE IntegratedSTEM Education Conference (ISEC)*. 2019. IEEE. https://doi.org/10.1109/ISECon.2019.8882112

[6] Konak, *A., Experiential learning builds cybersecurity self-efficacy in K-12 students*. Journal of Cybersecurity Education, Research and Practice, 2018. 2018(1): p. 6.

[7] *Public Infrastructure Security Cyber Education System (PISCES)*. 2023 24 July, 2023]; Available from: https://pisces-intl.org/about/pisces.

[8] Hamilton, M., *CI Security Partners PISCES to Provide a Public Option for Cybersecurity Monitoring*. 2018, Critical Insight.

[9] Tsikerdekis, M., S. Waldron, and A. Emanuelson, *Network anomaly detection using exponential random graph models and autoregressive moving average*. IEEE Access, 2021. 9: p. 134530-134542. https://doi.org/10.1109/ACCESS.2021.3116575

[10] Kolb, A.Y. and D.A. Kolb, *Experiential learning theory as a guide for experiential educators in higher education*. Experiential Learning & Teaching in Higher Education, 2017. 1(1): p. 7-44. https://doi.org/10.46787/elthe.v1i1.3362

[11] Kolb, D.A., *Experiential learning: experience as the source of learning and development*. 1984, Englewood Cliffs, NJ: Prentice Hall.

[12] Sampson Jr, J.P., et al., *Career Thoughts Inventory professional manual. Lutz, FL: Psychological Assessment Resources*. Inc.(PAR), 1996.

[13] Brown, S.D. and R.W. Lent, *Career development and counseling: Putting theory and research to work*. 2004: John Wiley & Sons.

[14] Super, D.E., *A life-span, life-space approach to career development, in Career choice and development: Applying contemporary theories to practice, 2nd ed*. 1990, Jossey-Bass: San Francisco, CA, US. p. 197-261.

[15] Arnett, J., *Emerging Adulthood: The Winding Road from the Late Teens Through the Twenties (2nd edition)*. 2019.

[16] Sampson, J.P., et al., *Introduction to Cognitive Information Processing Theory, Research, and Practice*. 2020.

[17] Esters, L. and M. Retallick, *Effect of an experiential and work-based learning program on vocational identity, career decision self-efficacy, and career maturity*. Career and Technical Education Research, 2013. 38(1): p. 69-83. https://doi.org/10.5328/cter38.1.69

[18] *Vocational Identity - IResearchNet*. 2016 2016-09-18 [cited 2023 September 15]; Available from: https://psychology.iresearchnet.com/counseling-psychology/identity-development/vocational-identity/.

[19] *Career Decision Self-Efficacy Scale - IResearchNet*. 2016 2016-02-04 [cited 2023 September 15]; Available from: https://psychology.iresearchnet.com/counseling-psychology/career-assessment/career-decision-self-efficacy-scale/.

[20] *Career Maturity - IResearchNet*. 2016 2016-02-07 [cited 2023 September 15]; Available from: https://psychology.iresearchnet.com/counseling-psychology/career-counseling/career-maturity/.

[21] Plasman, J. and C. Thompson, *The value of informal learning within work-based learning: The economic benefits of WBL*. International Journal of Training and Development.

[22] Wolfe, J. and C.R. Roberts, *The external validity of a business management game: A five-year longitudinal study*. Simulation & Games, 1986. 17(1): p. 45-59. https://doi.org/10.1177/0037550086171004

[23] Kronholz, J.F. and D.S. Osborn, *The impact of study abroad experiences on vocational identity among college students*. Frontiers: The Interdisciplinary Journal of Study Abroad 2016. 27: p. 70-84. https://doi.org/10.36366/frontiers.v27i1.375

[24] Galles, J., et al., *Mindfulness and decision-making style: Predicting career thoughts and vocational identity*. The Career Development Quarterly, 2019. 67(1): p. 77-91. https://doi.org/10.1002/cdq.12164

[25] Sampson, J.P., et al., *Career counseling and services: A cognitive information processing approach*. 2004: Thomson/Brooks/Cole Belmont, CA.