A Comparison of Scenario Based with Maneuvers Based TAA Instrument Flight Training

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A **COMPARISON OF SCENARIO BASED WITH MANEUVERS BASED TAA INSTRUMENT FLIGHT TRAINING**

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A laboratory-controlled comparison of traditional maneuvers based training (MBT) and scenario based training (SBT) is described during the acquisition of technically advanced aircraft (TAA) instrument flight skills in a simulator. The study was conducted as part of the FAA Industry Training Standards (FITS) evaluation of SBT. All 27 participants were instrument rated pilots with less than 500 total flight hours and virtually no experience with TAA. All were randomly assigned to the MBT or SBT condition. All received 8 hours of MBT or SBT before the final posttest evaluation. The TAA simulator was a Cirrus SR20 with a Chelton primary flight display (PFD) and multi-function display (MFD) powered by Micro Soft Flight Simulator (2002). Experimentally blind expert raters scored instrument flight skills during a pre-training (pre-test) and a similar post training (posttest) data collection flights. The SBT Group performed statistically better on 5 of the 8 measures of piloting ability than the MBT for the posttest flight. In no case, did the SBT Group score worse than the MBT group. The results indicate that SBT may lead to improved piloting and navigation skills over traditional maneuvers based training for TAA flight. Although MBT is a reliable method to teach flight and has so for decades, SBT, which is recommended by the FAA Industry Training Standards (FITS) program, may be a better strategy for TAA instrument flight skill acquisition.

Introduction

Within the last few years there has been a huge leap forward in digital avionics leading to the advent of technically advanced aircraft (TAA). The microprocessors onboard today's TAA, coupled with satellite global positioning service have led to a revolution in the navigation displays rapidly emerging in general aviation. The standard instruments and analog gauges are shrinking on typical panels and many pilots are not learning the new technology with the same rigor with which they were required to learn the analog instrument navigation. The FAA developed a new procedure to ensure performance standards were met and a level of proficiency obtained in training GA pilots in this new equipment. These procedures have become known as the FAA Industry Training Standards (FITS) tenants. This report details an effort to compare the FITS tenants with traditional procedures that have been in place to train instrument flight since its inception.

The FITS approach is based on one that has worked successfully in other high technology domains, like medicine and military sensor training. This approach utilizes scenario-based training (SBT) in which the pilot is required to design and practice dozens of flight scenarios, from take-off and enroute navigation to flight emergencies and landing. Traditional instrument flight uses a skill based approach and can be considered task based not scenario based. Pilots are trained on particular maneuvers to acquire skills to the point that they produce an almost automatic response and will be referred to as maneuvers based training (MBT). MBT emphasizes the skills required of the FAA's Practical Test Standards (PTS) and over many years may have drifted towards a practice of teaching to the test. In addition, the skills are sometimes learned in isolation; for example, one learns the standard soft field landing technique rather than coupling that training with a condition or scenario in which it might arise during flight. MBT training is by example, the instructor's example, and the student mimics the maneuver until accomplishing it successfully, as determined by the instructor. It is rarely tied to any use other than the practice, and the student is passive in the process, not developing the ability to identify and correct weaknesses. It is important to realize that the MBT procedures have been successfully training pilots for decades. However, with the advent of the FITS program, the FAA hopes to address these deficiencies of MBT in a new generation of instrument pilots.

The idea underlying SBT is to give the learner opportunities to acquire knowledge and skills necessary for task performance via simulated "real-world" operational environments. The required competencies are trained within the scenarios, as well as upon completion via instructor feedback (Oser, 1999). Thus, active learning, extensive practice and feedback are the cornerstones of SBT, and these are also the characteristics that distinguish SBT from other training methods (Salas & Cannon-Bowers, 2000).

The procedures of SBT are not new to training operators of complex and sophisticated equipment; they are just new to flight training because an organized, large-scale effort has never been made to formalize the procedure. For quite some time training researchers and practitioners have known the value of using simulated tasks for skill development (Goldstein, 1993). The idea underlying SBT is to give the learner the opportunity to acquire the knowledge and skills necessary for task performance via a simulated "real-world" operational environment. The required competencies (e.g., operator knowledge, skills, and attitudes) are trained within the scenarios, as well as upon completion via instructor feedback (Oser, Cannon-Bowers, Salas, & Dwyer, 1999a). Thus, active learning, extensive practice and feedback are the cornerstones of SBT.

The experiment was designed to compare MBT and SBT procedures in training new instrument pilots in the use of TAA navigation equipment.

Methods

The research was conducted in the Technically Advanced Aircraft Performance (TAAP) laboratory for pilots located in the Human Factors and Systems Department research facility at Embry Riddle Aeronautical University in Daytona Beach, FL. The experiment was conducted as collaborative effort between the aviation subject matter experts (SME) at the University's College of Aviation and the human performance assessment experts in the College of Arts and Sciences.

Participants

Participants were kept unaware (experimentally blind) that the project was an FAA Industry Training (FITS) study as much as possible to prevent them from researching the specifics of the study from publicly available websites. Instead they were told that they were participating in a Technologically Advanced Aircraft Performance (TAAP) study for pilots, and all questionnaires and forms reflected the TAAP headline. Every effort was made to keep them from talking to other pilots who might also participate in the study.

The 36 participants were randomly distributed to the MBT or SBT conditions. They were solicited from the general population of ERAU students and had to fit the general requirements of having less than 500 total flight hours, IFR currency and none or very little experience with glass instruments for inclusion. Pilots who were selected for inclusion were compensated $100 for their time upon their completion of the study.

Instructors

The Instructors had the responsibility of training the participants in either the MBT or the SBT methods. They were required to be CFII flight rated and to be unfamiliar with (i.e. no formal training nor experience) TAA or glass instrument flight. ERAU has a large population of flight instructors from which to draw and the SMEs selected the most qualified to be MBT instructors. They were kept experimentally blind to the conditions of the study as much as possible for MBT training. They were trained in a classroom setting by the SMEs.

To assist continuity of instruction and to avoid differences in instructor quality, the same MBT instructors were trained to be SBT instructors.

Once they became SBT instructors, there was no longer any need to keep them experimentally blind to the conditions since they did not interact with the raters who tested typically on Fridays (pre-test) and Mondays (posttest). The Instructors typically trained the individual participants for four hours on Saturday and four hours on Sunday giving 8 hours of formal instruction. This is after the participants had been given the pre-test by the raters, usually four hours on Friday and before the participants had been given the posttest, usually four hours on Monday, as explained below.

Raters

Two raters were responsible for the pre and posttesting of all participants. They helped to develop the rating forms, along with the subject matter experts, that were used in the pre and posttests so they were very familiar with the intent and content of the rating forms before the experiment began. Rigorous efforts were made to keep the raters experimentally blind to the type of training each participant received. This was possible because the instructor training was typically done on the weekend, as explained above. They were both instrument rated and had received no formal training in SBT but had some familiarity with the concept from their classes. They both received thorough training in the use of the TAA simulation device and the procedures of the study prior to the beginning of data collection. To establish inter rater agreement, both raters evaluated the same 5 participants near the beginning of the experiment. The percent agreement was then calculated and, depending on the particular item being rated, agreement ranged between 65 and

100 percent. This check on inter rater agreement established compatibility. To further reduce the likelihood of rater bias, each participant was rated by only one rater. Thus, some participants were rated by "Rater A" while others were rated by "Rater B." The raters were experimentally blind to the training received by each participant.

Materials

Ratings of performance of the pre and post test scenarios were used as the primary data for the experiment. These forms were developed by subject matter experts from the University's College of Aviation.

The pre-test was supposed to parallel the post test in item specificity, differing only in location or altitude or heading or some other non-training-essential feature. For the event labeled Take-off and Departure (Event 4) for example, Vero Beach was the departure point for the pre test and Daytona Beach for the post test but otherwise this event was similar in the post test for both in terms of weather, fuel and passenger, all the principle details as for the pre test. The similarities of the event requirements were further enhanced by the raters during their training for inter rater reliability as explained below.

Both the pre-test and the post test considered the same piloting skills, as can be seen from Appendices 12 and 16. There were 8 phases of flight that were common to both:

Event 1: Flight planning
Event 2: Pre-Flight Preparation
Event 3: Pre-Take-off
Event 4: Take-off and Departure
Event 5: Re-Route
Event 6: En-Route
Event 7: Approach
Event 8: Missed Approach

Only the locations and specific events of the scenarios were different. Each of these events had numerous rating criteria. For example, for Event 3: Pre-Take-off, the pilot was rated as to whether he performed the engine run-up, set the avionics for flight, briefed the passenger and requested to be cleared to the active runway, among other criteria. For statistical evaluation purposes, the criteria for each event were compiled to give an event score rather than a criteria score. Further, a percent of those criteria that were correct for each event was used as the final score for each event. Thus, if a pilot got 3 out of 6 criteria correct for an event for example, that pilot's score would be 50%. These were the data that were entered into statistical evaluation considered in the Results section below.

Apparatus

Microsoft Flight Simulator (2002) was the software engine that drove both the traditionally instrumented Cessna 172 simulation device and the TAA instrumented Cirrus SR20 simulation device used in the study.

Flight Simulator is a well-known and reliable product, particularly in the Microsoft Windows environment. A number of third party products support Microsoft as the industry standard so it is easily interfaced with other software architecture. Primary among these were the Go-Flight (radio, electrical, throttle, autopilot) and other flight instruments (yoke and rudder) and the Chelton TAA instrument. The data recording capability of Flight Simulator permits aircraft state data to be captured, including switch positions, dial and gauge position and pilot input to the flight instruments, on a second by second capture rate captured as data for the study.

The Rater sat behind the participant at the instructor station for the Elite system and had access to the Microsoft Flight Simulator Instructor software to control weather and other system failures without the participant aware of the changes.

The TAA aircraft simulation device used in the study utilized a Chelton MFD and PFD as well as several instruments from Go-Flight that directly interfaced with Flight Simulator set up to emulate a Cirrus SR20 aircraft. As shown in Figure 3, the aircraft environment and instruments were given a lot of detail to increase the realism of the tests. An overhead projector cast the outside the windscreen view on to a large projector screen directly in front of the pilot. The pilot sat inside a Frasca 410 half shell aircraft simulation device on an adjustable aircraft seat. The windows were blocked to restrict vision to an outside the windshield view only.

The Chelton was interfaced into the MS FS environment by the FSUIPC EFIS system developed by Peter Morton through a Gateway Interface Port. All peripheral devices were fed into USB connections to a Dell Computer hidden from the pilots view. All extraneous material was removed from the pilot's field of view to increase the feeling of realism. A video camera, seen in Figure 3, was used to videotape the pilot's manipulation of the Chelton system for later off screen analysis.

Results

The tests in which SBT and MBT differed significantly (p<0.05) or produced a statistical result of (p<0.10) are graphed below, showing pre test and post test scores for both. A one tailed distribution was used for the alpha probability level since we hypothesized the direction of the SBT improvement over MBT. Although not significant, the NASA TLX data are presented to show a representative result that was at least visually in the predicted direction. In order to convey an idea of the central tendency of the results, the average and standard error of the SBT and MBT group means are graphed in each figure below. Although this is, strictly speaking, an incorrect way to show non-parametrically distributed data using a parametric measure of central dispersion, it was felt that this approach would convey the results better than simply presenting the non-parametric rank for each condition. For each graph then, the pre test and posttest scores are shown as an average plus the standard error of the mean. In the accompanying text, the Mann-Whitney U result is provided with the ranking results for each group.

Only those flight events (see Methods section above for all the events) that were determined to represent independent populations between the MBT and the SBT for the Rater derived posttest scores in that a statistically significant difference was found are presented.

Autopilot Use

The autopilot scores were obtained by compiling all the criteria in each flight event during the pre and posttests that required an autopilot use on the Rater checklist. The posttest difference between the MBT (mean rank 10.47) and SBT (mean rank 18.42) was represented by a Mann-Whitney U value of 37 and had a p value of 0.004. Figure 1 shows that the use of autopilot was performed correctly more often by the SBT group compared to the MBT group.

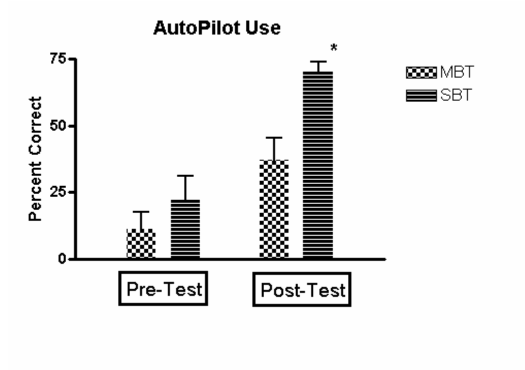

Figure 1. Autopilot useage in Pre- and Post tests for Maneuvers Based Training (MBT) and the Scenario Based Training (SBT) Groups. For all the graphs to follow the data are shown as a mean percent correct with the standard error of the mean shown.

Event 2: Pre-Flight Preparation

The pre-flight preparation event occurred in Vero Beach, FL for the pre test and from Daytona Beach, FL for the posttest on the simulator. In spite of the differences in location and ATIS information, the requirements for the pre and posttests were the same. As with all the flight events used to score piloting and navigation, the percent correct of the criteria for each flight event were used as the event score (see Methods). Figure 2 shows that the SBT (mean rank 18.83) correctly performed the items on the preparation checklist more than the MBT (mean rank 10.13) Group (U= 32; p=0.002).

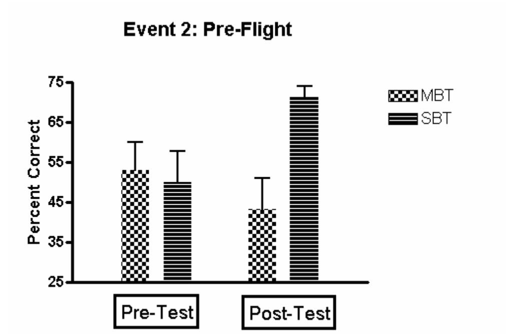

Figure 2. Pre-flight preparation for MBT and SBT pilots. This flight event showed SBT to be significantly better than MBT.

Event 5: Re-route

During the flight, the weather produced demanding instrument flight for both pre and posttests. The SBT pilots (mean rank 17.7) did better than the MBT pilots (mean rank of 11.47) as shown in Figure 3

(U=52.0; p=0.03). It is important to note that both MBT and SBT pilots showed a decrease in this measure, the SBT pilots less so, when considering the average percent correct score.

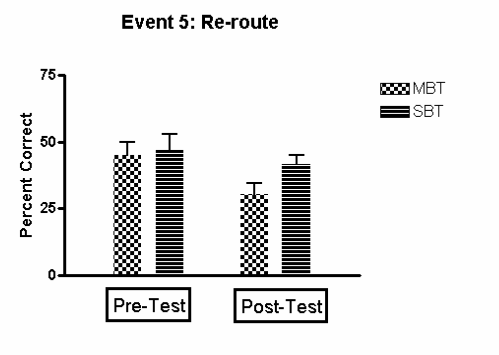

Figure 3. Re-Route Event for MBT and SBT pilots during flight. This flight event showed that SBT tended to be different from MBT although both groups decreased in the posttest compared to the pre-test.

Event 7: Approach

The Approach phase of flight was performed better during the posttest by the SBT group (mean rank of 17.7) compared to the MBT group (mean rank of 11.07) as shown in Figure 4 (U=46; p=0.015)

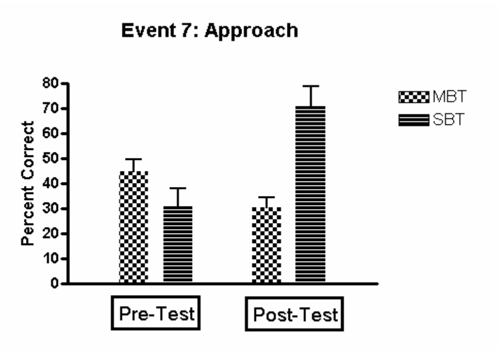

Figure 4. Approach Phase of flight for MBT compared to SBT. This flight event showed SBT to be significantly better than MBT.

Event 8: Missed Approach

The piloting and navigation responses to a missed approach during the posttest was better for the SBT group (mean rank of 18.08) compared to the MBT group (mean rank of 10.73) as shown by the graph in Figure 5 (U=41; p=0.008).

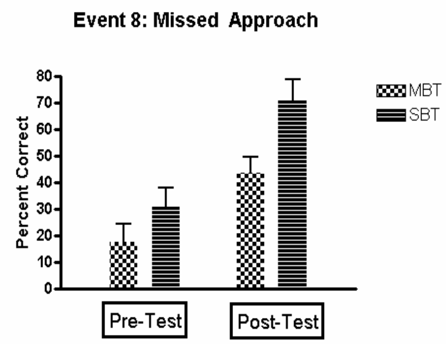

Figure 5. Missed approach event for MBT compared to SBT. This flight event showed SBT to be significantly better than MBT.

Discussion

The study was designed to provide a fair comparison between traditional (maneuvers based) training, the standard for decades in instrument flight instruction and scenario-based training, a new approach to instrument flight training that draws on that distinguished past as well as on new concepts in education, such as self-evaluation and relies on the importance of scenarios. The results argue that scenario-based training is better than task oriented or maneuvers based training on most measures of piloting and navigation proficiency as rated by experimentally blind expert raters. On the measures where statistical significance was not found to indicate SBT was better than MBT, SBT was found to at least show parity with MBT. In short, SBT pilots performed better than MBT pilots on most measures. The attitudes of the SBT pilots were in the right direction in most of the attitudinal and workload measures but were not statistically different. This suggests that pilots may demonstrate a measurably improved performance without necessarily being aware of it.

SBT emphasizes whole task training, using realistic scenarios, tightly coupled learning objectives, performance measures, and feedback. This report contrasts SBT with the maneuvers based approach to training instrument flight in TAA. The MBT approach has served aviation well for many decades. However, recent and radical advances in avionics that improves safety have been rapidly adopted by the aviation industry. The concept of FITS seems sound in improving piloting and navigation proficiency in TAA. It remains up to the academic, industry and FAA and its partners in industry and academics to make FITS work in application.

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