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AUKUS in Academics: Case Study on Cross-Disciplinary Collaboration in Submarine Engineering

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Introduction

The U.S. Navy's submarine fleet is set for major changes, with production and operational reach expected to expand significantly over the next decade. The production rate, stable at just under 2 boats per year for the past 15 years, is projected to exceed 5 boats annually by 2030 due to geopolitical uncertainty. This growth will necessitate a substantial increase in the submarine industrial base (SIB) workforce, with 15,000 annual new hires through 2032 [1]-[5]. These expansion efforts have driven considerable investment in developing a STEM-literate naval workforce pipeline in regions of high SIB density. This need is demonstrated in efforts pioneered in southern New England, developing new pedagogies for K-12 outreach and teacher support programs [6], [7].

This transitory period "could lead to a period of heightened operational strain for the SSN force, and perhaps a period of weakened conventional deterrence against potential adversaries such as China" [8]. These concerns inspired the AUKUS (Australia, United Kingdom, and United States) collective security agreement, wherein the United Kingdom and United States will provide the Royal Australian Navy with American *Virginia* class nuclear-powered submarines and jointly develop Australian production lines for domestic nuclear-powered submarines [9], [10]. This agreement has heightened engineering challenges facing the SIB while adding international policy considerations, including, but not limited to: arms control agreements, nuclear non-proliferation obligations, and the risk of an ongoing escalatory cycle with China.

Hence, the issues facing the U.S. submarine force present a need for increased policy and engineering integration to meet the Navy's needs for the remainder of the decade. Traditionally, however, engineering and policy offices have remained siloed, in both academia and industry; engineers build while policymakers decide how to utilize platforms. This paper discusses an attempt to synergize these domains at the University of Connecticut through a novel experiential learning course, Innovation and Entrepreneurship 4 Diplomancy, to break down systemic barriers and build an interdisciplinary approach to pressing STEM issues. The paper reviews previous interdisciplinary teaching attempts, details the new course, and uses case study analysis to interpret outcomes, suggesting a new interdisciplinary paradigm to tackling national security.

Background

Suggestions of integrating social science and STEM education are not particularly new; the earliest reference in the literature is Pletta's 1975 call for more civic education in engineering curricula to better prepare engineers for political leadership [11]. Prior ASEE presentations have similarly presented on interdisiplinary engineering and policy capstone courses, aligning with this case study [12]. However, as in that case, and with most of the literature, there are two broad approaches to policy-engineering integration: 1) political science is an underutilized tool in making better STEM students by expanding conceptions of the scientific method [13]-[18], or 2) policy-focused international relations students need STEM exposure to adaquetely perform science diplomacy [19]-[21]. The former has a more robust literature, but either approach tends to prioritize one field over the other, rather than combining their unique strengths to address complex societal problems on an equal footing. Our approach aims to overcome this within the case study by balancing problem sets while diversitying team compositions to equalize expertise and encourage interdisciplinary effort within student projects. This approach leverages the strengths of each field to find novel solutions to the given problem statement.

To do so we apply Gerring's (2006) case study definition: "[a] case study is an intensive study of a single case or a small number of cases which draws on observational data and promises to shed light on a larger population of cases" [22]. This study is descriptive over causal — we do not seek to understand the *cause* of team formation (the teaching team created groups), but rather to show that these fields can successfully work on complex, real-world, national security issues to produce a final product greater than would be produced by a displine-exclusive team [22], [23].

The Case – An Interdisciplinary Experiential Learning Course on National Security
The course ran during the Fall 2024 semester at the University of Connecticut. The course was cross-listed as an upper level undergraduate special topics course for engineering juniors and seniors (ENGR 3195, n=16), a graduate level special topics course for engineers (ENGR 5100, n=10), and a special topics course in political science open to all years (POLS 2998, n=5). Sections were combined and met formally once per week for 2.5 hours. Due to interest and accessibility considerations, an asynchronous option was offered to students who could not attend class meetings; lectures were recorded while the teaching team met with asynchronous teams independently to provide oversight and guidance.

Students worked in teams on one of six problem sets provided by the Department of State Bureau of Diplometic Security (DS). Students ranked their prefered problem sets; the teaching team placed students based on preference while optimizing potential for interdisciplinary collaboration. All teams included both undergraduate and graduate engineering students, facilitating a strong mentorship dynamic between graduate and undergraduate students, as well as cultivating a sense of empowerment for younger students contributing at an elevated level. Most graduate students naturally fell into this role, contributing to specific tasks while delegating responsibilities and providing advice on project management to younger students, fostering a sense of comraderie and community. All but one team had at least one political science student to ensure interdisciplinary dynamics [11], [14]. Moreover, problem sponsors were similarly interdisplinary, comprising both State Department policy-level actors and engineers with intimate knowledge of the systems teams were studying.

The teaching team was interdisciplinary to ensure pedagogy and advice covered a dynamic range [12], [18]. The team comprised: an Ed.D. with expertise in experiential learning and managing Navy-funded R1 research grants; a PhD student in political science with expertise in international security who has worked with the Navy on AUKUS questions, and a PhD candidate in mechanical engineering with expertise in vibrations and structural analysis who has worked extensively for Navy research labs. The teaching team was supplemented by mentors from DS as well as a third party non-profit providing pedagogical support.

The course utilized the flipped classroom model, with students performing most deliverables outside of class time. Class meetings were broken into three blocks: 1) a lecture on methods and problem development, 2) team progress presentations, and 3) free time for teams to develop their solutions with instructor guidance nearby. Asynchronous teams had weekly presentations scheduled at a separate time. Students were provided an initial contact list from their sponsors to initiate the exploratory and scoping phase of their problem. They were expected meet with these contacts initially and independently develop their list, with an expectation of 60-80 touchpoints by the end of the semester while developing a viable solution. Weekly presentations updated the teaching team on how many touchpoints teams had scheduled in the previous week and major developments on their solutions. The teaching team asked follow-up questions, ensuring consistent and timely progress while troubleshooting unforeseen difficulties. The teaching team also secured funding through Lockheed Martin to ensure each team could perform a site visit relevant to their problem set, many of which were international trips, to add analytical depth to their solutions. The final deliverable, both for the course and to DS, was a draft white paper of the proposed solution in the event the Department was interested in further research. Teams also provided a write-up on the impact of their site visit on their final product.

Figure 1 Course students presenting on their problem sets to Undersecretary of State for Arms Control Bonnie Jenkins

Problem sets were curated in collaboration between the teaching team, a third party non-profit, and DS to ensure feasibility, alignment with course goals, and an AUKUS nexus. Problem statements are as follows:

1. DS-41: The Diplomatic Security Counter-Unmanned Aerial System (C-UAS) Program Team needs scalable acoustic array detection capabilities in order to successfully detect modified adversary unmanned aerial vehicles (UAV) that do not emit signals detectable by traditional radio frequency (RF) systems and radars.
    a. Team n: 5; site visit: IEEE Conference in Hawaii
    b. AUKUS connection: Drone technology is a core component of AUKUS Pillar 2 [9]
2. DS-47: United States Embassy security personnel within Diplomatic Security need explosive detection equipment with more robust analysis capabilities optimized for use in the field in order to improve the accuracy and reliability of trace explosive residue testing while maintaining global transportability.
    a. Team n: 6; site visit: Lisbon, Portugal
    b. AUKUS connection: Securing new joint Anglo-American naval base in Perth
3. DS-48: Installers and Maintenance Staff in Engineering Service Offices (ESO) around the world need a standardized protocol for the production and acquisition of small-scale,

custom parts in order to solve unique situational installation problems with equipment and improve efficiency of older systems maintenance despite limited parts availability.
    a. Team n: 5; site visit: San Jose, Costa Rica
    b. AUKUS connection: NAVSEA is seeking to move significant submarine production to additive manufacturing
4. DS-49: Diplomatic Security Logistics Specialists within the Department of State need a comprehensive systems process that leverages existing supply chains and transportation routes in order to quickly and effectively fulfill urgent parts orders from global storerooms.
    a. Team n: 6; site visit: Frankfurt, Germany
    b. AUKUS connection: The international logistics necessary to maintain an international submarine fleet will be of substantial concern to the US Navy
5. DS-50: Logistics Specialists within Diplomatic Security need an automated inventory management system that integrates with systems of record (CMMS) in order to more efficiently address equipment disposition, reduce cumbersome manual processes, and ensure that Security Technology maintains a minimum but viable number of spare parts.
    a. Team n: 5; site visit: Frankfurt, Germany
    b. AUKUS connection: The international logistics necessary to maintain an international submarine fleet will be of substantial concern to the US Navy
6. DS-51: U.S. Department of State Diplomatic Security officials need a way to assess and compare the long-term costs and serviceability of electromechanical and hydraulic active barrier systems to make informed decisions about which systems to install at specific facilities, ensuring the highest level of protection against vehicle-borne terrorist attacks.
    a. Team n: 4; site visit: Washington, D.C.
    b. AUKUS connection: Securing new joint Anglo-American naval base in Perth

Findings

As noted above, our analysis is descriptive over causal [22], [23]. We shall demonstrate lessons learned and best practices from this attempt at interdisciplinary teaching, combining both policy and STEM students to solve national security issues. In demonstrating which aspects of this course succeeded and which fell short, future innovations can continue to push the goal of interdisciplinary learning. Major findings include the involvement of government officials and problem sets on learning outcomes, the impact of interdisciplinary teams as percieved by both STEM and political science students, and the role of site visits in furthering pedagogical goals.

A. Government Involvement and Real-World Problems on Learning Outcomes

Government sponsorship was vital to the viability of this course, and DS dedicated substantial time to ensuring student success. The use of real-world problem sets, which have a tangible benefit on the lives of government officials, was crucial to instilling a sense of value as students applied lessons outside the classroom. In working with diplomatic officers across the globe with budgetary and cultural constraints, students developed crucial interpersonal and communication skills. As one PhD student noted, “[t]his course has also given me the chance to expand my set of skills and knowledge in a new topic that I previously had no knowledge of and also improve on soft skills that are critical for engineers and researchers to have.”

Yet, due to the sensitivity of systems students were working on, and as their sponsors were often higher-level members of the civil/diplomatic service, there were also significant barriers to address. Several teams ran into classification issues, wherein they could not access all information wanted or needed for the best possible final deliverables as some material was CUI or SECRET. Moreover, several teams had communication barriers with sponsors, as several post-program statements indiciated. One team found "[f]eedback from direct beneficiaries (end-users) was limited, which made it hard to confirm whether we were on the right track and align our efforts with real-world needs." Another highlighted that "early reliance on sponsor input rather than proactive research delayed our ability to address knowledge gaps and hindered progress in the initial stages." These difficulties required students to develop an agile approach and/or intervention from the teaching team to ensure DS kept open lines of communication.

Upon final briefings from student teams to DS, the Bureau expressed immense satisfaction with team results, and expressed a willingness to continue collaborating with the teaching team for further iterations of the course. This is promising, as ultimately students expressed that the soft skills development and sense of ownership from working with real-world government problem sets outweighed access complications. The teaching team will integrate further agile innovation modules into future offerings to overcome this potential hinderance.

B. The Role of Interdisciplinary Teams

Mixed political science and engineering teams proved invaluable in ensuring the success of final deliverables. As all problems were sourced from the Department of State and involved international components, the expertise of political science students in navigating socipolitical frameworks was vital, even if problem statements trend towards engineeering-heavy solutions. To that end, as one political science student noted, "[t]his project gave me a chance to learn how technology and policy can complement each other. These opportunities showed me how important it is to consider policy when developing technical solutions." The most-praised solutions considered both a technical aspect and the wider geopolitical context in which it was deployed, accounting for potential cultural or legal concerns (*e.g.* sniffing dogs are an exceptionally-effective and low-cost solution for explosive detection, but are a cultural taboo in Middle Eastern countries and thus are not a viable universal option for problem set DS-47).

In the context of the communication concerns in *A*, the soft skills of political science students excelled in navigating interactions with government officials. As one master's student noted, "[t]his course has fundamentally changed my perspective on what it means to be an engineer. I have learned that technical expertise alone is not enough; successful engineering also requires effective communication, collaboration, and a deep understanding of end-user needs." While navigating the bureaucratic landscape of the diplomatic service, it was vital to have students with the technical experise to explain finer engineering details to senior officials cogently, and to also have students who understood the federal government well enough to find the right contacts to keep progress from stalling. This became all the more important during site visits.

C. Site Visits as Reifying the Classroom

The promise of international travel was a potent recruitment tool for the program. Upon marketing that student teams would have site visits as part of the course, course enrollment went from well under capacity to a 19-student waitlist by the start of the semester — a free trip to Europe is a powerful motivator. Yet, the site visits were vital in providing experiential hands-on learning alongside progress made in the classroom. An undergraduate engineer noted how "the site visit provided invaluable insight, significantly enhancing our understanding of technical and operational aspects, and directly informing our decision-making process." This was a common refrain. Many of the systems being developed were *in situ* globally. One may develop a viable solution from the comfort of the academy, but to fully understand the context and relevance of their work, teams needed to see these systems in person. Site visits also gave students another chance to develop soft skills — political science students could directly interface with the diplomatic service and work with policymakers at embassies, while engineering students had to refine their ability to explain complex technical concepts to lay audiences coherently.

We must, however, note the significant cost of this endeavor. Site visits were possible for each team in the course, but at a cost in excess of $25,000. This was possible due to a student support grant from the Common Mission Project Student Innovation Fund and Lockheed Martin, which may prove limiting to others seeking to emulate this program. However, we find site visits were exceptional in connecting the classroom to real life, complementing the interdisciplinary lessons of the course, while adding analytical depth to final deliverables from all student teams. With careful planning, similar results could be achieved without expensive international travel — either through domestic alternatives (as with the team addressing DS-51 visiting Washington) or else forgoing visits while preserving the pedagogical aspects of the course.

Conclusions

This paper presents a case study which brought engineering and political science students together in a flipped-classroom, experiential learning course. The impetus for this course is the need for interdisciplinary thinking to address the nation's most pressing national security challenges, especially in the naval landscape. This course thus explores how the two disciplines could be combined to solve real-world problems provided by the Bureau of Diplomatic Security and which engage issues surrounding the AUKUS collective security agreement.

We find students are very receptive to interdisciplinary work and the mixed-team format worked exceptionally well, gaining praise from both students and the DS. The dynamic of students with diverse technical and policy experience allowed for better analytical rigor in problems requiring nuance and sensitivity to international relations. Moreover, the use of real-world problems is critical. The praxis of problem sets sourced from government officials cultivated a sense of ownership for students, driving much of the success of the program. Despite commication and access issues arising from work with federal agencies, we remain adamant that any program seeking to replicate such an interdisiplinary experiential course should endeavor to find government partners. Site visits likewise were a significant boon to experiential learning, which reified classroom concepts. However, due to the significant cost of implimentation, we do not find them to be as crucial to programmatic success. One should endeavor to make student travel available if at all possible, but a similar course can find significant success in developing interdisciplinary thinking while adhering to budgetary restrictions.

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