E-Learning: The Future of Pilot Safety Training

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Introduction

The number of new pilot jobs is expected to grow at least 40% over the next decade and the volume of air traffic is expected to triple by 2025 (Federal Aviation Administration, 1993; Raisinghani, Chowdhury, Colquitt, & Reyes, 2005; Sams, 2006). In addition to new positions becoming available, the general pilot population is aging and the number of replacement pilots required to cover retirements are also significant (Raisinghani et al., 2005). This requires aviation psychologists to focus on ideal teaching practices and emerging instructional technologies to meet future instructional demands in the aviation industry.

Despite the need for crew resource management (CRM) that is economical and that can be widely distributed, computer-based CRM training has received minimal attention (Brannick, Prince, & Salas, 2005). A common perception in the industry is that CRM training is ill suited to computer-based learning (CBL) due to the team focus and the active practice requirement which is typically conducted in a flight simulator (B. Olah, personal communication, May 24, 2007).

A recent adaptation of CRM is single-pilot resource management (SRM) training. SRM adapts concepts from CRM to the single-pilot environment. Topics included in SRM include situation awareness, workload management, aeronautical decision making, and automation management. This training is gaining attention as single-pilot aircraft are undergoing a rapid increase in technological sophistication evidenced by technically advanced aircraft (TAA) and very light jets (VLJs) (Strait, 2006).

In SRM training, the team focus is eliminated and PC-based flight simulators can be embedded into the training as a method of active practice (Koonce & Bramble, 1998). E-learning offers several advantages for SRM including supporting tactile learners, geographic flexibility, and cost savings.

Ideally, instructional materials should support auditory, visual, and tactile learners. However, traditional non-technical instruction is delivered in a lecture format with visual aids. This training method best supports auditory and visual learners. The problem is that the majority of pilots, 44%, are tactile learners (Raisinghani et al., 2005). Delivering this content in an online environment would allow for the design of interactive materials that better support pilot learning.

Although no research evaluating a fully online and comprehensive CRM training course could be found, significant research has been performed on the use of inexpensive personal computer (PC) based simulations and games for crew training. Several PC-based flight simulation programs exist which are marketed for licensed pilots to refine their skills (Koonce & Bramble, 1998). In addition, several games are available that offer a variety of aircraft, the ability to fly out of virtually any airport, weather controls that reduce ceilings and visibility, and the capability to fail certain systems or instruments for practice purposes (Koonce & Bramble, 1998). Yet, with the option of purchasing yoke, throttle lever, and rudder pedals, these low-fidelity simulations become more than just a game (Koonce & Bramble, 1998). This reasonably priced alternative to high-fidelity flight simulators could allow students to complete the practice component of CRM or SRM training from a PC.

Many organizations utilize high-fidelity simulators for CRM instruction and practice (Helmreich, Merritt, & Wilhelm, 1999). High-fidelity simulations are characterized by high scene detail and motion platforms. However, current investigations have shown no differences in training transfer between high- and low-fidelity simulations (Salas, Bowers, & Rhodenizer, 1998). Research suggests that low-fidelity simulation is effective as long as it simulates the cognitive processes required in the real world, termed psychological fidelity (Bowers & Jentsch, 2001). This has lead to the conclusion that high-fidelity is not a requirement for effective training and transfer (Baker, Prince, Shrestha, Oser, & Salas, 1993; Koonce & Bramble, 1998; Salas et al., 1998). Following, Jentsch and Bowers (1998) conclude that aviators find low-fidelity simulations realistic and acceptable for CRM training.

Brannick and colleagues (2005) conducted an investigation into the transfer of training of pilot assertiveness taught with a PC-based simulator. Brannick et al. (2005) found positive quasi-transfer from a PC-based simulator to a high-fidelity simulator, providing strong evidence that inexpensive simulators can effectively teach CRM skills (Brannick et al., 2005).

Instructional Design of Computer-Based Pilot Training

From an instructional design perspective, several questions remain unanswered about how to effectively teach SRM. The few SRM programs that are in existence deliver this material in lecture format (receptive architecture). This approach takes the perspective that learners are “sponges” waiting to soak up knowledge (Clark, 2003).

A cognitive apprenticeship methodology was chosen for the computer-based SRM training in the present investigation (Collins, Brown, & Newman, 1989). Clark (2003) explains that this approach is best utilized with far transfer tasks, learners with content knowledge, and for building problem solving skills: All of which describe the requirements of SRM training for the general aviation (GA) pilot population. Rather than utilizing a traditional receptive architecture, where learners are passive recipients of information, this approach requires active constructivist learning. Constructivist learning assumes that knowledge is constructed by each individual based on their personal interpretations and past experiences (Jonassen, 1999). Therefore, effective instruction should include experiences that allow learners to construct knowledge (Jonassen, 1999).

Historically, pilot training operates under the traditional master-apprentice model. When an individual seeks to become a pilot he or she is assigned to an instructor pilot. Until the student pilot has achieved their license, most flight time will be spent observing and working with an instructor. As experience increases, reliance on the instructor decreases until the necessary knowledge, skills, and abilities are passed down to allow for safe operation. The major difference between the traditional master-apprentice model and a cognitive apprenticeship is that the traditional model allows for the observation of psychomotor skills only. A cognitive apprenticeship identifies expert thought processes and makes them visible to the student (Collins, Brown, & Holum, 2004). An added benefit of cognitive apprenticeships is that multiple situations and scenarios can be presented to the student which would be unlikely to encounter in the real world (Collins et al, 2004).

The computer-based SRM program that was developed for this investigation asked pilot learners to model expert pilot behavior, incorporated a coaching agent to provide tips, asked learners to articulate thought processes and reflect against expert behavior, and provided an opportunity to explore and practice concepts through scenarios which took place in a PC-based flight simulator either hands-on practice or through guided mental practice (Collins, Brown, Newman, 1989). Woolley and Jarvis (2007) argue that a cognitive apprenticeship model effectively prepares students for the operational environment and lays the foundation for the development of a competent practitioner with the required physical and cognitive skills.

Pilot Attitudes Towards Computer-Based Learning

In 2005, Raisinghani et al. developed and analyzed surveys to evaluate pilot attitudes towards CBL. Although this study focused on primary flight training, rather than SRM training, it is applicable to the present study. This investigation determined that pilots are comfortable with new technology and capable of utilizing CBL. To promote pilot acceptance of CBL it must be interactive with audio, visual, and tactile features, understandable and flexible, and present material in logical modules (Raisinghani et al., 2005). CBL caters to the demands of modern aviators and cost conscious operators who wish to reduce time spent at training centers (Raisinghani et al., 2005). They concluded that CBL, rather than traditional lecture based training, supports the training requirements of modern pilots (Raisinghani et al., 2005).

This information is useful in the present investigation as it provided some guidelines about the design of instruction. In addition, the positive response of pilots to CBL indicates that they are affectively open to this training delivery method.

Guided Mental Practice

Brannick and colleagues (2005) investigation suggests that CRM training could be delivered via computer through training incorporating low-fidelity flight simulation and yoke, rudder, and throttle peripherals. However, bulky and expensive peripherals limit online distribution of CRM training. The present investigation assessed two practice options in a situation awareness training program: (a) practice in a computer-based flight simulator utilizing yoke, throttle, and rudder pedals, and (b) guided mental practice (GMP) where the learner watched a video of a flight simulator scenario and imagined themselves as the pilot.

Wiley and Voss (1999) determined the practice exercise does not matter, it is the mental process it facilitates that results in enhanced learning. “Humans have the ability to generate mental correlates of perceptual and motor events without any triggering external stimulus, a function known as imagery” (Jackson, Lafleur, Malouin, Richards, & Doyon, 2001, p. 1133). Research has determined that this imagery, or mental practice, is a powerful instructional tool for improving performance on both cognitive and psychomotor skills (Driskill, Copper, & Moran, 1994).

GMP describes practice that takes place without any hands-on interaction yet is facilitated by a computer-based flight simulator scenario embedded within an asynchronous training program. Within GMP, participants are asked to view a video of a flight simulator in a scenario and imagine themselves as the pilot of the flight. GMP differs from traditional mental practice, which is typically an entirely internal imagery process, as an external medium guides the learner through the practice exercise. Utilizing GMP in a computer-based SRM or CRM training program would allow the training to be offered without any external peripherals. This would allow pilots to complete the training from any computer at a time that is convenient. This dramatically reduces the cost of delivering training, improves accessibility, and automates performance tracking.

Method

To assess the feasibility of computer-based SRM training thirty six licensed pilots were recruited. The pilots were separated into three equal groups: (a) computer-based training incorporating hands-on practice with a yoke, throttle, and rudder pedals, (b) computer-based training incorporating guided mental practice, and (c) a control group that did not complete any training. Following, all participants completed a performance evaluation in a high-fidelity flight simulator in which the situation awareness global assessment technique (SAGAT) was administered (Endsley, 2000). The SAGAT required the pilot to fly a predetermined flight plan within the high-fidelity flight simulator. During the flight a researcher paused the simulation at random intervals, the pilot was asked to turn away from the control panel, and queries about the status of the flight were asked.

Results

The sample included a total of 36 individuals. Each of the three defined groups (hands-on training, guided mental practice training and control group) had 12 individuals. There were a total of 32 males (88.9%) and 4 females (11.1%).

The following table presents descriptive statistics on the individuals' age and hours of flight experience:

Table 1. Descriptive Statistics of Participants' Age and Flight Hours

	N	Minimum	Maximum	Mean	*SD*
Age	36	18	31	22.14	3.04
Flight hours	36	50	825	164.76	166.12

The following table shows the proportion of individuals in the sample that, beyond the base requirement of a Transport Canada private pilot license, also possessed a commercial pilot license or an instrument rating. Additionally, the proportions of individuals with prior computer-based training (CBT) experience are presented:

Table 2. Descriptive Statistics of Participants' Advanced Qualifications

Category	*N* (%)
Commercial License	
No	30 (83.3%)
Yes	6 (16.7%)
Instrument Rating	
No	32 (88.9%)
Yes	4 (11.1%)
CBT Experience	
No	21 (58.3%)
Yes	15 (41.7%)

Performances of individuals in the sample were measured using the situation awareness global assessment technique (SAGAT). Table 3 presents the mean and standard deviation of the performance measure, overall and for each individual group.

Table 3 presents data that, based on a univariate analysis, identifies significant differences across groups at the 0.05 level for the SAGAT performance measure ($p = 0.001$). In order to assess the nature of the group differences, a post hoc Least Significant Difference procedure was performed. This procedure allowed performing multiple pairwise comparisons in order to determine which groups had significantly higher or lower scores than others.

Table 3. Mean, Standard Deviation and Significance of Differences of Performance Measure by Group

Group		SAGAT
Hands-on practice	Mean	13.08
	SD	2.35
Mental practice	Mean	13.50
	SD	2.43
Control	Mean	10.00
	SD	2.22
Total	Mean	12.19
	SD	2.77
p value		0.001

Note: the *p* value in this table corresponds to one-way ANOVA using the performance measure (SAGAT) as the dependent variable and Group as the independent variable.

For the SAGAT variable, it was found that the control group had lower scores than the mental practice ($p = 0.001$) and hands-on practice ($p = 0.003$) groups. However, no significant differences were found between the mental and hands-on groups ($p = 0.665$).

Conclusions

The results of this study indicated that computer-based training, incorporating either hands-on or GMP, improved pilot situation awareness.

Recommendations

The results of this investigation suggest that guided mental practice is a promising instructional strategy that allows for the online delivery of SRM training. However, to allow for CRM training, additional work is required to develop and assess team training methods in a computer-based asynchronous learning environment.

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