2007

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REFINEMENT OF A FLIGHT TRAINING DEVICE VIRTUAL ENVIRONMENT FOR AB-INITIO PILOT TRAINING

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A recent experimental flight training program at Embry-Riddle Aeronautical University investigated the amount to which flight simulation could be used in the training curricula by comparing two groups of ab-initio pilots to different amounts of exposure to the flight training devices (FTD). The results from the amount of transfer from the FTD to the actual aircraft flight suggested implications for both adjustments to the flight training curricula and for specific modifications to the flight simulation training environment as applied in an ab-initio training program. More specifically, these results provided an indication that greater visual fidelity, in terms of graphical 3D artwork, was necessary in the virtual environment for particular ground reference maneuver tasks and flight at low altitudes. Additionally, the level of traffic in the scenario and degree of complexity in simulated airspace affected transfer to the real world flights. These results suggest that specific refinements to the FTD-based flight simulation are necessary for future effective application during ab-initio pilot training.

Introduction

There have been numerous aviation training programs in the past that have endeavored to instill the best skills in their pilots while learning about how the fidelity of flight simulation impacts the training of those skills in the pilots (Gerathewohl, Mohler, & Siegel, 1969; Hays, Jacobs, Prince, & Salas, 1992; Stewart, Dohme, & Nullmeyer, 2000; Taylor, Talleur, Emanuel, & Phillips, 2005; Waag, 1981). These past studies have illustrated the impact of simulator fidelity in the training of pilots in various ways.

Kaiser & Schroeder (2003) describe four different forms of simulator fidelity: physical, visual, motion, and cognitive. Physical fidelity refers to the degree to which the physical form of the simulation matches the physical appearance of its real-world counterpart. Visual fidelity involves the match between the visual scenes viewed in the simulation compared to the scenes experienced by a pilot in the actual aircraft. Motion fidelity describes the relationship between the movement dynamics of the simulation to the movement dynamics of the simulated system in the real world. Cognitive fidelity relates the cognitive activities engaged in by the pilot to the cognitive activities actually performed by the pilot in the actual aircraft.

Embry-Riddle Aeronautical University (ERAU) recently completed an eighteen month training program investigating the use of a high fidelity simulation with enhanced visual capabilities for ab-initio pilots obtaining their private pilots license. This program incorporated all four forms of fidelity into the training program including physical fidelity encapsulated by the simulation housed inside an actual aircraft shell from Cessna aircraft to visual fidelity being provided by a 220° visual field to the pilot. Motion fidelity was enhanced through augmented flight dynamic modeling and cognitive fidelity was produced through a carefully designed curriculum.

A description of the full study is outlined in Macchiarella, Arban, & Doherty (2006) but the purpose of this paper is to provide an overview of the lessons learned from the development of that study and the implications of those lessons for future flight training scenario development. To understand those lessons, a brief overview of the basic study must be outlined.

Method

Participants

The study utilized 38 participants in two groups: an all-flight training control group and a combined simulation and flight training experiment group. The experiment group received a combined simulation and aircraft training experience through a curriculum that was comprised of 60% simulation-based flight and 40% aircraft-based flight. All participants were required to have less than one hour of flight time at the beginning of the study.

Apparatus

The simulation platform used was a Frasca 172 Level 6 FAA qualified flight training device (FTD) housed within a physical Cessna C-172S cockpit shell. This FTD was enhanced to include accurate flight dynamics and other sensory cues such as aural cues from engine RPM and tactile cues such as wind from air vents. The FTD was also augmented with a 220° visual system that provided information on weather conditions and terrain information in high fidelity at high altitudes.

Procedure

Participants were randomly assigned to either the all-flight curriculum or the hybrid simulator and aircraft curriculum before beginning flight training at ERAU. All participants then proceeded through standardized instruction in ground classes. The ground classes were paired with aircraft flight training for the control group and simulator and aircraft flight for the hybrid group. During the flight portions of the training, pilots were assessed in their abilities on 34 basic flight skills as defined by the FAA private pilot practical test standard (PTS) both in the simulation and in the aircraft.

Lessons Learned

In the development and analysis of this study a number of lessons were learned. Some were learned during the implementation of the training program while others were discovered once the results had been obtained.

The basic results of the study illustrated that the hybrid curriculum pilots required fewer trials in the aircraft than the all-flight control group on 33 of the 34 PTS tasks once the additional trials in the FTD were taken into account through standard transfer of training calculations. In addition, over half of the tasks were significantly different between the groups (see Macchiarella, Arban, & Doherty, 2006, for the full results).

Adjustments to Curricula

The PTS was selected as the measurement tool early in the training program process because it provided a set of observable tasks that can be verified by the instructor pilot during aircraft operations that include tasks such as cockpit management and flight maneuvers. However, the lesson learned with these PTS standards is that some tasks were more easily objective to the instructor pilots rating performance than others. For example, the task of cockpit management identifies correct assessment of resources in the cockpit during flight. However, the precise specification of what information and procedures to achieve completion of this task wasn't clear. This task was different between the two groups in the study but the reasoning behind that difference is not readily available because cockpit management is not directly measured along a single dimension of performance so the differences between the groups could be due to differences in the student pilots learning this skill or inherent differences between instructors on the exact requirements for completion of this skill. The implication for this to the curriculum is a more precise refinement of those tasks or evaluation of traffic patterns that are not as clearly defined as other skills such as engine starting that have a clear observable measurement. The selection of the PTS as a tool for measuring pilot skill also does not address other skills for flight that may account for variability in pilots during training such as automation management that is becoming more prevalent in many newer flight training systems.

Flight Training Environment

One benefit of the FTD utilized in the study was the addition of the 220° visual system. This allowed for the presentation of high visual fidelity in the training of the hybrid simulation and flight group that mimicked the visual field that would be seen in the actual aircraft. This high level of visual fidelity appeared to positively impact a number of the flight tasks but did not enhance tasks that required low-level ground maneuvers. The most logical explanation for this effect was in the discrepant visual fidelity that occurred depending on altitude. The visual fidelity provided by the visual system was optimized for operations at 3,000 feet above ground level (AGL) or above. The tasks that required ground-based referencing were typically performed between 600 and 1,000 feet above and therefore did not receive the improvement in performance provided by the visual fidelity in other skill areas. This lack of visual enhancement for ground-based maneuvers suggests that either the visual database must be uniformly supported at all altitudes, which may be prohibitive in cost in development or computationally or suggests that the level of visual fidelity in the graphical artwork generated by the computerized visual databases for simulation might necessarily be adaptive to accommodate changes due to visual perception for highly visual tasks in the aircraft itself.

The visual fidelity also appeared to impact tasks related to traffic scenarios and simulated airspace. The visual database was optimized for terrain features at high altitudes but lacked many traffic features during the simulation component of the hybrid training group. Consequently those pilots were less familiar with physical traffic in the airspace when they reached the aircraft flight portion of the curriculum. While this did not appear to impact the

PTS tasks directly, subjective reports from the instructor pilots and students indicated that this was one area in which pilots in the combination simulation and flight group had some difficulty. The implication of this is to include additional traffic within the simulation scenarios in order to increase the visual and cognitive fidelity, especially for areas with a high volume of traffic in the traffic patterns.

Inter-Rater Reliability

One final issue that emerged at the end of the study involved the assessment of the student pilots by their instructors. In order to provide individual instruction to each student pilot in the study and to address practical issues such as flight scheduling, student pilots were matched with a specific flight instructor. This pairing provided consistency in instruction for the student pilot but failed to provide any cross-validation of instructor pilot judgments of student pilot success across instructors. In other words the degree to which the various instructor pilots agreed in their judgments about student skill, known as inter-rater agreement (Shrout & Fleiss, 1979), was unable to be assessed directly. This meant that skills that were judged different between the two groups might be due to differences in opinion about judging student performance amongst the various instructor pilots used in the study rather than any difference in skills between the two groups. While the results in the study appeared robust despite this issue it raised the problem of how to resolve this concern in the future. Unfortunately, in order to obtain inter-rater reliability amongst instructor pilots multiple instructor pilots need to observe the same student's performance in order to determine the agreement amongst the instructor's judgments. This solution is prohibitive in scheduling personnel and requires multiple instructor pilots to view the student pilot at the same time which may, on occasion, be impractical based on the number of instructor pilots that are available. The current study combated this problem by having an instructor pilot meeting every other week to coordinate activities and provide reminders regarding consistent judgment of student skill.

Conclusion

Together, a number of lessons were learned during the creation, implementation, and analysis of a recent training program. Issues surrounding the use of the private pilot PTS for measurement, variations in visual fidelity for flight maneuvers and inter-rater reliability illustrate the fact that many factors must be considered when developing a training program that utilizes high-end flight training equipment.

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