

GENERAL AVIATION PILOT TRAINING FOR SITUATION AWARENESS: AN EVALUATION

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This study reports on efforts to improve situation awareness in general aviation (GA) pilots. Several training modules for enhancing skills that underlie the development of good SA were created and evaluated in a study with GA pilots. This paper describes the testing for two modules: contingency planning and preflight planning. These modules were developed to train higher order cognitive skills used in SA formation. Student pilots from Embry Riddle Aeronautical University participated in the study. The results from this test provide some evidence of a relationship between the two training modules and improvements in SA.

INTRODUCTION

Due to the important role that situation awareness (SA) plays in the pilot decision making process and its substantial role in aviation accidents and incidents, the operational community is interested in finding ways to improve SA through training programs. As part of a 3-year research program we created six different training modules designed to teach skills that underlie the development of good SA. This paper presents the results of the validation effort for two of these modules: contingency planning and preflight planning. These modules were designed to teach higher order cognitive skills that are applicable to pilots at all levels of experience. Each module was evaluated in terms of its ability to improve knowledge of the training material, SA and performance in General Aviation (GA) flying.

Preflight planning has been found to be an effective tool that experienced pilots use to organize their world and that forms the original foundation for pilot SA (Endsley, 1988, 1995). Based on the preflight plan, pilots will look for key information to tell them where they are in the world and will constantly assess the status of their flight as

compared to the plan. This plan can be a very effective tool for SA, providing expectancies, which forms the basis for filtering and interpreting the information they perceive to develop SA. It can greatly reduce the cognitive demands of in-flight information processing and decision making. The average GA pilot possesses all the skills necessary to make a rudimentary, functional flight plan. However, the average plan of the GA pilot provides little information in the way of when, how or where to execute tasks en route. Most GA pilots wait until they are in flight to prioritize and execute tasks such as en route fuel burn computations and information gathering (i.e. the arrival airports ATIS.) Unfortunately, getting caught up in these processes at the wrong moments usually results in GA pilots losing SA as they fall further behind the aircraft. The GA pilot is better served by determining more efficient methods of executing these tasks prior to each flight.

Contingency planning is also highly related to SA. It is a skill clearly linked to Level 3 SA (projection of the future). Good pilots are able to use low workload periods to anticipate and plan for contingencies, allowing them to be proactive rather than reactive if those future events occur (Amalberti

and Deblon, 1992; Endsley 1993, 1995). Contingency planning greatly contributes to high levels of SA projection (the highest level of SA) and the ability to quickly detect and comprehend events. Pilots who do not actively engage in contingency planning are far more likely to be overloaded by events in high workload periods. While some experienced pilots have learned to do this naturally, most GA pilots do not appear to be actively using contingency planning (Endsley, et. al, 2000; Prince and Salas, 1998). By training GA pilots in the importance of contingency plans and providing them with specific problems to work through in the training, the contingency planning training module seeks to increase the frequency of contingency planning and situation projection in GA pilots.

METHOD

Design

This study used a 2 by 2 within subject design. Two groups of pilots participated in each of two conditions: test and control. The test group received the two training modules. The control group received a comparable period of time with standard flight training material. Both groups were tested at two times: before and after training.

Participants

Pilots of all experience levels were invited to participate. The average age of the test group was 21.8 years and the average age of the control group was 20.6 years. The pilots in the test group had accumulated an average of 367.5 hours of flight experience, while the control group had an average of 175.8 hours.

A total of 24 pilots were recruited for this study. The majority of the pilots were students at ERAU. All pilots held at least a Private Pilot certificate, which is an entry-level GA pilot license.

Simulation

The simulator consisted of a PC using Windows Millennium running Microsoft Flight Sim2000®. The terrain in the simulation was

adequate for flight using visual references and a standard sectional chart. The simulator used multiple screens to enhance realism. One screen depicted a forward visual view with primary instrumentation, while a second screen depicted user configurable avionics such as communications and navigational radios. Pilots had to plan and fly their flight using visual references and radio navigational aids without ATC assistance. Pilots were required to plan a VFR flight from Shenandoah to Washington Dulles with a course change over Front Royal (KFRR), Virginia. The scenarios required a flight time between 20 and 25 minutes. The only difference between the pretest and posttest simulation flights was that the flight path the pilots were asked to fly was different.

Training Modules

Two training modules were evaluated in this study: contingency planning and preflight planning.

Preflight Planning. The preflight planning module was a self-paced tutorial created in Macromedia Director. Its objective was to teach GA pilots how to increase their overall situation awareness by developing useful pre-flight plans. This module guided pilots through a comprehensive flight planning process.

Contingency Planning. The contingency planning module was also a self-paced tutorial created in Macromedia Director. Its objective was to train GA pilots in the importance of contingency planning and to provide them with some of the information that should be considered when making contingency plans. By training GA pilots in the importance of contingency plans and providing them with specific problems to work through in their training, the module was designed to increase the frequency of contingency planning and situation projection in GA pilots.

Control Task

The control group was assigned to view 1 hour and 15 minutes of selected clips on flight planning and contingency planning from *Jeppesen CFI Renewal Program, Volume 1, Issue 8* by Jeppesen, and *Coping with the Unexpected*, by Airmanship, Inc.

DEPENDANT MEASURES

Evaluation of the effectiveness of the training modules in improving SA and performance was conducted in two simulated flights. One flight was conducted before participants began training on the modules and the other flight was conducted after training. Pilot knowledge, SA and performance were measured in the pre and posttest simulation flights for both test and control group participants.

The pilots planned a cross-country trip. Following development of the plan, participants were assessed on their knowledge of preflight and contingency planning by taking an identical short, timed test. The Situation Awareness Global Assessment Technique (SAGAT) was used to measure situation awareness. Four freezes were inserted into the flight simulation to query pilots about important aspects of their SA using SAGAT. SAGAT included fifteen queries that were specifically designed for GA based on an analysis of SA requirements for this population and the relevance to the simulated flights. In addition, at the end of the scenario the participants were asked to make an emergency landing and to report the factors they would consider in making such a landing. A subject matter expert scored their responses for accuracy and completeness.

PROCEDURES

Prior to the pre-training flight, the participants were given all the necessary data to create a flight plan. The participants were required to complete the flight plan with all essential computations and any other data they felt was needed for the safe conduct of the flight. The participants then took a short quiz (pretest knowledge evaluation) requiring them to pull critical items from their flight plan such as appropriate en route flight service station frequencies and sources of weather updates at their course change checkpoint. They then flew that planned flight in the simulator.

After the simulated flight the test group received training on the two test modules while the control group received the control task. Upon completion of the assigned modules (control or training), the pilots were asked to create a flight

plan for a second flight. They completed a second timed questionnaire (post-test knowledge evaluation), and then flew the flight they just planned.

RESULTS

Pre-post difference scores were created for each pilot on each dependant measure by subtracting the pilot's post-test performance on each measure from their pre-test performance and these difference scores were used in all subsequent analyses. In all reported analyses, a .05 level of significance was used.

Task Knowledge Performance

The effectiveness of the modules for conveying knowledge on preflight and contingency planning was evaluated through performance on the questionnaire. Performance on two test items increased significantly more for the test group than the control group: best glide speed estimate and the factors to consider for engine failures (prior to rotation). Overall, test group participants exhibited a greater increase in accuracy at estimating their best glide speed, $t(20) = -1.79, p < .05$. Their posttest performance was higher than their pretest performance, whereas the control group's performance declined (see figure 1). A similar pattern is evident in the question asking what factors need to be considered when planning for an engine failure. The test group also listed more correct factors on their posttest than their pretest and the opposite trend was observed for the control group. The analysis of the difference score was significant, $t(21) = -1.95, p < .05$.

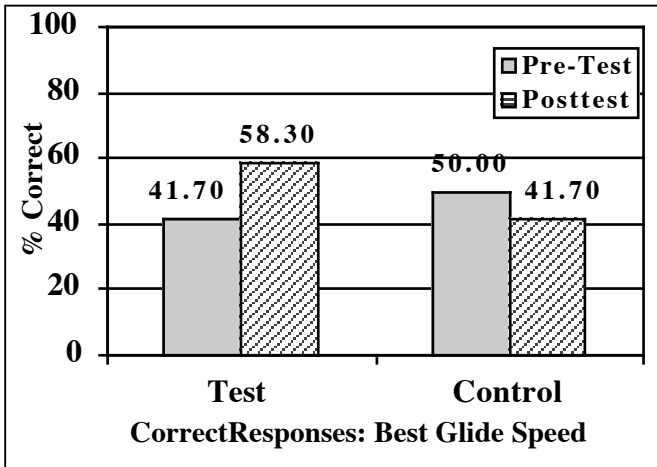


Figure 1: Percentage of Participants Correctly Reporting Best Glide Speed.

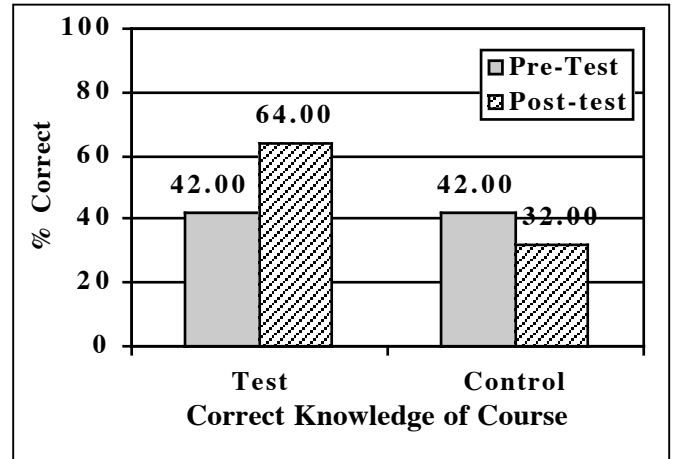


Figure 2: Percentage of Participants Correctly Reporting Current Course.

SAGAT

While participants responded to each SAGAT query, an experienced instructor pilot completed an answer form based on full knowledge of the actual state of the simulated flight providing the correct answers to the SAGAT queries. Videotapes of the flights just before each SAGAT stop were also reviewed to clarify any questions regarding the correct answer. The participants' SAGAT answers were compared against the answer form to determine their correctness. All queries were scored as either correct or incorrect. An arcsine correction factor was applied to the data to correct for non-normality.

Two queries showed a significant difference in changes in participant scores between the two groups. The test group's knowledge of wind direction remained relatively unchanged (64% vs. 66%) from the pre to posttest sessions, while the control group experienced a large decline (91% vs. 66%), $F(1, 170) = 3.96, p < .05$. In addition, knowledge of course improved slightly for the test group (42% vs. 64%) although it declined slightly for the control group (42% vs. 32%), $F(1, 141) = 3.73, p < .05$. This is shown in figure 2.

In addition, SA changed for both groups on some queries. Both groups showed a significant decrease in knowledge of bearing to the nearest airport, $F(1, 131) = 10.07, p < .05$. The test group decreased from 45% to 23% and the control group decreased from 34% to 8%. There was also a significant increase in SA among the test group from pre- to posttest in knowledge of distance to destination (39% to 61%), as well as among the control group (43% to 61%), $F(1, 111) = 4.48, p < .05$. Knowledge of system degrades, $F(1, 172) = 3.80, p = .05$, was also slightly higher in the posttest as compared to the pretest for both groups. Knowledge of system degrades went from 49% to 54% for the test group and from 24% to 48% for the control group.

Simulator Flight Performance

The effects of the training modules on simulator performance were evaluated in a variety of ways. First, simulator performance was evaluated by including several unplanned events in the flight. For example, the participant's turn coordinator failed. The SAGAT query asking about system degrades did detect an improvement for the test group in noticing this degrade. Secondly, during the flight the ceiling was lower than planned which required the pilots to drop below their planned altitude. However, the SAGAT query addressing planned altitude was not significant. This altitude change would also affect the gliding distance of the aircraft. The SAGAT query asking

about gliding distance did not detect any significant differences between the two groups. Lastly, the participants were instructed at the very end of their flight to make an emergency landing. At this time they were asked what they would do in such a situation and what factors they would need to consider. Test participants did not perform better than the control group.

DISCUSSION

The preflight and contingency planning training modules were well received by the test participants who found them useful and informative. Some improvement in planning performance was indicated following the training modules. There was also evidence of improvement in SA following the training, which is fairly good for an investment of only 1 hour of training. Upon completion of the training modules, test group pilots were better than the control group at estimating their best glide speed, identifying whether they were on course, and were aware of more factors that need to be considered when planning for an engine failure. Evidence of transference of these skills to the simulated flight task was limited, however. When evaluated in the simulator, test group pilots only fared slightly better than the control group. This could be due to the limited realism of the simulator, the scenario, or sensitivity of the measures that proved limiting in detecting any differences, or it could be because improvements in flight performance were not present following this limited training session. As the skills being trained are fairly broad in nature, translations to improvements in performance may be more apparent during more complex flights in real-world situations. Future tests of these training modules should include an actual in-flight evaluation.

Additionally, while attempts were made to balance the control and test groups in terms of flight hours, two Certified Flight Instructors (CFI) were included in the test group and this significantly increased the average number of flight hours for that group. While the modules were designed for pilots of all levels and experience, more data are needed to validate the training modules.

In conclusion, the modules were somewhat successful for improving SA and the pilots in many cases found them informative and useful. The following quote about the preflight planning module is from a Certified Flight Instructor who participated in the study “It was excellent! It made me remember and become aware of certain aspects of flight and planning. I hope this is used more widely and not just for this project.”

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