FACILITATING COMMUNICATION FOR AVIATION TRAINING AND MAINTENANCE

Lorraine E. Holtaway
Kyle Jackson
Sarah M. Hubbard, Ph.D.
Purdue University
West Lafayette, IN

Maintenance errors are the primary cause of approximately 8% of commercial aircraft accidents worldwide. One factor that contributes to human errors is miscommunication. Clear communication is critical in aviation education and in aviation maintenance operations. A fundamental concept for clear communication is both the transmission and receipt of a common message. This research explores the miscommunication and misinterpretation of instructions used in maintenance training. Miscommunication may be due to ambiguity, use of jargon, and different individual interpretations and methods for standard practices. First, an example of a commonly misunderstood process is identified. Next, enhanced training tools are developed to reduce the likelihood of miscommunication. These enhanced training tools include detailed illustrations and the addition of descriptive text to provide more information, including additional physical characteristics and technical context. Finally, the proposed training aids are assessed in a controlled study to determine their effectiveness.

The Purdue University School of Aviation and Transportation Technology offers an Aviation Engineering Technology (AET) bachelor's degree that includes the opportunity for students to participate in a Federal Aviation Administration (FAA) 14 CFR Part 147 program. Students who complete the Part 147 program are eligible to for Airframe and Powerplant (A&P) certification, the designation for licensed aircraft mechanics. One course required to meet the Part 147 requirements is Advanced Aircraft Powerplants, which involves learning maintenance and overhaul procedures for reciprocating aircraft engines.

One of the laboratory activities the students perform in the Advanced Aircraft Powerplants course is manually adjusting the valve clearance, the amount of space between the valve stem and the rocker arm, on a Lycoming O-290 engine. The students are given a Service Instruction written by Lycoming as the procedure for completing the laboratory activity. One problem the students encounter is that the Lycoming Service Instruction was written for trained mechanics, not students. In previous years, the instructor would demonstrate the process to a small group of students, and they would only use the Service Instruction as a reference, not their primary source of instruction. As class sizes grow, instructors are not able to give as much individualized attention to the students. The students need to be able to learn more independently and the course materials need to communicate instructions clearly.

The research objective of this study is to assess the effectiveness of training tools that provide more technical context and descriptive illustrations. We hypothesize that enhanced training tools will reduce the likelihood of miscommunication so students will be better able to understand the instructions and learn independently. The objective of this paper is to describe the research and the methodology, and present preliminary results.

Literature Review

The Federal Aviation Administration (2014) states the importance of communication for aviation maintenance in *The Operator's Manual for Human Factors in Aviation Maintenance*. A research study in 2007 found that in eight percent of the commercial aircraft accidents from 1990 to 2006, the primary cause was maintenance. The leading factor for the FAA initiating Letters of Investigation (LOI) and taking administrative action on Aircraft Maintenance Technicians (AMTs) is failure to follow written procedures. Approximately 83% of maintenance Aviation Safety Reports (ASRs) from 2010 to 2013 were related to technical publications and other written company procedures. Training is a critical activity in the aviation industry, and it is identified as the top intervention for risk reduction (Federal Aviation Administration, 2014).

According to Chaparro and Groff (2002) in *Human Factors Survey of Aviation Technical Manuals*, an analysis of aircraft maintenance error causation ranked information as the highest contributing factor. Only a small number of the errors attributed to information were due to incorrect data, however, and more often the technicians did not refer to the information, misunderstood the information, or disregarded it in favor of an alternative method of performing the maintenance procedure. While this problem could be addressed through training or disciplinary action, it could also be a result of a problem with the usability of the technical documents (Chaparro & Groff, 2002).

The usability of aircraft manuals "includes how easy they are to use, how well they match the technician's representation of a task, how easy they are to read and interpret, and how useful the information is they contain" (Chaparro & Groff, 2002, p. 2). If the maintenance manuals contain misleading information, insufficient information, or unclear procedures, they can contribute to maintenance error. The work in *Human Factors Survey of Aviation Technical Manuals* researches the human factors issues in the development of aviation technical manuals and recommends improvements to the documents (Chaparro & Groff, 2002).

The results of the survey indicate that the documentation provided to maintenance technicians needs to contain accurate technical information and needs to be presented in a way that matches the way technicians actually do their job. A high percentage of survey responses were "disagree" or "strongly disagree" to the questions "the manual describes the best way to do a procedure" and "the manual writer understands the way I do maintenance." These responses show that manual usability is a common problem, and the potential consequences of these problems are the safety, speed, and cost of aircraft maintenance. The recommendations for addressing usability problems are increased feedback from the users, including an error reporting system, and controlling formatting consistency and reading level through standardization guidelines, including the ordering of procedural steps, the wording of procedures, the use of illustrations, and the level of detail (Chaparro & Groff, 2002).

A Design Aid for Improved Documentation in Aircraft Maintenance: A Precursor to Training provides background, research, and recommendation for writing documentation that reduces the likelihood of errors. The demand for error reduction in aviation maintenance is increasing, and the study evaluates a tool to help present complex work instructions in a way that will minimize error opportunities. The FAA Office of Aviation Medicine (FAA/AAM) has been funding research into human error, and one area studied was the information environment of the people performing inspection and maintenance activities. They found that much of the paperwork used to control hangar-floor activities did not follow good human factors practice. Aviation maintenance documentation is often used under non-optimal environmental conditions and with time stress, so any means of reducing errors, such as better workcard design, is cost-effective (Drur & Abdulkadir, 1997).

Drur and Abdulkadir (1997) undertook their study to provide a job aid for document writers to help them apply good human factors practices to their documents. They worked with an airline partner to examine existing workcards for specific problems using task observation, interviews with mechanics and inspectors, and survey data. Existing human factors research findings were also used to determine good practices. The research resulted in a Document Design Aid (DDA) that was arranged in steps, with sign-offs at each step, that could be used as a checklist to ensure that a document was well designed (Drur & Abdulkadir, 1997).

The researchers then evaluated the DDA for its usability and effectiveness. Usability was defined as a job aid being usable for its intended purpose by intended users, and effectiveness was defined as whether or not the intended users perform their job better with the job aid. A sample of intended users were assigned the task of modifying and existing engineering order (EO) to conform to the guidelines in the DDA. Usability was measured by user rating scales, and effectiveness was measured by comparing the changes made to the EO by each user to a master list of changes made by expert users. Users had sixty minutes to mark up the test EO, and they found and average of thirty-five percent of the changes suggested by the experts. The researchers considered this performance to be adequate because most of the major changes were found (Drur & Abdulkadir, 1997).

The literature review indicates that maintenance is a critical part of aviation safety, and that misuse or misunderstanding of documentation are leading causes of error. It also establishes the importance of measuring the usability and effectiveness of technical publications in order to decrease the occurrences of miscommunication and the resulting errors.

Method

The participants in this study were students enrolled in the Advanced Aircraft Powerplants class at Purdue University during the spring semester of 2017. The students in the class are working toward earning their FAA A&P certificate. Twenty-six students were enrolled at the time of the study.

The study was true experimental research with experimental and control groups. The participants were randomly assigned into two groups by drawing their name out of a hat. The students assigned to the control group were given the original set of instructions in the existing lab manual. The students in the experimental group were given a set of instructions enhanced with pictures and more description in addition to the original set of instructions. The participants were directed to perform the valve clearance laboratory activity.

The researchers observed the students as they performed the laboratory activity. The data collected was the date, the student’s participant number, whether or not the student received the enhanced instructions, the number of attempts the student took to complete the activity, the amount of time taken to complete the activity, the student’s perception of the quality of the instructions, and what questions the student asked during the project. The researchers also recorded comments on the types of errors the students made during the process. An attempt was defined as each time a student tightened the jam nut on the rocker arm. The valve clearance laboratory activity was considered complete when the student was able to set the distance between the valve stem rocker arm and demonstrate to the instructor that it was within the manufacturer's limitations. The student's perception of the quality of the instructions was measured on a scale of one to five.

Preliminary Results

Preliminary observations suggest that the primary metric to evaluate the quality of the instructions may be the number of questions the students ask while performing the laboratory activity. This metric reflects a student's ability to understand the instructions on their own, and predicts how much time the instructor would need to spend with individual students to provide support information needed to complete the lab. Fewer student questions indicate that a student has a better understanding of the process, presumably due to better instructions, which allow the student to learn more independently with less instructor involvement. The questions the students ask and the researchers' comments on the errors the students make also provide insight into the types of problems encountered during the learning process. The specific questions can be used to further improve the instructions.

The number of attempts the students take to complete the activity and the student perception of the quality of the instructions appear to be useful measures reflecting the quality of instruction. These measures appear to suggest differences between the current and proposed instructions based on preliminary results.

The amount of time students take to complete the activity, however, may not be a reliable metric to assess the quality of the instructions. A student using the current instructions written for experienced mechanics could become frustrated earlier in the process and ask the instructor for help sooner, which could allow them to complete the activity in less time than a student who works independently with the enhanced instructions. Alternatively, a student may find the enhanced instructions help them to work quickly through the activity while a student using the current instructions may take time to struggle to understand the process.

Further research is needed to fully determine the effectiveness of the enhanced instructions. Increasing the sample size in this study would reduce the impact of any outliers within the population. For example, some students have more mechanical experience in general, which would affect their performance. A larger sample size would encompass a broader range of abilities. In addition, some students did not follow the procedure correctly, but still managed to produce acceptable results. The researcher observing these students attributed their successful completion of the activity to luck, which would also have less of an effect in a larger sample size. The current study also does not address if the enhanced instructions enable the students to better retain the information they learned. This may be likely, since often visualization techniques are recommended as memory aides. Adding a secondary evaluation to assess how well the students remember the process after some time has passed (perhaps two weeks or a month) could lend another dimension to assess the effectiveness of the enhanced instructions.

References

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