Protecting Educational Laboratory Equipment from Operator Error Using a Qualitative Research Approach

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Protecting Educational Laboratory Equipment from Operator Error Using a Qualitative Research Approach

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Abstract: An industry-based “mistake-proofing” technique and a qualitative research approach were applied to an academic setting to identify and eliminate root causes that result in damaged laboratory equipment and educational aids by college students or instructors. Instructors in an Aviation Technologies (AT) program were interviewed to yield numerous recurring issues when using equipment and/or educational aids. Ten key issues were selected and discussed at a structured brainstorming session with AT students. These students were asked to input ideas that would be potential solutions and corrective actions. Ideas were generated for potential solutions and evaluated for practicality, cost, and time of implementation by the Principle Investigator (PI) and solutions were prioritized for having the highest likelihood for success. These qualitative results were evaluated in two ways: (1) the effectiveness of the methods and materials, and (2) the entire process to address the stated purpose. All recurring issues were documented and numerous relevant solutions for corrective actions were generated. In addition, the entire process was successful in developing proposed procedures and designs for corrective actions from student participation. Future research will implement and evaluate these proposed corrective actions when incoming AT students are exposed to the proposed changes.

Keywords: mistake-proofing, Poka-yoke, brainstorming, damaged items

1. Introduction

In college courses that are conducted in a laboratory environment, students work with a number of different types of equipment, aids, and educational materials. Even though training to operate the equipment and proper use of aids and materials is conducted, the learning curve and level of proficiency associated with the operation of different equipment can be very different from one student to the next. Occasionally these items become damaged and need to be repaired, or even replaced.

In many cases the same operations have occurred multiple times with the same results. In industrial settings the same multiple operations or tasks are often performed by a single individual. In contrast, in an educational practical laboratory project, multiple individuals will perform a single operation or task. No one intends to make mistakes, but while we are working, defects can show up without our noticing. How can we catch these errors before they turn into defective parts (Shingo, 1986)? There are industrial techniques that were developed to eliminate wasted time and money by designing procedures and equipment to eliminate the possibilities of improper procedures and operations.
Issues that cause a disruption in the laboratory class session can be detrimental to the learning process and cause the objectives of the lesson plan to change. A minor issue can cause minimal class disruption; for example, a computer rebooting or a very short power outage can very easily be adjusted in the lesson plan. Large issues can cause a lesson to be taught over. The large issues that occur during the laboratory class at a Federal Aviation Administration (FAA) regulation Part 147 (2005), Airframe and Powerplant program must be repeated if the tasks approved for the program were not completed. Some of these large issues result in damage to equipment and instructional aids. This damage cannot only cause down time for the lesson, but can result in a financial burden for the program. Issues that can cause delays and repeated assignments must be eliminated. This research utilized some industrial techniques that can be adapted to an academic environment.

As stated earlier to reference the industrial workplaces, multiple operations or tasks are often continuously repeated by the same individual. In academic settings, students typically work with a number of different types of laboratory equipment, in some instances for the first time, thus proficiency can be highly variable between pieces of equipment as well as between students.

The industrial technique called Poka-yoke (pronounced “POH-kah YOH-kay”) which literally means “mistake-proofing” (Shingo, 1986) and Error Proofing (GOAL/QPC, 2002) was developed as a formal process to help eliminate defects and errors by identifying the root cause of an issue and preventing it from happening again. The essence of Poka-yoke is to design your process so that mistakes are either impossible or are easily detected and corrected (Robinson, 1997). This approach has been used in various industries including construction (Dos Santos & Powell, 1999; Sadir, Taheri, Azarsa, Ghavan, 2011), software development (Nataraj, 2013; Robinson, 1997), and the automotive industry (Magdoiu & Oprean, 2013). Adapting these techniques for the aviation academic laboratory environment will result in developing procedures or redesigning equipment to ultimately mitigate the possibility of improper operations and damage. The process described in the materials and methods portion of this paper will be a continuous improvement process that can be used to eliminate current and future issues and errors.

The purpose of this research is to use qualitative research methods to apply a formal industry-based technique to an academic setting to identify and eliminate the root cause of issues that damage laboratory equipment and educational aids by college students or instructors.

2. Materials and Methods

The material that must be taught at an aviation Part 147 school is in the format that has courses with mandatory lecture and laboratory hours for students seeking an Airframe and Powerplant (A&P) certificate. This research is focused on the laboratory portion of the courses taught at a mid-western university Aviation Technologies department. A qualitative research approach was selected because it derives data from observation, interviews, or verbal interactions and focuses on the meanings and interpretations of the participants (Holloway & Wheeler, 1995). Some laboratory tasks are complex and include working with tools, equipment, aircraft, and aircraft appliances. All required laboratory tasks were considered when developing the methods used for this research. The methods for this research can be separated into three parts: (1) an instructor interview; (2) a structured brainstorming session with senior students; and (3) review/concept development.

An interview form (see Figure 1) was developed from the Poka-yoke system technique. This form was designed for the educational environment. The purpose of this form was to initially record issues that have occurred in the laboratory classes. It was also used as the main document throughout the process to record relative information. The form has block areas to record the Date, Course Number, Course Title, Labora-
The form was designed to cover multiple types of issues and corrective actions. Not all blocks were necessary for every interview or issue. Two senior students in the program that have had experience in the laboratory classes were asked to participate by interviewing all nine instructors in the department. Using the form, they recorded numerous issues that occurred in the laboratory classes. Ten issues that resulted in “damaged items” in the laboratory classes were selected based on priorities identified by the instructors during the interview.

### FIGURE 1 – Form after Interview
interviews and were used as the subject issues in a structured brainstorming session. Because of the number of students enrolled, a single course may have multiple sections of the same laboratory content taught by different instructor’s accounts for the 10 groups of issues generated from nine instructors (see Table 1).

A structured brainstorming session as described by the Six Sigma Memory Jogger II Desktop Guide (GOAL/QPC, 2002) was used to gather ideas for potential solutions and corrective actions from senior students. Six students participated in the session. The brainstorming session encourages open thinking when the “same old way” is not working (GOAL/QPC, 2002) and generates numerous ideas quickly. This type of process allowed each student to give ideas in turn. The process consisted of the following: (1) an issue was stated, agreed upon, and displayed on an overhead projector screen; (2) each team member in turn, gave an idea; (3) ideas were generated and entered on the display under the issue; (4) ideas were generated in turn until each student passed, indicating that the ideas were exhausted; and (5) a priority was placed on the ideas for each issue.

Each issue and idea was reviewed by the PI for concept development and implementation. A sample of five issues was selected from the original 10 for application of the corrective action ideas based on an estimated cost and time to implement. The Interview Form was completed by entering the proposed corrective action description in the After Improvement Block. The descriptions were entered on the form in any one or combinations of the following: text, drawing, or photo documenting the change (see Figure 2). Any additional information can be entered as developed. The Interview Form is a fluid and versatile document that changes as the process changes and is a record of the results of corrective actions.

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<th>ISSUES</th>
<th>DAMAGE ISSUES</th>
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<td><strong>32</strong></td>
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3. Results

The results of the research can be divided into two different categories: (1) the results from the materials and methods used in this project, (2) the results of how well the entire research format can successfully be used as a continuous improvement process to eliminate the root causes of issues. Preliminary results from the instructor interviews revealed that the perception of “damaged items” is not necessarily limited to equipment and instructional aids, they also included tools; aircraft powerplant or airframe parts; books or manuals; facility; and/or recurring missing items.
Results of using the redesigned Poka-yoke system technique as an Interview Form yielded 58 total issues identified by nine instructors in eight different laboratory classroom environments. Thirty-two of the 58 issues compiled during the instructor interviews resulted in damaged items. An actual sample of the form with the issues gathered for one of the laboratory classes is displayed in Figure 1. As stated in the material and methods section, 10 issues were selected based on priorities identified by the instructors during the interviews.

The results of using the structured brainstorming session to develop potential solutions and corrective actions are displayed in Figure 3. Sixty-six corrective actions were generated by six students for the 10 issues presented. These ideas were evaluated for practicality, cost, and time for implementation by the PI. One idea was selected for each of the 10 issues as being a high priority for success. All of the ideas for each priority issue were entered on a single form in the block titled “After Improvement” with the highest priority idea identified as the “Proposed Change Description” see actual sample in Figure 2.
4. Discussion and Conclusions

All recurring issues were documented and numerous relevant ideas for corrective actions generated. Thirty-two of the 58 issues listed from the interview resulted in damaged items. Why not all 58 issues listed resulted in damaged items? The instructions that accompanied the interviewers were not precise and restrictive enough as wanting only issues that resulted in damage. This gave the instructor too much latitude. The instructions will need to be revised to yield better results in future research.

The entire process was successful in developing proposed procedures and designs for corrective actions from student participation. Many of the ideas were procedural changes and not physical design types. Procedural changes have merit, but can be open for interpretation, where a physical design is more restrictive. Future research should include a small presentation of how to physically redesign equipment or work areas before the brainstorming session. This will focus the ideas toward that approach.

As stated in the material and methods section a sample of five issues were selected for corrective action idea implementation. The PI has implemented the corrective action for one of the sample issues described in Figure 2. The timeline to implement the corrective actions for the remaining four sample issues will depend on approval by the other instructors that participated in the interview.

Conclusive results will be determined after the proposed corrective actions are implemented and when incoming students are exposed to changes. Cost reduction, cost avoidance, and reduced class disruptions data will be used to determine the success of the continuous improvement process portion of the research. Follow-up interviews will be conducted during upcoming semesters to determine if the corrective actions have eliminated the root causes.

5. References


GOAL/QPC. (2002). The Six Sigma Memory Jogger II. Salem, NH.


