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SAFTE-VAT Functionality Effects on Flight Instructors' Situation Awareness and Instrument Student Pilots' Performance during FTD Training

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by

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Abstract

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SAFTE-VAT is a virtual air traffic control systems that adds the capability to integrate automated air traffic control functionality and generate semiautonomous and autonomous air traffic to the Frasca 172S level 6 plus FTD to improve behavioral fidelity and to facilitate flight instructors the capacity to focus more on instructing student pilots instead of role-playing ATC duties. While SAFTE-VAT may offer a more realistic ATC interaction experience onboard the FTD that may result in a positive transfer of training increase, the effects on flight instructors' situation awareness and overall student pilot performance are uncertain. In this small study, flight instructors and instrument student pilots were observed completing while lesson 32 of the FA221 instrument course was onboard a Frasca 172S level 6 plus FTD with and without the used of SAFTE-VAT. During each FTD lesson 32 flight instructors were queried to test for situation awareness. Student performance data was collected upon completion of each FTD lesson and analyzed. The results revealed the possibility of situation awareness decrease during periods of low FTD activity levels when SAFTE-VAT was used. Student performance data favored the lessons conducted without the SAFTE-VAT.

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Chapter I

Introduction

Flight simulators and flight training devices (FTD) have played an important role in the development of pilot skills. Hayes and Langois (2005) described the Antoinette Trainer as one of the first true flight simulators. The platform was formed from two half-sections of a barrel mounted and moved manually by the instructor pilot to represent pitch and role of an aircraft. The students' duty was to counter the instructors' inputs and align a reference bar with the horizon by applying appropriate control inputs through a series of pulleys (Adorian, Staynes, & Bolton, 1979). It was early in the development of flight simulation where the instructor pilot role-play became an evident key factor in the development of student pilots.

In 1929 Edward A. Link received a patent for his generic ground-based simulator which was designed to demonstrate simple control surface movements and was later upgraded to be used for instrument flight instruction (Moroney & Moroney, 1999). In 1934, the Navy and the Army Corps recognized the potential of the Link trainer for flight instruction and began acquisition of the trainer. The instructors were tasked to monitor and evaluate the student pilot actions and movement of flight surfaces (Fischetti & Truxal, 1985).

Today, flight simulators are far more technical and complex than the Antoinette and Link Trainer. Technological advances have helped developed simulators that are capable of creating realistic environments through high visual fidelity displays and full motion giving the pilot the sensation of actual flight. This concept has led many to believe that high fidelity FTDs are essential to improve behavioral fidelity and therefore substantially improve the transfer of training effectiveness on student pilots. Behavioral fidelity primarily focuses on pilot's cognitive processes necessary for authentic replication of the real world (Macchiarella, 2008). Behavioral fidelity bridges the pilot's mental activities performed in the simulator to the mental activities in the aircraft.

Some researchers may argue that devise fidelity is not as important to achieve positive transfer of training. Talleur (2004) stated that task similarity from a procedural standpoint would promote positive transfer regardless of devise fidelity. Similarly, some researchers have indicated that instructors' motivation, level of knowledge, and instructional techniques are crucial in the transfer of training and are just as import as instructional design and method of delivery. Moroney and Moroney (1999) believe that the instructors' motivation, level of knowledge, and skills greatly determined the outcome of transfer of training in simulators. Additionally, McCauley (2006) indicated in his research that the value of a simulator is derived in large part from instructional design and content rather than the simulators' hardware and software that represent the functionality of the aircraft.

Significance of the Study

A study conducted at Embry-Riddle Aeronautical University-Daytona Beach (ERAU-DB) campus by Macchiarella, Arban, and Doherty (2005) identified procedural similarity or "behavioral fidelity" as one of the factors that can effect transfer of training from FTDs to flight on student pilots. The study also revealed evidence that during the use of the FRASCA Level 6 plus Cessna 172S FTD the instructors were overloaded with the duties of role-playing air traffic control and air traffic in order to generate a realistic environment. Furthermore, the task overload inhibited the instructor from fulfilling the functions of instruction and evaluation during FTD sessions. Although, positive transfer of training was documented during this particular study, it opened the doors to further enhance the FRASCA Level 6 plus Cessna 172s FTD with the Synthetic Automated Flight Training Environment with Virtual Air Traffic (SAFTE-VAT).

In 2009, ERAU-DB added the SAFTE-VAT to the high fidelity FRASCA F172 FTD (Collins, 2009). SAFTE-VAT added the capability to integrate automated air traffic control functionality and generate semiautonomous and autonomous air traffic. SAFTE-VAT was designed to engage pilots with virtual ATC and virtual air traffic communications during simulation training to decrease instructor pilot workload and increase behavioral fidelity (Macchiarella & Doherty, 2007). Since SAFTE-VAT was integrated with the ERAU FRASCA Level 6 plus Cessna 172s FTD in 2009 there has been no research conducted to determine the added value of the system and the effects it may have on flight instructors' situation awareness (SA).

Statement of the Problem

The SAFTE-VAT represents another step forward to improve behavioral fidelity and generate a sense of realism in FTDs. The idea of introducing SAFTE-VAT was not only to generate autonomous and semiautonomous virtual air traffic and virtual air traffic control, but also to free the instructor pilot from role-playing duties. The instructor in turn can devote more resources to instructing and evaluating the student when the ATC role-playing is not required. As a result, the student pilots benefit from a more realistic FTD scenario and the instruction and guidance of the instructor pilot during FTD flights. It is unclear as to what should be credited for the increase of transfer of training effectiveness—the SAFTE-VAT realism, or the additional flight instructor attention generated by the SAFTE-VAT. Furthermore, it could be that the SAFTE-VAT is generating flight instructor underload and directly affecting flight instructors' SA. This study analyzed the use of SAFTE-VAT on the ERAU FRASCA Level 6 plus Cessna 172s FTD and intended to determine its effects on instructors' SA and student pilots' performance with and without the use of SAFTE-VAT.

Purpose Statement

The purpose of the research was to determine how the employment of SAFTE-VAT affects instructor pilots' SA and student performance when in use onboard a FRASCA level 6 plus Cessna 172S FTD.

Hypotheses

H1. There will be no significant difference in instructor pilots' SA when training instrument student pilots onboard a FRASCA level 6 plus Cessna 172S FTD with the SAFTE-VAT function or without the SAFTE-VAT function.

H2. There will be no difference in instrument student pilots' performance when training onboard a FRASCA level 6 plus Cessna 172S FTD with the SAFTE-VAT function or without the SAFTE-VAT function.

Delimitations

The research was conducted at ERAU-DB with instrument student pilots during their instrument flight training. The study utilized the FRASCA level 6 plus Cessna 172S FTD equipped with SAFTE-VAT. Mod 32 from FA-221 instrument course was selected and scheduled to be used with and without SAFTE-VAT.

Limitations and Assumptions

The researcher used ERAU-DB aeronautical science students during their instrument flight training and was limited by the number of participants available. Also, the study was limited by the number of FTD sessions required per subjects in accordance with the curriculum to conduct the study.

The study was conducted under the assumptions that all subjects were honest in regards to their flight training experience and that they were all considered to be novice instrument student pilots. It was also assumed that the instructors involved in the study were fully qualified and credited by ERAU-DB.

List of Acronyms

ATC	Air Traffic Control
ERAU-DB	Embry-Riddle Aeronautical University, Daytona Beach Campus
FAA	Federal Aviation Administration
FTD	Flight Training Device
GPS	Global Positioning System
SAFTE-VAT	Synthetic Automated Flight Training Environment - Virtual Air Traffic
SA	Situation Awareness
VAT	Virtual Air Traffic

Chapter II

Review of Relevant Literature

The study conducted focused on flight instructors' situation awareness and student pilots' performance while learning on high fidelity simulators with improved behavioral fidelity via embedded systems. Thus, it is important to understand the principles in which training transfer is believed to take place. Transfer of training has been defined as the extent to which learning of a response in one task influences the response in another task or situation (Adams, 1987). For example, a task learned in the flight simulator will generate similar responses in the actual aircraft. Holton, Bates, Seyler and Carvalho (1997) define transfer of training as "the degree to which trainees apply to their job the knowledge, skills, behavior and attitudes they gained in training" (p. 96). Recently, Blume, Ford, Baldwin, and Huang (2010) defined transfer as consisting of two major dimensions: (a) generalization - the extend to which the knowledge and skill acquired in a learning setting are applied to different settings, people and/or situations from those trained, and (b) maintenance - the extent to which changes that results from a learning experience persist over time. For example, the way a novice pilot applies the concepts of aeronautics to understand how to fly the aircraft (generalization), and as pilots continues training, impacts the way they are able to retain and build on the knowledge acquired over time (maintenance).

Theories of Transfer of Training

Over the years, two main theories of transfer of training have prevailed as groundwork to understand the conditions necessary for positive transfer. These theories are known as the identical elements theory and principles theory.

Theory of identical elements. The theory of identical elements states that through identical elements, a mental function or activity improves others in so far as they are in part identical (Thorndike, 1906). The greater the similarity between two situations, the greater the opportunity exist for positive transfer of training (Rouiller, 1989). Macchiarella (2008) suggested that Thorndike's theory is adaptable when examining a simulated environment for student pilots training.

Principles theory. The principles theory as discussed by McGehee and Thayer (1961) and Goldstein (1993) suggests that training should focus on general principles to learn a task. This theory implies that learning general concepts will help learners apply the learned skills or concepts and respond in the transfer environment. The theory constitutes an overall understanding of the task instead of just learning the rote mechanisms of performing a task.

Near and far transfer. The theory of identical elements and the principles theory are important to the comprehension of transfer of training and they both contribute to the application of near and far transfer. Near transfer is the application to learning situations similar to those in which initial training has taken place (Yamnill & McLean 2001). Near transfer is supported by the theory of identical elements because it relies in the similarities between tasks for the attainment of transfer. Near transfer is most suitable in technical environments because it centers on specific behaviors and procedures of individual's current job (Laker, 1990). Far transfer is the application of learning circumstances dissimilar to those of the original learning experience (Yamnill & McLean 2001). Far transfer aligns with the principles theory because it focuses on the importance of understanding the general concept and the why of the learning event. The principle theory is critical to far transfer because knowledge can be abstracted and connected to new problems (Yamnill & McLean, 2001). Far transfer stresses that if individuals learn based on general principles, then that same knowledge could be applied to new training and in multiple situations.

Transfer of Training Model by Baldwin and Ford

The purpose of discussing the transfer of training model by Baldwin and Ford (1988) is to establish a common understanding on transfer of training. Although other models such as Holton's model (1996) were reviewed during the research, the Baldwin and Ford model best provides the groundwork to further discuss transfer of training within the context of the research.

The model of transfer process presented by Baldwin and Ford (1988) classified the factors affecting transfer of training into three categories: training inputs, training outputs, and conditions of transfer. Conditions of transfer include the generalization of the material learned and maintenance of learned materials over a period of time. Training outcomes are described as the amount of original learning that occurred during the training period and maintained over a period of time. Training inputs are divided into three categories: trainee characteristics, training design and work environment.

Training inputs set the initial stage for positive transfer. All three training inputs are seen as affecting learning and retention, which directly influence generalization and maintenance (Yamnill & McLean, 2001). Figure 1 demonstrates how the factors are linked together, and shows how training inputs have direct and indirect effects on training outcomes and conditions of transfer (Baldwin & Ford, 1988). To better understand the process of transfer of training and how it works, the transfer of training inhibitors must be recognized. Understanding of such factors will help in the overall improvement of transfer of training.

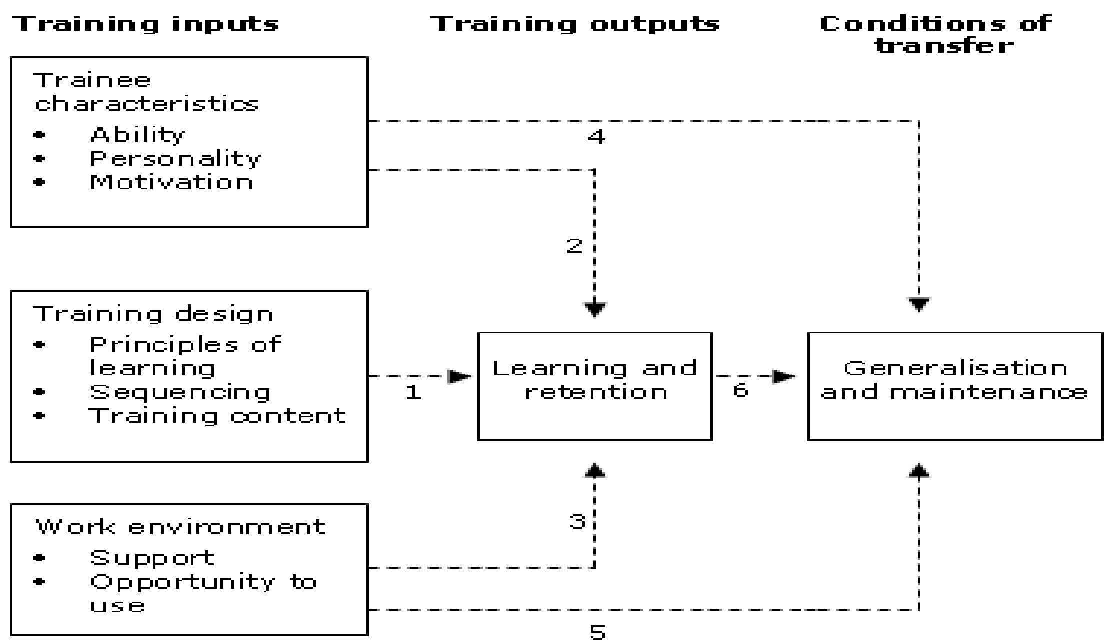

Figure 1. Model of the Transfer Process. Reprinted from *Transfer of Training: A Review and Directions for Future Research* (p. 63), Baldwin, T. T. and Ford, K J. Personnel Psychology, 1988.

Transfer of Training Inhibitors

Foxon (1993) conducted an analysis of 30 articles, which led to identification of approximately 128 inhibiting factors. Foxon organized these factors in four separate groups: (a) organizational climate factors, (b) training design factors, (c) individual learners characteristics, and (d) training delivery factors.

Organizational climate factors as inhibitor factors refer to the negative environment created by the supervisor and, to an extent, co-workers (Foxon, 1993). Generally, the organizational or training climate refers to the type of support or inhibitors trainees will likely encounter in their jobs concerning the use of training received

(Roullier, 1989). Negative environments for training transfer may be created in situations where trainees may face supervisors or co-workers who are performing their work in a manner not consistent with the training offered (Roullier, 1989).

Training designed factors speak to whether or not the content is too much theory or not practical enough, and whether the training was developed, planned, and organized within the means to properly train and maintain the trainees intended (Roullier, 1989). As Holton (1996) mentioned, one of the failures to transfer factors is that training design barely provides for transfer of training. This process indicates training may have occurred, but there was no plan for trainees to practice or implement what was learned, therefore resulting in loss of transfer.

Low levels of motivation to apply training along with learners' difficulties to master skills and knowledge are considered to be another major inhibitor factor that falls in the individual learner's characteristic category (Roullier, 1989). Behavioral change is likely to occur when trainees learn the material or skill and have the desire to apply the skill or knowledge learned (Yamnill and McLean, 2001). Tubiana and Ben-Shakhar (1982) discovered a positive relationship between motivations to succeed in training and performance. Although, Roullier (1989) states that individual characteristics account for only 21% of the inhibiting factors, without motivation to learn or to use the acquired knowledge, transfer is not likely to occur. Well-learned skills may not be maintained on the job due to lack of motivation (Baldwin & Ford, 1988).

Roullier (1989) referred to training delivery factors as inhibitors when inappropriate methods, media, and delivery style are used. Roullier also mentioned that low level of trainer credibility could act as a transfer of training inhibitor. The theory of identical elements concurs with these inhibiting factors in the sense that if elements are not alike to the real world, then methods, materials, and conditions are not appropriate and transfer is not effective. In regards to aviation training, the Link trainer was not a high fidelity simulator by today's standards, but at the time, served the purpose and generated some positive transfer of training (Moroney & Moroney, 1999). The Link trainer was considered to be the first simulator to achieve the feel of an actual aircraft (Kaiser & Schroeder, 2003). Another example of inappropriate instruction material was a report by Maden (1992) stating that the simulator instructor manuals were written at the engineer level and were not user friendly. Equally important, Huddleston and Rolfe (1971) stated that simulator effectiveness depends as much on the quality of the instructor as does the educational value of piece of chalk on the quality of the teacher.

Instructor to Student Interaction

"Without positive encouraging words of a flight instructor, the simulator's "hints" of deviation from desired parameters may have induced stress, negative thought, and other distracting emotions" (Koonce, 1998, p. 785). This statement strongly advocates the importance of the instructor, guidance, and experience in the training environment. Foxon (1993) mentions that low levels of training credibility may be considered an inhibiting factor. Foxon (1993) also indicates that professionals regard lack of supervisory encouragement and reinforcement to apply the training as the principal inhibiting factor in the transfer process. Furthermore, Huczynski and Lewis (1980) and Richey (1992) concurred that supervisors are the most important influence on the transfer process and where they encourage and model the desire behavior.

The model of transfer of training presented by Balwin and Ford (1988) hardly discussed the relationship of instructor in the transfer of training process and barely addressed the instructor's influence as a behavioral stimuli. Conversely, they addressed supervisor as a supporting role of motivation in the transfer of training model, mainly because employees look at supervisors for relevant information regarding how to successfully work within the social environment (Balwin & Ford, 1988).

Huczynski and Lewis (1980) as cited by Baldwin and Ford (1988) stated that employees who perceived training was important to a supervisor would be more motivated to attend, learn, and transfer trained skills to the job. Moroney and Moroney (1999) also believed that in most training, skills, knowledge, and enthusiasm of the instructor as well as the management policy greatly determine simulator effectiveness. Proportionately, if a supervisor shows disinterest or reluctance about a training session it may lead to demotivation and lack of interest (Baldwin & Ford, 1988).

Bhatti, Battour, Sundram, and Othman (2013) showed a disagreement among researchers in supervisory support to transfer of training. In their research, Bhatti, Battour, Sundram, and Othman found that Chiaburu & Tekleab (2005) encountered no relationship between supervisory support and skill transfer when measuring in terms of employee developments and practice of new skills. Also, Nijman (2006) found that supervisor support had no direct effect in transfer when considering motivation to transfer. In contrast, Facteau, Dobbins, Russell, Ladd, and Kudisch (1995) found positive supervisor influence in transfer during pre-training motivation when measured in terms of supervisor's tolerance for change. Additionally, Velada, Caetano, Michel, Lyons, and Kavanagh (2007) found positive supervisor support effects in transfer when measured in terms of ways to apply training on the job, problems in using training, interest in training, feedback on performance, and goals to apply training on the job. Bhatti, Battour, Sundram, and Othman (2013) concluded that supervisor support positively influences transfer motivation and indirectly influence the transfer of training. Although, there might be a disagreement among researchers, it is challenging to ignore the research that supports the direct and indirect influence of supervisors and instructors on transfer of training, particularly in regards to the training of pilots.

As part of the training design, instructor pilots are considered an essential part in the training and development of novice pilots. As mentioned by McCauley (2006), “quality instructional designed, when implemented by quality instructors, will result in positive transfer of training” (p. 29). Macchiarella, Brady and Arban (2005) referred to the quality of instructor as a human center issue in flight simulation training that may negatively affect the outcome of training when lack of knowledge, poor techniques, inattention, and mood swings are displayed. Further, Macchiarella, Brady and Arban (2005) added that even well-designed training programs might not produce the intended results, unless it is recognized that transfer is a functions of motivation, opportunity, and feedback. Motivation, opportunity, and feedback are functions performed by the instructors in most training environments.

Rees (1995) analyzed the transfer of information between instructor and student pilots for linked and unlinked flight control aircraft. Rees was concerned with the procedural transfer of follow-through training practice obtainable onboard linked flight control aircraft. This procedure is not available for unlinked flight control aircraft because inflight computers receiving inputs from the cockpit to control surfaces of the aircraft. Onboard unlinked flight control aircraft or simulators instructor pilots are unable to physically demonstrate the flight control actions, and the students are unable to follow-through. Equally, the instructor is unable to physically follow the student's actions in the flight controls (Rees, 1995). Rees' research was summarized by a statement provided much earlier by Masson (1990), where he argued that skill performance is based on procedural knowledge, which is not verbalized or usually available in consciousness: thus the quality of information being transmitted from instructor is likely to be severely degraded.

Instructor Role-Play in Simulators

Over time, the role of the instructor pilots in simulators has evolved from manually moving a barrel on the Antoinette trainer to managing and operating highly sophisticated computers and virtual scenarios. The Antoinette trainer did not have effective control surfaces and instructors had to physically move the trainer to create the effects of disturbances, which then the student pilots would attempt to compensate and overcome. As the use of flight simulators increased, greater emphasis had to be placed on the role of the instructor as part of the instructional design (Moroney & Moroney, 1999). Today, during simulator flights, instructor pilots find themselves spending much of their time operating the simulator, and role playing ATC and air traffic to complement virtual scenarios. Role play is one method of training that uses targeted practice and feedback to train skills (Beard, Salas & Prince, 1995). As the aircraft complexity increases, the instructor's stations proportionally increase to match the virtual world required to execute the training, along with role-playing, the instructor becomes less likely to monitor and instruct the student pilots (Ford, 2009). Instructor pilots often feel unsure about what the purpose is, how to run a role play and whether it would work, causing the credibility of the role play to become inadequate due to previous unsuccessful encounters in role playing (Beard, Salas & Prince, 1995).

The instructor pilot workload escalation due to role play duties is mainly due to the inherent low ability of the FTD to generate a realistic training environment (Macchiarella, 2008). Instructors are placed in a position where the role play is just as critical to the training as FTD's functions in order to mimic real world situations and improve chances of transfer in accordance with the theory of identical elements. The instructor pilot capability to role play ATC and air traffic directly relates to making the students believe they are in a real flight environment (Macchiarella, 2008). Atkins, Pfister, Lansdowne, and Provost (2002) also supported the theory of identical elements on flight training and affirmed that the greater the similarity between systems, the greater is the probability to predict transfer.

Robinson and Mania (2003) addressed the instructor's workload in flight training when considering the performance of ATC and air traffic duties during virtual environment scenarios. Robinson and Mania (2003) called these conditions less ideal for several reasons: the same instructor sounds the same for all sector controllers, the instructor workload increases and detracts from his observation in the trainee, sector frequencies may not be accurate, and there may not be an accurate display visually or on radar. "Delivering instruction in the FTD can heavily task flight instructors through the need to serve as a copilot, and role playing the multiple complexities of ATC and air traffic" (Macchiarella, 2008, p. 5). As discussed, both authors seem to share the conclusion in reference to the additional workload added by role playing the duties of

ATC and air traffic. It is not surprising that both articles shared in common the recommendation of adding an autonomous and automatic systems capable of handling the functions of ATC and air traffic to enhance behavioral fidelity and allow the instructor to focus in instructing and observing the student pilot.

Robinson and Mania (2003) recommended the creation of system capable to run applications with the ability to recreate various controllers' voices, command sets and the use of voice recognition to virtually recreate numerous airspaces and place more demands on the student pilot. Robinson and Mania (2003) believed this system would increase behavioral fidelity, enhance training demands on student pilots, and significantly reduce the instructor pilot workload to allow instructor pilots to focus on instructing and monitoring student pilot activities. In 2008, ERAU-DB and Frasca International Inc. developed the Virtual Air Traffic (VAT) functionality into the existing Frasca FTDs at ERAU-DB (Macchiarella, 2008). VAT shares similar characteristics to the systems mentioned by Robinson and Mania. VAT functionality is capable of creating semiautonomous and autonomous virtual air traffic centered on a scenario based training, triggered by speech recognition, location of training aircraft, time, or specific location in the scenario (Macchiarella, 2008). The VAT functionality was developed with the end goal to create an FTD based training environment that could accurately replicate the real world delivering a high degree of procedural similarity/behavioral fidelity while releasing the instructor from role playing ATC and air traffic and allowing them to concentrate on instructing (Macchiarella, 2008).

Fidelity and Behavioral Fidelity

Fidelity. Fidelity has been defined in numerous ways, especially when referring to flight simulation. Fidelity was described by Hays (1980) in accordance with the Seville Research Corporation as the details of the characteristics of the equipment or item which are present in the simulation and the mode in which those details are represented, and which are specifically included for training purposes. Hays (1980) simplified the term fidelity as the degree of similarity, both physical and functional, between a training device and the actual equipment for which training was designed. Hays and Singer (1989) provided a different concept and defined fidelity in terms of situations and not equipment; they defined simulation fidelity as the similarity between the training situation and the operational situation. Similar to the definition given by Hays and Singer, Noble (2002) conveyed that fidelity was the degree to which a simulator or simulated experience imitates the real world.

Perhaps a more complete definition of fidelity was provided by Dillard (2002) expressing that fidelity is the degree to which a model or simulation reproduces the state and behavior of the real world, or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner. Dillard's approach addressed all aspects of simulation including physical characteristics and behavioral functionality.

Behavioral Fidelity. Condon, Ames, Hennessy, Shriver, and Seeman (1979) introduced the term of behavioral fidelity as the replication of machine interactions (behaviors) determined as a result of task analytic procedures. As discussed in a paper published by Baum, Smith, Hirshfeld, Klein, and Swezey (1982), Condon, Ames, Hennessy, Shriver, and Seeman's concept of behavioral fidelity was similar to the term task fidelity introduced earlier by Mirabella and Wheaton (1975) and Wheaton, Mirabella, and Farina (1975), describing the task correspondence between the simulator and the operations equipment. Macchiarella (2008) suggested that during flight training, behavior fidelity relates to the mental activities engaged by a pilot in simulation to the cognitive activities performed by a pilot in the aircraft. A study on conducted on drivers by Lee, Ward, Boer, Brown, Balk, and Ahmad (2013) provided a similar definition in which explained behavioral fidelity was viewed as the degree to which behavior of the drivers in the simulator matches the behaviors of the drivers on the road, and further added, that behavioral fidelity is linked to the simulator's ability to duplicate the behavior in the real world.

It is important to establish the relationship between fidelity and behavioral fidelity to further understand how they interact in the transfer of training process. Hays (1980) hinted to the relationship between fidelity and behavioral fidelity indicating that while attempting to train individuals to behave a certain way, the level of fidelity should be driven by the behavior goal. A similar statement was provided by Matheney (1978). Boothe (1994) noted that in order to obtain transfer behavior, the task performed in the simulator must be equal to the tasks performed in the aircraft. He believed that identical elements would reproduce identical responses in the aircraft. Roscoe (1991) contradicted Boothe's concept and argued that training devices should be based on training effectiveness and not in the similarities. Macchiarella (2008), believed that the increase in similarities to the real world can produce a setting with higher levels of behavioral fidelity that affords students to incur cognitive activities that match the real world. Lee et al. (2013) research also showed that high physical fidelity simulators demonstrate high behavioral fidelity. Although researchers lean to both sides of the fence on the subject of the relationship between fidelity and behavioral fidelity, it is difficult to ignore the evidence that hints direct or indirect influence of fidelity on behavioral fidelity and how it affects transfer of training.

Fidelity vs. Transfer of Training

The majority of the research found in the subject of the relationship between fidelity and transfer of training indicates that fidelity has very little effect in the transfer of training in flight simulators. Detailed imitation of the control, display, and environmental dynamics is based on the unsupported belief that higher fidelity simulation results in greater transfer of training from FTD to actual aircraft (Moroney & Moroney, 1999). Dahlstrom, Dekker, Winsen and Nyce (2009), also stated that while there have been studies of transfer of training from photorealistic simulators to aircraft, and the problems of conducting such studies have been documented, there seems to be an assumed relationship between fidelity and transfer of training in the aviation community. Moreover, Martin and Waag (1978) revealed that high fidelity actually detracted from transfer of training on ab initio pilots due to the high volume of information provided by the high fidelity FTD.

A review conducted by Caird (1996) indicated that high fidelity simulators have little to no influence on skills transfer and that reduction of fidelity produces more transfer. Atkins, et al. (2002) stated that the extensive use of low fidelity simulators is transfer research has provided numerous demonstrations of the ability of such simulators to disclose transfer relationship and produce positive transfer effects.

Kinkade and Wheaton (1972) indicated that the overall level of fidelity is partially determined by the amount of transfer of training desired. Although not clearly stated, they suggested that there is a connection between fidelity and transfer of training, and that amount of fidelity should not exceed what is adequate for the training.

Given the technology in the midst of the 20th century, early studies approached the relationship between simulator fidelity and transfer of training effectiveness in terms of cost. Miller (1954) suggested that the cost of training would increase as the fidelity of the simulator increased. One of the reasons for departure from high fidelity proposed by Blaiwes, Puig, and Regan (1973) was that a lower fidelity simulator should cost less than the actual equipment and still produce adequate levels of transfer of training. Roscoe and Williges (1980) explained the relationship between cost and fidelity and labeled as the "honey region". The honey region is the area where the cost efficiency factor meets simulator fidelity design and the intended end user (Macchiarella, Brady & Lyon, 2008).

Over time, technology developments have made simulator technology more affordable and the cost of increasing fidelity is not necessarily viewed from the previously held perspective of high cost. High fidelity and low cost FTDs are now available for ab initio pilot training (Macchiarella, 2008). Conversely, it is not necessary to deliberately increase fidelity levels and incur unnecessary cost without intention to improve the overall training design. Hays and Singer (1989) advised that the effectiveness of the simulator is not a function of the capabilities and characteristics of the same, but how the simulator interacts to support the training system. Hays and Singer (1989) suggested that increasing fidelity would have no value if it does not fit within the training design.

Situation Awareness

Endsley (1999) defines situation awareness “as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future” (p. 258). This definition was first presented by Endsley in 1988, and has been widely used by others authors. Vidulich (2003) further adds that situation awareness is not concerned with the load inflected by a task’s information, but with the quality of information apprehended. Endsley (1999) states that situation awareness involves the perception of critical factors in the environment and explains Level 1, Level 2, and Level 3 of situation awareness.

Endsley (1999) describes the three levels of SA as follows: Level 1 SA is the perception of the elements - when an individual perceives the status, attributes, and dynamics of relevant elements in the environment. Level 2 SA is the comprehension of the current situation – when an individual must understand what was perceived a Level 1 SA. Level 3 is the projection of future status – the ability to project the actions of the element in the environment within the near future.

Situation awareness model. Endsley developed a model that summarizes the factors and processes that influence the development of situation awareness. In the model, Endsley illustrates that the development of long-term memory stores, goal directed processing, automaticity of action from training and experiences are instruments to overcome the factors and situation awareness limitations of human attention and working memory (1999). Attention is required to perceive and process the environment and working memory is essential to comprehend the meaning of the information acquired and to generate an accurate SA picture (Endsley, 1999). Figure 2 is a diagram of the model presented by Endsley in 1995.

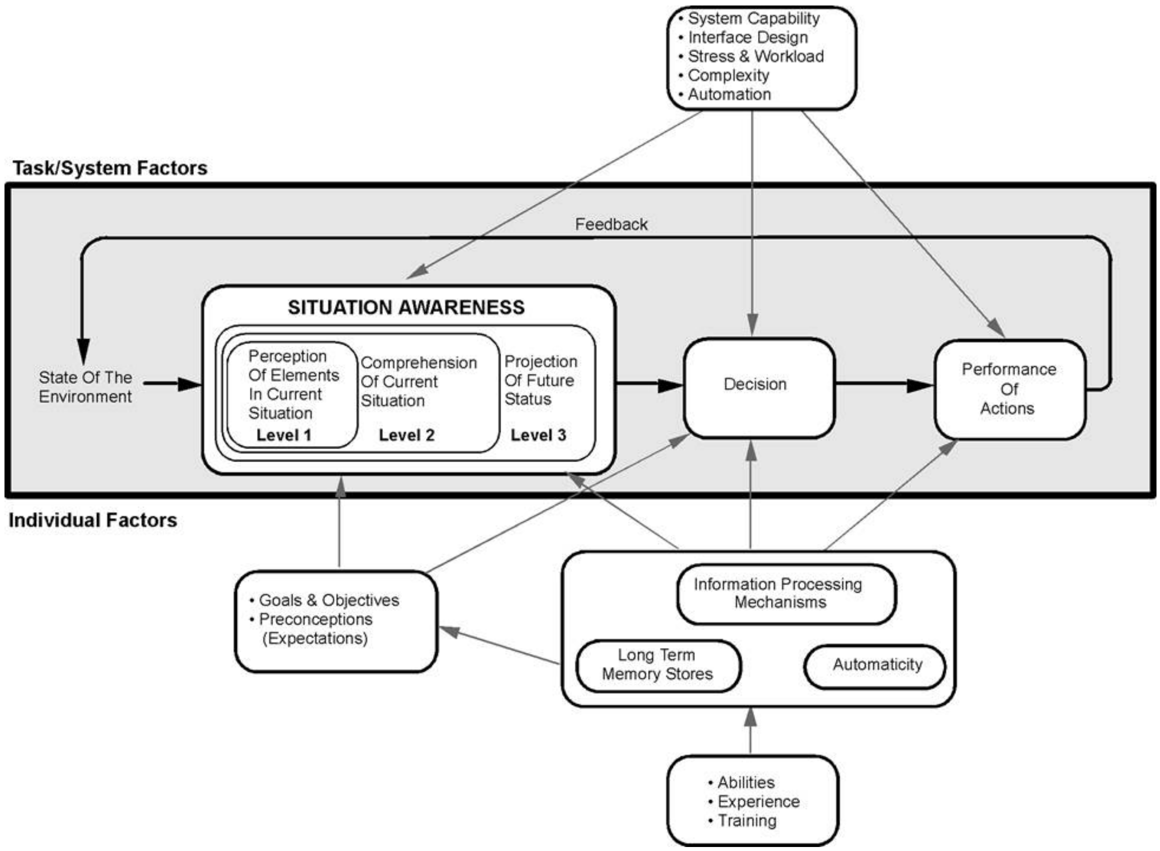

Figure 2. Model of situation awareness from Endsley. Reprinted from *Situation Awareness in Aviation Systems.* (p. 261), Endsley, M. R. Handbook of Aviation in Human Factors, 1999.

Attention affects SA because the supply of attention is limited, and when too much attention is focused on any one particular piece of information, a loss of overall SA may occur which may result in poor decision-making (Endsley, 1999). Similarly, a heavy loaded working memory caused by the integration and comprehension of new information may be very taxing and could limit the ability to project further conditions as new information is presented (Endsley, 1999).

Overload/underload. Poor SA could also be a result of mental workload overload and underload. An overload may occur when the amount of information or present task is too great for an individual to process and manage, therefore causing loss of SA (Endsley, 1999). Similarly, in a situation where a condition of low workload is created due to inattention, vigilance problems, or low motivation, SA could be negatively affected (Endsley, 1999).

Virtual Air Traffic (VAT)

VAT concept emerged from the research titled *Ab Initio Flight Training Device Effectiveness Study* conducted by Macchiarella, Arban, and Dogherty (2005). The study revealed that during FTD sessions instructor pilots were spending great amounts of time on roleplaying duties of ATC and air traffic, and not enough time focusing on the students' instruction. Similar observations were noted by Ford (2009) and Robinson and Mania (2003) in separate flight simulation studies. ERAU, in partnership with Frasca International Inc., decided to develop VAT with the goal to produce a system that would eliminate the instructor's need to role play and concurrently increase the behavioral fidelity of the training environment (Macchiarella & Meigs, 2008).

VAT is an embedded system designed to work with the existing FTDs. VAT uses voice recognition to link semiautonomous and autonomous virtual ATC and air traffic integrated into the FTD's virtual environment (Macchiarella & Meigs, 2008). VAT allows student pilots to establish two-way communications with virtual controller and air traffic via voice over (VoIP) and voice recognition software increasing similarities to real flight (Macchiarella & Meigs, 2008). VAT was designed to increase real world similarities given the sense of a more realist virtual environment where the instructor pilot could be free to interact with the student pilot as the instructor would in the aircraft. In accordance with Thorndike (1906) theory of identical elements, the additional similarities between FTDs and the real world flight should improve the probabilities of transfer of training. Macchiarella and Meigs (2008) concluded that VAT has the potential to improve behavioral fidelity and provide students the opportunities to obtain cognitive activities that match real flight, and the capability to enable the instructor pilots to focus in instructing.

Summary

The research conducted focused on flight instructors' SA while instructing instrument student pilots with the embedded SAFTE-VAT system onboard a Frasca 172S Level 6 plus FTD. Conversely, the literature reviewed was conducted on transfer of training theories due to the importance in understanding apply to flight training. Although other theories were examined, the theory of identical elements and the theory of general principles provided a proper understanding of how the transfer of training occurs in a virtual flight environment.

The transfer of training process model proposed by Baldwin and Ford (1988) is one of the most reviewed transfer models. This model illustrates how training inputs, training factors, and conditions of transfer connect to produce and maintain transfer of knowledge and skills. The researched also revealed approximately 128 transfer of training inhibitors categorized in four groups: (a) organizational climate factors, (b) training design factors, (c) individual learners characteristics, and (d) training delivery factors (Baldwin & Ford, 1993). By recognizing and learning the symptoms of the inhibiting factor, the instructional process should be able to mitigate loss of transfer of training.

Significant evidence was found to support the importance of the instructor interaction in flight simulators. Instructor motivation, experience, and knowledge also play a crucial role and are capable of affecting the pre-training student's disposition to learn. In regards to fidelity, several researchers agreed that high fidelity is not necessary to achieve transfer of training. In fact, some stated that excess fidelity could deter transfer of training on pilots due to overload of information. Others related the increase of fidelity with the increase of the cost of training, stating that when fidelity increases, the cost of training increases proportionally. Conversely, as new technology is developed and it becomes easily accessible to upgrade simulators and increase fidelity. Additionally, other researchers believe that high fidelity simulators that create a near real world virtual environments produce positive transfer of training.

Although contradicting points of views were encountered, recent research showed significant evidence to support the relationship between fidelity and behavioral fidelity, indicating that when fidelity increases, behavioral fidelity increases. Some FTDs required instructors to role play ATC and air traffic in order to increase behavioral fidelity and create a realist virtual environment. This detracts instructors from instructing and monitoring the student as they would during a normal flight. ERAU and Frasca International developed a Virtual Air Traffic (VAT) functionally designed as an embedded system to existing FTDs. VAT was designed to perform ATC and air traffic roles and release the instructor pilot to perform his or her duties as intended. It is important to address that research indicates that a low workload may also cause a loss of

SA, indicating the possibility that when a flight instructor is underload while teaching in an FTD environment his or her overall SA may be negatively affected.

Chapter III

Methodology

Research Approach

This experimental research was based on a quantitative approach and studied instructor pilots' SA while conducting training on a selected cross-country flight onboard a Frasca 172S FTD with and without the use of the SAFTE-VAT functionality. SAFTE-VAT functionality provides all ATC and air traffic calls as designed for each scenario, and it is normally used for the selected cross-country scenario. When SAFTE-VAT was not used as designed, the instructor role-played all ATC and air traffic calls.

Design and Procedures. Instrument flight instructors at ERAU and their students were tested while instructing a cross-country flight lesson in a FTD. When the SAFTE-VAT was not in operation, the flight instructor played the role of ATC.

Student participants were all enrolled in FA221 instrument course. All flight instructor participants completed a Flight Instructor Data Sheet to record flight experience data. Flight instructors were assigned a number on the flight instructor data sheet to ensure privacy and confidentiality. No names or biographical information was collected. Appendix B contains the flight instructor data sheet.

FA221 flight training (FT) Lesson 32 of the Instrument Rating Airplane – Single Engine Land Revision 11 curriculum was selected to conduct the experiment. This flight lesson is a short cross-country scenario where SAFTE-VAT functionality is required to be used. SAFTE-VAT acts as ATC and air traffic.

The student pilot participants were divided into two groups of 10, for a total of 20. A total of 8 instructors participated and provided instruction to both student pilot groups.

Group A completed FT Lesson 32 operating SAFTE-VAT functionality per ERAU FA221 syllabus. Instructor pilots provided instruction and evaluation of student pilots in accordance with the lesson plan. Group B completed FT 32 without the operation of the SAFTE –VAT. The participants of group B repeated FT lesson 32 with SAFTE-VAT to assure the necessity of the training obligation and requirements were met. During group B FT lesson 32, instructor pilots provided instruction and evaluation while running the scenario in addition to role-playing ATC and air traffic per the lesson plan. Only the group B completion of FT lesson 32 without the use of SAFTE-VAT was used for the experiment.

Students' performance data was collected from the flight data recorded at the Frasca 172s level 6 plus FTD data server. No biographical information was attached to the students' FTD performance data.

During each FTD flight, the researcher was positioned behind the cockpit of the Fresca 172S FTDs and equipped with a headset and microphone to monitor the cabin and the audio from the control station. Student pilots were positioned on the left seat of the cabin and instructor pilots sat on the right seat. Instructor pilots had the capability to remotely input simulations such as component faults from a tablet.

Instructor pilots were asked a series of five pre-selected questions. The questions were administered at a 7 to 10-minutes interval to ensure questions did not interfere with instruction or scenario. The list of questions is shown in Appendix C. The questions were pre-recorded using Audacity, a program designed to record, reply, and analyze audio files. The answers to the questions and the response times were recorded within the FTD server. Although the length of the FTD flight was approximately 1.5 hours, data was only collected during the first hour of the scenario. Instructor pilots and student pilots were compensated for their participation.

Apparatus and materials.

Frasca C172 FTD. The FTD flights were completed in the Frasca C172 level 6 plus simulator. This FTD was designed to emulate the Cessna 172S. The Cessna 172S has a cruise speed of 123 knots at 75% and 8,000 feet, and a maximum sea level speed of 124 knots. The Cessna 172S stall speed is 40 knots with flaps down and 48 knots with flaps up. The Cessna 172S is also equipped with the Garmin G1000 glass cockpit and an Automatic Dependent Surveillance-Broadcast (ADS-B). In addition to the Garmin 1000 glass cockpit, this FTD is also equipped with the embedded SAFTE-VAT functionality.

SAFTE-VAT. VAT is an embedded system designed to work with the existing FTDs. VAT uses voice recognition to link semiautonomous and autonomous virtual ATC and air traffic. SAFTE-VAT allows student pilots to establish two-way communications with virtual controller and air traffic via voice over (VoIP) and voice recognition software.

FA221 Syllabus and lesson plan. FA221 is the Instrument Rating Airplane – Single Engine Land course. FA221 delineates all ground training, FTD and flight training requirements to achieve the instrument rating airplane – single engine land at ERAU.

Lesson 32 is a short cross-country FTD flight, which requires the operation of SAFTE-VAT. This lesson is conducted at night to familiarize the student with the airport, runway, and taxiway lights associated with the night IFR environment. The lesson’s objectives for the students are to review IFR departure, en route, and arrival procedures; gain additional experience with partial panel flight and the use of the magnetic compass;

introduce alternator failure during the en route segment of flight; emphasize sound decision making and safety of flight considerations; and learn how to apply the appropriate lost communications procedures and the steps to follow so as to arrive safely at the destination or alternate airport. Appendix D contains FA221 FT lesson 32.

Instructors' SA questions A list of 16 questions was developed and designed to access instructors SA during FTD flights. Although only a series of 5 questions were selected prior to each FTD flight and administered at a 7 to 10 minute interval, 16 questions were developed to avoid repeating questions to flight instructors participating multiple times. The flight department director at ERAU Daytona Beach campus approved the number of questions. The list of questions is located in Appendix C.

Population/Sample

The population was collegiate flight student enrolled in FA221 instrument syllabus at the ERAU Daytona Beach campus and ERAU instrument flight instructors. A list of instrument flight students and instrument flight instructor was obtained from the Flight Department at ERAU Daytona Beach campus. An e-mail was sent to prospective student and instructors with a brief description of the research requesting their participation. A brief introduction of the experiment was conducted to explain the purpose of the research. The sample of this study consisted of 12 ERAU instrument instructor pilots and approximately 20 ERAU instrument student pilots. Instructor pilots possessed an FAA Commercial Pilot certificate with an airplane category Single-Engine Land Class rating and an Instrument-Airplane rating, or an Airline Transport Pilot certificate with airplane category Single-Engine Land Class rating in addition to a Flight Instructor certificate with and airplane category rating, Single-Engine Land Class rating and Instrument airplane rating. All instructors also had at least a current 3rd class medical certificate. All instrument student pilots were enrolled in FA221.

Data Collection

Student performance data was collected from the Frasca 172S level 6 plus FTD server. Since the data collected was retrieved directly from the server no biographic information was attached. Each student participant was assigned a number to be used as a participant identifier.

All the answers to the SA questions conducted were recorded during each FTD flight. Questions and answers provided by instructor pilots along with the time the question was asked and the response time was recorded and transferred to a spreadsheet for analysis. Upon completion of training each FTD scenario was reviewed to verify voice recording and accurate time data collection to the millisecond. Instructor pilots were assigned numbers to be used as participant identifiers. There was no direct link between participant identifier numbers and their personal information. Every attempt was made to maintain anonymity of the participants.

Instrument validity and reliability. The director of ERAU Flight Department, the Assistant Professor of Graduate Studies Department, and the Master of Science in Aeronautics Program Coordinator are subject matter experts in the field of aviation. They conducted a comprehensive validation of instructor pilot’s SA questions. The grading sheets used for the research are the existing FA221 Instrument Rating Airplane-Single Engine Land Revision 11 curriculum grading sheets revised and approved by ERAU Daytona Beach campus Flight Department and leadership.

Treatment of Data

The data collected from the flight instructor SA questions was scored based on the accuracy and response time in milliseconds. Answers were assessed as correct or incorrect, and the time lapsed between the end of the question and the response was measure to the milisecond. If the question was repeated, then the response was scored from the end the second time the question was asked. Accuracy and response times were reviewed during debrief and scenario playback.

The student's performance was scored retrieving the data collected and saved in the FTD server. Student performance was assessed based on the delta between the intended track and actual track in reference to altitude, lateral deviation, and airspeed.

The testing and analysis of the data was completed using Statistical Package for Social Science (SPSS) software.

Descripted Statistics. The responses to the SA questions given to the instructor pilots are displayed herein as table to establish SA of instructor pilots during FTD scenarios. Accuracy and response time was recorded for each question. Tables depicted mean, median, and standard deviation of accuracy and response time. The data provided indications of instructor's SA status at the time of the questions.

The recorded student performance data from each FT lesson 32 completed showed the delta of airspeed, heading, and altitude from the intended track. Altitude was measured in feet, airspeed was measures in knots, and lateral deviation was measure in dots as indicated in the course deviation indicator. Tables exhibited mean and standard deviation of the student performance when operating the FTD with the use of SAFTE-VAT and without the use of SAFTE-VAT.

Hypothesis Testing. Hypothesis testing was conducted by analyzing instructor's SA and student's performance. First, instructors SA questions scores were compared between the group trained on FT lesson 32 with the operation of SAFTE-VAT and the group trained on FT lesson 32 without the used of SAFTE-VAT. Second, students' performance data (altitude, lateral deviation, and airspeed) difference between the intended track and actual student track was compared between control and experimental groups. Independent *t*-tests were calculated to determine statistical differences between control and experimental groups in both instructors and students.

Chapter IV

Results

Descriptive Statistics

The sample included a total of 23 participants, 8 flight instructors, and 15 instrument student pilots. All flight instructors were full time employees at ERAU. All student participants were full time student pilots enrolled in FA-221 single engine instrument course at ERAU.

A total of 16 FTD observations of Module 32 of the FA-221 course were completed. Module 32 is a cross-country event and one of the last modules of FA-221. Due to technical difficulties, the situation awareness voice data from five of the 16 FTD were unusable. Figure 3 illustrates the total number of FTD observations completed and the number of voice recorded FTD observations with active SAFTE-VAT and SAFTE-VAT not active.

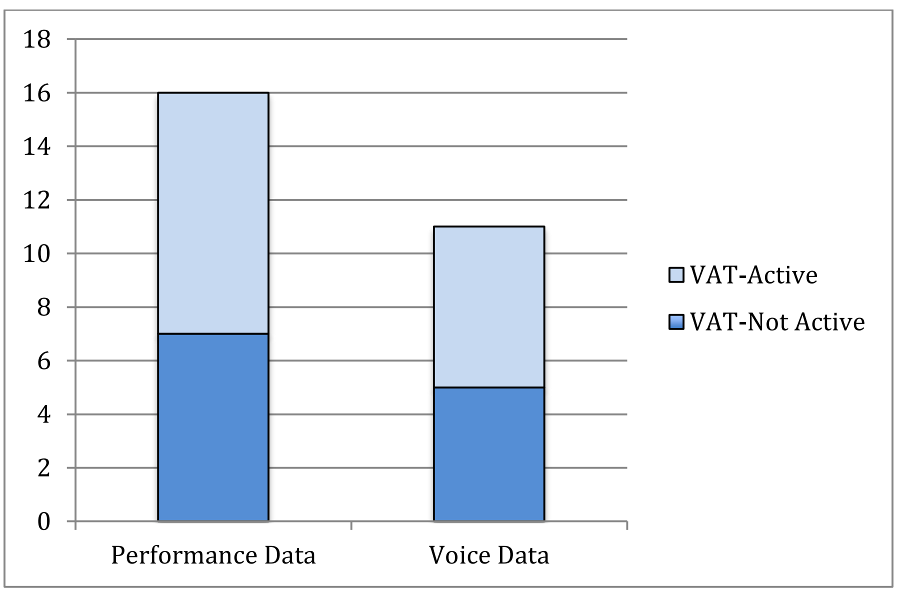

Figure 3. Number of participant data that was analyzed.

Situation awareness questions data. A total of six observations with SAFTE-VAT active and five observations with SAFTE-VAT not active were completed. Five situation awareness questions were measured during each FTD event. Questions were asked at intervals of 7 to 10 minutes to prevent interference of flight instruction.

Figure 4 shows the mean and standard deviation of the recorded response times in seconds of the first question for SAFTE-VAT active group and SAFTE-VAT not active group. The first question was normally asked shortly after takeoff while the student pilot was in the process of climbing to a cruising altitude after receiving instructions from ATC.

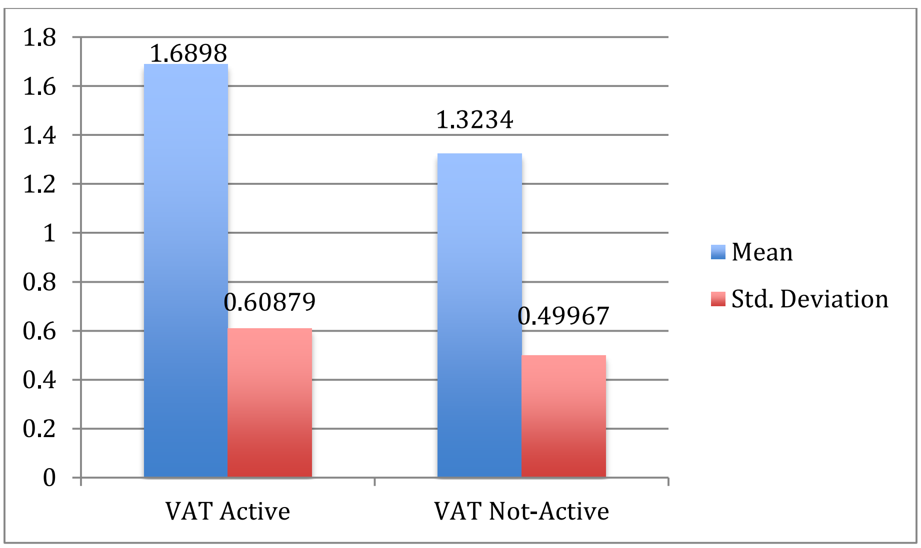

Figure 4. First SA question.

Figure 5 illustrates the mean and standard deviation of the recorded response times in seconds of the second question for SAFTE-VAT active and SAFTE-VAT not active groups. Normally, the flight instructor was queried with the second question while the student pilot was already at cruising altitude en route to the destination.

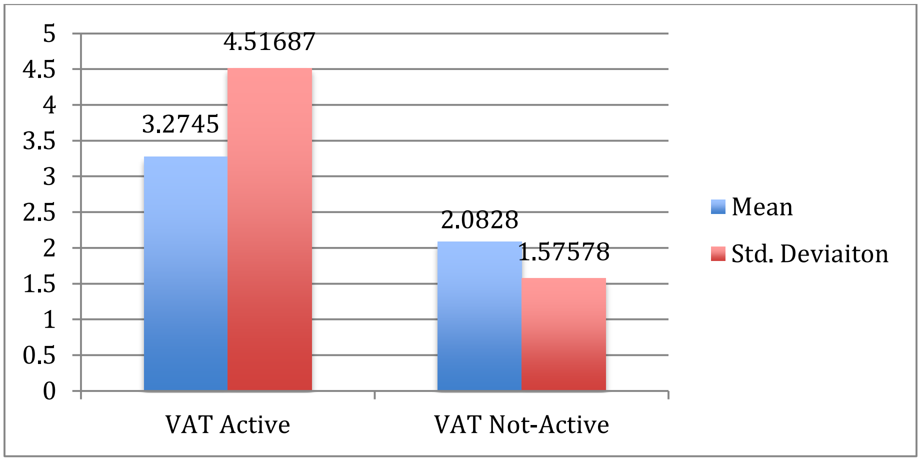

Figure 5. Second SA question.

Figure 6 illustrates the mean and standard deviation of the recorded response times in seconds of the third question for SAFTE-VAT active and SAFTE-VAT not active groups. Normally, the flight instructor was queried with the third question while the student pilot was descending to 2000 feet to intercept the VOR approach.

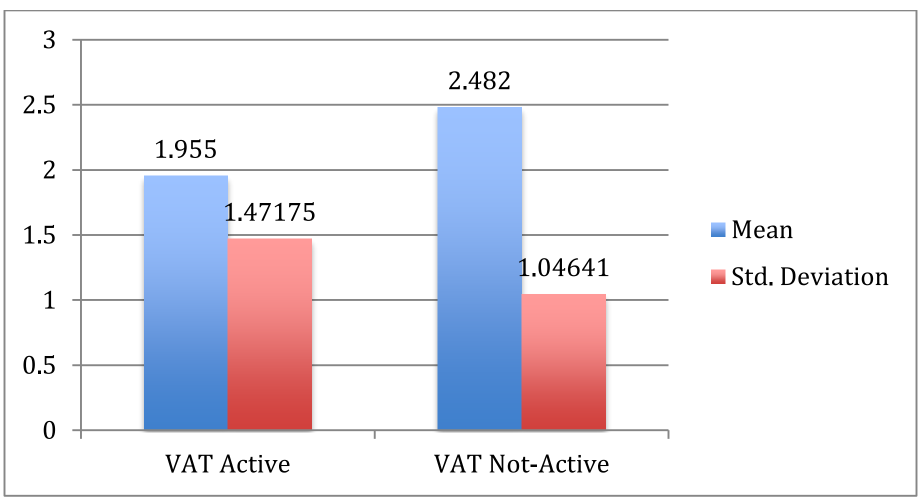

Figure 6. Third SA question.

Figure 7 illustrates the mean and standard deviation of the recorded response times in seconds of the fourth question for SAFTE-VAT active and SAFTE-VAT not active groups. Flight instructors were normally queried with the fourth question while student pilots were descending to the final approach and handling an inflight emergency.

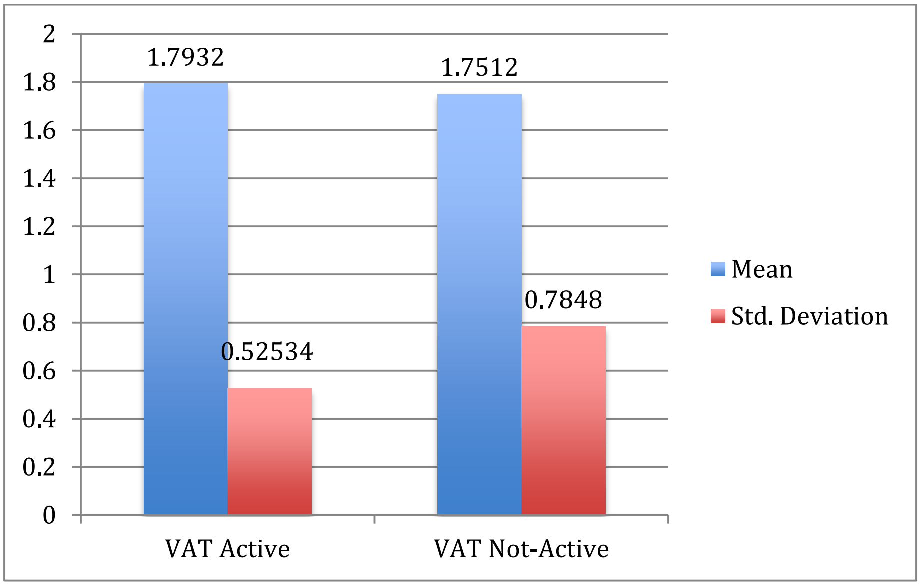

Figure 7. Fourth SA question.

Figure 8 illustrates the mean and standard deviation of the recorded response times in seconds of the fifth question for SAFTE-VAT active and SAFTE-VAT not active groups. The flight instructor was normally queried with the fifth question while the student pilot was performing missed approach procedures and climbing to 2000 feet. Following the missed approach, student pilots normally contacted ATC to receive instructions to the alternate destination.

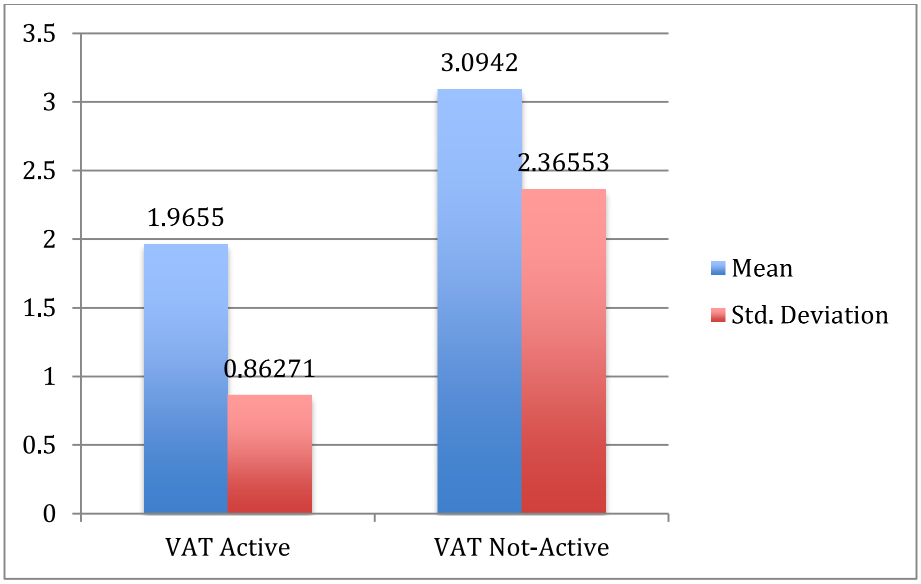

Figure 8. Fifth SA question.

Instrument student pilots' performance data. Recorded data were extracted from a total of 9 FTD sessions using SAFTE-VAT and a total of 7 observations not using SAFTE-VAT. The data extracted included altitude, lateral deviation, and airspeed. Each data point extracted from the FRASCA Level 6 Cessna 172S FTD was provided at a .2 second interval. All data were revised and deemed accurate with the scenario recorded.

Altitude data show the difference between assigned altitude and actual altitude measured in feet through out the flight. Sections of the flight where the student pilot was transitioning from a set altitude to another were taken into account. The average altitude of each flight recorded was then used to obtain the mean and standard deviation for each group. Figure 9 illustrates the mean and standard deviation of the altitude difference in feet for SAFTE-VAT active and SAFTE-VAT not active groups.

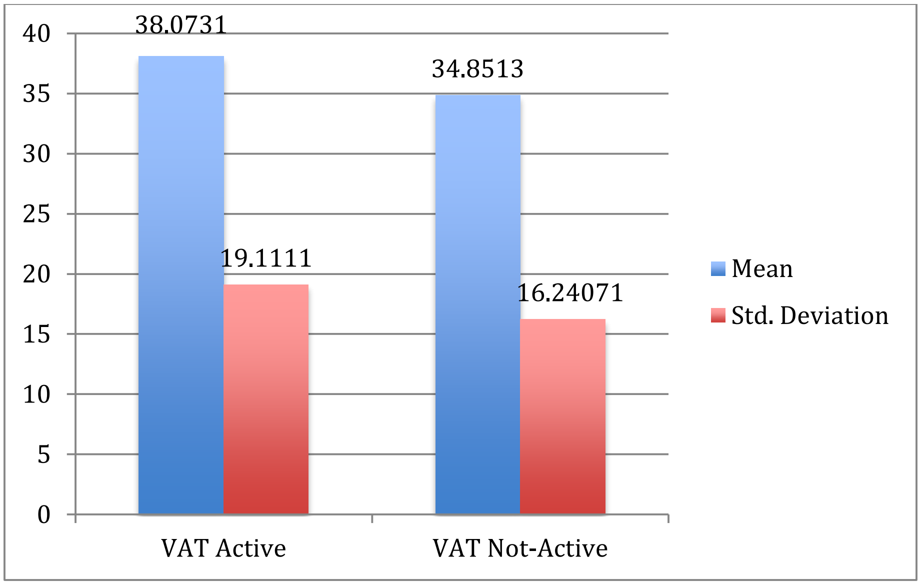

Figure 9. Altitude difference between assigned altitude and actual altitude.

Lateral deviation data is represented here in dots. Lateral deviation data were obtained from the cockpit course deviation indicator (CDI) and represent the angular separation from course based on the VOR station or GPS course line. Figure 10 illustrates the mean and standard deviation of the lateral deviation measured in dots for SAFTE-VAT active and SAFTE-VAT not active groups.

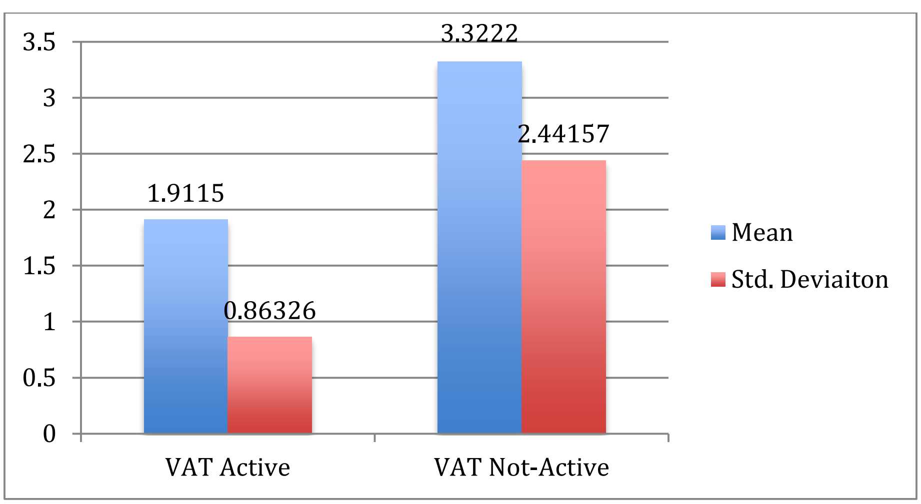

Figure 10. Lateral deviation recorded from CDI

Airspeed data collected represent the airspeed difference between assigned airspeed and actual speed. Assigned airspeed was determined by ATC commands, VOR approach instructions, or flight instructor instructions. The following speed were used as assigned airspeed to measure the delta between assigned airspeed and actual airspeed: 90 knots for ascending altitudes, 100 knots during cruising altitudes, 110 knots for descending in altitude, and 100 knots while performing an approach. Figure 11 illustrates the mean and the standard deviation of the delta between assigned airspeed and actual airspeed measured in knots for SAFTE-VAT active and SAFTE-VAT not active groups.

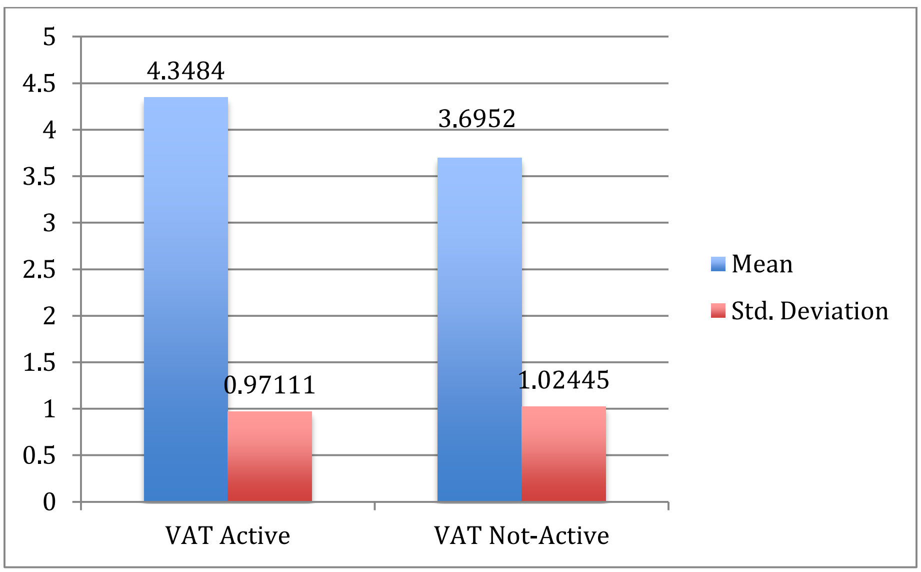

Figure 11. Airspeed delta recorded.

Inferential Statistics

Situation awareness questions observed data. A t-test was used to test the null hypothesis: There will be no significant difference in instructor pilots' situation awareness when training instrument student pilots onboard a FRASCA level 6 plus Cessna 172S FTD with the SAFTE-VAT function or without the SAFTE-VAT function.

The *t*-test failed to reject the null hypothesis *t*(9)=0.26, *p*=.980. Table 1 illustrates the Independent-sample t-test performed for all situation awareness questions.

Table 1.

Independent-sample t-test for situation awareness questions

		Levene's Test for Equality of Variances		t.test for Equality Mean						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence of the Difference	
									Lower	Upper
SA	Equal varainces assumed	0.896	0.369	-0.025	9	0.98	-0.01112	0.43997	-1.0064	0.98416
	Equal Variances not assumed			-0.026	8.55	0.98	-0.01112	0.42092	-0.97275	0.95051
SafteSA1	Equal varainces assumed	0.384	0.551	1.075	9	0.31	0.36643	0.34086	-0.40464	1.13751
	Equal Variances not assumed			1.096	9	0.301	0.36643	0.33422	-0.38963	1.1225
SafteSA2	Equal varainces assumed	1.875	0.204	0.558	9	0.59	1.1917	2.13556	-3.63928	6.02268
	Equal Variances not assumed			0.604	6.397	0.567	1.1917	1.97407	-3.56701	5.95041
SafteSA3	Equal varainces assumed	0.334	0.578	-0.669	9	0.52	-0.527	0.78719	-2.30775	1.25375
	Equal Variances not assumed			-0.692	8.84	0.507	-0.527	0.76158	-2.25458	1.20058
SafteSA4	Equal varainces assumed	2.354	0.159	0.106	9	0.918	0.04197	0.39571	-85320	0.93713
	Equal Variances not assumed			0.102	6.788	0.922	0.04197	0.41131	-0.93684	1.02077
SafteSA5	Equal varainces assumed	1.775	0.216	-1.094	9	0.302	-1.1287	1.03126	-3.46158	1.20418
	Equal Variances not assumed			-1.012	4.888	0.359	-1.1287	1.11498	-4.01476	1.75736

Instrument student pilot performance observed data. A t-test was also used to test the null hypothesis for altitude, lateral deviaiton, and airspeed: there will be no difference in instrument student pilots' performance when training onboard a FRASCA level 6 plus Cessna 172S FTD with the SAFTE-VAT function or without the SAFTE-VAT function. The t-test failed to reject the null hypothesis for all three performance data points measured: Altitude *t*(14) = .356, *p* = .727, lateral deviaiton *t*(7.173) = 1.459, *p*= .187 Equal variances not assumed, and Airspeed *t*(14) = 1.304, *p* =.213.

Chapter V

Discussion, Conclusions, and Recommendations

Discussion

Issues collecting data were incurred due to the lack of participants' availability and willingness and to participate in the research. Also, because the research parameters required the execution of Module 32 of the FA221 instrument course, there was a limited pool of participants at any given time. The continuous participants request via email and in person, and the assistance of the flight department training managers was crucial in the recruitment of participants.

Situation awareness questions lapsed response times revealed that for the first, second, and fourth questions flight instructors had slower response times (albeit non significant) when the SAFTE-VAT function was being used. Third and fifth questions resulted in faster response times for flight instructors when the SAFTE-VAT function was not being used. Results observed on the instrument student pilots' performance data collected, where the data revealed that altitude and airspeed deviation showed worst performance when the SAFTE-VAT function was being used, and lateral deviation was higher when the SAFTE-VAT function was not being used.

Situation awareness questions data. SA questions were designed to test flight instructors' situation awareness while instructing Mod 32 of the FA-221 instrument course with and without the use SAFTE-VAT by asking details about the FTD flight in which they were instructing instrument student pilots. Mod 32 of the FA-221 instrument course was chosen because it requires the use of SAFTE-VAT functionality.

Flight instructors were normally queried with the first question shortly after takeoff when the student pilots had already received instructions to climb to a cruising altitude and continue to the next destination. Although there was no statistical significant difference, $p = .310$, data show that the group of flight instructors that did not use SAFTE-VAT had a response time mean of 21.68% faster than the group that used SAFTE-VAT during the first SA question.

Flight instructors were normally queried with the second question approximately 20 minutes into the FTD flights while the student pilots were at cruising altitudes and speeds. No statistical significant difference was recorded, $p = .590$; however, the data show that the group of flight instructors that did not use SAFTE-VAT had a response time mean of 36.39% faster than the group that used SAFTE-VAT.

Flight instructors were normally queried with the third question approximately 30 minutes into the FTD flight while the student pilots were descending to 2000 feet to intercept the VOR approach. No statistical significant difference was recorded, $p = .669$; conversely, the data show that the group of flight instructors that used SAFTE-VAT had a response time mean of 21.23% faster than the group that did not use SAFTE-VAT.

The fourth SA question was normally asked to flight instructors approximately 40 minutes into the FTD flight while the student pilots were descending to the final approach and handling an inflight emergency. No statistical significant difference was recorded, $p = .918$, conversely, data shows that the group of flight instructors that did not use SAFTE-VAT had a response time mean of 2.34% faster than the group that used SAFTE-VAT.

Flight instructors were normally queried with the fifth SA question approximately 50 minutes into the FTD flight while the student pilots were executing missed approach procedures and following instructions to the alternate destination. No statistical significant difference was recorded, p=.302, conversely, data shows that the group of flight instructors that used SAFTE-VAT had a response time mean of 36.47% faster than the group that did not use SAFTE-VAT during the third SA question indicating faster response times for the group that used SAFTE-VAT.

Although not quantitatively recorded, FTD activity levels were noted during all FTD flights recorded. During the first, second, and fourth questions, FTD activity was generally minimal for both groups, SAFTE-VAT active and SAFTE-VAT not active. Conversely, the group of flight instructors that did not use the SAFTE-VAT was generally observed preparing to execute ATC duties. SAFTE-VAT not active group showed quicker response time during periods of low flight instructor workload.

Contrariwise to the first, second, and fourth questions, during the third and fifth questions an increase on FTD activity levels were noticed along with the more complex progression of the FTD flight for both groups. A slightly higher workload was observed on the group of flight instructors that did not use SAFTE-VAT. The group that used SAFTE-VAT demonstrated higher response time during periods of increased FTD activity levels.

Performance data. Altitude, lateral deviation, and airspeed data was extracted from each FTD flight observed on the FRASCA level 6 Cessna 172S FTD.The purpose of the data analysis was to the observe any statistical significant difference in instrument student pilots' performance when training onboard a FRASCA level 6 plus Cessna 172S

FTD with the SAFTE-VAT function or without the SAFTE-VAT function. Although no statistical significance difference were observed for altitude $p = .727$, lateral deviation, $p = .187$ equal variances not assumed, and Airspeed $p = .213$, the mean difference of the data observed between the two groups is worthy of mention.

The mean of the altitude difference of the group of student pilots that were instructed with the SAFTE-VAT function active was 8.46% higher than the mean of the group of student pilots that were instructed without the SAFTE-VAT function. The mean of the airspeed difference of the group of student pilots that were instructed with the SAFTE-VAT function active was 15.02% higher than the mean of the group of student pilots that were instructed without the SAFTE-VAT function. Conversely, the lateral deviation mean of the group of student pilots that were instructed without the SAFTE-VAT function active was 42.46% higher than the mean of the group of student pilots that were instructed with the use of SAFTE-VAT function. Two of the three performance data results exhibited indications that student performance was more precise while being instructed without the use of SAFTE-VAT.

Conclusions

Due to the parameters established by the researcher and the availability and response from participants, both instructor pilots and instrument student pilots, the study was under powered. Nonetheless, future research on SAFTE-VAT is warranted.

The quantitative data collected from both flight instructors' situation awareness questions and instrument student pilots' performance data did not provide significant statistical evidence to indicate difference between the groups that conducted FTD flight training with and without the use of the SAFTE-VAT function. It is possible that the research did not show significant differences because of the small number of participant and small sample of data collected.

Individual SA questions data could suggest there was a possible relationship between SA question response time and FTD activity level while SAFTE-VAT was in use. Observed data from the first, second and fourth SA questions indicated in the form of longer lapse response time that when FTD activity levels were low, situation awareness decreased. This could suggest flight instructor were not as alert during low FTD activity levels when SAFTE-VAT was in use. Equally, data from the third and fifth question suggest that as FTD activity levels increased, situation awareness increased when the SAFTE-VAT was in use. Inversely, observed data from the first, second, and fourth SA questions indicated in the form of lapse response time that when FTD activity levels were low, situation awareness increased when SAFTE-VAT was in use. Similar inverse relationship was detected for the third and forth questions. Table 2 illustrates the overall relationship between the FTD activity level and situation awareness for each of the five SA questions posed to the groups that conducted training while using and not using the SAFTE-VAT function.

Table 2.

FTD activity level vs. situation awareness relationship for SAFTE-VAT and Non SAFTE-VAT FTDs

SAFTE-VAT			Non SAFTE-VAT	
Activity	SA	Question	Activity	SA
↓	↓	1	↓	↑
↓	↓	2	↓	↑
↑	↑	3	↑	↓
↓	↓	4	↓	↑
↑	↑	5	↑	↓

Although not supported by statistical significance, instrument student pilots' performance data suggest that students' performance was more accurate when SAFTE-VAT was not being used. This could indicate that instructors were more focused on students' performance while the SAFTE-VAT was not in use because instructors were more involved in the FTD flights and were not under loaded. Thus, it is possible there was a loss of SA when the SAFTE-VAT was in use due to underloads during periods of low activity levels in FTD flights resulting in the inattention of students' flight performance.

Recommendations

Because of the small number of participants in this study, a repeat of this study with a larger sample size is recommended. In this future study, the goal would be to conduct at a minimum of 20 FTD observations of flight instructors and instrument student pilots while using SAFTE-VAT and 20 observations of flight instructors and instrument student pilots while not using SAFTE-VAT to generate possible statistical significance for SA questions and instrument student performance. To meet the required number of participants for the study, it is recommended to offer extra credits for students and increase compensation for flight instructors.

It would also be recommended to the possibility of measuring FTD activity levels to further analyze how FTD activity levels may affect flight instructors' situation awareness while using SAFTE-VAT versus not using SAFTE-VAT. Also, the added power may show some group differences.

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Appendix A

IRB Approval

Embry-Riddle Aeronautical University
Application for IRB Approval
Exempt Determination

Principle Investigator: Dr. Andrew Dattel **Other Investigators:** Rafael Abreu **Role:** Student **Campus:** Daytona Beach **College:** COA
Project Title: SAFTE-VAT Functionality Effects on Flight Instructors' Situation Awareness and Instrument Student Pilots' Performance During FTD Training
Submission Date: 3/11/2015 **Determination Date:** 4/10/2015

Review Board Use Only

Initial Reviewer: Dr. Michael Wiggins/M.B. McLatchey

Exempt: Yes

Approved: Mike Wiggins /M.B. McLatchey
Pre-reviewer Signature / Chair of the IRB Signature

Brief Description: The purpose of this experiment is to study the Effects of SAFTE-VAT on Instructor Pilot's Situation Awareness and student performance during FTD flights. Instrument flight instructors at ERAU, and their students will be tested while conducting a cross-country flight lesson in a FTD with the operation of SAFTE-VAT and without the operation of SAFTEVAT. This research will follow the existing ERAU ground and flight training curriculum that meets the requirements for instrument pilot training under 14CFR Part 141.Student participants will be enrolled in flight classes and flight laboratories. All flight instructor participants will complete a Flight Instructor Experience data sheet to collect flight experience information. Flight experience data sheet data will not include names nor instructor personal information. Instructors will be assigned a number to track corresponding data.

This research falls under the exempt category as per 45 CFR 46.101(b) under:

> ☒ (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

An exempt research project does not require ongoing review by the IRB, unless the project is amended in such a way that it no longer meets the exemption criteria.

Appendix B

Flight Instructor Data Sheet

Flight Instructor Data Sheet

Instructor Number: ___________________________

1. Please indicate your Flight Experience in hours:

____

2. Please indicate your FTD Experience in hours:

____

3. Please indicate your total Flight Instructor Experience in hours:

____

4. Please indicate your total Instrument Flight Instructor experience in Hours:

____

Appendix C

List of SA Questions for Flight Instructors

List of SA Questions for Flight Instructors

1. What is the aircraft current heading?

2. What is the aircraft current altitude?

3. What is the aircraft assigned altitude by ATC?

4. What is the aircraft current attitude?

5. Is the student flying the aircraft at the assigned altitude?

6. Is the student pilot following ATC heading instructions?

7. Tell me one thing the student missed on the take off checklist, if nothing please state none.

8. What are the ceilings given by the ATC?

9. Did the student follow proper ATC departure procedures, yes or no?

10. Is the student using aircraft GPS to track course along his intended track?

11. Is the student following proper course?

12. What is the current aircraft speed?

13. Is the student maintaining adequate air speed, above or below assigned airspeed?

14. Is the student operating the aircraft within limits of the assigned heading?

15. Is the student operating the aircraft within limits of the assigned altitude?

16. Has the student made any ATC jargon mistakes when communicating with ATC?

Appendix D

FA221 FTD Lesson 32

Lesson 32 (SE FTD)(X-C)

Lesson Objectives:
Review IFR departure, en route, and arrival procedures. Student will gain further experience with partial panel flight and the use of the magnetic compass. Introduce alternator failure during the en route segment of flight. Special emphasis should be placed on sound decision making and safety of flight considerations. Student should learn how to apply the appropriate lost communications procedures and the steps to follow so as to arrive safely at the destination or alternate airport. This training activity will be conducted at night to familiarize the student with the airport, runway, and taxiway lights associated with the night IFR environment.

1. Cockpit Management
2. Checklist Usage
3. Weather Information
4. IFR Cross-Country Procedures
5. Air Traffic Control Clearances
6. Compliance with Departure, En Route and Arrival Procedures and Clearances
7. ILS Approach Procedures
8. VOR Approach Procedures
9. GPS Approach Procedures
10. Loss of Communications
11. Missed Approach
12. Timed Turns to Magnetic Compass Headings
13. Approach with Loss of Primary Flight Instrument Indicators
14. Emergency Procedures
15. Single-Pilot Resource Management

Pre-briefing:
Instructor will discuss the objective of the lesson and determine whether the student is adequately prepared for the activity. Each line item will be briefly covered and the student should have a clear understanding of how the training activity will be conducted and what standards will be expected of them.

Completion Standards:
Selects, tunes, identifies, and confirms the operational status of the navigation equipment used en route and for the approach. Copies correctly, in a timely manner, the ATC clearances as issued. Interprets correctly the ATC clearance received and, when necessary, requests clarification, verification, or change. Uses the current and appropriate navigation publications for the proposed flight and selects and uses the appropriate communication frequencies. Demonstrates adequate knowledge of GPS and RAIM. Intercepts, in a timely manner, all courses, radials and bearings appropriate to the procedure, route or clearance. During the en route segment of the flight, maintains the applicable airspeed +/- 15 kts., headings +/-15°, altitude +/-150' and maintains positive course guidance on all radials, bearings and courses tracked. While on the final approach segment, does not allow more than three-quarter-scale deflection of either the glide slope and/or localizer indicator. Maintains course guidance within 10° for non-precision approaches. Executes the missed approach procedure when the required visual references for the intended runway are

not distinctly visible at the MAP. Applies appropriate loss of communications procedures so as to arrive safely at the destination or alternate airport.

Debriefing:
Solicit a self-critique from the student(s) about their personal performance. Use this information to direct your analysis of their flight, and then discuss what you perceive to be their strong and weak points. Provide guidance on how they should prepare for the next flight activity so as not to diminish their strong points, and to improve upon their weak points.