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Harnessing Case Studies and Hands-on Learning to Empower Non-Engineers to Excel in a Tech-Driven World

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Abstract

This paper presents an experience report on a new general education course designed to build confidence in students across all academic majors, most of which are non-STEM, in exploring, evaluating, and adopting emerging technologies for their future careers. The modular course combines case studies with hands-on learning activities that incorporate generative AI, equipping students to thrive in an era of rapid technological change. Results from pre- and post-course surveys show a marked increase in student confidence in achieving the course outcomes. Furthermore, module-specific surveys indicate positive student perceptions, highlighting the curriculum's combination of case studies and hands-on learning as effective in boosting confidence and achieving the course objectives.

Introduction

This paper describes the experiences from a pilot course at the United States Military Academy (USMA) in West Point, NY. The pilot, designed as a trial implementation to test and refine the curriculum, aims to transform an existing general education course that introduces all upperclassmen to cyberspace and information technology (IT). Given the rapid pace of technological change, particularly in artificial intelligence (AI), the outcomes of this pilot course were broadened to encompass a wider range of technologies while also prioritizing the development of students' confidence and abilities to explore and interact with new and emerging technologies. To achieve this, we redirected time previously devoted to skill-based development for specific applications and instead focused on cultivating higher-order attributes and attitudes, such as the ability to evaluate and embrace a new technology early and analyze how to ethically integrate, scale, or adapt it for competitive advantage.

The heart of this new curriculum is its series of experiential learning modules. Each module begins with a case study, followed by a hands-on learning activity. The case study serves to motivate exploration of a technological paradigm and to demonstrate a subset of the course's underlying themes. The subsequent related hands-on learning activities deepen students' appreciation of the technology's inner workings while boosting their confidence by reinforcing the idea that the barrier to entry is lower than they might have imagined. To demonstrate the accessibility of some technologies, students are encouraged to collaborate with generative AI to build and understand technological products, enabling faster progress and a deeper understanding of key concepts. Together, the case studies and hands-on assignments emphasize several recurring themes, including the advantage of exploring emerging technologies early and finding novel ways to employ them. Another critical theme is the transient nature of technological superiority, which highlights the importance of continuous assessment, adaptation, and exploration of new applications to maintain a competitive edge. This modular structure with repeated experiential learning activities aims to build student confidence and adaptability, preparing them to engage with unfamiliar technologies in the future.

The use of case studies in education is a well-established pedagogical approach, but its definition and delivery vary across disciplines, cases, and teaching methods [1]. Case studies have been shown to increase student motivation to participate in class activities, enhance learning outcomes, and improve assessment performance [2]. They also support recall and understanding of central ideas and theoretical concepts [3]. As a result, the case study method has gained popularity in recent years across a range of scientific disciplines [2]. However, limited research exists on the use of case studies to motivate non-STEM majors to study technological topics, particularly in contexts where hands-on technology activities complement the case study by exploring its underlying themes and demonstrating the significance of the technology. In this course, the case studies serve an additional purpose; they provide real-world examples of the impact of either embracing or ignoring a new technology.

Self-efficacy refers to the confidence in one's ability to accomplish specific tasks, and enhancing students' self-efficacy increases the likelihood of achieving desired outcomes [4, 5]. Research across various disciplines highlights the critical role of experiential learning in building self-efficacy. For example, educators in health professions have demonstrated the effectiveness of experiential-based curricula in improving both self-efficacy and outcome proficiency [5]. Similarly, hands-on activities in K-12 cybersecurity education have been shown to enhance students' self-efficacy and problem-solving skills [6]. Accordingly, our curriculum design of utilizing case studies to motivate learning and highlight key themes, followed by hands-on activities to build self-efficacy, is grounded in research supporting the effectiveness of our approach.

This paper is organized as follows. The next section provides background and motivation for the course. Afterwards, the overarching course concepts and themes are introduced, followed by an overview of the initial set of case studies and hands-on learning activities designed to reinforce these concepts. The subsequent section analyzes students' impressions of the course. Finally, the conclusion outlines future directions for course development.

Background and Motivation

The curriculum for this exploratory course was developed to meet an institutional requirement ensuring that every graduate possesses foundational knowledge, skills, and abilities (KSAs) related to information technology and cyberspace (IT/Cyber) [7]. The current version of this junior-level course, titled *Cyber Foundations*, is part of the core curriculum at the United States Military Academy (USMA), where all students are required to complete a series of mandatory classes throughout their four-year student experience [8]. While Cyber Foundations is the current name of the course, the pilot adopts broader goals and a more expansive view of technologies, while maintaining a focus on analyzing and exploring technologies through a cyberspace lens.

The general education curriculum at USMA ensures that every graduate acquires the KSAs deemed essential for leadership roles in the workforce and service to the nation [8]. The IT/Cyber graduation requirement is partially fulfilled through this junior-level course, which is complemented by a freshman-level course in computing fundamentals. The freshman-level course introduces the principles and practices of computing and cybersecurity, along with foundational design and construction techniques for computer programming [9]. It is worth noting that select STEM majors, representing approximately 30% of the total student population, do not take the junior-year course as they satisfy the institutional-level IT/Cyber requirement through their ABET-accredited curricula.

This experience report focuses on a single section of a pilot conducted during the fall semester of 2024. The section included 16 students: 1 sophomore, 7 juniors, and 8 seniors. The pilot was motivated by the department's assessment and continuous improvement processes, which involve periodic reevaluation of the institutional-level IT/Cyber requirements [10]. Through this assessment, it was determined that the existing version of the course, while valuable in certain respects, placed excessive emphasis on developing skills for specific data and IT tools. This focus detracted from a broader, knowledge-based approach aimed at fostering critical thinking and reinforcing enduring principles and attitudes toward technology.

Several additional factors motivated the creation of this pilot course. First, the existing approach of focusing primarily on the use of specific applications risks frequently becoming outdated given the rapid pace of technological change. Second, because most of our students are non-engineers who are likely to serve as leaders rather than engineers or technicians after graduation, it is more effective to emphasize higher-level concepts rather than dedicating significant time to teaching the navigation of specific tools, such as data management applications. Instead, that time could be reallocated to exploring a broader range of cyber, IT, and emerging technologies, with a focus on analyzing common and enduring themes. Finally, using the rapid evolution of artificial intelligence (AI) and other emerging technologies as a case-and-point, it is inevitable that our graduates will encounter technologies in the future that were not covered in class. Therefore, it is more important to cultivate foundational attitudes toward embracing emerging technologies and adapting to technological change through case studies and experiential learning activities.

Building students' motivation to adopt an emerging technology and their confidence to explore it is essential for graduates who will lead in an increasingly technologically advanced world. The rapid pace of technological change is reshaping society's approach to acquiring and integrating technology, underscoring the importance of this course modification. For example, the military is experimenting with new acquisition processes to accelerate the fielding of emerging technologies [11, 12], and research programs are prioritizing soldier-centered experimentation as products mature before deployment [13]. Consequently, our graduates will increasingly be tasked with exploring and evaluating emerging technologies, often without established doctrinal frameworks to guide their use. Attributes in leaders such as adaptability, confidence, persistence, and critical thinking will therefore be invaluable for meeting society's future needs.

Concepts and Themes

After reevaluating the institutional-level IT/Cyber outcomes, we focused on redesigning the junior-level course to better reinforce those outcomes. This process involved identifying central, enduring concepts about modern and emerging technologies that would shape the course content while aligning with the desired outcomes. To achieve objectives such as "evaluate emerging technologies for their risks, challenges, and opportunities" and "explore and analyze ways to integrate technology for competitive advantage," the course first exposes students to modern case studies that illustrate the historical precedent for technology's powerful, multiplier effect in achieving strategic goals. Given that the majority of students taking this core course are non-STEM majors, we felt that they might be less inclined or confident in exploring technology to understand its strengths and limitations. Additionally, this demographic may be more likely to abandon technology prematurely due to the learning curve or other complexities, potentially missing opportunities to integrate it effectively. To address this, each case study was paired with an experiential learning activity designed to build students' confidence in exploring technology, increasing the likelihood that they will adopt and leverage technological advantages in the future.

Based on these motivating principles, we identified five central themes that the case studies and experiential learning activities reinforced throughout the course:

1. Technological innovations, ranging from novel breakthroughs to simple adaptations, can provide significant and often disruptive advantages.
2. The accelerating pace of technological innovation rewards those who remain at the forefront, but technological superiority is transient, requiring continuous assessment, adaptation, and innovation to maintain an edge.
3. The increasing accessibility of technology, driven largely by generative AI, lowers barriers to entry and accelerates productivity.
4. Innovation with technology can emerge from both top-down and bottom-up approaches.
5. The value of a new technology depends on multiple factors, necessitating careful analysis of risks and integration strategies to ensure its successful adoption.

Collectively, these themes serve as a foundation for fostering a mindset of curiosity and adaptability, equipping students with the motivation and confidence to engage with emerging technologies and leverage them strategically in their future roles.

In addition to these themes, we introduced foundational concepts at the start of the course to provide frameworks for analyzing the effects of technological change within the context of students' future roles as decision-makers. For the military, one such concept is the battlefield model of the 'operational environment (OE),' which includes five combat domains (land, air, sea, space, and cyberspace) and three cross-cutting dimensions (human, information, and physical) that influence and interact with each domain [14]. This model has parallels in civilian professions through frameworks like PESTLE (Political, Economic, Social, Technological, Legal, and Environmental), which evaluate external factors influencing organizational decision-making and technological adoption [15]. Given our setting within a military academy, the nine classical principles of war [14] were used to analyze the effects of technological change on enduring truths of conflict, while analogous civilian models, such as Porter's Five Forces [16], can be employed to assess competitive environments. Decision-making frameworks, including the OODA loop (observe, orient, decide, act) and DOTMLPF-P (doctrine, organization, training, materiel, leadership, personnel, facilities, and policy), were also introduced. The OODA loop, which is broadly applicable in both military and business contexts, emphasizes filtering information, contextualizing it, and making timely decisions [17]. In contrast, DOTMLPF-P is primarily used in military contexts as a framework for leaders to analyze the implications of organizational change from the perspectives outlined in the acronym [18]. Finally, given the course's overarching emphasis on cyberspace, a three-layer model of the domain [19] was introduced to help students analyze dependencies, vulnerabilities, and other critical aspects of a given technology. Models such as these were employed throughout the course as tools to evaluate technological innovations and their implications for decision-making.

Curriculum Design: Case Studies and Experiential Learning

The curriculum was designed with a modular structure, as depicted in Figure 1. The course begins with three lessons devoted to establishing the foundational concepts and themes described earlier. Following this introduction, the course transitions into a series of modules, each consisting of a case study followed by several lessons involving experiential learning activities conducted both in and out of the classroom. As noted previously, each module reinforces the course's core concepts, themes, and desired outcomes. One advantage of this modular approach is its flexibility; individual modules can be easily updated or replaced to reflect changes in technology or shifts in course emphasis. The course concludes with a case study that synthesizes key course themes by examining the strategic AI modernization strategies of two nation-states, followed by two lessons dedicated to student presentations and one dedicated to reflecting on the foundational concepts and themes while looking back at the course. All through the course, students were introduced to various emerging technologies, however, for the final assignment, students submitted and presented an in-depth paper in which they conjectured which emerging technology, or combination of technologies, will become game changers in the future. This final module assignment requires students to justify their reasoning and evaluate the implications of their chosen technologies using the concepts and decision-making frameworks emphasized throughout the course.

The three-credit-hour pilot consisted of seven modules distributed across 40 lessons, with each lesson lasting 55 minutes. Each case study had a single lesson dedicated to discussing and analyzing it. To prepare for these discussions, students were required to complete assigned pre-class readings and review assigned pre-class videos, ensuring they could actively engage in analyzing the case study's significance during class. This approach allowed more class time to focus on connecting the case study to the course's models and themes, rather than merely reviewing the historical context. One primary purpose of using case studies, rather than simply going straight to the technical subject, was to ground the material in historical significance while reinforcing the course's themes. The curriculum design was based on the belief that presenting the broader context through case studies would be essential for motivating students, particularly non-STEM majors who may lack intrinsic interest in technical topics.

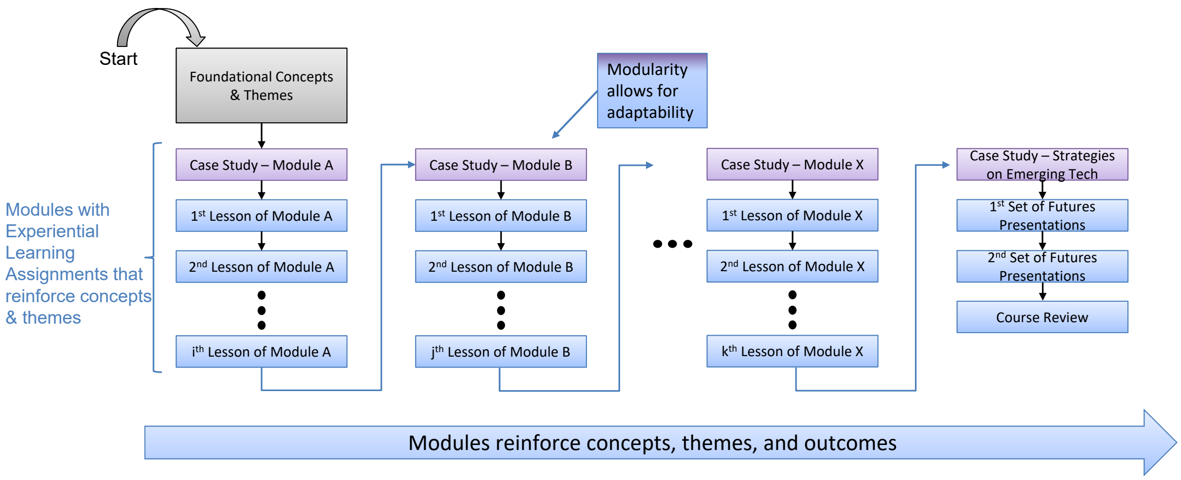

Figure 1: Concept of modular course design, consisting of case studies followed by hands-on lessons and assignments.

Following each case study lesson, a variable number of lessons are dedicated to exploring a specific aspect of a technology connected to and inspired by the case study introduced at the start of the module. This portion of each module emphasizes hands-on activities, allowing students to gain a deeper understanding of the technology. Additionally, these activities provide students with opportunities to build their confidence in exploring various, often new to the student, technologies while directly engaging with key course themes, such as the "low barrier to entry" of certain technologies and how "partnering with generative AI" enhances accessibility and accelerates product development.

Table 1 (below) outlines the case studies and experiential learning activities included in the first pilot and planned for the next iteration of the course. It is important to note that the case studies and activities listed are tailored to our institution and its unique stakeholder needs. The main pedagogical contribution of this paper and course lies not in the novelty of these specific pairs, but in the overall design framework, which aims to build student self-efficacy in navigating and leveraging technologies in an era of rapid technological growth. Other institutions and programs could adapt this framework by selecting case studies and hands-on activities that align with their own objectives and the needs of their stakeholders.

To provide a clearer understanding of the curriculum's design, we will discuss some modules from Table 1, focusing on the first two rows for brevity. The first module begins with a case study on the Gulf War of 1990–1991, during which U.S. forces demonstrated the potential of network-centric warfare [20]. Widely regarded as the first major "space-based war," the first Gulf War featured extensive use of American military satellites for navigation (e.g., the Global Positioning System, or GPS), communications, and intelligence gathering [21]. The flow of information through satellites, part of the cyberspace domain, enabled the use of connected technologies like GPS-guided precision weapons, which played a pivotal role in the conflict. The extraordinary firepower displayed by U.S. forces – enabled in part by cyberspace and interconnected networks – was closely observed by adversaries, who soon initiated strategic and

Case Study	Experiential Learning Activity
The Gulf War & Network-Centric Warfare	Wireshark packet capture and network protocol analysis using Python and matplotlib
The Iraq and Afghanistan Campaigns and the Improvised Explosive Device	Basic circuit breadboarding and creation of a wirelessly activated LED and buzzer circuit
Drones in the 2nd Nagorno-Karabakh War & Ukraine	Various microcontroller breadboard experiments & building a radio-controlled payload dropping mechanism
Annexation of Crimea & Cyber Gray Zone Activities	Use generative AI to create a message to influence a targeted audience (e.g., deep fake)
The Integrated Visual Augmentation System (IVAS) Acquisition Program	Exploration and functionality testing of Tactical Awareness Kit (TAK) app for Android and iPhone
The Role of Electronic Warfare and Starlink in the Russia-Ukraine War	Spectrum analyzer analysis of AM and FM modulation and electronic jamming demonstration
Maven Smart System (AI for Intelligence) and DARPA Racer (AI for Offroad Autonomy) Programs	Altair RapidMiner (AI Studio): building and evaluating AI models using datasets
US and China Modernization and AI Strategies	Paper and presentation on future warfare based on emerging technologies

Table 1: List of Case Study and Hands-on Activity Pairs

innovative modernization efforts to counter U.S. warfighting capabilities [22]. These efforts included developing anti-satellite weaponry, electronic warfare capabilities, and anti-access/area-denial (A2AD) strategies [23]. This case study reinforces a central theme of the course: that technological superiority is often transient, underscoring the importance of continuous innovation and strategic analysis.

The experiential learning activity for the Gulf War module involved analyzing a Wireshark packet capture file using Python. Before engaging in this exercise, students reviewed a simplified four-layer network model consisting of the physical, network, transport, and application layers. They also studied common protocols associated with each layer and their roles in supporting end-to-end communications. To reinforce these concepts, students were assigned a homework task requiring them to create a Python script, with the assistance of generative AI, to parse a packet capture file and visualize various network traffic characteristics. These visualizations included identifying the top talkers and listeners, analyzing traffic distribution by protocol type, and examining the distribution of packet sizes. For many students, this assignment required stepping outside their "comfort zone," as they had no prior experience with Wireshark and had not programmed in Python since their freshman year. This challenge was intentional, emphasizing the course's goal of fostering confidence in exploring unfamiliar tools. The use of generative AI was encouraged to aid students in navigating these technologies and achieving results more efficiently. A key course outcome was to teach students how to partner with and integrate technology, particularly generative AI, to enhance their capabilities. After generating the required plots, students were tasked with relating their visualizations to the networking concepts discussed in class and answering a series of network-related questions designed to promote critical thinking and deepen comprehension.

The second module and case study focused on the use of improvised explosive devices (IEDs) during the wars in Iraq and Afghanistan. This case study naturally emphasized several course themes, including 1, 2, and 4 listed above. The notion that relatively simple, bottom-up innovations can be highly disruptive, along with the need to adapt to innovation cycles, is highlighted by the continuous measure-countermeasure cycle between insurgents and US forces pertaining to the IED [24].

The hands-on portion of this module introduced students to basic electronic skills, such as constructing simple breadboard circuits using batteries, resistors, LEDs, manual switches, and transistors functioning as electrically controlled switches. The culminating assignment required students to build and demonstrate a functional circuit capable of detecting a voltage change from the headphone port of a push-to-talk radio, which would then activate an LED and buzzer to simulate triggering an IED. A snapshot of a student's demonstration of this circuit is shown in Figure 2. Throughout the circuit-building activity, students were encouraged to use generative AI for assistance, particularly in understanding the functions of each component in the design. By completing the exercise, students gained firsthand experience with the course themes while building their self-efficacy.

Student Experience

To evaluate the pilot course's effectiveness, we administered pre- and post-course surveys that asked students to rate their confidence and perceived value of the course. The surveys used a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) and were designed to measure key learning objectives. The following statements were included: *"The value of this course to my future career is clear compared to other courses," "I can evaluate emerging technologies for their risks and opportunities," "I can analyze the role and effect of cyberspace in a given application setting," "I can apply a critical mindset to analyze technologies for their risks, challenges, and opportunities,"* and *"I can explore and integrate technology for advantage."*

The surveys were anonymous and optional, with all 16 students from this single-section course completing the pre-course survey and 14 students completing the post-course survey. Although two students did not participate in the post-course survey, the response rate was 87.5%, making it a reasonable indicator of overall trends.

The results, summarized in Figure 3, show an increase in mean scores across all five statements. Error bars indicate standard deviations, and responses generally trended toward higher confidence

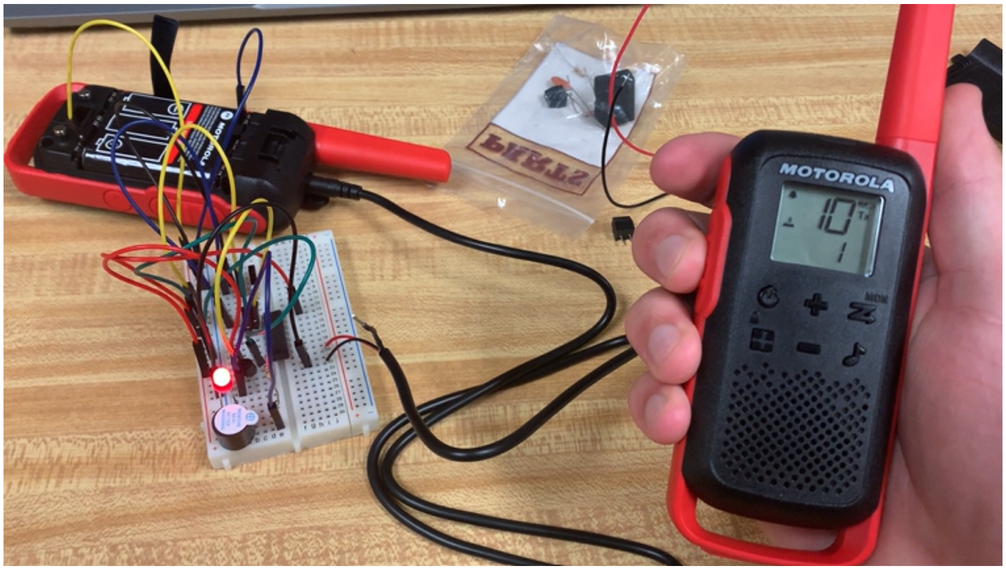

Figure 2: A picture showing a student's demonstration of a wirelessly activated LED and buzzer; this was an assignment after the case study on the evolution of IED technology during the Iraq and Afghanistan conflicts.

levels by the end of the course. The Wilcoxon Signed-Rank Test, appropriate for paired, non-parametric data, revealed statistically significant improvements $(p < 0.05)$ across all five statements. To further assess the magnitude of these changes, Cliff's Delta was calculated, with results presented in Table 2. Cliff's Delta values indicate a large effect size across all five statements, reinforcing the practical significance of these improvements and suggesting a meaningful increase in student confidence.

Statement	**Cliff's Delta**	**Effect Size Interpretation**
Value of Course	0.563	Large
Evaluate Emerging Tech	0.759	Large
Analyze Cyberspace	0.786	Large
Apply Critical Mindset	0.625	Large
Explore & Integrate	0.821	Large

Table 2: Cliff's Delta Effect Sizes for Pre- and Post-Course Survey Responses

To further assess student perceptions, we conducted module-specific surveys at the end of each major topic. These surveys asked students to rate their level of agreement with statements such as: *"The assignment(s) increased my confidence in exploring and experimenting with technology," "The assignment(s) inspired me to want to learn more about the topic area," "The module reinforced [learning objectives and course themes],"* and *"The assignment(s) were a valuable learning experience."*

The results of these surveys, presented in Figure 4, highlight consistent positive responses across all modules. Each bar represents the mean response, with error bars showing standard deviation. Because the surveys were anonymous and optional, the sample sizes varied slightly across

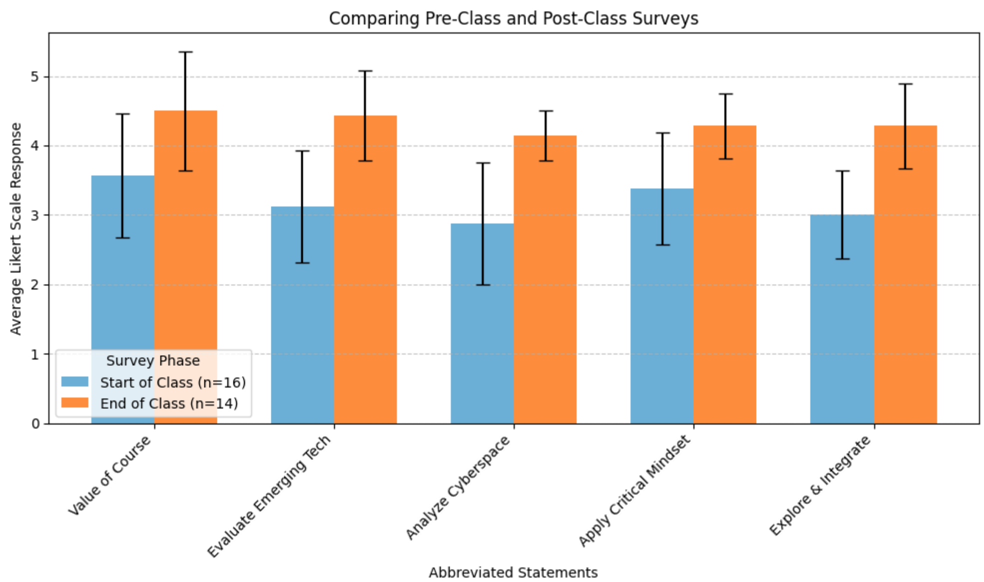

Figure 3: Survey results comparing the students' opinions on the value of the course and their confidence to accomplish the primary course outcomes.

modules. The legend in Figure 4 provides the specific number of responses for each module. The signature assignments for the "Networks" and "Electronics" modules were discussed earlier, while the "Drones" module refers to the third entry in Table 1, and "Influence" corresponds to the fourth-row activity (i.e., the Annexation of Crimea case study).

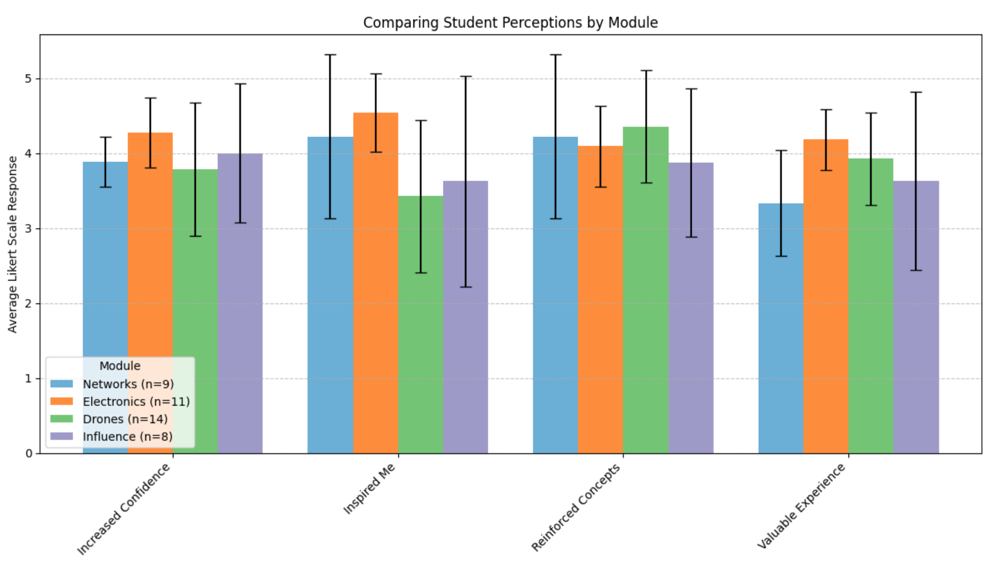

Figure 4: Survey results comparing the students' opinions of select modules.

Overall, the plot demonstrates that students generally agreed with the survey statements, with most average responses nearing 4.0 on the 5.0 Likert scale. This indicates a positive perception of the modules and their associated assignments. Among the modules, the data shows that students found the electronics module to be the most valuable, inspirational, and confidence-boosting. While none of the modules averaged a negative response, scores between 3.0 and 4.0 suggest opportunities to enhance assignments to make them more engaging and impactful learning experiences. Additionally, we acknowledge potential limitations, including self-selection bias (since participation was voluntary) and self-reporting bias (as students may have overestimated their confidence). Future iterations of the course could incorporate longitudinal assessments or external performance-based evaluations to complement self-reported data.

Conclusion and Future Work

The pilot course demonstrated the effectiveness of combining case studies with hands-on learning activities to enhance the confidence and capability of students, most of whom are non-STEM majors, in exploring and integrating emerging technologies. These cases and activities collectively reinforced five central themes, summarized as the value and accessibility of technology, along with the critical importance of identifying innovation opportunities, evaluating integration considerations, and mitigating risks. Survey results highlighted substantial increases in student confidence, particularly in modules like the electronics module, which students found highly valuable and inspirational. These outcomes align with the course's primary objectives of fostering an open and critical mindset toward technology in an era defined by significant and rapid technological change.

While the pilot achieved its goals, the assessment data revealed opportunities for improvement. Some modules were relatively perceived as less engaging or impactful, indicating an opportunity to refine assignments to better align with course themes and inspire greater interest. Additionally, feedback suggests that providing more structured support for students unfamiliar with certain tools, such as Python or Wireshark, could further enhance the learning experience.

Looking ahead, future iterations of the course will incorporate updates to modules based on student feedback and emerging technological trends. These updates include identifying new case studies and developing new experiential learning activities to reflect advances in areas such as generative AI, robotics, and cybersecurity. Special attention will be given to exploring case studies and activities inspired by the civilian sector, broadening the course's context beyond military applications. Expanding the course to include more interdisciplinary applications may further enhance its appeal and relevance. Additionally, plans are underway to explore the scalability of this modular approach, with a particular focus on ensuring the hands-on activities can be effectively scaled to accommodate more sections of students.

The success of this pilot highlights the value of integrating historical context, experiential learning, and generative AI to prepare non-STEM students for leadership roles in a tech-driven world. By fostering curiosity, adaptability, and confidence, this approach equips students to navigate and leverage emerging technologies both ethically and strategically. As technological innovation continues to accelerate, cultivating the skills needed to explore and evaluate technology will remain essential for future leaders.

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