# Designing IDPro: The Process of Establishing an Interdisciplinary Projects Program for Undergraduates

**Abdulrahman Alsharif, Virginia Polytechnic Institute and State University**

Abdulrahman M. Alsharif is a research assistant for the Engineering Education Department and a PhD candidate at Virginia Tech.

**Dr. Mark Vincent Huerta, Virginia Polytechnic Institute and State University**

Mark Huerta is an Assistant Professor in the Department of Engineering Education at Virginia Tech. He earned his PhD in Engineering Education Systems & Design at Arizona State University and has a BS/MS in Biomedical Engineering. His research focuses on exploring and understanding engineering learning environments. He harnesses these insights to propose solutions that encourage the creation of safe and inclusive educational environments conducive to learning, professional development, and innovation. His research interests include graduate student mentorship, faculty development, mental health and well-being, teamwork and group dynamics, and the design of project-based learning classes.

**Dr. David Gray, Virginia Polytechnic Institute and State University**

Dr. Gray receieved his B.S. in Electrical and Computer Engineering from Virginia Tech in 2000. He then earned a M.S. and a Ph.D. in Materials Science and Engineering from Virginia Tech in 2002 and 2010, respectively. Much of his graduate education focus

**Dr. Lisa D. McNair, Virginia Polytechnic Institute and State University**

Lisa D. McNair is a Professor of Engineering Education at Virginia Tech, where she also serves as Deputy Executive Director of the Institute for Creativity, Arts, and Technology (ICAT).

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## Abstract

This paper discusses the process for establishing a new interdisciplinary program for undergraduate students at [redacted for review]. We build off well over a decade of work by using a Vertically Integrated Projects (VIP) model.  which enables undergraduate students of all levels to participate in various interdisciplinary projects over multiple semesters. A core benefit of VIP is enabling students to bridge theoretical knowledge with practical applications while addressing authentic challenges. VIP facilitates experiential learning where students actively collaborate with peers and faculty, immersing themselves in ongoing research and cultivating skills ranging from creativity to teamwork.  Our Interdisciplinary Projects Program draws from VIP to provide a holistic learning journey with immense potential to advance students' academic and professional development in an interdisciplinary setting. Key steps in designing the IDPro curriculum included adapting a performance-based evaluation model for assessing learning outcomes, identifying and scoping interdisciplinary projects, optimizing team structures of students, faculty mentors, and external partners, and applying an implementation strategy. Challenges involved recruiting faculty and students for diverse projects, assessing individual contributions in interdisciplinary teams, and working across traditional academic units. This paper aims to describe how the program was developed and to share experiences with other institutions looking to establish similar interdisciplinary, experiential learning programs.

**Background**

In the pursuit to further enhance the educational experience of students, in the summer of 2023, our team embarked on the development of an Interdisciplinary Projects Program (IDPro), drawing from our diverse experiences in designing interdisciplinary curricula and adapting the Vertically Integrated Projects (VIP) approach. Over time, our team developed interdisciplinary curricula, including undergraduate design courses, a "pathway" minor, entrepreneurial design, and undergraduate research groups. Adding to this depth of experience, we adapted the successful Vertically Integrated Projects (VIP) model, which had already made significant strides in fostering interdisciplinary collaborations and offering experiential learning opportunities.

VIP programs offer a distinctive pedagogical approach designed to enrich the academic experience of undergraduate students. By emphasizing long-term, large-scale projects, the program enables students to immerse themselves in existing projects, thereby honing their leadership skills [1]. Integral to VIP courses are assignments that necessitate collaboration with faculty and fellow team members, ensuring that students are actively engaged in the nuances of their chosen projects [2]. VIP programs provide opportunities for students to bridge theoretical knowledge from their coursework with practical applications, addressing authentic challenges related to their respective fields [3]. This experiential learning not only deepens their comprehension of their discipline but also positions them as contributors to ongoing research endeavors [4]. Participation in the program cultivates many skills, from creativity and resourcefulness to self-motivation and teamwork [5]. A notable aspect of the VIP model is its community-centric approach, promoting collaboration among undergraduates, graduate students, and faculty. This interconnected environment nurtures mutual respect, innate curiosity, and a spirit of creativity [2]. The VIP model presents a holistic learning journey that holds immense potential for students' academic and professional trajectories [2].

Our journey began by recognizing a gap between first-year project-based learning (PBL) engineering courses and the Interdisciplinary Capstone (IDC) for senior engineering students. We created IDPro to fill this gap, enabling students to engage in long-term, interdisciplinary projects involving community stakeholders, research, industry, and entrepreneurial endeavors in their second and third years. Existing vertically integrated projects, such as the Engineering Projects in Community Service (EPICS) program, were influential in our program design as we sought to broaden the scope beyond just community service projects. In building IDPro, we recognized that existing efforts like [redacted for review], which already engages students in PBL, could be integrated into this programmatic structure to provide a continuous, interdisciplinary experience throughout the undergraduate years.

These programs served a subset of students, and their structures were limited in scale and accessibility. The [redacted for review] program is managed by a single faculty member who is thus responsible for all aspects of the program, from recruitment to pedagogy to administration.

The IDC program is restricted to senior engineering students. Our objective is to develop a new scalable program that would enable students across the university at all academic levels to engage in authentic, interdisciplinary projects. Drawing from the strengths of both courses, we identified key components that could be adapted and incorporated into our new program, IDPro. The emphasis was on providing students with opportunities to engage in real-world projects over multiple semesters in collaboration with community stakeholders. As we developed IDPro, it became clear that integrating design principles across various disciplines was crucial. We believed this would provide students with a unique blend of theoretical knowledge and practical design skills. By combining the foundational elements of [redacted for review] and IDC with the design-focused approach of IDPro, we aimed to create a comprehensive program that would serve students from all disciplines in their early collegiate life (i.e., sophomore and above). In extending the principles from [redacted for review] to IDPro, we also emphasized community building, which is similar to the VIP model's approach. We wanted to ensure that students, graduate participants, industry mentors, and faculty could collaborate seamlessly, fostering an environment of mutual respect, curiosity, and creativity. Our aim in this work-in-progress paper is to outline the program's development process and provide a scalable framework for educators.

**Background of Other Programs**

Vertically Integrated Projects is a multidisciplinary educational model that allows students to work on long-term, large-scale research projects under the guidance of faculty members [3]. In an assessment of the VIP for first-year engineering pathway at a public university, Ramirez and Zoltowski collected data that suggested a positive impact on participants' academic and professional qualities after participating in a VIP program [3]. The survey data highlighted the program's efficacy in fostering research and experiential activities, as reflected in a mean score of 4.14. out of 5. Early engagement in research projects and teamwork has been shown to promote academic success and retention of students in STEM fields [6], [7]. However, undergraduate research experiences differ based on the program objectives and goals. To understand the range of VIP's effectiveness, we surveyed multiple programs worldwide. Starting with the Universidad del Norte VIP Program in Colombia, there is a strong emphasis on multidisciplinary and team-based learning [8]. Here, students from diverse academic backgrounds collaborate in teams, often exceeding 15 members, to undertake long-term research projects. These projects, proposed by faculty members, benefit from the guidance of a faculty advisor. Regular team meetings foster collaboration, while bi-semester peer evaluations ensure continuous feedback and growth [8]. The overarching goal is to yield tangible results, such as publications or innovative prototypes.

Moving to Korea, the Inha University VIP Program stands out as an accredited course with cross-disciplinary teamwork at its core. Under the mentorship of a guiding professor, students engage in long-term projects spanning at least two years. A notable feature is the government's financial support, which aids in the program's endeavors [8]. Seasoned students

play a key role in integrating newcomers, ensuring a smooth transition and knowledge transfer. The program's pillars are research, problem-solving, leadership, teamwork, and communication skills, all of which prepare students for diverse challenges.

Lastly, Scotland's University of Strathclyde VIP Program showcases vast and diverse participation with over 230 students from all academic sectors [8]. These students collaborate on advanced projects with a strong industrial focus. What's remarkable is the multidisciplinary nature of the teams, with participation from students representing more than 35 majors [8]. Beyond technical skills, the program is committed to enhancing students' employability by imparting a wide-ranging skill set. This VIP approach includes unique humanities, entrepreneurship, and life sciences projects.

**Program design**

An essential component of developing IDPro was determining how to effectively integrate it into the curriculum. We explored which existing courses would align well with IDPro projects to provide relevant knowledge foundations. At the same time, we recognized the potential need to develop new courses customized around particular project activities or outcomes. We decided to initially integrate IDPro with the existing [redacted for review] Undergraduate Research and Interdisciplinary Capstone course based on their project-based learning models. Regarding assessment, we promote performance-based evaluation to assess learning outcomes. Ongoing refinement of the curriculum design will occur as the program evolves. Program features include:

1. ***Flexibility in credit.*** We needed to be flexible to allow students to take the course for as many credits as their schedules allowed. Students might have limited time, and opt for a lower commitment, enrolling in a 1-credit P/F course. Others would have more time and would appreciate the ability to substitute the credit earned for elective credits in their major. In this case, students often need a letter grade assessment and more time devoted to the course and will enroll for a 3-credit A-F option. We also supported a 2000-level and 4000-level course. Students in their first semester on a project team would typically enroll in the 2000-level version, and those continuing in the course additional semesters register for the 4000-level. Such flexibility in course administration is not typical for most course types at our institution, but our format does align with university-wide initiatives. For example, we used a Field Study course type that allowed for flexibility and was differentiated from an Undergraduate Research or Independent Study format in that the Field Study counts for “experiential learning” credit required for all undergraduates. In addition, with these affordances students can take the course multiple times, which enables hands-on project-based learning and interdisciplinary professional skills throughout their undergraduate curriculum.

2. ***Diverse portfolio of projects.*** We wanted the program to serve as wide an array of project types as possible, from faculty-led research projects to community service projects to industry-sponsored projects or even student-initiated. Our motivations here were to provide the widest range of possible project types to appeal to a diverse set of student and faculty interests, and to develop a financially viable sponsorship model to support the program's longevity.

3. ***Engaging and supporting faculty coaches***. Faculty time is incentivized in several ways. Different academic units might count faculty coaching of such projects towards their service or teaching load. In some departments, supporting capstone projects is an expectation of the role. One of our challenges was developing a mechanism for incentivizing faculty to serve as coaches in the program. We arrived at a model of a modest fund transfer to an institutional account (such as a general research fund) for each semester of service as a coach. Many faculty members are passionate about mentoring undergraduate research teams but do not receive credit for their time. Engaging these faculty is the basis of our goal to provide value by guiding students through project management–both conceptually and in scheduled deliverables.

4. ***Performance-based assessment.*** Instead of regularly graded assignments, the course is structured around deliverables and performance reviews. Ungraded deliverables include weekly progress reports, meeting minutes, and an individual portfolio near the end of the semester. These deliverables are marked complete/incomplete. Graded deliverables include: 1) a planning document, 2) a midterm presentation, 3) a final presentation, and 4) a final report. Each team presents their work to instructors three times across the semester. These reviews and the weekly progress reports are designed to have students continuously assess their progress, make changes if needed, and update the instructors and coaches.

**Identifying Projects**

A key priority in developing IDPro was identifying a diverse blend of project types, themes, and focus areas that align with the program goals. Specifically, we wanted to incorporate industry-based projects, community service initiatives, faculty-led undergraduate research, sponsored projects, and student-oriented endeavors. This variety would allow students to gain experience across different real-world contexts. We also aimed for targeted interdisciplinarity across the university, not restricting participation to just engineering majors. Involving students from different disciplines in ways that address project goals would enable valuable collaboration and knowledge sharing. The intent was to make IDPro accessible to motivated students and faculty across campus and model transdisciplinarity through purposefully structuring teams to leverage the expertise of different disciplines for particular projects. Pursuing a blend of project types and targeted interdisciplinarity would allow IDPro to provide enriching experiential learning grounded in working on real challenges. By working with faculty, sponsors, students, and other stakeholders, we have created 12 projects from which students can choose. Project titles, descriptions, and types are presented in the table below:

Table 1. Descriptions of Project Titles, Goals, Origin and Disciplinary Breadth

| **Project Title** | **Project Goals** | **Project Origin and Disciplinary Breadth** |
|---|---|---|
| Automatic Measurement of Plant Growth Through Computer Vision Analysis (AMPGTCVA) | Develop a system for automatic image collection, processing, and analysis, with the aim of monitoring and predicting the growth rate of plants in a controlled environment. | Faculty Research<br>School of Plant Sciences, Computer Science, Computational Modeling and Data Analytics, Electrical Engineering |
| Automatic Nutrient Solution Management System for Hydroponics (ANSMSH) | Design and develop an innovative system capable of automatically measuring, analyzing, and adjusting the N/P/K contents and pH levels of nutrient solutions used in hydroponics. | Faculty Research<br>School of Plant Sciences, Computer Science, Computational Modeling and Data Analytics, Mechanical Engineering |
| Bacon Efficiency | Quantify and compare the energy utilized by hydraulic and servo motor-actuated pressing rams in shaping partially frozen pork bellies before slicing. | Industry Sponsored<br>Electrical Engineering<br>Computational Modeling and Data Analytics<br>Animal and Poultry Science |
| Gadolinium-Based Magnetothermal Heat Switch | Create an autonomous heat switch based on the second-order magnetic phase transition in gadolinium. | Faculty Research<br>Mechanical Engineering<br>Physics |
| Huckleberry Trail Counter | Develop, construct, and evaluate a trail counter prototype with the capability to detect and classify individuals in motion. | Community Service<br>Computer Science<br>Electrical Engineering<br>Mechanical Engineering |
| Inclusive Aircraft Interiors for Disabled Passengers (IAIDP) | Investigate opportunities for innovation in aircraft cabins for persons with neurodivergent challenges and demonstrate an implementation in at least application context. | Industry Sponsored<br>Aerospace Engineering<br>Computer Science<br>Computational Modeling and Data Analytics<br>Industrial and Systems Engineering<br>Neuroscience |
| Middle Year Slump | Examining loss of motivation or interest among students during their second or third year in college, this team has developed a survey and | Faculty Research<br>Criminology<br>Cognitive and Behavioral Neuroscience |

| | | |
|---|---|---|
| | interview protocol to explore the observed 'slump' phenomenon. | Psychology |
| Mind-Body Connections in Art | The project explores the body-brain connection in art, specifically stone carving, by recording and sonifying biometric and EEG data to create new art forms. | Faculty Research<br>Animal and Poultry Science<br>Cognitive and Behavioral Neuroscience<br>Industrial and Systems Engineering |
| Phased Array Microphonics | Develop a cost-effective remote, phased array microphone system for applications like classrooms and theaters, allowing selective amplification of audio based on time of arrival. | Faculty Research<br>Clinical Neuroscience<br>Computational Modeling and Data Analytics<br>Computer Science<br>Electrical Engineering<br>Mechanical Engineering |
| Software Managed Arduino-based Residential Toolkit (SMART) | With a focus on preserving user privacy, this project aims to explore and create accessible and affordable smart home devices, utilizing low-cost electronics and coding to enhance security and reduce energy consumption. | Student Initiated<br>Computer Science<br>Cybersecurity Management and Analytics<br>Mechanical Engineering |
| Rural Trash Collection | This project aims to develop a third-generation platform equipped with essential sensors like LIDAR, GPS, and machine vision, capable of automated roadside trash collection. | State Government Sponsored<br>Computational Modeling and Data Analytics<br>Computer Science<br>Mechanical Engineering |

This diversity of projects in IDPro provides opportunities for students across majors and disciplines to work together. Challenges revolve around soliciting projects and developing a centralized model for funding project development. Especially in the pilot semester, it was difficult to solicit projects for a program under development. The program did not have a name, learning outcomes had not been finalized, and the overall structure of the course was still under development. Furthermore, the program had no pedigree, so we could not rely on word of mouth or internal institutional communications to market the program. To fill our initial portfolio of projects, we drew from the [redacted for review] portfolio, from prospective IDC projects that were not adequately scoped for a senior design capstone, and from faculty in our department who had extracurricular side ongoing projects. We had intended to develop a shared funding model where projects would charge a nominal fee to participate in the program. Since many of our projects were drawn from relatively unfunded sources in the pilot year, the budget for faculty

coach incentivization and project materials and supplies were limited. Fortunately, the program was seeded by a gift from a corporate sponsor, investment by the engineering education department, and time volunteered by multiple faculty members to serve as team mentors.

**Team Structure and Project Duration**

We designed the recruitment process to result in teams of roughly 4-6 students. This number was drawn largely from experiences in first-year engineering design courses, undergraduate research, and interdisciplinary project-based learning courses taught or supported by our developmental team. In our experience, 4-6 person teams ensure meaningful contributions from each member while still allowing close collaboration, within certain assumptions about project scope [12]. Too few students may limit the project scope, while too many can make coordination difficult [12]. Since we designed the program around vertically integrated projects, we also had a goal that teams retain at least a nucleus from semester to semester rather than experience frequent complete turnover, as continuity allows knowledge development. Hence, with the guidance of industry and faculty members, interdisciplinary teams of around 4-6 undergraduates can provide an enriching, collaborative environment in which to undertake projects over an extended timeline of two semesters or more.

Another important consideration was defining the appropriate project length and timeline. We opted for projects extending across multiple semesters rather than a single semester or year. Longer-term projects allow students to immerse themselves deeply and see meaningful progress on complex challenges that do not have quick solutions [9]. Short, semester-constrained projects often fail to provide enough time for teams to coordinate, test things out, make improvements, and finalize deliverables, while year-long involvement enables students to continue building on their work rather than constantly restarting [9]. We highly encourage multi-year projects spanning students' entire undergraduate tenures. Multi-year participation allows individual growth as students move into leadership roles and provide continuity for project advancement. While single-year projects offer value, students with continuous multi-year participation can achieve a depth of skills and ownership of outcomes [10]. Thus, full academic year and multi-year projects enable impactful experiential learning, while short semester projects may limit student growth. One challenge to multi-year participation for students is fitting the additional work-load and credit hours into their schedules.

**Faculty Instructors and Mentors**

IDPro is taught through an approach that brings together program and project management. The course is led by a single lead instructor of record (IOR) and a graduate teaching assistant for two-semester timelines. While the IOR establishes the course syllabus, provides content and assignments, conducts performance reviews, and assigns grades, their primary role is critical in terms of administration and program management. This role has a distinct set of responsibilities that includes initiating and sustaining relationships between

stakeholders, monitoring team dynamics, managing budgets, overseeing space, recruiting students, and forming teams. The IOR's responsibilities are focused on program management rather than project management or strictly instructional duties. In addition to the IOR's role, each team requires a faculty or industry mentor to dedicate one hour a week to guide the team and consult on content. Each faculty mentor works with the team for the duration of the project to provide continuity and guidance. Finally, we encourage students and mentors to identify and include a range of stakeholders. This blended approach provides stability while exposing students to diverse perspectives and necessary content expertise. We also aim to incentivize faculty participation by highlighting IDPro mentoring in evaluation processes (e.g., as service and as undergraduate research advising) and providing financial compensation. These development opportunities will be key in sustaining engagement and enrichment for students and faculty in IDPro.

**Implementation Planning**

Thoughtful implementation planning has been and will continue to be critical for launching IDPro successfully. This includes establishing projects, recruiting students, and using an application process to assemble interdisciplinary teams with the needed skills and motivations. Establishing projects is complex but critical to success. A project must be developed by multiple stakeholders, including a funding liaison, a local faculty advisor, the course instructor, and often an industry or community partner. This team creates a project description with background, objectives, content areas, physical space, equipment needs, and lab spaces needed for the project. Cultivating external partnerships with industry, non-profits, government entities, and alumni expands project opportunities. We are also pursuing funding sources through institutional grants, corporate sponsors, and other means of funding. For marketing and outreach across campus, we have used flyers, email communication, and a website that contains descriptions of all the projects and provides channels for students to apply for their desired projects. However, word of mouth between students is proving to be most effective. We successfully received 53 responses in the first semester, and that number increased to 87 in the second semester. Table 2 shows the distribution of students' majors in IDpro.

Table 2. Students Majors breakdown, Fall 2023. The fields range across four colleges at our university, including engineering, business, social sciences, and science.

| **Field** | **Count** | **Percentage** |
|---|---|---|
| Aerospace Engineering | 4 | 7.69% |
| Biomedical Engineering | 1 | 1.92% |
| Chemistry | 1 | 1.92% |
| Cognitive & Behavioral Neuroscience | 3 | 5.77% |
| Computational and Systems Neuroscience | 2 | 3.85% |

| | | |
|---|---|---|
| Computational Modeling & Data Analytics | 7 | 13.46% |
| Computer Engineering | 1 | 1.92% |
| Computer Science | 13 | 25.00% |
| Electrical Engineering | 6 | 11.54% |
| General Engineering | 1 | 1.92% |
| Mechanical Engineering | 5 | 9.62% |
| Neuroscience | 1 | 1.92% |
| Physics | 1 | 1.92% |
| Psychology | 2 | 3.85% |
| Psychology & Criminology | 1 | 1.92% |
| Robotics and Mechatronics | 2 | 3.85% |
| Sociology and Political Science | 1 | 1.92% |
| Total | 52 | 100.00% |

**Limitations**

While IDPro offers exciting opportunities for interdisciplinary collaboration and experiential learning, some potential limitations will need to be addressed. First, the logistical challenges of navigating institutional structures is complex. The curriculum integration between IDPro and existing courses remains a work in progress that will require ongoing improvement. Securing adequate resources such as lab spaces, equipment, and funding sources to support diverse projects poses another limitation. Moreover, the complexity of scheduling and coordinating among faculty mentors, industry partners, and students across disciplines represents a logistical challenge.

The central challenge of our program is to effectively integrate students from vastly different backgrounds into well-fitted teams and enable them to thrive in situations where it is critical to embrace uncertainty. While initial student recruitment efforts have garnered interest, systematically evaluating IDPro's impacts on interdisciplinary learning outcomes and skills development remains essential. We are modeling the assessment of learning outcomes on performance-based evaluation, and our initial program evaluation is based on collecting survey and focus group data from students about their perceptions of growth. Developing robust assessment mechanisms to demonstrate IDPro's benefits will be crucial for the program's longevity and continuous improvement. With thoughtful ongoing mitigation of these limitations, IDpro can fulfill its goal of increasing interdisciplinary collaboration and experiential learning. However, joint efforts from all stakeholders will be critical to ensure the program's smooth functioning and evolution.

## Conclusion

IDPro is an exciting curricular advancement aiming to enrich undergraduate education through experiential interdisciplinary collaboration and project-based learning. As described, IDPro draws inspiration from the success of existing programs like the Vertically Integrated Projects (VIP) model that integrates education with the excitement of real research [11]. To foster inquiry, innovation, and project-based learning across disciplines, the IDPro journey began by adapting components of previous interdisciplinary curricula, including an undergraduate research group and an interdisciplinary engineering capstone. Central to IDPro is linking theoretical knowledge with practical application through long-term industry, community, and research projects guided by faculty mentors [3]. Notable aspects of the development process included identifying diverse real-world projects, structuring interdisciplinary student teams, and planning multi-year timelines to enable deeper immersion. While initial integration with current courses provides a starting point, ongoing curriculum design enhancements may be warranted as IDPro evolves. Key opportunities exist around developing partnerships and resources to support ambitious experiential learning goals. Limitations around team dynamics, scheduling, and logistics present challenges to address. However, the enthusiastic student response spanning over 15 majors suggests a strong demand for IDPro's approach. With careful development centered on student enrichment, IDPro may become a transformative signature program empowering undergraduates across disciplines.

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