Supporting Undergraduate Engineering Students Through an Introductory Drone Education: Impacts on Self-Efficacy, Sense of Belonging, and Engineering Identity: Year 1

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Dr. Jae Ryu is a Professor at the University of Idaho whose research focuses on advancing environmental monitoring through the use of Unmanned Aerial Systems (UAS, commonly known as drones). He currently leads the Idaho/Interstate Drone League (iDRONE), an immersive, STEM-based experiential learning program that engages students from grades 6 to 12. Dr. Ryu earned his Ph.D. in Civil and Environmental Engineering from the University of Washington, Seattle, in 2006. From 2015 to 2016, he participated in the U.S. Air Force Faculty Fellowship Program at the United States Air Force Academy (USAFA), where he gained hands-on experience with various UAS technologies and sensor platforms. In addition to K-12 education, his ongoing educational research activities supported by NSF RIEF and REU grants aims to enhance the impact of UAS research and engineering education and outreach at higher education. Dr. Ryu's efforts will help broaden participation within the ASEE community and strengthen the nation's competitiveness in the UAS ecosystem and global job market in the years ahead.

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Background

Engineering students face different difficulties in their undergraduate studies. For example, many first-year engineering (FYE) students face transitional challenges adapting from high school to university environments, with research frequently reporting high attrition rates during and after the global pandemic (COVID-19) [1-3]. Literature emphasizes that psychosocial factors, particularly self-efficacy (SE), sense of belonging (SB), and engineering identity (EI), serve as crucial determinants of student persistence and success in engineering programs [4-9]. COVID-19 accelerated the adoption of flexible learning modalities in engineering contexts. However, limited research exists on the effectiveness of learning approaches that integrate emerging technologies in the development of FYE students [10]. This project, funded by the National Science Foundation's Professional Formation of Engineers: Research Initiation in Engineering Formation (NSF PFE: RIEF) program, investigated how the introduction of drone education to engineering students influences the development of their SE, SB, and EI.

Drone technology provides an exceptional platform for engineering students to apply and integrate knowledge from multiple disciplines. It combines mechanical engineering for designing lightweight, aerodynamic structures through 3D modeling; computer science for developing software-guided autonomous flight missions and incorporating artificial intelligence (AI) for perception and decision-making; and electrical and electronic engineering for optimizing power distribution, sensor integration, and circuit performance. In addition, civil engineering students can utilize drones to inspect construction sites and ensure operational safety, while robotics offers opportunities to achieve mission-oriented, automated tasks such as environmental monitoring or sample collection. The multidisciplinary nature of drone technology not only strengthens student technical competency but also fosters collaboration, creativity, and systems thinking essential for modern engineering practice. This study, therefore, addressed the need for flexible pedagogical approaches that accommodate diverse student learning preferences while fostering their engineering identity development [11].

Project Approach and Implementation

The research team implemented "Drone 101: Introduction to Drones" in Spring 2025 as a one-credit course at an R1 public university in the U.S. Pacific Northwest. This course initially targeted undergraduate students across multiple engineering disciplines, including computer science, mechanical, electrical, bioengineering, and agricultural engineering. The course utilized two delivery learning modes: in-person and HyFlex, allowing students to choose between in-person participation or remote participation via Zoom. Of the 17 students who registered for the course, 14 attended in person, and 3 participated remotely. It should be noted that 14 students took either the pre-survey, post-survey, or both, and three students took part in the interviews in addition to survey activities. The curriculum integrated hands-on learning experiences, including drone building from scratch and coding using open-source software, 3D modeling, drone

component design and fabrication using 3D printing, and interdisciplinary team collaboration. Students worked in pairs from different engineering disciplines to develop engineering solutions for drone-related projects, including but not limited to transportation, delivery services, wildfire monitoring, and law enforcement. The HyFlex format enabled virtual collaboration through Zoom breakout rooms, ensuring remote students maintained meaningful engagement with their partners [12]. Students responded to an online survey comprising demographic information, six-point Likert-scale items (1 = Strongly Disagree to 6 = Strongly Agree), and open-ended questions on motivation, self-efficacy, sense of belonging, and engineering identity. Pre- and post-surveys were administered at the beginning and end of the course, respectively, to assess changes in students' perceptions of motivation, engineering self-efficacy, sense of belonging, and engineering identity. Finally, three volunteer students were interviewed after the semester ended.

Key Findings and Contributions

The project successfully demonstrated the feasibility of delivering a technology-intensive engineering course by using HyFlex mode while maintaining hands-on learning experiences essential for engineering skills and mindset development [13]. Preliminary observations indicated that the flexible format accommodated diverse student needs without compromising collaborative learning opportunities or technical skill acquisition. Additionally, the interdisciplinary collaboration structure fostered cross-disciplinary understanding and communication skills critical for modern engineering practices [14].

Table 1 summarizes descriptive statistics for all participants' responses on the six-point Likert-scale items. Pre-survey results indicated that, prior to the course, students on average rated the introductory drone course's potential impact on self-efficacy between Somewhat Agree and Agree; after the course, the mean shifted upward to fall between Agree and Strongly Agree. Students' sense of belonging also increased, although the average ratings remained within the Somewhat Agree–Agree range. Likewise, the mean rating for the course's influence on engineering identity rose modestly; however, responses still clustered between Somewhat Disagree and Somewhat Agree, suggesting a neutral overall perception of identity change.

Table 1. Descriptive analysis of all participants' perceptions of self-efficacy, sense of belonging, and engineering identity (adopted from [15])

	Pre-survey			**Post-survey**		
	n	***M***	***SD***	***N***	***M***	***SD***
Self-efficacy	13	4.67	0.23	8	5.19	0.18
Sense of belonging	13	4.03	0.43	8	4.58	0.48
Engineering identity	13	3.44	0.54	8	3.87	0.72

Table 2 contrasts open-ended responses from first-year and upper-year students. The excerpts are aligned with the pre- and post-survey results by presenting matched responses from the same student at each time point. Each pre–post response pair represents a different individual, illustrating how students in both cohorts described changes in motivation, self-efficacy, sense of belonging, and engineering identity from the start to the end of the course.

Table 2. Comparisons of first- and upper-year engineering student example open-ended response

(adopted from [15])

Perceptions	First-Year Engineering Students	Upper-Year Engineering Students
Motivation (Based on Expectancy-Value Theory)	*Pre: "I have always been interested in drones, but have had limited access to them. I hope that I can learn the fundamentals of drone construction, coding, piloting, and general knowledge about drones. I hope that I will be able to use this knowledge moving forward with my schooling and career."*	*Pre: "I was already interested in drones and I worked at a drone start up but I wanted to learn the fundamentals of building them and a whole understanding of the systems involved"*
	Post: "It helped me understand how drones work better, due to having built one and learning about propeller direction."	*Post: "It reinforced my previous interest by giving me a better base understanding of drones."*
Self-Efficacy (Student)	*Pre: "It's another class that requires time to be blocked out each week but I think it's very doable."*	*Pre: "With this class I can get a better understanding of the hardware aspect that pairs with the software."*
	Post: "Intro to Drones assisted my capability to perform successfully as a student."	*Post: "Not sure there was much of an impact."*
Sense of Belonging	*Pre: "Classes that increase my knowledge of a certain technology or industry tend to make me feel more included in engineering."*	*Pre: "I'm not entirely sure."*
	Post: "I feel more included as an engineer now."	*Post: "Building the drones made me feel like the engineering part was possible rather than just the software as a CS major."*
Engineering Identity	*Pre: "I think it will increase my confidence as an engineer now and later."*	*Pre: "No individual course affects my feelings about whether I am an engineer."*
	Post: "I see myself as more of an engineer now."	*Post: "It hasn't. I know I'm an engineer"*

Dissemination and Future Work

Course materials have been made publicly accessible through the project website (https://sites.google.com/view/introtodrones/home), supporting broader adoption of similar pedagogical approaches. A comprehensive pre- and post-survey analysis evaluating changes in students' motivations, SE, SB, and EI is currently underway, with the results informing curricular refinements needed for future implementations. This study addressed a gap in the engineering education literature by examining how an introductory drone course influenced engineering student motivation, self-efficacy, sense of belonging, and engineering identity.

Overall, the findings suggest that the course positively impacted first-year student self-efficacy,

sense of belonging, and engineering identity. Moreover, these benefits were generally comparable for first-year and upper-level students; in some areas, most notably sense of belonging, the gains appeared more pronounced for first-year students. Collectively, the results indicate that offering an introductory drone course to first-year engineering students can strengthen foundational understanding of drone technologies while also supporting improved self-efficacy, sense of belonging, and engineering identity outcomes. This NSF RIEF supported research contributes to the growing understanding of flexible learning environments in engineering education while addressing the specific needs of engineering students in their undergraduate study.

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