ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #32070

Re-Engineering a Mini-Drone as a Project for First-Year Engineering Students

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Full Paper: Re-Engineering a Mini-Drone as a Project for First-Year Engineering Students

Introduction

Drones, also known as unmanned aerial vehicles (UAV), have a major influence on our daily lives including transportation, agriculture, communication, and environmental preservation [1]. A wide range of drones with capabilities to adjust in confined man-made spaces are being utilized in situations where the presence of humans is difficult, or dangerous. In recent years, drones have been developed with improvements in fabrication, navigation, remote control capabilities and power storage systems [2].

Although the use of these autonomous flying robots was earlier restricted to only military purposes, they have now been extended to commercial or civilian purposes as well. Aerial photography for documentaries, journalism, land surveys, and real estates have become much easier with the use of drones. Crop investigations, and power and gas pipeline inspections from a safe distance has now become possible with the help of drones. Recently, companies have also been investing time to develop drones for shipping and delivery to access remote areas and thus reach out to a wider population [3]. Another recent development is the use of underwater drones to study shipwreck, inspect offshore rigs, and underwater pipelines etc. [4]

As drones become an integral part of our daily lives, it becomes important for engineers to learn about their operation, design, and applications. Keeping this in mind, a design project is developed to integrate drones into the curriculum of first-year design course. This paper further elaborates on the activities performed to implement this idea, as well as the authors' efforts in indulging the students' interest into the topic and thus, in the process giving a hands-on experience in reverse-engineering, assembling, and redesigning a mini drone in a first-year engineering design class. The authors believe that this is an engaging activity to introduce the concepts of engineering design to the students and in line with other successful activities integrated in the past [5, 6].

Literature Review on Drone-based Projects

Many schools and universities have tried to incorporate drone technology and its importance into their curriculum to create awareness among the students about its benefits and give them an advantage over others in the competitive world outside. Several institutions focus on the use of drones in the field, their applications in engineering, and as a means to promote ethics. Russell and Ristvey of University Corporation for Atmospheric Research (UCAR) establish that story-driven engineering tasks, where real life obstacles were given to students to realize the potential of drone technology, encouraged student enrolment in the course and enhanced their understanding at a practical level. These tasks focused on flying, comprehending the

performance limits of drones, mounting attachments such as cameras or weights for the study of aerial surveys, and data collection using sensors [7]**.** Similarly, Rowan University combines studies of drone technology along with discussions on social justice, equality and how engineers can create a positive difference in the world [8].

On the other hand, some universities focus more on the design and working aspect of the drone technology. Purdue University has integrated drone technology along with the study of a few software. Students are first required to design a frame for the quadcopter, check proper fitting and finally 3D print the parts, assemble them, and take it for a test drive. Many students were later known to create more advanced quadcopters on their own, once the course has been completed [9]. A few universities have even incorporated drone technology via competitions rather than making it a part of their curriculum. Students from all years of Mississippi State University are encouraged to form teams to participate in a competition where tasks such as retrieving secret codes or collecting important data are provided. While learning about drone technology, design and its applications, students also learn to work in teams, communicate with others, ask questions, and use the power of their imagination as well [10].

Methodology and Implementation

The fundamentals of engineering design course at New Jersey Institute of Technology (NJIT) is offered to all incoming first-year engineering students. Students take different versions of this course depending on their major, although, the goals and learning outcomes are consistent across all offerings. The authors are involved in the planning and the instruction of this course for the General Engineering student population. General Engineering houses students that are still deciding their major and those who are underprepared for engineering study based on their application data. In Spring 2019, four (4) sections of the design course were offered for General Engineering, with 85-95 students in total. This course is set up as a common lecture for all four (4) sections with separate laboratory experiences in a computer lab. In each of the four (4) lab sections, students are asked to form teams of three to work on the drone project.

For this project, students are asked to (1) reverse engineer, (2) physically assemble, and (3) redesign a mini-drone. The objective of this project is to introduce engineering world – from all its angles – to students and teach them how to transform an idea into a real product. The students are asked to come up with their own designs to create a drone with improved capabilities by either altering the basic drone body already provided or starting from scratch. For simplicity, design process is subdivided the into three (3) milestones as discussed below. Students spend the first nine weeks to learn the 3D modeling software, get trained on the 3D printers, and attend a soldering workshop. They are then expected to complete the following milestones in the remaining weeks of the semester with lab time dedicated to assisting them and keeping them in check.

Milestone 1: 3D Model all parts of Drone in Creo Parametric

Each group is given a mini drone kit bought from RadioShack (see Figure 1). Each kit encloses the components shown in Table 1. All groups are asked to measure and hand-sketch each component as a step prior to 3D modeling. This pre-step is not graded. However, it is a crucial step before starting with 3D modeling. Once the sketches are completed, students use their 3D modeling skills they learned, to produce 3D models on CREO Parametric. Figure 2 shows various parts that comprise the mini drone. By the end of this stage, students have 3D modeled all the parts that constitute the drone.

Table 1. RadioShack mini drone kit

Component	Quantity
Upper Shell	1
Lower Shell	1
Remote Control	1
Battery	1
Charger	1
Motors	4
Propellers	4 (+2 spare parts)
LEDs	5
Screws	12
Circuit Board	1
Landing Buttons	4

Figure 1. RadioShack mini drone kit

Once all individual parts are modeled, students assemble them together to come up with the whole final product – this is called the initial model of the mini drone. Figure 3 shows the drone assembly in unexploded view. The 3D modeling process has been simplified for the students by applying the following simplifications:

- Circuit board can be modeled as a simple rectangular piece without the electronic components (transistors, resistors, etc.)
- Adding wires in the 3D model can be skipped
- Adding threads onto screws can be skipped
- The remote control can be designed as one unit – without disassembling it

Milestone 2: Build the Drone by Assembling all Physical Components

The drone is physically assembled by putting all the original pieces from the RadioShack kit together. The instructional team organize a soldering workshop to teach students how to properly solder motors and LEDs onto the circuit board. First, all four (4) motors and five (5) LEDs are soldered following the proper polarity. The mini drone kit comes with a user manual that clearly indicates the proper polarity/ports for both LEDs and motors. Second, the circuit board, the battery, the motors, and the LEDs are fitted in the proper position in the bottom shell. Once everything is in place, the top shell is screwed to the bottom one and the drone is ready to fly.

Milestone 3: Redesigning the drone

After flying the drone, each group is assigned to redesign the drone. Some redesign ideas are shared with the students (e.g. add a landing pad; design a motor cage; design a more aerodynamic body). Additionally, a basic drone (starting part) body designed by the instructor is provided to each group. Students can either add upon the basic design or come up with new designs from scratch. The newly designed model is expected to incorporate the battery, the circuit board, and the motors. While redesigning, the students are motivated to gather potential ideas for redesign. This task is essential, not only for students to comprehend the design limitation and constraints, but also to learn and build teamwork skills. This helps them explore the possibilities with a better understanding of the variety of shapes and sizes to be considered and how each factor would contribute to an overall effective design.

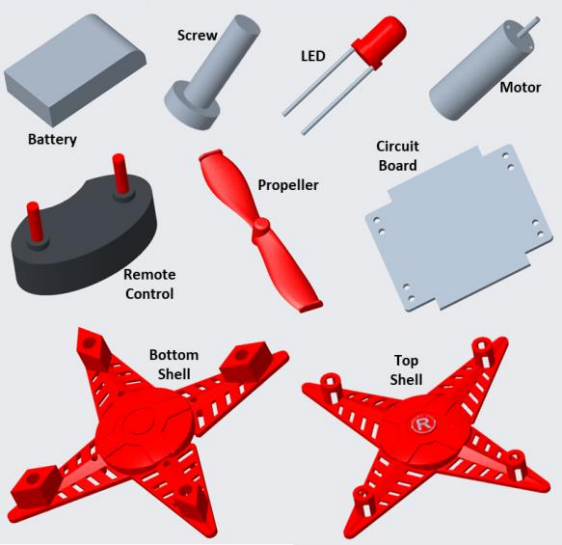

Figure 2. All mini drone parts 3D modeled on CREO Parametric

Figure 3. Mini drone assembly in unexploded view

After redesigning the drone, students 3D print the newly designed part(s) and rebuild their drones. At this stage, students are able to conclude whether their design is better than the original design that came with the kit. A better model can have one or more of these: (1) lighter in weight, (2) more aerodynamic, and (3) safer for the user (e.g. has propeller cages). Figures 4 and 5 show a better and successful (a redesign is considered successful if the new drone is still able to fly) and unsuccessful designs, respectively. In Figure 4, the new design is lighter than the original, and the drone is able to fly. In Figure 5, adding propeller cages results in a very heavy drone. As a result, the motors could not lift the drone up – and the drone fails to fly.

Student Feedback and Discussion

To assess the effectiveness and impact of this new project concept on students, a survey was developed that students were asked to take upon completion of the project. The survey was

Figure 4. Successful lightweight redesign

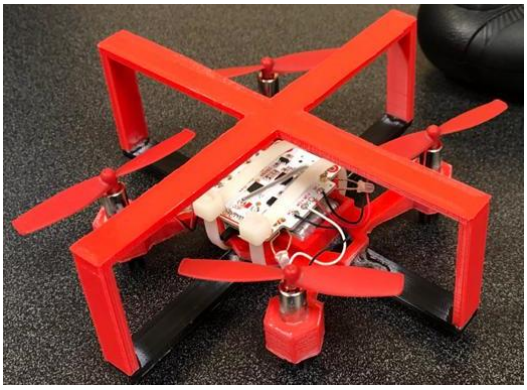

Figure 5. Unsuccessful heavy redesign

anonymous, and participation did not have any influence on student's grade in the course. However, students were highly encouraged to complete the survey. As this survey was sent out at the end of the semester, a slightly low response rate (43%) was observed. Students' feedback was collected for the three (3) questions below and reported in Figure 6 (for question 1), Figure 7 (for question 2), and Table 2 (for question 3).

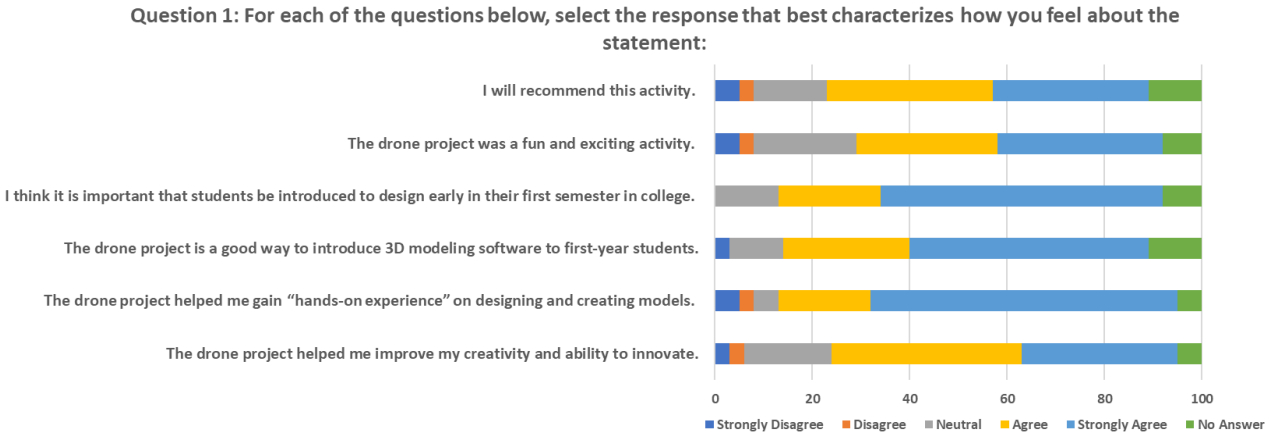

Figure 6. Students' answers to Question 1

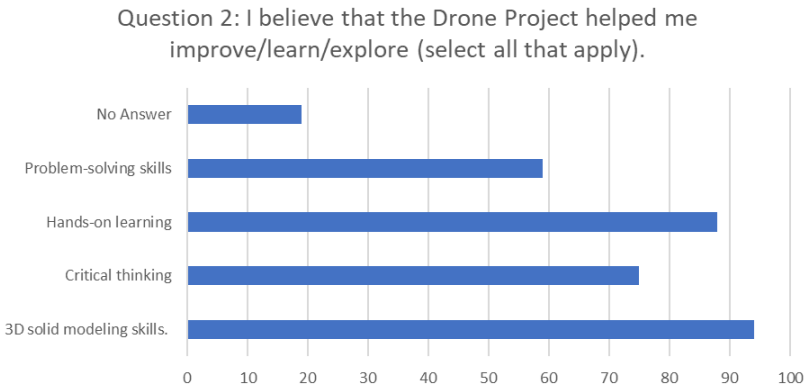

Figure 7. Students' answers to Question 2

Table 2. Students' general comments on the drone project

Students	Comment
Student 1	Very fun and I would retake this class just to do the Drone Project again.
Student 2	Overall, it was a good project for first year students. It is a great mixture of learning as well working hands-on. Would recommend to others who intend to take the class.
Student 3	I liked it; it gave me a sense of accomplishment.
Student 4	The project was great, and I would recommend it for first year students.
Student 5	I enjoyed the drone project. I think it was the best feature of the course.
Student 6	A great overall project as it teaches students the hands-on/ designing portion of engineering, unlike any other courses.

Graphs in Figure 6 divulge that the majority of students agreed (or strongly agreed) that the drone project improved their creativity and ability to innovate (61% agreement), and helped them gain hands-on experience on designing and creating models (81% agreement) (subgraphs a & b). Furthermore, most of the students believed that it is important to introduce 3D modeling software to first-year students (79% agreement) (subgraph d) and that the drone project was a good way to introduce the 3D modeling concept/software (76% agreement) (subgraph c) since it was a fun and exciting activity (63% agreement) (subgraph e). Finally, 66% of the students who took the survey recommend this activity to other students. Bars of Figure 10 demonstrate that the drone project has also helped the students improve their 3D modeling skills, critical thinking, hands-on learning, and problem-solving skills. At the end of the survey, students were given the chance to leave their general comments on the drone project. We present six (6) comments from six (6) different students in Table 2. Table 2 also show students' agreement with the implementation of the drone project in first year programs. This project has helped to introduce to the first-year students the engineering world by engaging them with hands-on activities that align with theoretical concepts they learn in their classrooms.

Conclusion

This paper introduces a neat design activity for a first-year engineering design class. This project was implemented at our university in a course that caters to first-year General Engineering students. The paper shows a step-by-step implementation of this idea along with examples of projects made by first-year students. While the project helped students expand their engineering skills, they were also encouraged to work in teams, share their ideas and opinions and use their imagination to implement the ideas within a limited time period. Students' feedback was also collected and the impact of this new project concept on students was accessed. The majority of students found this project interesting and liked the hands-on learning that they were able to accomplish, while learning about the various facets of engineering design.

Acknowledgements

The authors would like to acknowledge the contribution of NJIT graduate student Ms. Athira S. K. Nair in completing this work.

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