Providing Research Experience to Undergraduate Students in NASA Summer Bridge and Internship Programs

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Abstract

Undergraduate students need exposure, initiation, motivation, and guidance to develop an orientation toward research that will benefit them not only in their capstone projects but also in their future careers. Elizabeth City State University (ECSU) made such an opportunity available to the rising junior and senior students of the Engineering Technology program.

Fifteen rising junior students were selected to participate in the summer bridge program, and four rising junior and senior students were selected to participate in a summer internship program at the Coast Guard's aircraft facility. The project's scope was to engage students in designing, prototyping, and fabricating Unmanned Aircraft Vehicles (UAVs) and related topics since ECSU has vital Aviation and UAV programs. All the extracurricular activities were supported through a grant from NASA.

This paper not only presents the details of the work carried out but also highlights the significant outcomes of the projects. It concludes with a roadmap for the continued development of these initiatives, providing a clear vision for the future. Additionally, it reports the assessment and tangible outcomes of the project, showcasing the practical value and potential of these programs.

Introduction

ECSU received a grant from NASA to prepare students with advanced manufacturing competencies delivered through practical manufacturing training, including academic preparation, summer bridge workshop, internship experience, and industry certification. The novel of building academic preparation was reported in ASEE 2023 [1] and IMEC conferences [2]. This paper reports on the workshop and internship activities and findings that introduced and provided hands-on activities in reverse engineering techniques, design, simulation software, 3D printing, and manufacturing processes.

Workshop

A two-week summer bridge workshop in advanced manufacturing using drone platforms for designing and manufacturing processing was accomplished at ECSU in June 2023. The Engineering Technology student participants were engaged with lectures on the introduction to UAV design, SIMNET simulation software [3], design of airframes, and prototyping and fabrication of drones. The workshop surveys were given to the participants to assess the workshop's impact on the baseline knowledge of conceptual design and manufacturing process.

Two groups of students were formed to accomplish the goal of the summer bridge program. One group focused on the structure design and fabrication of a fixed-wing UAV, while the other worked on a quadcopter's airframe design and fabrication. The design was accomplished in two stages. In the first stage, students used SIMNET as the software tool to configure models in SIMNET that can fly virtually with a remote control attached to the computer. After the design was altered to make it maneuverable with all acceptable flight characteristics, it was imported to

SolidWorks CAD software, where the structure design was refined to make it 3D printable. The students were trained to make the components on Stratasys and MakerBot 3D printers. The process of designing and fabrication of the drones is depicted in Figures 1-5.

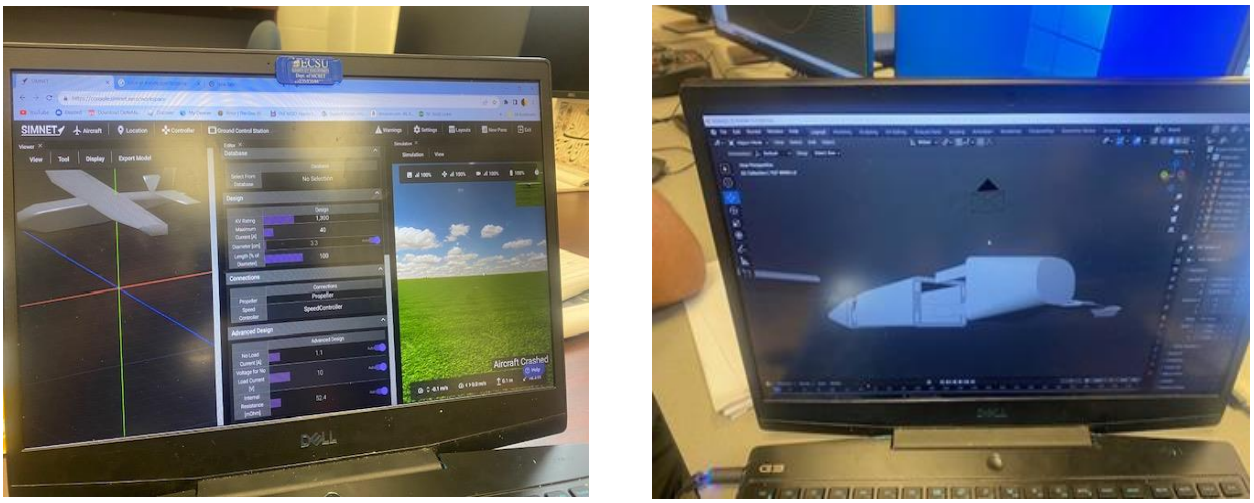

Fig. 1: SIMNET simulation of fixed wing UAV

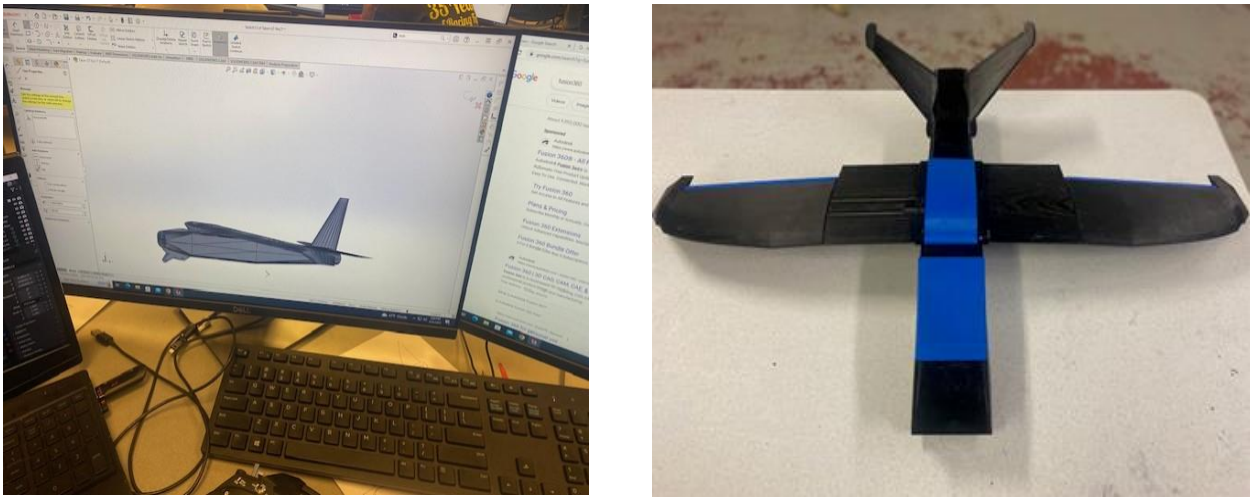

Fig. 2: CAD design and prototyped fixed wing UAV

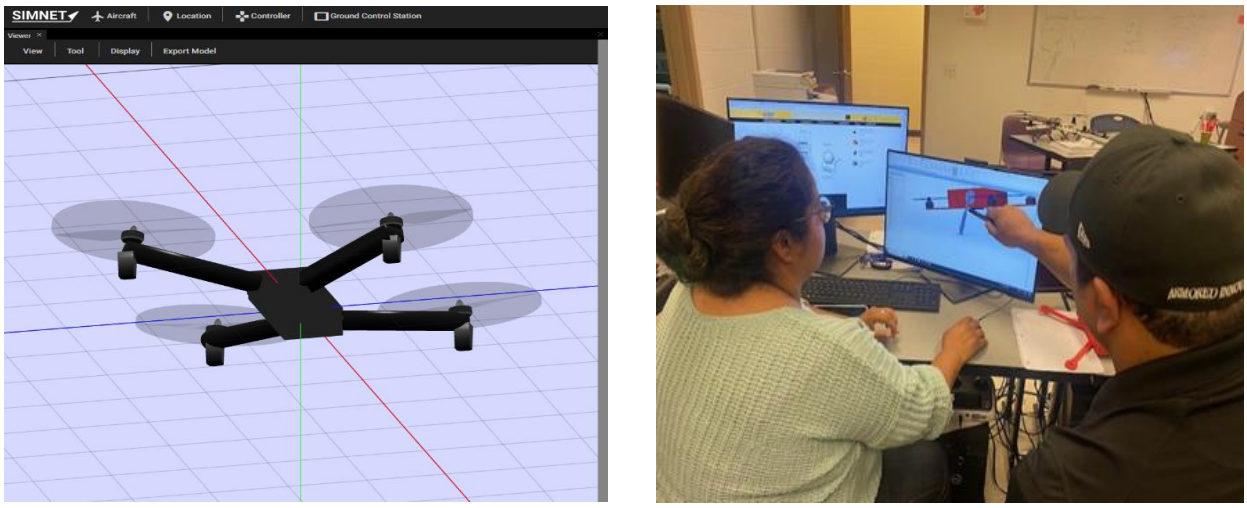

Fig. 3: SIMNET simulation and modeling of quadcopter

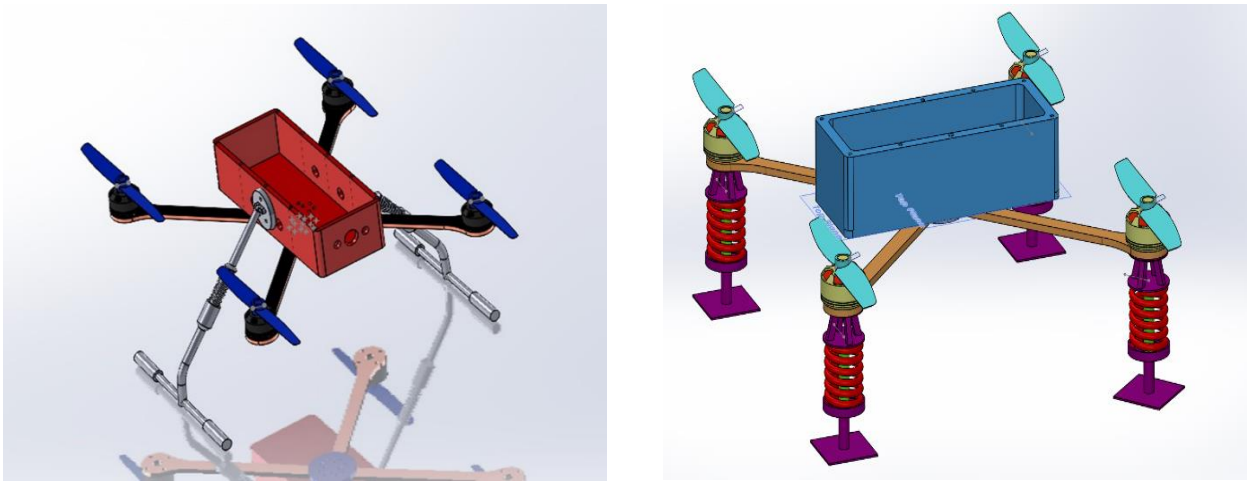

Fig. 4: CAD models of UAV with two different landing gear models

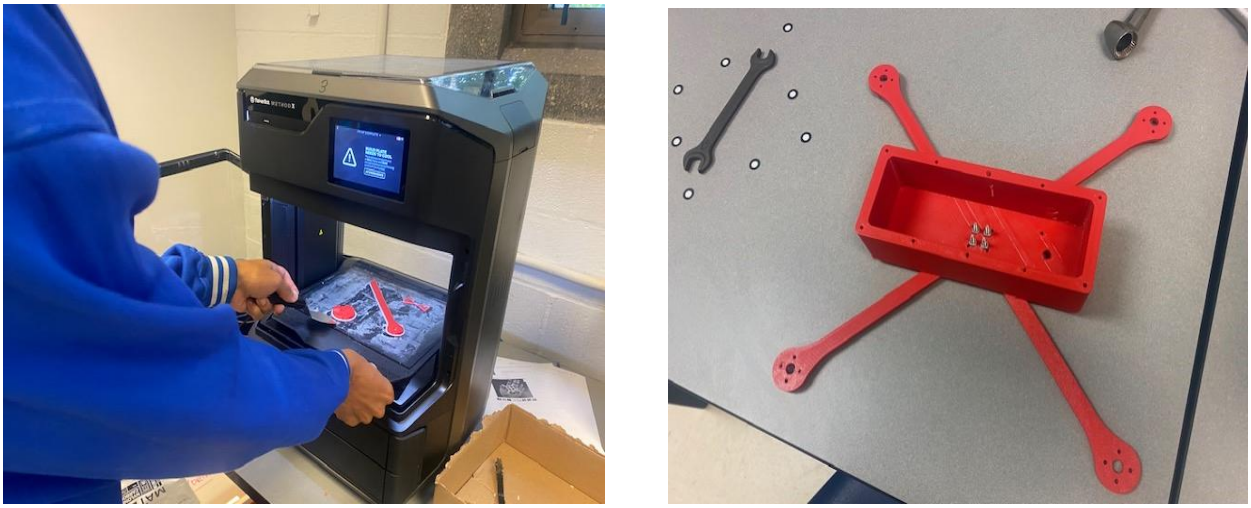

Fig. 5: Prototyping the quadcopter.

In addition, the students observed three presentations from industry representatives, including engineering materials presented by Coast Guard engineers, demonstrating 3D scanning technology [4] representative, and drone technology by the consulting company. All these presentations provided an opportunity for hands-on experience with the equipment and software. Students were fully engaged during the presentation, asking questions before the beginning, during, and after. The students were eager to try the technology and remained task-focused throughout the hands-on opportunity. The presentations and demonstrations are depicted in Figures 6-7.

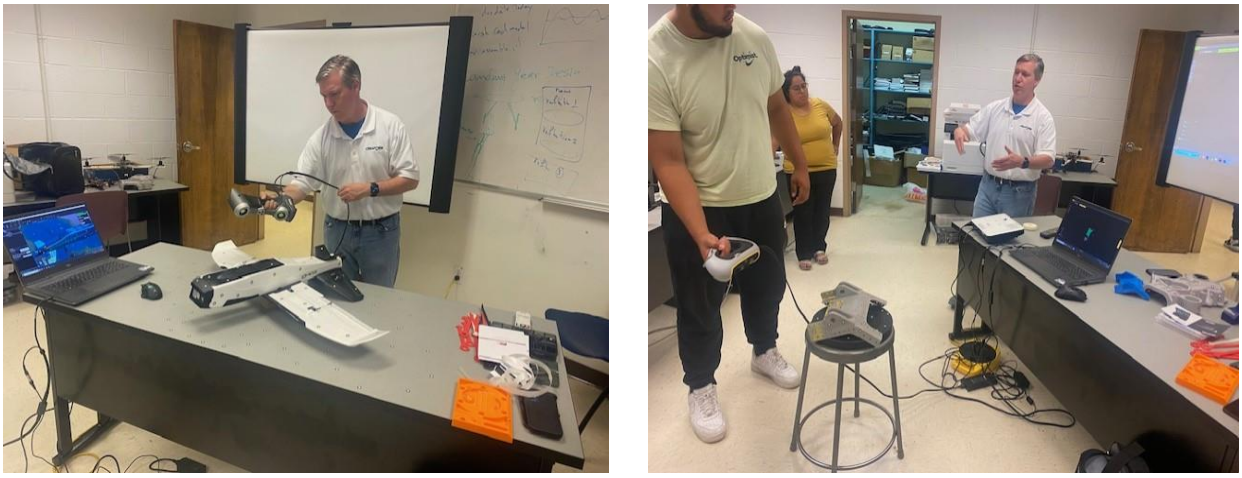

Fig. 6: 3D scanner presentation and operation

Fig. 7: Measurement and calibration presented by industry representatives

Internship

The other four students attended a five-week internship program at the Coast Guard's aircraft facility to determine the safety of connecting the Search and Rescue (SAR) Litter V-Rings and the Triton Harness to the Rescue Hook simultaneously. Figure 8 shows pictures of the components.

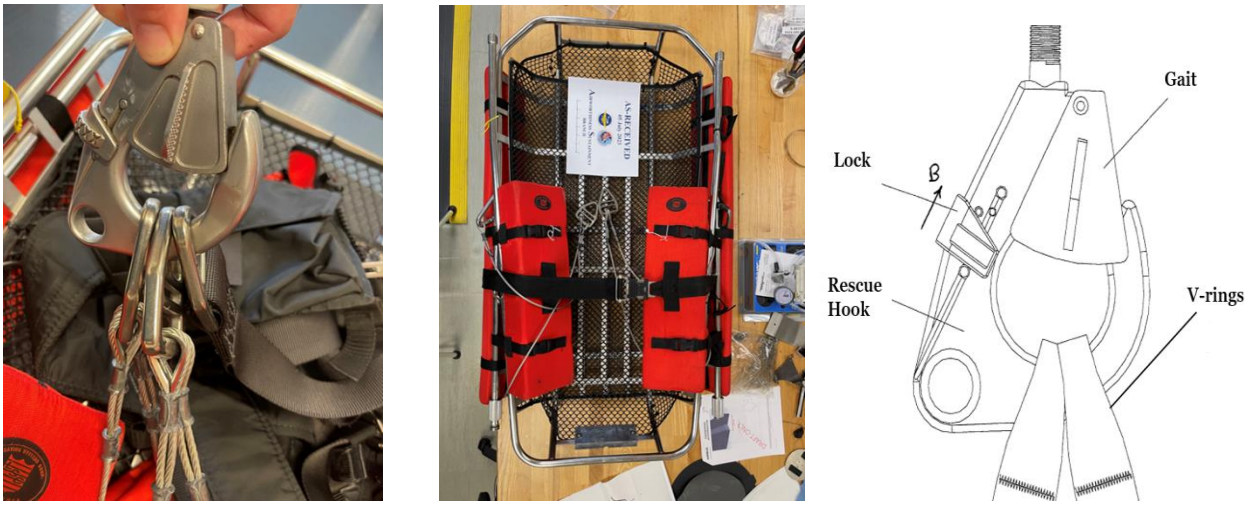

Fig. 8: Components of hook and SAR

Interns conducted physical testing to determine the required force to retract the lock, and also Finite Element Analysis (FEA) included force analysis on the Rescue Hook's Gate and Slide Latch and the corrosion potential of the Gate's Torsional Spring. Interns used the faro arm [5] to get hook measurements and generate a CAD model in SolidWorks software for stress analysis. Figures 9 and 10 show the modeling and simulation of the hook and interns in the Coast Guard facility, respectively.

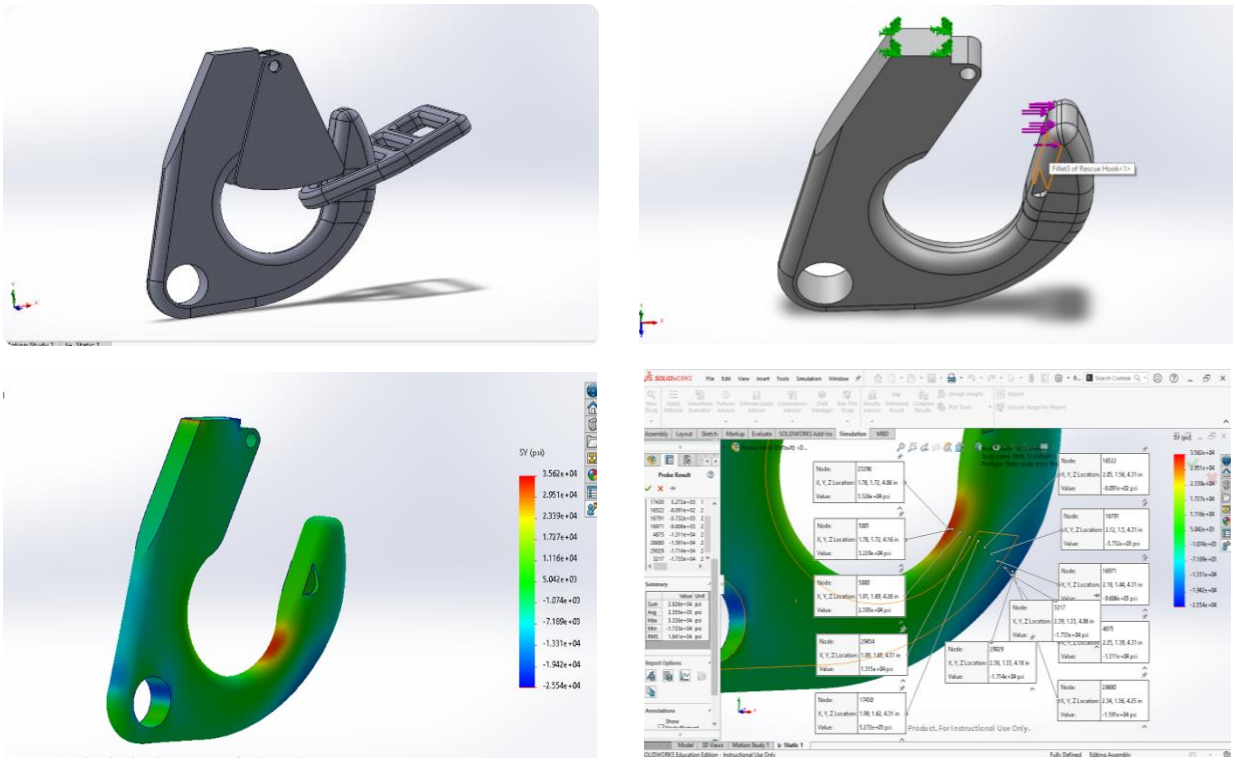

Fig. 9: CAD and FEA model of hook

Fig 10: Interns in Coast Guard facility

In addition, interns used classical analysis calculations to find the maximum and minimum stresses and compared them to FEA simulation results to validate the FEA simulation results.

Survey Results

The assessment data collected by rubrics are summarized based on predefined criteria. The students were deriving a great deal of benefit from their experience. These observations were confirmed by their responses to the survey. The rubrics are given in Appendix I and II.

a. Workshop survey results

Students who attended the summer bridge program provided feedback using the rubric in Appendix I, which assesses their perceptions of the workshop's effectiveness. Here is a summary of the assessment.

In their opinion, students were asked to indicate how 'effective' the overall Summer Bridge program and its components were in providing them with necessary knowledge, skills, and abilities on a scale from 1 (Not at all effective) to 6 (Extremely effective). The frequencies are shown in Table 1, with the mode for each indicated. Students overwhelmingly indicated the overall program, and the individual components were effective. Fourteen students responded to the survey and almost all of them were highly interested in participating in a similar experience in the future, which is a testament to the program's success.

Item	Not at all effective 1	2	3	4	5	Ex-tremely Effective 6	N/A
1. In your opinion, how effective was the overall Summer Bridge experience in providing you with important knowledge, skills, and abilities?	-	-	2	2	2	8	
Effectiveness of each of the following							
2. Training on industry-related competencies	-	-	-	4	5	4	-
3. Increased training on design software	-	1	1	1	2	9	-
4. Increased training on manufacturing equipment	-`	-	-	2	6	6	-
5. Instruction related to technical writing	-	2	3	3	1	1	4
6. Workshop(s) on entrepreneurship	-	-	2	5	1	4	2
7. Workshop(s) on financial accounting	2	2	3	1	-	1	5
8. Workshop(s) on business operations	-	1	3	5	-	2	3
9. Workshop(s) on workplace etiquette and preparedness	1	1	1	3	3	4	1
10. Workshop(s) on product commercialization	1	2	-	2	3	4	2

Table1: Ratings of the overall summer bridge experience

Student self-efficacy was assessed using the Engineering Skills Self-Efficacy Scale [6]. The scale was developed to assess the different dimensions of self-efficacy for undergraduate students across various engineering-related disciplines. The measure reports three sub-scales: Experimental Skills, Tinkering Skills, and Design Skills. To assess the effectiveness of the additive manufacturing project-based experiences, the project evaluator wrote four items modeled on the existing items on the Engineering Skills Self-Efficacy Sub-Scales to comprise an Additive Manufacturing Skills sub-scale. The content reflects the specific skills identified in the project design. Students respond using a 6-point Likert-type scale from 1 (Completely Uncertain) to 6 (Completely Certain).

Cronbach's coefficient alpha was calculated to assess the internal consistency of each scale. The Engineering Skills Self-Efficacy sub-scale values were good and consistent with those reported in previous research. The value was borderline for the newly developed Additive Manufacturing Skills scale, suggesting that the number or content of the items may need to be reviewed.

The means for all the scales were above the mid-point, suggesting that students had confidence in their abilities. As more data is collected in later semesters, the analyses will examine how self-efficacy changes over time. Engineering self-efficacy is reported in Table 2.

Engineering Self-Efficacy				
Scale	alpha	Mean	SD	Range
Experimental Skills	0.85	4.88	0.99	2.75 - 6.00
Tinkering Skills	0.87	5.17	0.88	3.00 - 6.00
Design Skills	0.92	4.81	1.20	2.25 - 6.00
Additive Manufacturing Skills	0.67	4.77	1.01	2.50 - 6.00

Table 2: Engineering self-efficacy

In addition, students were asked two open-ended questions concerning the Summer Bridge experience. The responses are summarized in Table 3. The example responses are paraphrased.

Most important thing you learned during this Summer Bridge experience?		
# of Comments	Category	Examples
4	References to specific equipment or skills	• …learned how to use 3D scanner… • …hands on experience using CAD design… • …technical know-how to use simulation software…
4	Personal: Self-efficacy, confidence, resilience	• …don't need to doubt myself. Be confident in my skill set… • …try new things before you say you can't do them… • ..confidence in having an idea.. researching, developing, designing. Producing…
3	Industry knowledge (growth, etc.)	• …professions that go hand in hand… • …different. Opportunities there are out there for us…
2	Professional skills: Networking & entrepreneurship	• …the more people you meet the more opportunities open…

Table 3: Responses to open-ended questions

These competencies include cognitive functions, skills, knowledge, and abilities essential for successful performance in the advanced manufacturing industry.

b. Internship survey results

Students who attended the internship program provided feedback using the rubric in Appendix II that assesses the students' perceptions of the internship's effectiveness. All four students indicated that their internship had increased their interest in aerospace-related additive manufacturing. Table 4 shows the summary of the assessment.

1. What did you find was the best thing about your internship experience?
• All students reported the hands-on experiences as the best part. • Two students mentioned that the work "really mattered" instead of simply being a class assignment.
2. What did you least like about your internship experience?
• Two of the students mentioned financial concerns. Expressly, room and board are not being provided by the University. This appears to have posed a particular problem for the participants as the stipend were paid in two increments at the middle and end, with no funds available at the beginning of the experience. • Other concerns were related to a brief start-up "miscommunication" (as described by the student) regarding the project they were supposed to be involved in and a disappointment that the project was not directly related to the student's specific career interest.
3. If you were going to participate in another internship, what would you do differently?
• Two students essentially said that they would do nothing differently. • One student mentioned wanting to work more "efficiently" to complete more project-related activities. • One student mentioned being better prepared for the financial challenges (i.e., room and board, stipend payment schedule)
4. How has this internship experience affected your academic and/or career plans?
• Two students reported academic-related changes, with one saying they felt more prepared for their upcoming courses and one reporting feeling more motivated to perform well academically. • The other students did not report specific changes; rather, the experience had reinforced their commitment to the field.

Table 4: Interns responses

All the interns responded to question five that they were more interested than I was before.

Summary

The impact of this project is significant as it addresses the growing demand for hands-on STEM education tools. By providing undergraduate students access to purpose-built educational drones, we aim to enhance their skills, promote innovation, and prepare them for careers in industries increasingly relying on drone technology and additive manufacturing. Furthermore, this project fosters interest in STEM disciplines and encourages students to explore emerging technologies.

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Reference

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[3] SIMNET simulator-Drone simulation and training. https://www.simnet.aero/simulator

[4] Creaform portable handy scan 3D. https://www.creaform3d.com/

[5] Faro arm-3D measuring and reverse engineering arm. https://www.faro.com/

[6] Mamaril, Natasha A.; Usher, Ellen L.; Li, Caihong R.; Economy, D. Ross; Kennedy, Marian S., "*Measuring Undergraduate Students' Engineering Self-Efficacy: A Validation Study*," Journal EJ1255073, ISSN-1069-4730, 2016.

APPENDIX I. Student Summer Bridge Survey

Completed by all students as they complete the Summer Bridge experience. Student responses will be linked to their responses on the Student Course Feedback Surveys.

1. In your opinion, how effective was the overall Summer Bridge experience in providing you with important knowledge, skills, and abilities?					
1 Not at all effective	2	3	4	5	6 Extremely effective

The next set of questions concern how effective you believe each component of the experience was.

2. Training on industry-related competencies					
1 Not at all effective	2	3	4	5	6 Extremely effective
3. Increased training on design software					
1 Not at all effective	2	3	4	5	6 Extremely effective
4. Increased training on manufacturing equipment					
1 Not at all effective	2	3	4	5	6 Extremely effective
5. Instruction related to technical writing					
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6. Workshop(s) on entrepreneurship					
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8. Workshop(s) on business operations					
1 Not at all effective	2	3	4	5	6 Extremely effective
9. Workshop(s) on workplace etiquette and preparedness					
1 Not at all effective	2	3	4	5	6 Extremely effective
10. Workshop(s) on product commercialization					
1 Not at all effective	2	3	4	5	6 Extremely effective

Your Final Thoughts

11. What do you think is the most important thing you learned during this Summer Bridge experience?

12. What would you suggest as ways that this Summer Bridge experience could be improved?

Appendix II. Student Internship Survey

This survey would be completed by students as they complete their summer internship experience.

1. What did you find was the best thing about your internship experience?
2. What did you least like about your internship experience?
3. If you were going to participate in another internship, what would you do differently?
4. How has this internship experience affected your academic and/or career plans?

5. How has your internship affected your attitudes towards learning more about additive manufacturing, including careers in aerospace-related additive manufacturing?

- o I am more interested than I was before.
- o I am less interested than I was before.
- o I was interested before, and this has not affected my interest.
- o I was not interested before, and this has not affected my lack of interest.