Electrical Systems Training for Aviation Maintenance Technicians

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Abstract

The Aviation and Transportation Department at a Lewis University is a Federal Aviation Administration (FAA) certified Aircraft Maintenance Technician (AMT) school. In order to become an AMT, the FAA requires topics related to aircraft maintenance be taught and a subset of these topics includes electricity. Historically, both electrical theory and application have been a difficult subject our students. In order to increase comprehension of material presented in the lecture portion of an upper-level electricity course, five new laboratory projects were developed. These projects involved troubleshooting faults on actual aircraft located in a hangar adjacent to the electricity laboratory. Students took pre and post course 7-point Likert scale surveys rating their knowledge on course topics related to these projects. Results from these surveys showed statistically significant increases in self-reported knowledge at the $p < 0.05$ level. Furthermore, data gathered from the study was used to develop more relevant laboratory projects for enhanced learning for their future careers.

Introduction

Aviation is an industry that allows for the rapid movement of goods and people around the globe. In order to facilitate this movement, aircraft are designed to operate at high altitudes at speeds that reach hundreds of miles per hour. This hostile environment leaves little error for mechanical or human error. To ensure that aircraft are in peak mechanical condition, maintenance tasks are performed at scheduled intervals by trained and certified maintenance technicians [1]. Within the United States, the Federal Aviation Administration (FAA), is tasked with overseeing aircraft operations and maintenance as well as certifying aircraft maintenance technicians (AMT). In order to become an AMT, a person needs to enroll into a FAA approved school with an AMT curriculum [2]. Students generally take 2 years to complete their courses work. At Lewis University, our AMT program is split into 2 different pathways:

The first is designed for traditional college students who take classes in person – lectures and laboratory. This pathway is generally designed for students ages 18-24. The second pathway called the 'Blended Program' and it is for adult students who are interested in career change, working full time, or first-time college students. It is designed for students ages 24 and older. These students take lectures online and laboratory in person. However, students in both pathways have the option to mix and match class options depending on their individual circumstances.

Regardless of the pathway, within the curriculum itself, concepts like regulations, sheet metal repair, electricity, structures, composites, and aircraft operations are covered. Once students have completed their coursework, they must take and pass FAA tests. These exams comprise of written, oral, and practical questions designed to test their knowledge of concepts learned during the coursework. When completed, the student will earn their FAA AMT certificate and be able to perform maintenance operations on aircraft within the United States.

Problem

Traditionally, our students in both pathways have found electrical theory and its practical applications to be challenging. Electricity is more abstract than riveting. For example, if a student is enrolled in a sheet metal class where the laboratory activity is to rivet 2 pieces of sheet metal together, a student can easily see the results of their work. Furthermore, if the rivet is installed incorrectly, it is readily visible. This conflicts with electricity. For example, in an electricity class, a laboratory project is to wire a circuit with a lightbulb following a diagram. The circuit will either work or not – the light is on or off. Students are not able to 'see' electrical flow within the circuit – only the results. The difference in visual context leads to a more challenging time for students enrolled in an electricity course. As a result, student knowledge on electricity concepts has been lower. In addition, scores on FAA AMT exams for students a Lewis University a generally lower for the electricity portion than the sheet metal portion. In order to address this disparity, 4 new electricity laboratory projects were developed for the Blended Program.

Review of the Literature

One of the primary advantages of laboratory work lies in its ability to facilitate learning. According to Kolb's Experiential Learning Theory students absorb information more effectively when they actively engage in hands-on experiences [4]. Lab work provides a tangible and interactive environment where students can apply theoretical knowledge learned in lecture to practical scenarios. This approach significantly enhances knowledge retention and promotes a deeper understanding of complex subjects [5][6]. This hands-on learning also serves as a powerful preparation for career success by aligning educational experiences with the demands of the workforce. A report by the National Academies of Sciences, Engineering, and Medicine titled "How People Learn II: Learners, Contexts, and Cultures" emphasizes the importance of aligning education with the skills needed for the workplace [7]. Laboratory projects that are well designed often mirror industry practices, equipping students with the technical skills demanded by employers [4]. Furthermore, hands-on experiences, critical thinking, and practical application, students not only enhance their knowledge but also develop essential skills for future endeavors. The combination of theory and practice prepares students for the challenges of the real world, ensuring a well-rounded and effective educational experience [7]

Laboratory Projects

In order to determine student knowledge within the course, 4 new laboratory projects were developed and students self-reported knowledge gained from them. The new projects involved 2 different aircraft: a Learjet and a Cessna 182RG. Both projects involved identifying faults with the aircraft electrical systems by reading wire diagrams / schematics, determining which component was bad, then replacing the component.

Learjet

The first set of laboratory projects involved a Learjet 24. This type of aircraft is used for corporate travel between cities not normally served by airliner traffic. This aircraft for class purposes was considered a large aircraft and it has both alternating and direct current electrical systems. This Learjet was normally located in the maintenance hangar at Lewis University. However, for the laboratory projects, it was towed outside for class. When conducting maintenance on aircraft, sometimes an AMT will have to complete their work outside and in inclement weather. The 2 lab projects were designed to simulate this type of work. The projects involved removing the starter-generator from the turbofan engines, conducting an operations check (Ops Check) on the exterior navigation lights, and replacing a faulty transformer-rectifier within the tail cone.

Figure 1. Learjet outside with students working on the lights

Figure 2. Learjet outside with students working on the starter-generator

Cessna 182

The 2nd set of laboratory project involved a Cessna 182RG. This type of aircraft is used for flight training or personal flights and it was located inside the maintenance hangar. This aircraft for class purposes was considered a small aircraft and it has a direct current electrical system.

The projects involved troubleshooting various faults with the electrical system. Students were required to use multimeters and electrical diagrams to find the problem.

Figure 3. Cessna 182

Experiment

In order to determine if the lab projects increased student knowledge of electrical concepts, the experiment was conducted within the Aircraft Electricity 2 class during the fall 2023 semester at Lewis University. These students were in the Blended Program and had the option to participate in the research study. The study was approved by the Institutional Review Board (IRB) at Lewis University. No compensation was offered as part of the study nor was participation a requirement for course grade.

There were 15 students were enrolled in the class and, 13 students participated in the pre-survey and 12 in the post survey. The paper survey was given to students at the start and end of the semester. The survey was a 7-point Likert scale and it consisted of 12 topics that were covered in class and the related laboratory activities. A sample of the questions is found in Table 1. Data were transferred from the paper surveys into a spreadsheet stored on secured device. Data were analyzed during one-sided ANOVA to the $p < 0.05$ significance level. 9 of the 10 questions. Data from the survey are summarized in Table 2 and Table 3.

Table 1: Sample Question

Rate your **knowledge** with the following 1-Not at all, 2-Sligthly, 3-Somewhat, 4-Moderately, 5-Knowledgeable, 6-Very, 7-Extremely Electrical schematics / diagrams 1 2 3 4 5 6 7

Results

Table 2: Summary of data collected

Question	Use of multimeter / voltmeters /ohmmeters	Electrical Load Analysis	Electric motors	Electrical schematics / diagrams	Electrical / circuit components	Trouble-shooting electrical systems
Pre (avg)	4.3	2.9	3.6	3.5	3.2	3.2
Post (avg)	5.4	4.8	5.0	4.8	4.9	5.2
Significant	no	yes	yes	yes	yes	yes

Table 3: Summary of data collected, part 2

Question	DC electrical theory	DC electrical systems	AC electrical theory	AC electrical systems	Small aircraft electrical systems	Large aircraft electrical systems
Pre (avg)	4.0	3.8	3.2	3.4	3.3	3.1
Post (avg)	5.4	5.3	5.3	5.2	5.3	5.3
Significant	yes	yes	yes	yes	yes	yes

Conclusion

Thousands of aircraft per day operate safely in an environment that is hostile to life. In order to maintain this high-level of safety, aircraft are required to undergo maintenance by Federal Aviation Administration certified aircraft maintenance technicians. To become an AMT, a person takes courses related to aircraft and several of these courses are electricity. In order to increase student knowledge of electricity, the author created several new laboratory projects. Self-reported pre-post surveys were used to evaluate student knowledge on 12 electrical concepts. 11 of 12 showed statically significant increase at a $p<0.05$ level.

Future Work

This study consisted of 12 adult students within the Blended Aircraft Maintenance Program during Fall 2023 semester Lewis University. While the results show statistical improvements, there was only 1 set of students involved in the study. Currently, the author is teaching the same Electricity course but in the Traditional Program. This course has 44 students and pre-course surveys have already been conducted. The author plans to complete post-course surveys once the semester is finished and compare results in both the Blended and Traditional Programs.

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