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Effect of Active Learning on Instrument Rated Pilots' Knowledge and Self-Efficacy

Robert LeRoy Thomas
Embry-Riddle Aeronautical University

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EFFECT OF ACTIVE LEARNING ON INSTRUMENT RATED PILOTS' KNOWLEDGE AND SELF-EFFICACY

By

Robert LeRoy Thomas

A Dissertation Submitted to the College of Aviation
in Partial Fulfillment of the Requirements for the Degree of
Doctor of Philosophy in Aviation

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EFFECT OF ACTIVE LEARNING ON INSTRUMENT RATED PILOTS' KNOWLEDGE AND SELF-EFFICACY

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This Dissertation was prepared under the direction of the candidate's Dissertation Committee Chair, Dr. Steven Hampton, and has been approved by the members of the dissertation committee. It was submitted to the College of Aviation and was accepted in partial fulfillment of the requirements for the
Degree of
Doctor of Philosophy in Aviation

Steven Hampton
Dr. Steven Hampton, Ed.D.
Committee Chair

Dr. Michael Wiggins, Ed.D.
Committee Member

Dr. Antonio I. Cortés, Ph.D.
Associate Dean, School of Graduate Studies

Dr. Elizabeth Blickensderfer, Ph.D.
Committee Member

Dr. Alan J. Stolzer, Ph.D.
Dean, College of Aviation

Dr. Andy Dattel, Ph.D.
Committee Member

Michael P. Hickey
Dr. Michael P. Hickey, Ph.D.
Dean of Research and Graduate Studies

Anne Little
Dr. Anne Little, Ph.D.
Committee Member

February 9, 2018
Date

ABSTRACT

Researcher: Robert LeRoy Thomas

Title: EFFECT OF ACTIVE LEARNING ON INSTRUMENT PILOTS' KNOWLEDGE AND SELF-EFFICACY

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The study examined the effect of active scenario-based training on the knowledge and self-efficacy of instrument rated pilots who were not instrument current. Additionally, this study addressed an issue that was not present in the existing literature by validating the potential of using at-home personal computer scenario-based simulation for instrument currency. The current method of maintaining instrument currency does not require any context or scenario-based training. At a minimum, a pilot must perform a specific number of instrument approaches and holds in an airplane, approved simulator, or training device.

Sixty-two non-current instrument rated pilots who represented the U.S. general aviation pilot population participated in the study. The participants were divided into three experimental groups, where each group received a different training method with varying levels of active learning. The first group experienced passive learning (only reading), the second group experienced some active learning (flying simulated approaches), and the third group experienced the highest degree of active learning (flying approach scenarios requiring decisions). Before and after the training, each of the participants took knowledge tests and self-efficacy questionnaires as a measure of training effectiveness. The results show that the increase of knowledge scores between pre-training and post-training was significant regardless of training type, $F(1,57) = 184.977$, $p < .001$, $\eta^2 = .764$. Additionally, the results show that the increase in self-efficacy scores between pre-training and post-training was significant, $F(1, 57) = 299.409$, $p < .001$, $\eta^2 = .840$. The increase in self-efficacy score was significant between the passive method of training, reading, and the most active method of training full scenarios with decision making involved, $t(38) = -2.653$, $p = .012$, $\mathrm{r} = .395$. Using active learning through personal computer-based flight scenarios is an effective method of refresher training for instrument rated pilots who are not instrument current.

DEDICATION

To Jason, I hope this inspires you to follow your dreams.

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CHAPTER I

INTRODUCTION

The Federal Aviation Administration (FAA) acknowledges that pilot currency and refresher training are critical to the safety of flight in both visual and instrument conditions (FAA, 2012a). In addition to mastering the psychomotor aspects of piloting an aircraft, refresher training includes the assimilation of new information as well as the reinforcement of previously learned knowledge. One important distinction that the FAA highlights is that a pilot who meets the currency requirements of Title 14 of the Code of Federal Regulations (CFR) does not necessarily equate to being proficient to operate the airplane. In other words, flying a prescribed number of hours or maneuvers does not equate to a minimum skill level. By maintaining proficiency, the pilot relies on the skills and knowledge that have been practiced to conduct each flight in a safe manner. It is recommended that pilots obtain and use an instrument rating to develop more experience and knowledge that will help enhance the safety of each flight (FAA, 2012b).

Outside of the structured aviation training environment, there does not appear to be standardization for general aviation (GA) pilots to maintain instrument flying currency and proficiency. Only the current FAA Instrument Airmen Certification Standard (ACS) and the FAA's Instrument Proficiency Check (IPC) guidance provide generic guidance for pilots and instructors (FAA, 2010; FAA. 2016b). Other than these documents, no clear recommendations exist pertaining to training strategy, tools, or techniques that should be used to maintain currency and proficiency. The aviation industry is currently undergoing a rapid development and implementation of new technologies, procedures, and airspace changes which result in a plethora of new knowledge that pilots must learn quickly to continue to operate safely in the National Airspace System. Today's technology allows the opportunity for learners to use scenario-based training (SBT) on various platforms ranging from personal computers to Full Flight Simulators (FFS) to take in new facts and information to remain current with aviation knowledge. Training with these devices will allow the transfer of knowledge to the learner to occur in addition to any psychomotor practice that comes with the physical skill of flying an aircraft. Learners can use a SBT approach to learn and apply the knowledge gained toward future situations that may be encountered.

Learning and Pilots

Learning any topic involves the learner developing an understanding of the current situation and its potential impact and outcome. Pilots must be able to solve problems and use their extensive knowledge and skills to handle both unpredictable situations and repetitive routine operations (Telfer & Moore, 1997). Determining the best way for a learner to gain knowledge and experience is the goal and a challenge that every flight instructor must face (FAA, 2008). Additionally, learning is not finished when a pilot completes initial training. Pilot currency and refresher training will occur throughout a pilot's aviation career.

Different methods of learning. There are several different methods through which learning can occur. Examples include passive learning, active learning, experiential learning, and SBT. When passive learning is taking place, it is an instructor-centered event. Passive learning is most commonly developed in the form of a lecture scenario, where learners are taking notes, and learner participation is not required (Wingfield & Black, 2005). Active learning incorporates learner engagement in lessons during training. Learners are exposed to assignments and activities that are designed to simulate or replicate events that have happened or could happen in the real world (Jones & Jones, 1998). Active learning can take a variety of forms, but two of the most common in aviation training are experiential learning and SBT.

Experiential learning, also known as learning by doing, is a method of providing the learner practice at a given task. Experiential learning tries to advance learning to the next step beyond rote memorization and the lecture method of learning (Furman & Sibthorp, 2013). Flight instructors will use a repetitive practice of various flight maneuvers, such as landings, in a variety of weather conditions, as a specific form of experiential learning called the drill-and-practice method, to help gain valuable experience for learners (FAA, 2008).

SBT is a method of active learning that has been recommended by the FAA as a key part of aviation training (FAA, 2008). SBT is defined by the FAA as using “a highly structured script of real-world experiences to address aviation training objectives in an operational environment” (FAA, 2008, p. 4-16). The increased realism in a training environment gives the learner an opportunity to practice in different scenarios and use a multitude of their senses in a constructivist approach to learning (Brown, 2014). Each scenario is created with a theme in mind to help a learner achieve a learning objective. The scenario will help the pilot develop a mental model through a situation that will allow the learner to refer to that scenario and use the practice and information gained to help improve future performance in terms of quicker response time, enhancing higher-order, and procedural skills. These types of SBT have been proven to have a high effectiveness (Blickensderfer, Strally, & Doherty, 2012; Fowlkes et al, 2009; Nicholson et al, 2009).

Self-efficacy

Aviation educators are also recognizing the importance the affective domain of learning plays on training. The affective domain focuses on the learner's emotions toward the learning experience, which includes the emphasis on the role of goals, motivation, values, and feelings on the learning process (FAA, 2008; Henley, 2003). One example is self-efficacy. Self-efficacy is an estimate or judgment of one's own ability to succeed in completing a specific task or reaching a specific goal. Taking a measurement of a learner's training attitudes and self-efficacy before and after training can be used as a measure of training effectiveness (Kraiger, Ford, & Salas, 1993). In fact, increasing a learner's self-efficacy can be a stated learning objective in a training program.

Research has shown that having a high self-efficacy level on a task or topic will result in a correlation to successful performance of that task or an increase in knowledge gained of the topic (Bandura, 2000; Zimmerman, 2000; Zimmerman & Kitsantas, 2005). If a pilot performs instrument approaches or uses Instrument Flight Rules (IFR) knowledge on a regular basis, increased confidence can be expected. Practicing these skills and, in turn, having an increased confidence level will lead to a pilot applying these skills safely and correctly in a real-world flight scenario. The importance of practice falls in line with the FAA's regulations regarding recent flight experience for a pilot-in-command (PIC) operating under IFR.

Instrument Rating Requirements

2016 FAA Civil Airmen Statistics show there were approximately 416,288 certificated private, commercial, and airline transport pilots in the U.S. Of the total number of certificated pilots, 72.7%, or 302,572, hold instrument ratings. All airline transport pilots and a majority of commercial pilots hold instrument ratings. There are 162,313 private pilot certificate holders, and 28.1%, or 45,672, have an instrument rating. Over the period of 2007-2016, an average of 10,396 private pilots obtained their initial instrument rating each year (FAA, 2016a).

An instrument rating is required when a pilot is operating in instrument meteorological conditions (IMC) and/or under IFR. The instrument rating will allow the pilot to fly in low visibility and in clouds, when maintaining visual references outside the airplane would not be possible. In addition, having an instrument rating can also help pilots gain further experience and knowledge in case the pilot encounters poor weather on a Visual Flight Rules (VFR) flight and inadvertently enters IMC conditions, a main cause of GA accidents (FAA, 2012b).

The requirements to obtain an instrument rating are found in Title 14 CFR 61.65. In summary, a person must hold at least a private pilot certificate or be concurrently applying for a private pilot certificate and be able to read, speak, write, and understand the English language. The person must receive ground and flight training from an authorized instructor covering the following knowledge areas relating to instrument flying:

1. Federal Aviation Regulations
2. Air Traffic Control (ATC) system, clearances, and procedures

3. Flight by reference to the instruments
4. IFR navigation, instrument approach procedures, and charts
5. Weather, weather reports, and recognizing critical weather situations
6. Safe and efficient operation of the aircraft
7. Aeronautical decision making (ADM) and judgment
8. Preflight and postflight procedures
9. Emergency operations

In addition to minimum flight hour and cross-country flight requirements, the pilot must also pass an FAA knowledge test on instrument knowledge as well as a practical test with an FAA inspector or designated examiner (Instrument rating requirements, 14 CFR 61.65, 2016).

After obtaining an instrument rating, a pilot must maintain instrument currency to operate under IFR. Instrument currency regulatory requirements for the PIC of an aircraft in the U.S. can be found in 14 CFR 61.57(c). The currency requirement states that in order to act as PIC of an aircraft under IFR, or in IFR conditions, the pilot must, within the previous 6 calendar months before the flight, perform the following in an aircraft:

1. Six instrument approaches
2. Holding procedures and tasks
3. Intercepting and tracking courses through the use of navigational electronic systems (Recent flight experience, 14 CFR 61.57, 2013).

There are other methods allowed to maintain a pilot's currency using simulation with other types of devices.

A flight simulator or Flight Training Device (FTD) can be used in the same manner as an airplane as long as the device represents the same category of aircraft the pilot intends to fly (FAA, 2014a). The requirements are the same in terms of the time period before the flight and the maneuvers and procedures required to be completed. Instrument currency duration and requirements change when a device like a Basic Aviation Training Device (BATD) or Advanced Aviation Training Device (AATD) are used. When using an AATD, the PIC must have logged within the two calendar months preceding the month of the flight, the following:

1. Three hours of instrument experience in the device
2. Holding procedures and tasks
3. Six instrument approaches
4. Two unusual attitude recoveries while descending at the airplane's published never exceed speed
5. Two unusual attitude recoveries while in an ascending, stall speed condition
6. Interception and tracking courses through the use of navigational electronic systems (Recent flight experience, 14 CFR 61.57, 2013).

There are also allowances in the regulation for pilots using a combination of aircraft, simulator, FTD, BATD, and AATD. The regulations list the specific requirements for each situation (Recent flight experience, 14 CFR 61.57, 2013).

If the pilot does not maintain instrument currency in the airplane or an approved FTD, BATD, or AATD, an IPC must be completed (Recent flight experience, 14 CFR 61.57, 2013). The requirements for an IPC are listed in the FAA's Instrument Rating ACS (FAA, 2016b). Any FAA inspector, FAA designated examiner, or Instrument

Flight Instructor can conduct an IPC. An AATD or FTD can be used for part of the IPC; however, the takeoff, circling, and landing must be completed in the airplane. The pilot must demonstrate a selected number of tasks laid out in the ACS that will “assure the competence of the applicant to operate in the IFR environment” (FAA, 2016b, p. A-11). The person conducting the IPC will select those tasks and use the guidelines of the ACS to ensure the pilot meets the standards. The pilot will then receive a logbook endorsement to show that they have completed the IPC (Recent flight experience, 14 CFR 61.57, 2013).

Significance of the Study

This study investigated the effectiveness of a carefully designed active learning experience using the SBT approach for instrument knowledge refresher training in terms of pilot knowledge gain and self-efficacy gain. Additionally, this study addressed an issue that was not present in the existing literature by validating the potential of using at-home personal computer-based SBT simulation for maintaining instrument currency. The development of personal computer SBT lessons that pilots can use from home would provide an opportunity for pilots to take advantage of new and updated training technologies. Being able to complete SBT on a personal computer without requiring FAA approved equipment or software could prove to be a possible avenue to increase instrument knowledge and pilot self-efficacy relating to instrument approach procedures. Regardless, if the FAA would approve the use of at-home CBT for currency requirements, SBT can reduce the flight time needed to ensure pilot proficiency in instrument flight operations. Furthermore, recent advances in simulation software on personal computers may help pilots learn and apply knowledge without the significant cost of aircraft, FTDs, AATDs, BATDs, and flight instructors. If effective, aviation education developers would be able to develop and distribute online training scenarios that use additional active and interactive methods of refresher training for instrument rated pilots and help maintain proficiency without flying.

Statement of the Problem

The flight training community has taken advantage of improvements in simulation and computer technology to enhance and augment the training process. Training hours using simulation and FTDs have been approved by the FAA to replace, thereby reducing, the hours flown in the aircraft toward a pilot certificate or rating, as well as to conduct portions of the practical test for a certificate or rating (FAA, 2014a). Personal computer-based flight simulation technology has advanced to the point where it has been demonstrated to teach instrument learners as certified AATDs (FAA, 2014a). Devices such as FTDs, AATDs, and BATDs have been utilized effectively as active training methods in flight training (Talleur et al., 2003). However, while new regulations allow for the use of AATDs to maintain instrument currency, the format behind maintaining instrument knowledge and currency has not changed significantly since the introduction of Personal Computer Aviation Training Devices (PCATD), BATDs, and AATDs.

The typical pilot certificate ground training program is lecture based, using slides as visual aids with learners taking a more passive role in the classroom or online by listening and watching the presentation. The emphasis in training has been on using technology in the flight portion of the course. However, there has not been much focus on using technology in refresher training to increase knowledge and self-efficacy. Simulation technology has already proven to help pilots practice the psychomotor skills needed to maintaining instrument currency (Taylor et al., 2003). Technology such as desktop flight simulation, can do a better job of presenting knowledge so that the information learned or refreshed can have better context and direct application for the pilot. In addition, simulation technology makes knowledge transfer simpler, cheaper, and more effective than other methods. The current method of maintaining instrument currency does not require any context or scenario-based training. The pilot must complete a specific number of instrument approaches and holds in an airplane, approved simulator, or training device (FAA, 2016b; Recent flight experience, 14 CFR 61.57, 2013). However, learning through SBT can also impact the self-efficacy of the pilot, where a pilot with high self-efficacy will perform to a higher level at a task compared to that of a low self-efficacy pilot (Bandura, 2000; Kirkpatrick, 2006; Kraiger, Ford, & Salas, 1993).

Purpose Statement

Maintaining currency for pilots is critical to the safety of flight. Pilots that are not able to maintain instrument currency may still wish to practice and improve their instrument knowledge and self-efficacy. The purpose of this research was to focus on using a flight simulation program on a personal computer to allow pilots who are not instrument current to maintain or develop a higher level of knowledge and self-efficacy in instrument operations, without the higher cost or availability associated with using an aircraft, FTD, or AATD. The study evaluated the effectiveness of active learning modules compared to a passive learning training module in terms of knowledge gain and self-efficacy of instrument pilots that are not instrument current using a pre/post-test design. The methodology that was used was based on Ortiz et al. (2016), a joint research study between Lockheed Martin and Embry-Riddle Aeronautical University (ERAU) that occurred in 2015. Ortiz et al. (2016) measured the effectiveness of an active learning module compared to a passive learning training module for student pilots where the material being presented to them was new information, as the student pilots did not have any prior instrument knowledge. The effectiveness was measured in terms of knowledge gain and self-efficacy using a pre/post-test design as well as participant reaction to the training and motivation level during the training (Ortiz et al., 2016). The current study focused on pilots that possess prior knowledge of instrument procedures and are using this training as a form of refresher training.

Hypotheses

The research question pertains to the effectiveness of active learning for instrument pilots that are not instrument current in terms of knowledge and self-efficacy gain. In this experimental study, three groups each received a different training method with varying levels of active learning. The first group read material relevant to instrument approaches, the second group flew instrument approaches on a desktop computer flight simulator, and the third group flew instrument approach scenarios where decisions must be made during the scenario. The first group was considered passive learning. The second and third groups were considered active learning, with the third group having more cognitive involvement and therefore a higher level of active learning. To simplify, the first group was referred to as the Read group, the second group was referred to as the Fly Only group, and the third group was referred to as the Fly and Decide group.

Hypothesis 1: After completing a lesson about IFR and missed approaches, participants will perform better on the post-training knowledge test than on the pre-training knowledge test.

Hypothesis 2: Participants in the Fly and Decide group will perform better on an instrument knowledge test than participants in the Fly Only group, who will perform better on an instrument knowledge test than participants in the Read group after completing the lesson about instrument knowledge and missed approaches.

Hypothesis 3: After completing a lesson about IFR and missed approaches, participants will have a higher self-efficacy pertaining to IFR operations when compared to their level of pre-training self-efficacy.

Hypothesis 4: Participants in the Fly and Decide group will have a higher self-efficacy pertaining to IFR operations than participants in the Fly Only group, who will have a higher self-efficacy pertaining to IFR operations than participants in the Read group after completing the lesson about IFR and missed approaches.

Hypothesis 5: Participants in the Fly Only and Fly and Decide group will have a higher satisfaction of training compared to participants in the Read group.

Delimitations

The FAA uses several objective measures to judge pilot performance. Those measures include knowledge tests and practical tests in accordance with FAA Practical Test Standards (PTS) or ACS. These different testing methods divide pilot certification testing into knowledge objectives and skill-based objectives (FAA, 2010). During recurrent training, flight instructors will use these same guidelines to measure pilot knowledge and performance. Instead of focusing on pilot “stick and rudder” skills, the research only addressed knowledge gain and the accompanying gain of pilot self-efficacy of pilots with an instrument-airplane rating who are not instrument current.

A second delimitation of the study was the demographics of the sample. The sample only included FAA certificated pilots with an instrument-airplane rating that were not instrument current as described by 14 CFR 61.57(c). The goal of the research was to provide results that were generalizable to the GA population, specifically, FAA certificated pilots with an instrument-airplane rating.

Limitations and Assumptions

Limitations. A computer-based desktop flight simulation software application and an internet browser were used to deliver the training and testing materials. Participants in the study who were not familiar with using computers and/or computer-based training could affect the results of the study. Additionally, any participants who were not familiar with using desktop flight simulation and controls may also affect the results. Participants that were not instrument current or proficient may have not retained enough basic information which may inhibit their performance in a way that could skew the results. The researcher relied on the truthful response from participants self-reporting their instrument currency and proficiency prior to the study. Any participant who was unable to effectively use the desktop-based flight simulation was not included in the statistical analysis of the data to ensure that these limitations did not affect the results of the study. Lastly, every attempt was made to make the three different types of training approximately the same duration. However, no specific time limits were set, and each participant was able to spend different amounts of time-on-task as needed to complete the training. If differing amounts of time existed, the differences have the potential to affect the amount of knowledge gained in the training.

Assumptions. The study operated under the following assumptions. First, the participants of the study were FAA certificated pilots who have obtained an instrument-airplane rating in compliance with 14 CFR. The participants, at the time of certification, displayed knowledge and skills that met or exceeded the FAA PTS or ACS standard to pass the practical test. Second, the participants answered truthfully on the demographic and flight experience survey. Finally, the participants were asked not to divulge information about the study to other participants or potential participants.

Definitions of Terms

Active learning	Learning that will engage the learner more directly in the learning process, increasing the level of cognitive involvement, increasing the level of learning effectiveness (Wingfield & Black, 2005).
Aeronautical decision-making (ADM)	A systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a

	given set of circumstances (FAA, 2008, p. G-1).
Aviation Training Device (ATD)	An ATD is a training device that has been evaluated, qualified, and approved by the FAA Administrator. In general, ATDs include a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft cockpit (FAA, 2014a).
Flight Training Device (FTD)	A replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft flight deck replica. It includes the equipment and computer programs necessary to represent aircraft (or set of aircraft) operations in ground and flight conditions having the full range of capabilities of the systems installed in the device as described in 14 CFR part 60 and the qualification performance standard for a specific FTD

	qualification level (14 CFR 60, Appendix F).
Instrument Flight Rule (IFR) conditions	Instrument flight rule conditions exist when the visibility is less than three statue miles and/or the clouds are less than 1,000 feet above ground level.
Instrument proficiency check (IPC)	A check given by a certificated flight instructor to a pilot who is not instrument current. The IPC consists of a series of instrument approaches and procedures listed in the current version of the FAA’s Instrument Rating Airmen Certification Standards.
Instrument rating	A rating that can be added to a pilot certificate to allow the pilot to operate under instrument flight rules.
Passive learning	Learning in the form of facts and theoretical principles with a low

	level of learner cognitive involvement (Jones & Jones, 1998).
Pilot currency	Requirements set forth in 14 CFR 61.57 to require pilots to meet specific recent flight experience requirements before being able to operate as pilot-in-command of an aircraft.
Scenario-based training (SBT)	Training method that uses a highly structured script of real world experiences to address aviation training objectives in an operational environment (FAA, 2008, p. G-6).
Self-efficacy	A measure of the confidence of an individual to complete a skill or task (Bandura, 2000).
Visual Flight Rule (VFR) conditions	Visual flight rule conditions exist when the visibility is at least three statue miles and the clouds are at least 1,000 feet above ground level.

List of Acronyms

AATD	Advanced Aviation Training Device
AC	Advisory Circular
ACS	Airmen Certification Standard
ADM	Aeronautical decision making
AOPA	Aircraft Owners and Pilots Association
ASI	Air Safety Institute
ATC	Air Traffic Control
ATD	Aviation Training Device
BATD	Basic Aviation Training Device
BRS	Ballistic recovery system
CBT	Computer-based training
CFR	Code of Federal Regulations
DOLA	Differentiated overt learning activities
ERAU	Embry-Riddle Aeronautical University
FAA	Federal Aviation Administration
FAAST	Federal Aviation Administration Safety Team
FDR	Flight data recorder
FFS	Full Flight Simulator
FTD	Flight Training Device
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument landing system

IMC	Instrument meteorological conditions
IPC	Instrument Proficiency Check
IRB	Institutional Review Board
ITER	Incremental transfer of training effectiveness
LOFT	Line-oriented flight training
PBL	Problem-based learning
PCATD	Personal Computer Aviation Training Device
PIC	Pilot-in-command
PTS	Practical Test Standard
P3D	Lockheed Martin Prepar3D
SBT	Scenario-based training
SME	Subject matter expert
TER	Transfer effectiveness ratio
VFR	Visual Flight Rules

CHAPTER II

REVIEW OF THE RELEVANT LITERATURE

Learning

The FAA defines learning as a change in behavior as a result of experience (FAA, 2008). Learning places an emphasis on the person in which the change occurs or is expected to occur. The learning process focuses on a change in the person’s behavior, knowledge, skills, and attitudes that are desired to occur. When defining learning, Knowles, Holton, and Swanson (2005) make a clear distinction between the terms education and learning. Where education focuses on the educator, learning describes the person in whom the change occurs or is expected to occur (Knowles et al., 2005). Kolb (1984) defines learning as “the process whereby knowledge is created through the transformation of experience” (p. 41). Kolb also states that the learning process requires six assumptions which are (a) learning is a process, not an outcome; (b) learning derives from experience; (c) learning requires an individual to resolve dialectically opposed demands; (d) learning is holistic and integrative; (e) learning requires interplay between a person and environment; and (f) learning results in knowledge creation (Kolb, 1984).

Kayes (2002) describes learning as involving two main processes, the acquisition of knowledge and the transformation of that knowledge into something meaningful the learner can use. During the acquisition of knowledge, the learner must balance between concrete experience called apprehension and comprehension of abstract concepts. Apprehension comes from the learner’s senses and their experiences with the world. Apprehension can also include the affective domain of learning through feelings and emotions. Comprehension transpires when the events the learner experiences are able to be broken down and understood in a meaningful way. Once apprehension and comprehension occur, the learner can move to the next phase of learning which is knowledge transformation. The transformation of knowledge has both an internal and external component. Internally, the learner will reflect upon all the knowledge that had been gained. Externally, the learner must interact with the environment around them to use that knowledge.

Mayer (2002) defines learning as a process that leads to change as a result of experience and increases the potential for improved performance and future learning. Mayer highlights three components of his definition:

1. Learning as a process not a product. The learning process can only be inferred because it transpires in the learner's mind.
2. Learning involves change in knowledge, beliefs, behaviors, or attitudes. Change occurs over a period of time and has a lasting effect on how learners think and act.
3. Learning is not something done to students, but rather something students themselves do. Learning occurs from the learner's experiences both conscious and unconscious as well as past and present (Mayer, 2002).

Ambrose, Bridges, DiPietro, Lovett, and Norman (2010) describe learning as a developmental process that is combined with other developmental processes in a learner's life. Learners approach any new topic with previously learned or experienced skills, knowledge, and abilities. The social and emotional state of the learner including self-image, self-worth, how learners view others, and how learners will interact during the learning process, must also be considered (Ambrose et al., 2010).

Learning theories. Several theories of learning exist, but in aviation education, the FAA places an emphasis on two theories in the Aviation Instructor's Handbook: behaviorism and cognitive theory (FAA, 2008). Being a pilot involves both the physical skill of flying an aircraft and the decision-making skills to safely complete a flight. Behaviorism focuses on the development of behaviors and psychomotor skills (Henley, 2003). Watson and Thorndike conducted research on behaviorism in their studies measuring animal behaviors in the late 19th century. Their studies dealt with each animal's responses to stimuli and their conditioned responses, creating a new behavior. These connections to the stimulus are the evidence that learning via the new behavior occurred. Thorndike also presented three laws of learning that governed learning in animals and human beings. First, the law of readiness states that the learner has to be in a state that is either satisfied or free from annoyance, to be open to leaning. Second, the law of exercise states that the connections between the new information presented will be stronger after practice. Third, the law of effect states that the connection to the new information is either strengthened or weakened as a result of its consequences and how positive outcomes are an effective motivator (Thorndike, 1898; Thorndike, 1927; Watson, 1930).

Pavlov's research on conditioning expanded on Thorndike's laws of learning by adding four concepts to the behaviorism theory. The four concepts are reinforcement, extinction, generalization, and differentiation. Reinforcement and extinction deal with the frequency of time between the stimulus and the response. As time passes without use, what was learned will become extinct and therefore forgotten. Generalization and differentiation refer to interference caused by other stimuli and the response that will occur because of those stimuli (Knowles, Holton, & Swanson, 2005).

Cognitive theory emphasizes the mental processes of thought, specifically processing and storing information (Henley, 2003). Researchers like Bloom and Piaget have focused on the cognition process and formation of conceptual thought, not just learning as a change in behavior (Knowles, Holton, & Swanson, 2005). The cognition process discusses the knowing, perceiving, problem solving, decision-making, awareness, and other kinds of intellectual activities that take place in the mind. Bloom developed a taxonomy that describes the six levels of intellectual behavior from simple to complex: knowledge, comprehension, application, analysis, synthesis, and evaluation (Anderson, Krathwohl, & Bloom, 2001). Bloom's taxonomy helped frame a new offshoot of cognitive theory called constructivism. Constructivism states that learners actively build knowledge through their experiences. Learning through the constructive process means the learner is using his or her senses along with their previous knowledge and experiences to build and construct new meaningful connections (Bruner, 1996). Learners that follow the pattern of constructivism to learn become better problem solvers and have strong critical thinking skills. Learners will also tend to take charge of the learning process and show increased motivation to learn new material and achieve the learning outcomes that have been set forth. The constructivist approach will allow learners to self-reflect and collaborate with others and build a positive learning environment (Brown, 2014).

Ambrose et al. (2010) have established seven general principles of learners based on previous research that should be considered by educators when teaching.

1. A learner's prior knowledge can help or hinder learning.

2. How a learner organizes knowledge influences how they learn and apply what they know.
3. A learner’s motivation determines, directs, and sustains what they do to learn.
4. To develop a mastery of a subject, the learner must acquire component skills, practice integrating them, and know when to apply what they have learned.
5. The quality of the learning can be enhanced with goal-directed practice and targeted feedback.
6. Learner’s current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning.
7. Learners must be able to monitor and adjust their approaches to learning to become self-directed learners.

Adult Learners

When developing training material, effective instructors should understand what their students’ characteristics are, how they learn, and adapt to best fit the learner as necessary (FAA, 2008). A distinction is drawn between how children learn, pedagogy, versus how adults learn, andragogy. In a pedagogical model of learning, the learners have little experience to draw on, they rely heavily on the teacher, and their motivation stems from external sources like competition for better grades and consequences for failure (Scott & Hargreaves, 2015). Andragogy deals with the adult learner that Knowles et al. (2005) define as one who can “arrive at the self-concept of being responsible for our own lives, of being self-directing" (p. 64). To model how adults learn, Knowles developed an andrological model of learning which is based on six assumptions.

1. Adult learners need to know why they need to learn something. Having knowledge of why, the adult learner will then place more effort into the learning process. The effort comes from understanding the positive impacts from learning the new information and the negative effects of not learning the new information (Knowles, Holton, & Swanson, 2005).
2. Adult learners have a self-concept of being responsible for their own lives and decisions. Adults will need to be guided by the instructor as a self-directed learner and not fully dependent on the instructor (Knowles, Holton, & Swanson, 2005).
3. Adult learners have a different level and quantity of previous experience compared to younger learners. Experience can act as the base on which adults will learn new knowledge. Instructors must tap into the learner's experience through various teaching techniques to teach in the most effective manner. The learner's experience can also have a negative effect on the adult learner. Adult learners may have developed biases, habits, and assumptions that can make it difficult for the acceptance of new knowledge (Knowles, Holton, & Swanson, 2005).
4. Adult learners come ready to learn new things, especially when the new knowledge will be able to be used immediately in their own lives. Instructors should look for developmental steps in the adult learner's life as an opportunity to teach. If those opportunities do not exist, the instructor will

have to use other techniques to encourage a state of readiness in the adult learner (Knowles, Holton, & Swanson, 2005).

5. Adult learning is based on a task or problem-centered design as opposed to a subject-centered design. Presenting new knowledge, skills, values, and attitudes in the framework of real-life scenarios will be the most effective teaching method (Knowles, Holton, & Swanson, 2005).
6. Adult learners respond better to internal motivation, like self-esteem and quality of life, to keep growing and developing as a person. Adults will respond to external motivation, like improving one's job or salary, but internal motivation is the most effective (Knowles, Holton, & Swanson, 2005).

By keeping these six assumptions in mind, the instructor can best facilitate adult learning and select the best method at which to present new information to the learner.

Aviation students and adult learning. The learning styles of students can be different based not just on age or level of life experience but also by the curriculum the learners have chosen to study. Brady, Stolzer, Muller, & Schaum (2001) tested a comparison of the learning styles between aviation and non-aviation college students by surveying 539 freshman students at three universities. The hypothesis was that aviation students will display more characteristics of adult learners compared to non-aviation students. The survey, based on Knowles model of andragogy, asked learners questions about several factors: self-concept, experience, the connection from classroom to real world, motivation relating to the readiness to learn and the orientation to learn, whether subject centered or problem centered. In all four aspects of the andragogy model, aviation students related more to adult learners. Since aviation students relate more to adult learners, they should be provided with opportunities to apply and try out what was learned quickly after the lesson. Additionally, Brady, Stolzer, Muller, & Schaum (2001) state that aviation students “are not searching for a career; they have found one and are taking steps to realize their dreams” (p. 40). The authors point out one limitation of the study being that the sample size may have been a little smaller than ideal. Had more colleges and universities been surveyed to provide a larger dataset for the statistical analysis, the results would have been more powerful (Brady, Stolzer, Muller, & Schaum, 2001).

Learning Methods

A variety of learning methods exist for pilot training. Traditional pilot training was developed to provide a large amount of broad knowledge on a variety of topics. Broad knowledge was taught using rote memorization levels of learning where passing written exams was the typical assessment approach. Rote learning fails to help learners reach a higher level of learning and develop critical thinking and decision-making skills (Henley, 2003).

Passive learning. The simplest way to differentiate between learning methods is to classify the method as either passive or active learning. In passive learning lessons, conceptual knowledge is presented to the learner in the form of facts and theoretical principles and does not include experiential training. These facts and principles will act as building blocks upon which future knowledge can build on (Jones & Jones, 1998). An example of a passive method of learning is the traditional lecture method where an instructor delivers knowledge to silent learners who observe and listen. While the lecture method is best for summarizing new topics and presenting large amounts of information to a learner, it does have some drawbacks. The lack of learner participation makes it difficult to assess the learner's understanding of the material. A passive learner does not receive any "hands-on" or active practice (FAA, 2008). Assessment in passive learning is typically in the form of multiple choice or true-false exams (Wingfield & Black, 2005).

Active learning. Active learning is defined as learning that will engage the learner more directly in the learning process. By being more engaged, it is assumed that the learner will learn more effectively because the learning experience is considered to be more intense and have a more permanent effect compared to passive learning (Labinowicz, 1980, as cited in Wingfield & Black, 2005). Dale (1969), starting in the 1940s, developed a model of learning that has come to be known as Dale's Cone of Experience. Dale's model describes a hierarchy (Figure 1) that states learners will retain more information by doing a task as opposed to just reading or hearing about that task. For example, at the lowest level in the hierarchy is verbal experience, then learning progresses through pictures and videos, demonstrations, and finally through direct, purposeful experiences. Treichler (1967) published an article giving a list of percentages regarding how much learners remember from different means of instruction. People generally remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say, and 90% of what they say as they do the activity they are talking about (Treichler, 1967). Over time, both Dale's Cone of Experience and Treichler's percentages have been combined into one image (Figure 1) (Dwyer, 2010).

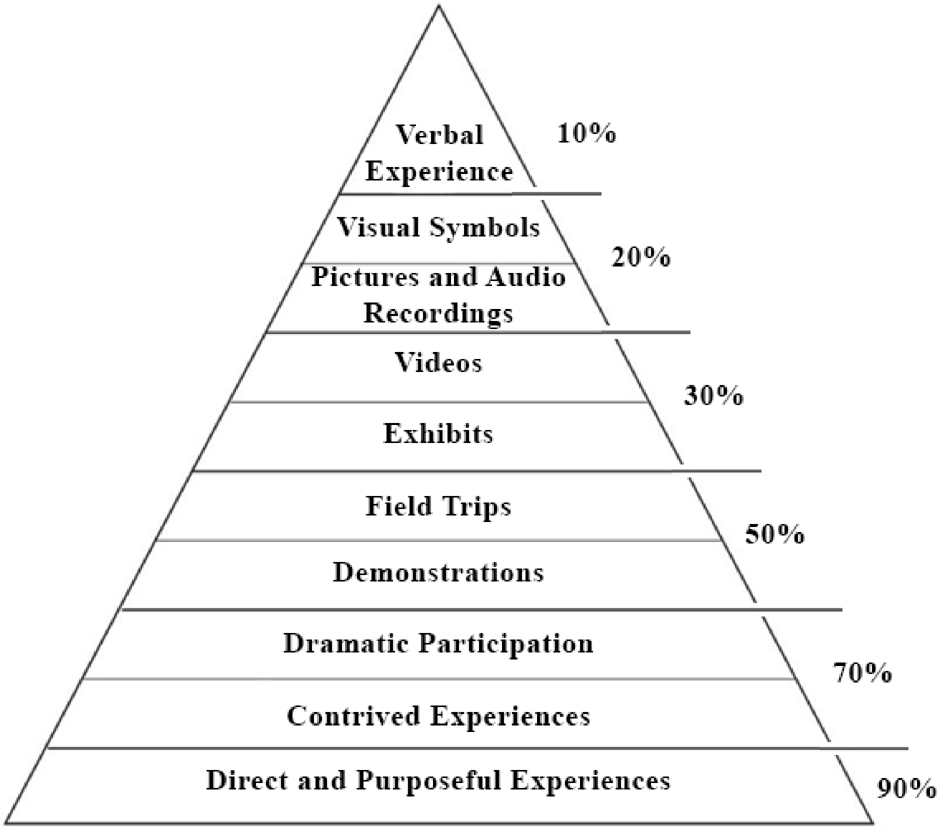

Figure 1. .Dale's Cone of Experience with Treichler's percentages (adapted from Dwyer, 2010).

Dale's Cone of Experience and Treichler's percentages provide some evidence that indicates that active learning is more effective than passive learning. Dwyer (2010) presents some criticism of these models.

1. There is not a clear description of how the data was obtained to develop the model and whether a controlled experimentation research method was followed.
2. There is no description of the sample used and therefore no way to determine what population the model applies to. Dwyer suggested the population is young male military recruits, based on Dale's publications.

3. There is no description on how instruction was presented to the learners. For example, if it was a self-paced or externally paced instruction or what kind of visual training aids or demonstrations were used.
4. There is no description of the learning objectives that the learners obtained after training.
5. There is no description of what assessment tools were used to measure the effect of the training (Dwyer, 2010).

Dwyer (2010) states that over time, Dale’s Cone of Experience and Treichler’s percentages have become accepted as fact because these two models have been around for such a long period of time without giving any consideration to the criticisms already presented. Baker and Dwyer (2005) reviewed eleven different studies focusing on using the various levels in Dale’s Cone of Experience and achieving learning goals. Baker and Dwyer noted that there is a significant difference in the effectiveness of training that stems from the learning styles of the individuals receiving the training. Also of importance was the level of prior experience that the learner possesses before the training began (Baker & Dwyer, 2005).

Research has shown that active learning can be linked to better critical thinking skills and higher knowledge retention (Wingfield & Black, 2005). Active learning can be further broken down into more specific methods like experiential learning and SBT (Wingfield & Black, 2005). Chi (2009) proposed a structure to define different active learning strategies into three different groups called differentiated overt learning activities (DOLA). The three different groups were classified as active learning, constructive learning, and interactive learning. Learning is placed into one of these three groups based on “their overt activities and their potential corresponding cognitive processes” as well as how effective each method is when comparing learner performance (Chi, 2009, p. 75). Menekse (2012) took a similar approach and divided learning into four different categories: interactive, constructive, active, and passive learning. Again, these terms can all be used to describe different methods of learning, and Menekse’s study aimed to define and validate the effectiveness of each learning type. Menekse’s research demonstrated that interactive learning is more effective than constructive learning, constructive learning is more effective than active learning, and active learning is more effective than passive learning (Meneske, 2012).

Experiential learning. Experiential learning is when knowledge is transferred to the learner through a learning experience. Experiential learning does not require an instructor and can even be self-taught. It can also take many different forms: problem-based learning, project-based learning, cooperative leaning, service learning, reflective learning, and SBT. To make experiential learning effective, both time for practice and active learning need to be present in the training (Furman & Sibthorp, 2013). Other factors that are critical to a transfer of learning are modeling, goal setting, and overlearning, where learners practice past the point of initial mastery (Furman & Sibthorp, 2013).

Experiential learning does have potential drawbacks that could cause difficulty when employed. A few of these drawbacks include the fact that developing and teaching in the experiential method can be time consuming, difficult, and inconvenient for teachers to use. In certain situations, other methods of learning are more effective, but the effectiveness depends on the subject of the lesson being taught (Furman & Sibthorp, 2013).

Some also argue that using experiential learning techniques do not teach an entire topic but only some of the aspects needed to complete a task. Experiential learning could leave out knowledge that is important for the learner to know. There is also a sense that there is a social aspect to learning that experiential learning does not account for and, therefore, does not give the learner the full picture of what is occurring (Kayes, 2002).

Self-efficacy

Self-efficacy is defined as a person's individual belief and confidence in their ability to perform a specific task (Bandura, 1997). Efficacy related beliefs are multifaceted in the sense that self-efficacy combines both physical skills and higher-order thinking skills. These beliefs influence human behavior through processes like cognitive thinking, decision making, motivation, and the affective domain (Bandura, 1997).

Evidence has shown that "efficacy beliefs contribute significantly to the level of motivation and performance" of an individual (Bandura & Locke, 2003, p. 87). Perceived self-adequacy does not just affect the behavior of an individual, but it can affect other aspects of a person's being. For example, self-efficacy can affect one's goals and aspirations, outcome expectations, and the perception of how the social environment affects themselves (Bandura, 1997). Efficacy plays a large role in how a person frames their thoughts in terms of being a strategic thinker or being optimistic versus pessimistic. The level of self-efficacy one has in a particular task also relates directly to how much effort they put forth as well as how willing they will be to attempt to overcome obstacles (Bandura, 2006; Zimmerman, 2000).

Those who show a high confidence level in a particular task will perform better at that task when compared to those with a lower confidence level (Bandura, 2000). Self-efficacy provides a measurement of confidence level and is predictive of both a learner's rate of performance and their expenditure of energy on a task. Measuring self-efficacy to determine a learner's motivation level on a task will relate directly to the persistence of the learner and their level of academic achievement. Having high levels of persistence will motivate the learner to self-study and self-evaluate to achieve a learning goal (Zimmerman, 2000). Furthermore, as time passes, a person's efficacy on a task can change. A change in self-efficacy occurs as tasks are completed correctly or incorrectly, as well as by how recently the task was accomplished (Kraiger et al., 1993).

If one experiences a "powerful mastery experience," it can serve as a transformation in personal efficacy beliefs (Bandura, 2006, p. 308). The change in efficacy beliefs can influence not just the current task or situation but can also apply to other domains of functioning. A person's self-efficacy beliefs can vary in strength from weak to strong. The stronger the belief in oneself, the harder it is to change one's own opinion on performance of a task. If the self-efficacy belief is weak, a small event can be enough to change one's self-efficacy, especially in the negative capacity (Bandura, 1977).

Negative effects of high self-efficacy. Having a high level of self-efficacy may pose potential hazards in some situations. In some cases, a high level of self-efficacy leads to a sense of overconfidence in individuals when completing a task (Stone, 1994). Overconfidence leads to situations where an individual may not devote enough resources to a task to complete it successfully (Stone, 1994). Vancouver, Thomson, and Williams (2001) indicated that learners with a high level of self-efficacy will perform poorly on tasks as a high level of self-efficacy creates a sense of relaxation, therefore effecting overall performance. Those with high levels of self-efficacy may even fall into risky behavior and may be less likely to fear a negative outcome (Kontos, 2004).

Self-efficacy effects dependent on the scenario. A high level of self-efficacy can have either a positive or negative impact on a given situation, and the details around that situation make the critical difference. Salanova, Lorente, and Martínez (2012) looked at different situations to see how self-efficacy affected the outcome of the event. The three settings Salanova et al. used were a learning setting, an innovating setting, and a risky setting (2012).

In the learning setting, college students were asked to rate their self-efficacy during college level courses before the course began and after the course was completed. Their self-efficacy was then statically measured against their performance in the course. The results show there was a statistically significant correlation between high pre-course self-efficacy and high academic performance. Meaning, that in the learning setting, those students with a high pre-course self-efficacy will perform better and score higher in the course compared to those that have a low self-efficacy going into the course (Salanova et al., 2012).

In the innovative setting, students were divided into groups to complete a project where their task was to solve three different problems. Each student's self-efficacy was measured after each separate problem scenario. Similar to the learning scenario, a high self-efficacy correlated with increased innovative performance (Salanova et al., 2012).

For the risky setting, Salanova et al. (2012) measured self-efficacy in construction workers from 10 European construction companies, due to the potentially dangerous nature of the construction industry. The researchers gave self-efficacy questionnaires and interviews to 228 construction workers. The questions focused on their behavior in use of safety equipment and procedures when compared to their self-efficacy to complete particular tasks. The results show that those workers who had a high level of self-efficacy did not demonstrate safe practices, meaning that those with high self-efficacy acted in a risky and more dangerous manner compared to those with low self-efficacy (Salanova et al., 2012).

Salanova et al. (2012) state that continuing the study over a longer timeframe would help judge the effects of self-efficacy on these situations over time. The research shows that in the learning and innovating environments, a high level of self-efficacy correlates to a positive outcome and positive academic performance. Also, in some cases, self-efficacy can result in negative and risky behavior. In those situations, it is important to stress the safe performance of a task (Salanova et al., 2012).

Self-efficacy questionnaire construction and analysis. When constructing a self-efficacy questionnaire, a balance must be maintained between being too general or too specific. Balancing the questions adds to the challenge of developing an effective data collection instrument. It is imperative to ensure that the instrument is appropriately framed in terms of the task or domain in which the person is operating (Bandura, 2006). Additionally, the efficacy items should be framed in terms of “can do” and not “will do”. Proper framing will ensure that the participants’ capability at a certain task is measured, not their intentions. The survey items must also differentiate perceived self-efficacy from self-esteem, locus of control, and outcome expectancies (Bandura, 2006).

Self-esteem is a measure of the person's own perception of themselves and may not reflect on their actual ability to perform a task successfully. Internal or external locus of control refers to the belief of whether a person has control of the outcome of a situation or if the situation will occur regardless of the person's input. A person with a high sense of *internal* locus of control believes that they have direct control over a situation and therefore can affect the outcome. In contrast, a person with a high sense of *external* locus of control believes that the outcome of a situation will be the same regardless of their actions. One's belief can vary between an internal or external locus of control depending on the specific situation (Rotter, 1966). One who believes they have a high external locus of control does not indicate a high level of confidence in the ability to successfully perform a task (Bandura, 2006). Bandura (2006) gives the example of students receiving academic grades. Some students feel they have a high internal locus of control because their performance is a direct correlation to their grades. However, some students who feel an external locus of control is present may feel hopeless and lack confidence to perform and achieve a high grade. These students will feel as if it is up to the instructor to have them achieve a high grade.

Outcome expectations are different from self-efficacy. Outcome expectations are an expectation of outcome that will occur based on one's ability to perform a task (Bandura, 2006). Outcome expectations take different forms. Some examples of outcome expectations include positive and negative physical, social, and self-evaluative outcomes (Bandura, 1986). Any positive outcomes will serve as positive reinforcement, while the opposite is true for negative outcomes. These outcome expectations will have a direct relationship to one's perceived self-efficacy, but the expectations are not the same as self-efficacy (Bandura, 2006).

Self-efficacy scale construction. The first step to build a self-efficacy scale is to develop a familiarity with the task in question. The construction process includes gaining knowledge of the domain of functioning and the activity domain. An assessment of more than just the person's belief in their capability to complete a task must be measured. The survey must gather information about a person's capability to complete and do whatever is needed to complete the task. Measuring other aspects of a knowledge domain that apply to the current task at hand is required. Next, a series of interviews with subject matter experts (SMEs) should be conducted to determine what steps, actions, or knowledge is needed to complete the task (Bandura, 2006).

Choosing a gradation scale is also an important consideration. Bandura (2006) recommends that a scale from 0 to 100 be used to avoid any ceiling or floor effects that may occur when using a smaller range of numbers. Range restriction and scales that use smaller ranges of numbers are also less sensitive and less reliable, as people tend to avoid picking near the extreme ranges of the scale. The self-efficacy survey or questionnaire itself should consist of a series of statements that ask a person to rate how difficult is it to complete each statement at the current moment. The participant would do so on a 100-point scale where 0 means “cannot do”, 50 means “moderately certain can do”, and 100 means “highly certain can do” (Bandura, 2006, p. 312).

When developing the items for the questionnaire, the items must have construct validity to ensure each item measures what is intended. If construct validity does not exist, the questionnaire will not be able to provide discriminative or predictive validity.

Once the individual items have been developed, the entire questionnaire must be pretested and special attention given to remove or replace any items that are ambiguous or could be potentially confusing, through a factor analysis and Cronbach's alpha calculation. Items should also be written in a way that requires the use of the same scale for each question. Items in the survey can address the same domains but can vary in difficulty level to help increase the level of detail of self-efficacy in each individual. These similar domain items can also be grouped together and correlated in a statistical and factor analysis to test the homogeneity of the similar items. Further analysis can be completed by using factors like Cronbach's alpha to determine internal reliability. There must be enough items on the questionnaire for Cronbach's alpha to work effectively, so the length of the questionnaire may need to be increased. Any items that test low in internal reliability should be rewritten or removed from the questionnaire (Bandura, 2006).

It is critical that the instructions of the questionnaire place the participant in the appropriate mindset to measure their own "belief in their personal capability" at the present time and disregard any future abilities (Bandura, 2006, p. 312). It may be helpful to add a few example items to the self-efficacy questionnaire to help make sure there is no confusion as to how to fill it out correctly.

Minimizing response biases. It is important to ensure that response biases are minimized to get the most accurate data on personal efficacy. The participants will not be allowed to write their name on any self-efficacy questionnaires; they should be labeled as a number to protect their anonymity and encourage them to answer freely. The title of the questionnaire should also use a non-descript title like "Appraisal Inventory". Before the participant takes the questionnaire, the researcher needs to inform them of the importance of the research goals and how their accurate answers will help improve the future (Bandura, 2006).

People judge their own self-efficacy across an entire task as opposed to a more level by level aspect of completing a task (Bandura, 2006). Bandura (1997) determined that a person’s self-efficacy on a task is the same regardless if they take a survey or questionnaire prior to completing the task in question. Additionally, the results of the questionnaire are not affected by social considerations or external pressures on the participant in the study.

Self-efficacy examples in other research. Several studies have been conducted to show the effect of self-efficacy and its relationship between confidence and performance.

Lane and Lane (2001) designed a study to examine the relationship between self-efficacy as a predictor in the academic environment. The study measured the performance and self-efficacy of 76 students enrolled in courses toward the degree requirements of a Master’s Degree in Human Resource Management. Participants were asked to fill out a self-efficacy questionnaire at the beginning of a 13-week semester and again at the end of the semester. The participant’s performance was measured by their final exam test grades and a complex written assignment during the semester long course. While there were many factors that affected the students during the semester, the self-efficacy questionnaire at the beginning of the term was shown to be an accurate predictor of academic performance. An important note about the Lane and Lane (2001) study is that the time delay between the initial self-efficacy questionnaire and the student’s final exam performance as well as the complexity of the task did not have any negative impact on the prediction of student performance (Lane & Lane, 2001).

Clauson-Sells (2014) conducted a study to compare the self-efficacy of international college students to their academic performance. The study had a total of 83 participants from 17 different countries. The students were given a self-efficacy questionnaire that was based on a standard Motivated Strategies for Learning Questionnaire. The students then completed a year of academic college coursework, and their final grades were recorded. A t-test was used to compare the answers of the self-efficacy questionnaire and the student's final grades. A significant statistical relationship was found between students that had a high level of self-efficacy and high final course grades (Clauson-Sells, 2014). The Clauson-Sells (2004) study is another example of how having a high level of self-efficacy prior to an academic course will lead to a high grade at the end of a course.

Blickensderfer, Strally, and Doherty (2012) examined the effects of a training module for pilots that provided a SBT approach to the use of an emergency whole-plane ballistic recovery system (BRS) parachute. A PCATD was specially outfitted with a BRS handle that was similar to what was found in the aircraft (Blickensderfer et al., 2012). The research divided participants into two groups, a control group and an experimental group, with the difference being the way the training was delivered. Each group took a pretest about knowledge of the BRS and its appropriate usage and a self-efficacy survey, before being given training. The control group received training via an instructor and a computer procedural trainer that covered information about the BRS and how to deploy the system as well as reading some manufacturer information about the BRS. Next, the control group flew a series of scenarios that allowed them to get used to the PCATD but did not involve any inflight reasons to deploy the BRS. The experimental group was briefed on how to use the BRS and then was presented 10 different scenarios where the participants had to decide if the use of the BRS was warranted. After each scenario, the experimenter provided feedback to the participant on what the correct course of action should be. The next day, participants from both groups were asked to fly a series of scenarios and told to act accordingly as if on a real flight. An observer rated the performance of the pilots in each scenario to determine if they used the BRS correctly. Besides observing, the participants were given a knowledge test and a self-efficacy questionnaire about the BRS (Blickensderfer et al., 2012).

The results of the study indicated that pilot performance did improve after training and that the SBT group performed better than the control group in the final test scenarios. In terms of knowledge gain, there was no significant difference between the two groups, meaning both had gained a basic understanding of the BRS. Finally, the posttest self-efficacy questionnaire revealed that the SBT group had a higher self-efficacy in the use of the BRS than the control group (Blickensderfer et al., 2012).

The Blickensderfer et al. (2012) study did have a few limitations. First, the participants in the study were entirely from a collegiate flight training program, with a mean age of 20.8 (SD = 1.9) and therefore may not have represented the entire GA pilot population. Second, the knowledge test may not have been in-depth enough to accurately measure knowledge beyond a basic understanding. Given these limitations, the study shows that SBT can positively impact a person’s self-efficacy (Blickensderfer et al., 2012).

Ortiz et al. (2016) used a lecture vs computer SBT approach to teach participants about IFR procedures specific to flying missed approaches. The lesson provided information about approach procedures, identifying minimum altitudes and missed approach points, interpreting weather reports to determine if weather minimums are met at the destination airport, and interpreting weather reports to determine a likely landing location at another airport. The study investigated the role of technology-enhanced learning specific to missed approach procedures. The study was designed as a proof of concept of testing new methods of self-study, simulation-based learning (Ortiz et al., 2016).

Since the Ortiz et al. (2016) study was geared toward testing the effectiveness of the training and knowledge retention for learners who had not yet obtained an instrument rating, the participants selected were private pilots that did not have an instrument rating. The participants were 35 certificated private pilots enrolled in an instrument ground course and were divided into two groups. The control group learned through the traditional lecture method of instruction, and an experimental group learned through a computer-based training (CBT) lesson and SBT. The design of the study aimed to test the students’ knowledge, self-efficacy, and reaction and motivation to the training at three time periods: before training, after training, and then retention a week after training. A 3 x 2 mixed factorial design was used to capture both groups’ results during the three time periods in question. Before any training was given, a knowledge pretest and a self-efficacy questionnaire was given to the participants. The knowledge test covered items related to flying instrument approaches and interpreting weather reports to decide if a legal landing could be made at each destination. Three parallel forms of the test were used to eliminate any practice effects. The self-efficacy questionnaire covered the participant's confidence levels in their knowledge of missed approach procedures, interpreting weather, and choosing airports based on reported weather conditions. Next, based on the randomly assigned groups, training was presented (Ortiz et al., 2016).

The training covered the same information and examples and only varied by the delivery method to the participants. The control group attended an in-person classroom lecture session where a flight instructor presented the appropriate information. The lecture session did not include any active practice scenarios, just text-based examples. The experimental group was trained using a CBT module through the Lockheed Martin Prepar3D (P3D) software. The training consisted of a 12-minute informational lesson followed by the students actively flying a flight simulation of six instrument approaches. The first two instrument approach scenarios had verbal prompts to teach and explain what was occurring to the participants, and the last four scenarios only provided feedback to the student after they personally hand flew and completed each of the instrument approaches. After the training was complete, each participant took a posttest knowledge test and self-efficacy questionnaire. Then, the participants were asked to return a week later to take a retention knowledge test and self-efficacy questionnaire (Ortiz et al. 2016).

The results of the Ortiz et al. (2016) study showed that for both the traditional lecture method and the SBT method, the knowledge level did improve significantly between the pretest and posttest, but there was no significant difference between the pretest and the retention test. In a similar manner, self-efficacy changes between the three time periods had the same effect. There was a significant increase in self-efficacy between the pre-training and post-training timeframe. However, there was no significant increase between the pre-training and the retention time frame in self-efficacy. Additionally, the participants in the lecture control group had a statistically significant higher reaction score to the training compared to the experimental SBT group. The higher reaction score indicates that the face-to-face lecture was slightly more enjoyable for the students. The motivation level between the participants of each group did not differ significantly meaning that both groups felt they were engaged by the lesson and training (Ortiz et al. 2016).

The Ortiz et al. (2016) study was a proof of concept design using new, inexpensive desktop computer-based technologies available through the P3D software. Some of the lower reaction scores could be related to technical issues that occurred during the lessons. Another limitation was that the participants were college students that held a private pilot certificate and were in an instrument pilot ground course and therefore did not have any experience flying instrument approaches in an airplane yet. The lack of skill in flying the scenarios may have negatively affected their self-efficacy scores. The material in the lesson may have been more appropriate toward a more experienced pilot population. The researchers recommend further research in making improvements to the training module as well as further data collection to verify the results of the study (Ortiz et al., 2016).

Computer Technology in Flight Training

Studies have shown that pilots in training using a PCATD have a statistically similar transfer of training effectiveness when compared to pilots in training using FTD toward an instrument rating on their pilot certificate (Combs, 2001; McDermott, 2005; Olson & Austin, 2005; Taylor et al., 2003; Talleur et al., 2003). Taylor et al. (2003)

tested the effectiveness of using a PCATD, FTD, and aircraft to prepare for an IPC. Taylor et al. demonstrated two important points. First, pilots who practiced instrument procedures in a PCATD or FTD twice during a six-month period performed better on an IPC compared to those that did not practice for that same time period. Second, practicing instrument procedures in a PCATD was at least as effective as practicing in the airplane (Taylor et al., 2003). Further, McDermott (2005) found no differences between pilot performance during an instrument approach when using a PCATD compared to an FTD (McDermott, 2005). Studies such as these have resulted in the FAA's development of rules regarding when these types of devices can be certified and used for various operations toward a pilot certificate or rating as well as PIC recent flight experience requirements for instrument currency.

PCATD simulation technology used in GA flight training has improved with advances in computer technology since the early 2000s. The FAA developed new and more specific classification for PCATD devices as either BATD and AATD. These devices represent different levels of fidelity of an aircraft and are based on personal computer technology. Both BATDs and AATDs can be used for training toward pilot certificates and ratings as well as instrument currency requirements. These devices lend themselves well to different training techniques and learning styles (FAA, 2014a). While many simulation companies exist, one example is Frasca Flight Simulation. The Frasca company manufactures a wide variety of simulation devices ranging from a Level 6 FTD with a full 220° degree wrap-around visual display to an AATD known as the Mentor (Frasca, 2017), both of which are recognized by the FAA to be used in flight training and, in some cases, able to be used during a practical test for a certificate and rating (FAA, 2016b).

Not all pilots have the ability to maintain instrument currency using an aircraft, FTD, or an AATD. Cost and availability of purchasing or renting an aircraft are limiting factors that pilots must consider. Exact cost can vary widely based on aircraft type and condition, but a single engine airplane capable of IFR flight, such as a Cessna 172S with glass cockpit avionics like a Garmin G-1000, can cost approximately $120 to $135 per hour to rent, with costs rising each year (Air America, 2017; Garett, 2013). Costs of FTDs and AATDs are harder to estimate due to the wide variety of devices and facilities that operate them, but compared to a newer aircraft rental, AATDs cost less per hour than an aircraft. If a pilot does not maintain instrument currency and does not regularly use those skills and knowledge, there is a potential for knowledge decay and a lack of confidence and self-efficacy in a pilot’s own skills and ability.

Besides the use of computer-based simulation, pilots can use online training courses to maintain their knowledge level. One specific avenue for pilots to use is the FAA’s online platform through their FAA Safety Team (FAAST) website found at https://www.faasafety.gov/. In addition to the in-person presentations that the FAAST team provides, the FAAST website is a collection of online training resources from a variety of authors that primarily rely on passive training methods to present information to pilots. The FAAST website allows pilots to log in and keep a record of the courses taken on various aviation related topics. The FAA also uses the web-based platform to allow pilots to meet certain regulatory requirements such as Special Flight Rules Areas like the one located around the Washington D.C. area (FAAST, 2014). The Air Safety

Institute (ASI) section of the Aircraft Owners and Pilots Association (AOPA) website is another example of a website that provides free online courses and videos to aid pilots (AOPA, 2016). The FAA also posts a library website containing handbooks and manuals that pilots can use to review and read instrument related publications as well as publications on numerous other aviation related topics (FAA, 2014b).

Skill retention and relearning . Skill Retention is defined as the degree of competence to which an acquired skill is retained through the passage of time (Ginzburg & Dar-El, 2000). Past research has shown that one's skills tend to decay with the passage of time (Sense, Behrens, Meijer, & Rijn, 2016). Relearning or retraining must occur in order for the skill to return to the same performance level as when originally learned. The time period where the relearning takes place will be shorter than the original learning period; however, the time for relearning will increase as a function of the interval between training and relearning. Additionally, relearning procedural skills takes more time then psychomotor skills (Ginzburg & Dar-El, 2000).

Ginzburg and Dar-El (2000) conducted a study to test members of the military on their level of skill retention on certain high skill level tasks. The study focused on tasks that were not performed often, and refresher training was required to maintain skill retention. Fifty-three participants were divided into groups that would receive refresher training at various intervals of one month, two months, or three months, followed by a test at six months from the start of the study. The refresher training involved the use of what was termed a partial-simulator that replicated a specific military electronic warfare task. The participants were then graded on their performance by an SME observer. The results show that there was a significant difference in performance between the one-month and two-month groups when compared to the performance of the three-month group. Regular retraining prevented a loss of skill retention, especially when the skill was a procedural skill. The study also demonstrated that the psychomotor skills did not deteriorate as quickly as the procedural skills. Retraining acted to “jump-start” the relearning process. Finally, a partial simulator was a close enough medium to achieve refresher training for complex tasks (Ginzburg & Dar-El, 2000).

Simulation fidelity. Simulation fidelity refers to the level of realism of a simulation compared to the real activity. In aviation, simulation fidelity describes how realistic the simulation is in comparison to the real aircraft (Rehmann, Mitman, Reynolds, & Crew System Ergonomics Information Analysis Center Wright-Patterson AFB OH), 1995). High simulation fidelity means the simulator is very similar to the real aircraft, while low simulation fidelity means the simulator is not close to an exact representation of the aircraft (Liu, Macchiarella, & Vincenzi, 2009). Fidelity of a simulation can be broken down further into categories, two of which are physical fidelity and cognitive fidelity. Physical fidelity refers to comparison of the physical features of the simulator to the aircraft. For example, an aircraft simulator with high physical fidelity would be built using the switches and flight controls that are the exact copy of and the exact location to what is installed in the aircraft. Cognitive fidelity, sometimes referred to as perceptual fidelity, refers to the level of psychological and physiological realism that is felt by those using the simulator (Rehmann et al., 1995).

There is a tradeoff that must be considered when deciding when to choose between low and high-fidelity simulation in training. There is a high cost to develop and operate high-fidelity simulators (Liu, Macchiarella, & Vincenzi, 2009; Rehmann et al., 1995). Simulation fidelity “has been determined to have a strong link to transfer of training” (Liu, Macchiarella, & Vincenzi, 2009, p. 61). However, depending on what skill is being taught or practiced, a high level of fidelity may not be required (Rehmann et al., 1995). The relationship between learning and fidelity is non-linear and depends on learner experience, and in some cases, lower fidelity simulation is better for learning to occur. High-fidelity simulators usually involve higher complexity scenarios that will increase learner workload, which can inhibit learning. Low-fidelity simulation can take advantage of already proven instruction techniques to make training effective (Alessi, 1998).

When conducting research in simulation devices, the researcher must select a simulation that will have enough fidelity to ensure that the appropriate variables can be measured. Also, the simulation must possess enough control to allow for experimental research to be conducted. Using a high-fidelity simulation is beneficial to ensure realism and will cause research participants using the simulation to display the same behavior as they would in the aircraft. High-fidelity simulation will provide accurate measurements in research and provide face validity in the experiment to outside researchers. However, using a simulation with a high level of fidelity may present a situation where unknown extraneous factors can affect participant behavior, which may interfere with the results of the research (Rehmann et al., 1995).

Transfer of learning. The transfer of learning is defined as the “ability to apply knowledge or procedures learned in one context to new contexts” (FAA, 2008, p. 2-36). If a learner can bring in previous knowledge to a situation or topic, the rate at which learning takes place will increase. The transfer of learning can be positive or negative. A positive transfer of learning is when previously learned knowledge helps in learning a new skill. A negative transfer of learning is when previously learned knowledge interferes and makes learning a new skill more difficult or affects the retention of new knowledge. For example, the predictiveness principle states that more attention is paid to cues that have led to an outcome based on past experiences. Another principle called the uncertainly principle, states that learners will not pay much attention to cues about which little is known (Griffiths, Johnson, & Mitchell, 2011). Instructors must anticipate the transfer of learning and be able to plan lessons using the principle of transfer of learning to their advantage (FAA, 2008).

As instructors use devices like ATDs, FTDs, and FFSs, it is important to be able to evaluate the transfer of learning of the student through a measure called the transfer of training effectiveness. There are two methods to measure transfer of training. The first, percent transfer, measures the amount of aircraft flight time which can be reduced by using a training device or simulator. Percent transfer does not take into account how much time or how many trials are needed in the training device to gain the savings of flight time. Another transfer of training measure is the transfer effectiveness ratio (TER). TER factors in time savings in the aircraft as a function of time or trials in the training device. An increase of training time in the training device will result in a higher percent of transfer but a lower TER. A variation on the TER called the incremental transfer of training effectiveness (ITER), is a measure that allows the effectiveness of the transfer of training to a specific flight maneuver. The ITER allows a more specific determination of which maneuvers of the training device are the most effective (Taylor et al., 1999).

The PCATD is the precursor to the FAA terms AATD and BATD. Based on the definitions of an AATD and BATD, a PCATD is comparable to a BATD. The study took 107 private pilots in training toward an instrument rating and divided them into a control group that was assigned to only fly the airplane during their training and half that used the PCATD to supplement their training. The flight training took place over the period of two semesters and included all aspects of training required to meet the FAA requirements for the instrument-airplane rating. Those students in the PCATD group were taught all the maneuvers and procedures prior to attempting it in the airplane. Students had to demonstrate proficiency before progressing to the airplane to perform the same maneuvers and procedures. Once in the airplane, both groups had to perform the maneuvers and procedures to the appropriate objectives and completion standards. The flight instructors conducting the training were also trained and calibrated experimenters who would grade the students' progress in each flight lesson and for each flight maneuver. The grades allowed researchers to calculate a percent transfer, a total TER, and an ITER for each maneuver (Taylor et al., 1999).

The results of the Taylor et al. (1999) study show that the values of percent transfer and TER changed significantly between maneuvers. The percent transfer ranged from 33.3% to -13.2%, while the TER ranged from 0.39 to -0.11. TER values also decreased as the instrument training progressed, meaning the PCATD was the most effective at introducing maneuvers rather than practicing the maneuvers later in the course. For example, the first time an Instrument Landing System (ILS) approach is introduced to a student early in the instrument course, the percent transfer is 33.3% and the TER is 0.28, which was the highest percent transfer and TER in the first part of the instrument course. Later in the flight course, close to the time for students to take the practical test, ILS approaches were reviewed, and the percent transfer was -11.9% and the TER was -0.11. When comparing total flight time between the two groups, the airplane only group spent 3.91 more hours in the aircraft during the duration of the entire flight course, and the results were statistically significant (Taylor et al., 1999).

Taylor et al. (1999) demonstrated that using a PCATD can positively transfer learning to the aircraft, with its most significant effects early on in training when maneuvers are first introduced to the students. Furthermore, students toward the end of the training did not benefit from PCATD lessons, as they were just reviewing the maneuvers and not learning any new material. One limitation was that the amount of PCATD time and the way it was introduced in the lessons may not have been the most efficient way of training. However, the results highlight that as students returned from a four-week break between college semesters, the first lesson completed at the beginning of the semester had a high percent transfer and a high TER. The high percent transfer and high TER indicated the potential for the PCATD to be helpful for refresher training (Taylor et al. 1999).

Scenario-based training. SBT is a type of problem-based learning (PBL) method. In PBL learning, a problem is constructed that is the basis for the rest of the learning experience. The learners will then recall previously learned information and apply it in new ways to the current scenario (Henley, 2003). SBT is ideal for teaching cognitive skills to the learners, including decision making and judgement. SBT should include real world scenarios and effort by the instructor to frame the scenarios in a manner that allows the learner to actively participate and make decisions as they would in the aircraft (FAA, 2008). In airline training, these types of scenarios are referred to as Line Oriented Flight Training (LOFT) (Barshi, 2015). These scenarios are designed to allow the learner to put the theories they have learned into practice (Meyers & Jones, 1993). SBT can challenge the learner's current way of thinking and allow them to:

1. Practice general or specific skills,
2. Develop problem solving skills,
3. Use synthesizing skills, and
4. Develop empathic skills (Meyers & Jones, 1993).

The FAA lays out some specific guidelines as to what makes good in-flight SBT. The scenario:

1. Should not be a test,
2. Will not have one correct answer,
3. Does not offer an obvious answer,
4. Should not promote errors, and
5. Should promote situational awareness and opportunities for decision-making (FAA, 2008, p. 4-17).

Examples of SBT in aviation. One example of a study using SBT examined the efficacy of using SBT to train pilots how to use an emergency whole-aircraft ballistic parachute. The participants were divided into two groups: one using the traditional lecture method with a computer-based training component and a second group using SBT. Participants who learned using the SBT method performed significantly better compared to those who did not learn via the SBT method (Blickensderfer, Strally, & Doherty, 2012).

One active learning approach used in aviation training is LOFT. LOFT training is primarily used in airline training and places an airline transport crew in a realistic flight SBT situation and then presents various issues or problems that the pilot must overcome. The scenarios help develop ADM skills and experience that pilots draw upon in the future (Barshi, 2015). In the GA setting, only practice or SBT with a certificated flight instructor who develops a scenario for a pilot would be similar to LOFT. The flight instructor must place the learner in a realistic scenario that would be common in the GA environment. The realism of the scenario allows the learner to rehearse and practice, both physically and mentally, what was taught, as many times as needed to reinforce the knowledge. Some of the drawbacks of LOFT type scenarios are the amount of time it takes to develop scenarios as well as having subject matter and technical experts that can build the scenario (Barshi, 2015).

Airlines use LOFT as a method of SBT training. After completing an online or classroom training course on the basic and advanced information on the aircraft and flight procedures and written knowledge testing, the learners will then participate in a series of simulations. These simulations are designed as full flights from departure point to arrival point, not just smaller situations. The simulations completed in a FFS are designed to increase in complexity as the training program continues. The easy-to-difficult planning method allows the learner to develop mental relationships between the previous ground training and the flight. Also, the simulator sessions give the learners time to actively practice the procedures and maneuvers as well as work on troubleshooting, problem solving, and decision-making skills. LOFT scenario-based training is also completed every six months by pilots flying in U.S. air carriers (Barshi, 2015).

Current methods of aviation computer-based simulation and instruction. Recently, the FAA made available the FAAST website and passive training methods to present information to pilots that meet the regulatory requirements for pilots to operate in Special Flight Rules Areas like the one located around Washington D.C. (FAAST, 2014). The ASI section of the AOPA website provides online courses, safety quizzes, safety videos, webinars, and more to provide free training and supplementary materials on a wide variety of topics to pilots (AOPA, 2016). Other improvements in computer technology have allowed the FAA to approve the use simulators and FTDs toward pilot and instructor certificates and ratings. An Aviation Training Device (ATD) is defined as a training device that is not an FFS or FTD but has a replica of the aircraft instruments, equipment, panels, and controls. It does not have to be a fully enclosed cockpit design but must have the proper hardware and software to represent the aircraft on the ground and in flight. There are two classifications of ATD: basic and advanced. While both devices can be used for pilot training and certification, the AATD is more representative of the specific aircraft types in terms of avionics displays, cockpit design that replicates the aircraft, and performance of the aircraft in terms of pitch, bank, and yaw. Manufacturers of ATDs must have the FAA approve their devices in accordance with FAA Advisory Circular (AC) 61-136A. Once approved, the device will receive a letter of authorization that will be valid for a period of five years (FAA, 2014a).

The FAA has determined that an ATD is an effective teaching tool that allows a flight instructor the ability to teach procedural skills and operational skills to a learner. The learner can then positively transfer these skills directly to the airplane (FAA, 2014a). In VFR flight training, ATDs can be used to learn procedural skills like slow flight, stalls, traffic pattern operations, and navigation as well as operations skills like emergency operations and flight by reference to flight instruments. In IFR operations, ATDs can be used to learn a multitude of skills and maneuvers including flight by reference to instruments, abnormal and emergency procedures, radio navigation procedures, instrument approach procedures, communication procedures, and cross-country procedures (FAA, 2014a).

FTDs and FFSs are governed and approved in a similar manner by the FAA through the current versions of Advisory Circulars: AC 120-45 for FTDs and AC 120-40 for FFSs (FAA, 1992; FAA, 1991). There are several levels of certified FTDs ranging from Level 1 to Level 6, each with their own fidelity requirements. A Level 6 FTD has the highest fidelity requirements (FAA, 1992). There are four levels of FFS ranging from A, B, C, and D, with D being the highest fidelity level (FAA, 1991). The types of maneuvers that are approved in each type of device or simulator can be found in the appendix of the FAA's PTS or ACS for each specific pilot or instructor rating or certificate (FAA, 2016b).

PCATDs, FTDs, and instrument currency. A study sponsored by the FAA was conducted to determine the effectiveness of using PCATDs and FTDs toward instrument pilot currency requirements. The study took 106 instrument rated pilots from the central Illinois area with ages ranging from 22 to 76 and flight experience ranging from 150 to 24,000 hours. At the time the study began, they were all instrument current, as required by 14 CFR 61.57. Each pilot was asked to perform an IPC as a baseline measurement of pilot performance. Then the pilots were divided into four groups: the control, PCATD, FTD, and airplane group. To ensure that no flight or PCATD experience would interfere, all the pilots agreed to refrain from non-study related instrument flight for six months. During the six-month period, the pilots received 1.8 hours of flight experience in the device they were assigned to practice instrument maneuvers, with the control group receiving zero experience. After six months, the pilots in all four groups were asked to complete an IPC in an aircraft to evaluate their skills. Pilot performance was measured by a flight instructor observing the activity as well as a flight data recorder (FDR) installed in the aircraft (Taylor et al., 2003).

The results of the Taylor et al. (2003) study show that 42% of the pilots were able to pass the initial IPC baseline check. The low percentage of pilots who passed the IPC baseline check highlights the fact that before the study began, pilot currency did not necessarily equate to pilot proficiency. At the end of the six-month period, the overall pass rate on the final IPC check increased to 52%. The best improvement was seen in the FTD group where the pass rate increased from 48% to 70% and the PCATD group where the pass rate improved from 41% to 59%. FDR data was able to measure the change in skill improvement and deterioration by group. Table 1 shows the skill improvement and deterioration over the six-month period of the study. The groups with the largest improvement were the FTD and the PCATD group, and the control group which did not have any practice over the six-month period, had the largest skill deterioration (Taylor et al. 2003).

Table 1

Skill Improvement and Deterioration over a Six-month Period

Group	Improvement %	Deterioration %
Aircraft	33.3%	36.4%
FTD	57.1%	15.4%
PCATD	37.5%	9.1%
Control	12.5%	40.0%

(Data from Taylor et al., 2003)

The results highlight the benefit of practice in maintaining instrument proficiency. Additionally, evidence was provided showing that PCATDs and FTDs have a benefit in maintaining proficiency, and the use of these kinds of devices are helpful for pilots to use for practice. Taylor et al. (2003) also pointed out the possibility of requiring specific kinds of approaches to maintain instrument currency as a way to help guide pilots to be more proficient in a variety of approaches. One limitation that may have affected the results was the pilots not being familiar with the specific type of aircraft used in the study (Taylor et al., 2003).

McDermott (2005) conducted a study that compared pilot proficiency between the use of a PCATD and a FTD at flying an ILS approach. The study took 63 pilots of various background and experience levels and divided them into two groups, a FTD group and a PCATD group. Each group would conduct four 20-minute practice activities in the device and then a final test to assess proficiency. The FTD group did all their practice and the final test in the FTD, while the PCATD did all practice in the PCATD, but the final test was in the FTD (McDermott, 2005).

McDermott (2005) showed that there was no significant difference in performance between the FTD and PCATD groups. Both a FTD and PCATD were equally effective at maintaining pilot proficiency on an ILS approach. Additionally, the data revealed that one device, FTD or PCATD, was not better than the other in terms of pilot proficiency. McDermott also recommends further research in exploring what other areas that PC-based, low-cost flight simulation technology and home-based flight simulation can benefit GA pilots by increasing their safety and pilot proficiency skills (2005).

Perceived effectiveness of PCATDs on instrument flight training. Beckman (2003) conducted a study to measure the perceived effectiveness of a PCATD on instrument flight training. Beckman aimed to specifically measure the students and flight instructors in a college setting and found the PCATD to be useful in their instrument training. Fifty-seven students and 12 flight instructors participated in the study. Participants were given a Likert scale survey after they had completed their instrument flight course. In addition to student’s opinions on the PCATD, they were also asked if their instructors assigned them extra homework assignments on the PCATD. Both students and flight instructors rated the PCATDs effective at introducing a new skill. Other lessons where skills were practiced were still considered effective but scored lower than when that skill was brand new to the learner (Beckman, 2003).

One other point made was that limitations in the PCATD not simulating accurately to the aircraft were rated as ineffective by both the learners and the instructors. Finally, learners and instructors both felt that homework, meaning PCATD time flown outside of the regular instrument flight course, was both a beneficial and effective practice. Of the students surveyed, 67% of the students practiced on their own without being assigned homework from the instructor. The high percentage of learners practicing on their own provides an indication that pilots are self-motivated and that practicing on their own will benefit the learners during their aviation training (Beckman, 2003).

Advantages and disadvantages of computer-based instruction. As computer-based learning systems and instruction become more popular and proven learning tools, there are some advantages and disadvantages that need to be considered. The primary advantage of a computer-based learning system is the flexible delivery that is afforded where the learner can choose when and where to take the training as well as choose an option that best fits their own learning styles. Also, the flexibility allows the option to build an individual learning program that will be designed to fit specifically to what new knowledge the learner needs to acquire. Since the training is on a computer, it is very easy for the computer to be reset, and the learner can conduct the training another time for more practice or to correct mistakes when done the first time. The ability to easily reset the computer reduces the demand on the instructor and the equipment needed to conduct the training, which can result in cost savings (Henley, 2003).

One disadvantage to a computer-based learning system is the expense required to design and operate the system. One example of the vast expense of designing a computer-learning system is the SimuFlite Training company. The SimuFlite company provided advanced training to pilots on a variety of aircraft. Millions of dollars were spent to develop training material, and an additional staff of over 40 people was needed to continue to improve course material for their training curricula (Bovier, 1993). A complex and adaptive training environment will require time to develop and program before it can be implemented (Wiggins as cited in Henley, 2003). While there can be some variability, on average, one hour of computer-based training can take between 118 and 365 hours to develop. The more interactivity within a CBT course, the more hours will be needed to develop it. When developing simulations, the time to develop one hour of training ranges from 949 and 1,743 hours to develop (Kapp & Defelice, 2009). Kapp and Defelice (2009) note that clear communication and orientation for those involved in developing the training can reduce those time estimates.

The cost of initial development of a CBT course is much higher than the cost of a regular face-to-face teaching lesson development, and additional costs will occur in operating and maintaining the system. Another disadvantage is that some learners will not perform well without face-to-face or direct contact with an instructor. Some learners may have a preconceived notion about how training was given to them in the past. It will be important for the instructor who created the training to develop some sort of preparatory material to inform the learners as to how the training will be different. The creation of preparatory material can impose an additional cost to the training, but research has shown that it will be beneficial in the long-term (Henley, 2003).

In aviation, the use of simulations with flight scenarios can pose a difficulty to instructors to assure that all possible outcomes are covered. Learners could attempt to use a wide range of actions, some of which may be incorrect given the situation, but those actions may still lead to a positive flight outcome. While the variety of options in a scenario may be considered a disadvantage to instructors, the learner can test different options and actively see what outcomes will occur. Active practice will make for a more powerful training experience for the learner that can help improve decision-making and problem-solving skills (Wiggins as cited in Henley, 2003).

These factors should be considered in determining the feasibility and effectiveness of developing a computer-based learning system for training. Proper planning must be used to ensure that the system remains cost-effective as well as effective in its main goal of knowledge acquisition and retention in learners. When done properly, computer-based learning systems can be an effective way to individualize a meaningful learning experience to a learner (Wiggins as cited in Henley, 2003).

Lockheed Martin Prepar3D. There are many flight simulation software programs available for personal computer usage. One such program created by Lockheed Martin is P3D. P3D flight simulation software was developed based on the original Microsoft Flight Simulator X software source code. P3D's purpose is to provide a platform for training for both civilian and military customers. The first version of P3D was released in November of 2010, and P3D continues to be under active development, with the most recent software update being released in 2016. P3D features realistic aircraft models and cockpit replications as well as high fidelity weather and airport layouts. There is also built-in, automated ATC communications and other vehicles to add to the realism (Lockheed Martin, 2016).

One of the features built into P3D is a scenario development tool called SimDirector. SimDirector allows an instructor to develop a scenario-based lesson within P3D. The scenario will include a series of trigger events that will allow the student to have a more immersive and realistic training experience. The instructor builds a scenario computer file and gives the file to a student to practice on their own personal computer or in a computer lab environment. The student is allowed to complete the lessons asynchronously or as a homework assignment and receive feedback from the scenario itself or from an instructor at a later time (Lockheed Martin, 2016).

P3D was chosen to be the software program for this research project for three reasons. First, it provides the ability to allow a realistic in-flight scenario to be built, developed, and run on a desktop based personal computer. Second, the researcher has familiarity with the software prior to this study. Lastly, Lockheed Martin and Embry-Riddle Aeronautical University have developed a close working relationship, having used P3D software in a prior study (Ortiz, 2016).

Measuring Training Effectiveness

Kirkpatrick's four-level training evaluation model. Kirkpatrick (2006) developed a four-level training evaluation model in 1959 and has updated the model most recently in 2006. Kirkpatrick's model works as a framework of measuring training effectiveness by looking at four levels:

1. Reactions
2. Learning
3. Behavior
4. Results

The reaction level looks at how the learners reacted to the training. It is important that the learner enjoyed the training and felt that it was a valuable experience. Also, having a positive view of the training delivery and technology is key. Comments from learners can help developers amend the training to be even more enjoyable in future versions of a course (Kirkpatrick, 2006).

At the learning level, the direct knowledge increase is measured in the learners. Measuring the knowledge increase should be done by creating an assessment tool that uses the learning objective or goals of the course to test learning knowledge gain. It is also recommended to measure the learner's knowledge both before and after the training to get a clear indication of the knowledge gained (Kirkpatrick, 2006).

A change in the learner's behavior indicates how the learners will apply the information learned. To measure a behavioral change, one must observe the learner in their own environment, and the learner must be willing to demonstrate the knowledge that was learned. Both the opportunity to demonstrate the learned information and the willingness to do so must be present to measure learning at the behavioral level. Observation can be conducted by watching someone who participated in the training teach the knowledge learned from that course to another individual. Typically, behavior measurement is something that must take place over a longer period (Kirkpatrick, 2006).

The fourth and final part of the Kirkpatrick model requires a look at the final results of the training. The overall benefit to the organization will highlight the effectiveness of the training. Some of the outcomes that can be measured are increased employee retention, increased production, higher morale, reduced waste, increased sales, improved knowledge, higher quality ratings, increased customer satisfaction, and fewer staff complaints (Kirkpatrick, 2006).

The third and fourth levels of the Kirkpatrick model are the most expensive and time-consuming to measure. However, measuring at the third and fourth levels will provide the most useful information on the total impact the training has on the organization or learner. The model also implies that each level's importance is greater than the previous level. It should be noted that some changes in knowledge or behavior can come from factors other than the training that was provided to the learner, and care should be taken to recognize when that occurs (Kirkpatrick, 2006).

Kraiger, Ford, and Salas' method of training evaluation. Kraiger, Ford, and Salas' (1993) method of training evaluation focuses on three different types of outcomes: cognitive outcomes, skill-based outcomes, and affective outcomes.

Cognitive outcomes consist of verbal knowledge, knowledge organization, and cognitive strategies. Verbal knowledge is defined as declarative knowledge, procedural knowledge, or strategic or tacit knowledge. Verbal knowledge can be assessed through basic testing using multiple choice, true-false, or free recall exams. However, the intelligence level of the individual can cause inaccurate scores. Testing can take two forms, a speed test where learners answer a certain number of questions in a given time or a power test where there is no time limit to answer test questions. The speed test will measure learners rate at which they access knowledge. The power test will measure the accuracy of the stored information. Testing learners before training occurs will give scores that will have the best use for predicting learner performance (Kraiger, Ford, & Salas, 1993).

Knowledge organization describes how learners develop procedural knowledge and how that knowledge is organized in the learner's mind. The learner uses the knowledge organization process to form mental models or cognitive maps. Experts will be able to access mental maps quicker than a novice. Experts have a stronger mental model that has a better hierarchical organization. Testing mental models can involve a learner physically creating a mental model on paper and having that mental model be compared to a model created by an expert. A mathematical comparison or a structural assessment where models are scored numerically can also be done to compare scores between learners' and experts' mental models (Kraiger, Ford, & Salas, 1993).

The final cognitive outcome measure is based on the creation and use of cognitive strategies. As a learner gains more experience, they can internalize complex behaviors and leave more cognitive resources available for other tasks. Measuring the usage of cognitive strategies would give an evaluation measure of an entire learning program or curriculum. Additionally, learners possessing self-regulation who can detect when they have made an error are showing signs of developing good cognitive strategies. Testing learners compared to experts in tasks like estimating the difficulty of new problems or how many trials it will take to complete a task as well as asking more detailed questions as to why certain actions will occur, are ways to measure cognitive strategies (Kraiger, Ford, & Salas, 1993).

Skill-based outcomes focus on the development of technical or motor skills (Kraiger, Ford, & Salas, 1993). A learner that learns a new skill will progress through three steps: initial skill acquisition, skill compilation, and skill automaticity (Anderson, 1982 as cited in Kraiger, Ford, & Salas, 1993). The initial skill acquisition takes the learner from declarative knowledge to procedural knowledge. During skill compilation, the learner will practice the skill, making fewer errors each trial and becoming faster at completing tasks. With continued practice, the learner can develop skill automaticity where the task can be completed quickly while the learner can perform other tasks at the same time. Skill-based outcomes can be evaluated by observing the learner in a simulated or actual environment completing a learned task. Measures such as time to complete a task and a count of the number of errors that occur during a trial will give numerical data for comparisons (Kraiger, Ford, & Salas, 1993).

Lastly, Kraiger, Ford, & Salas (1993) describe affective outcomes as internal attitudes or motivations that can determine behavior or performance. A learner's attitudes can be changed through different experiences such as a training course or real-world situations. "Once the learning objective is specified as the attitude object, measures of attitude strength can be useful for inferring learning during training" (Kraiger, Ford, & Salas, 1993, p. 319). Measuring the changes in attitude strength, or self-efficacy, before and after training indicate a change in one's attitudes on a subject and show whether learning or skill development has occurred. Furthermore, training on a topic that causes a change in attitude will cause learners to pay closer attention to that topic and use the skills learned in the future. Some training courses will list enhanced self-efficacy as an objective of training (Kraiger, Ford, & Salas, 1993).

Summary

Learning is a change of behavior as a result of different experiences. There are many ways to deliver training, both passive and active, but active learning through SBT is the most effective way to allow learners to develop decision-making and problem-solving skills. Having a high amount of self-efficacy of topic or on a task is a predictor of positive performance in that topic or task. A learning objective of any training should be that the training produces an increase in the learner's self-efficacy. Research has already shown that FTD and simulation can positively transfer training into the aircraft and that personal computer-based simulation has a positive transfer in terms of flight maneuvers as effective as an FTD. This research tested how well three different levels of active learning impacted the knowledge gain and self-efficacy gain of instrument rated pilots who are not instrument current.

CHAPTER III

METHODOLOGY

The methodology used in this research project was based on a study conducted as a joint project between ERAU and Lockheed Martin to build and test training lessons using the P3D software. The Ortiz et al. (2016) pilot study was completed in late 2015 and early 2016 at the ERAU Daytona Beach Campus. The pilot study aimed to measure the effectiveness of new features in the P3D software to present a lesson to a student pilot with no previous knowledge of instrument flight using SBT delivery on a personal computer. A population of ERAU student or private pilots that did not hold an FAA pilot certificate with an instrument rating was chosen to test the effect of presenting new knowledge to college students using the P3D software compared with the presentation of the same material in a classroom lecture setting. The knowledge tests and questionnaires that were used in this study were based on the training scenarios and data collection devices that were developed in the Ortiz et al. (2016) study but targeted a different population of GA pilots.

Research Approach

The experiment used a quantitative study design. All participants watched a computer-based training activity in the form of a narrated instructional video slideshow and were divided into three groups to complete a second training activity. One group received a passive training module, and the remaining two groups received an active training module, each with a different level of cognitive involvement and therefore a different level of active learning. All three groups were designed to replicate different methods pilots can use to review material relating to instrument knowledge and missed approaches on their own time without access to an aircraft. The first group read material relevant to instrument approaches, the second group flew instrument approaches on a desktop computer flight simulator, and the third group flew instrument approach scenarios where decisions must be made during the scenario. The first group was referred to as the Read group, the second group was referred to as the Fly Only group, and the third group was referred to as the Fly and Decide group. Participants were randomly assigned to one of the three groups.

Design and procedures. The design was a 3 x 2 mixed design with three between subject groups (one passive learning module and two different types of active learning modules) and two within-subject levels of progression (pretest vs. posttest). The lesson consisted of two training activities. By providing all three groups two training activities, participants received an equal number of training activities to learn the material presented. All three experimental groups received the same computer-based training activity first. The second training activity differed between the three groups.

Upon arrival at the experimental site, participants were greeted and completed the following. First, participants were provided with two copies of the Informed Consent Form, one to review and keep, and one to sign and be kept by the researcher. Second, the participants filled out a demographic questionnaire, a pre-training self-efficacy questionnaire, and a pre-training knowledge test. Then the participants of all three groups completed the first training activity. Following the completion of the first training activity, the second training activity occured. Following the second training activity, the participants completed a reaction questionnaire, a post-training self-efficacy questionnaire, and a post-training knowledge test. Each participant took approximately 2 to 2 1/2 hours to complete the entire training and testing, and time per activity was as shown in Table 2. Participants could take optional breaks as needed throughout the experiment.

Table 2

Approximate Experiment Timeline

Activity	Time
Informed Consent Form	5 minutes
Demographic Questionnaire	5 minutes
Pre-training Self-Efficacy Questionnaire	5 minutes
Pre-training Knowledge Test	30 minutes
First Training Activity	20 minutes
Optional Break	5 minutes
Second Training Activity	30-40 minutes
Read group – Passive Training Module	
Fly Only group– P3D Training Module flying approaches	
Fly and Decide group - P3D Training Module flying approaches and making decisions	
Optional Break	5 minutes
Reaction Questionnaire	5 minutes
Post-training Self-Efficacy Questionnaire	5 minutes
Post-training Knowledge Test	30 minutes
Total Time	135 – 150 minutes

Apparatus and materials. The research design relied on the usage of a windows-based personal computer with an internet connection. The demographic questionnaires (Appendix B), pre-training and post-training self-efficacy questionnaires (Appendix C), pre-training knowledge test (Appendix D), post-training knowledge tests (Appendix E), and reaction and motivation questionnaire (Appendix F) were administered electronically. The training lessons were delivered via a personal computer that had an Internet browser, Internet connection, and P3D flight simulation software installed. The computer had a 23-inch Dell monitor and a commercial off the shelf yoke, throttle quadrant, and rudder pedal system manufactured by Saitek that mimicked the basic controls of a small GA airplane, specifically a Cessna 172S as shown in Figure 2 (Saitek, n. d.).

Figure 2. P3D participant desktop test-bed.

First training activity. The first training activity was a computer-based self-paced lesson presented in both an audio and visual format via a web browser. The lesson was created by an FAA certificated flight instructor using FAA publications as source material to ensure accuracy of the lesson. The training was a narrated, slide based presentation completed at the learner's own pace that took between 15 and 20 minutes. The topics covered in the lesson were:

- Identifying minimum altitudes on an instrument approach chart
- Approach categories and speeds
- Descent rates

- Visual descent points
- 14 CFR 91.175, specifically landing from an Instrument Approach Procedure
- Required visibility on approaches
- Components of the landing environment
- Fuel consumption considerations
- Selecting an instrument approach based on current weather conditions
- A guided example using instrument approach charts and weather reports

Second training activity. Each group received a second training activity to ensure an equal number of training activities among the experimental groups. The Read group's second training activity was a passive learning activity. The passive learning activity consisted of participants reading a selection of material from FAA publications that were the source material for the creation of the first training activity. The reading material included passages from 14 CFR 91.175, the FAA's Instrument Flying Handbook, and the FAA's Instrument Procedures Handbook all relating to instrument approaches and missed approaches. Reading these FAA publications simulated a passive method of review a pilot can complete to review instrument flying related topics.

The Fly Only group's second training activity was an active training lesson that involved the use of the personal computer desktop flight simulation software, P3D. The Fly Only group hand-flew a series of four instrument approaches at four different airports.

Each of the four instrument approach scenarios followed these steps:

1. The participant received an instrument approach chart and the current weather conditions at the airport.

2. In the simulation, the aircraft was placed 5 miles away from the final approach fix; all avionics were preset for the approach and paused until the participant was ready to begin flying.
3. The participant flew the approach without the use of autopilot and when reaching the missed approach point, and if participant determined if the landing could be made, the simulation continued, and the participant was able to land on the runway. If the weather did not allow a legal landing in accordance with 14 CFR 91.175, the participant began the missed approach procedure, and then the simulation ended.
4. The participants then began the next approach, and the process repeated until all four scenarios are completed.

If at any time the participant failed to maintain Instrument Rating-Airplane ACS standards during the approach, the simulation paused and prompted the participant to restart the approach. Due to time constraints, the participant was only allowed one chance to restart the approach. If the participant failed to maintain Instrument Rating-Airplane ACS standards during the second chance at the approach, they were instructed to move on to the next scenario.

The Fly and Decide group's second training activity was a SBT active training lesson that involved the use of the personal computer desktop flight simulation software, P3D. The Fly and Decide group flew instrument approaches where the participants were able to put into practice what was taught during the first training lesson. This group was considered the highest level of active learning of the two active learning training types because of the higher cognitive involvement.

Participants hand-flew a series of four instrument approach scenarios, each at a different airport, which included ATC clearances and radio communications, weather information, prompts to answer questions about the approaches, and feedback at the end of the scenario based on the choices made by the participants.

Each of the four instrument approach scenarios followed these steps:

1. The participant received an instrument approach chart and the current weather conditions at the airport.
2. In the simulation, the aircraft was placed five miles away from the final approach fix; all avionics were preset for the approach and paused until the participant is ready to begin flying.
3. The participant flew the approach without the use of autopilot and upon reaching the missed approach point was prompted to answer two questions. The first question asked the participants if the aircraft could have legally landed on the runway, having both the required visibility and the landing environment in sight.
4. If the runway was in sight (Figure 3) and the participant deemed the landing could be made, the simulation continued, and the participant was able to land on the runway. If the weather did not allow a legal landing in accordance with 14 CFR 91.175, the participant was then presented a second question.
5. The second question presented weather at three possible alternate airports located nearby with one specific instrument approach available for each airport. The participants were asked to use the weather information and approach chart to select an airport that would give the best chance of

allowing a legal landing. Of these choices, only one airport had weather conditions that would allow a landing based on the minimum altitudes of the instrument approaches (Figure 4).

6. Feedback was given on-screen to the participant as to why their choices were correct or incorrect.
7. After the feedback is given, the participants began the next scenario, and the process repeated until all four scenarios were completed.

Over the course of four instrument approaches, the participants were able to land once from the original instrument approach and selected an alternative airport three times. If at any time the participant failed to maintain Instrument Rating-Airplane ACS standards during the approach, the simulation paused and prompted the participant to restart the approach. Due to time constraints, each participant was only allowed one chance to restart each of the scenarios. If the participant failed to maintain Instrument Rating-Airplane ACS standards during the second attempt at the approach, they were instructed to move on to the next scenario.

Figure 3. Screenshot of the P3D training module showing the pilot approaching the runway with fog and low clouds reducing visibility. The runway and approach lights are visible near the center of the image.

Scenario Menu

Select the correct alternate airport:

1 - [KTSP 071535Z AUTO 11018G23KT 5SM BR OVC004 18/17 A2994]
2 - [KDNV 071535Z AUTO 09014G18KT 7SM -RA SCT004 OVC012 23/22 A2989]
3 - [KBMI 071541Z 05016KT 1 1/2SM -RA BR OVC007 17/17 A2998]
4 - [KAAA 071555Z AUTO 01013G18KT 1/2SM BR BKN009 BKN017 OVC027 19/18 A2997]
5 - [Select to review the weather of each airport again.]

Figure 4. Screenshot of P3D training module pop-up window displayed after performing a missed approach asking the participant to select a new airport based on weather conditions.

Population/Sample

The population for the study was all FAA certificated pilots that held an instrument-airplane rating that were not instrument current as defined by 14 CFR 61.57(c). FAA certificated pilots that held an instrument-airplane rating that were not instrument current as defined by 14 CFR 61.57(c) and responded to a request for participants to complete the study comprised the sample. A power analysis was completed using the statistical software G*Power. Through this software, using an effect size of 0.3 and a confidence interval of 0.95, it was determined that the minimum sample size needed was 48 pilots with 16 participants in each of the three experimental groups (Faul, Erdfelder, Buchner, & Lang, 2009; Morris, 2007).

Advertisements for participants took place across central Florida and Illinois at the following airports: in Florida at Daytona Beach, Ormond Beach, Flagler, New Smyrna Beach, St. Augustine, Palatka, Spruce Creek, and Sanford; and in Illinois at Carbondale, Marion, Mattoon-Charleston, Champaign, Lewis-Romeoville, Kankakee, Lansing, Chicago Executive, and Rockford. Additionally, advertisements were made at Embry-Riddle Aeronautical University and other flight training schools around the Daytona Beach Metro Area including Phoenix East Aviation, Sunrise Aviation, Air America, and Epic Aviation. Upon initial contact, each participant was asked to verify that they were a certificated pilot that held an instrument rating and are not instrument current as defined by 14 CFR 61.57(c). Demographic information about the participants allowed a stratified random sampling method to obtain pilots from various backgrounds to attempt to achieve a sample that represented the entire GA population of certificated pilots that hold an instrument rating and are not instrument current as defined by 14 CFR

61.57(c). Microsoft Excel was used to create a random number list to assign participants into one of the three experimental groups. Before the participant began the study, he or she was issued a number between 1 and 60. Participants with numbers 1 through 20 were assigned to the Read group, numbers 21 through 40 were assigned to the Fly Only group, and numbers 41 through 60 were assigned to the Fly and Decide group. The stratified random sampling method ensured that each experimental group would not have more than 50% of that group's participant pilots from Embry-Riddle. If a participant was a pilot at Embry-Riddle Aeronautical University, and the group to which they were assigned already reached the 50% threshold, a new random number was assigned to the participant and he or she was placed in a different experimental group.

Potential threats to internal validity. Several factors posed a threat to internal validity and each was addressed to limit any effect on internal validity for this study. To safeguard against selection bias, the stratified random sampling method ensured that each experimental group would not have more than 50% of that group's participant pilots from Embry-Riddle Aeronautical University. The study relied on using knowledge test scores as one of the dependent variables. While taking tests can influence participant's behavior, every attempt was made to make the participants feel at ease and allow participants to take breaks when needed. The knowledge tests were different but parallel to one another, verified by SMEs to ensure that the tests cover the same content and are of the same level of difficulty. Furthermore, to limit any diffusion that may occur, participants were asked not to reveal any information about the research to other potential participants. While the Read and Fly Only groups did not participate in the full SBT scenarios, the participants were still presented with all relevant knowledge information.

This guaranteed that each participant received the same value of training from the experiment. Finally, compensatory rivalry was not an issue as the participants were not competing against each other's scores in this research. The researcher personally conducted all trials in this experiment, therefore, removing any potential confounding variables that could occur from having multiple researchers and ensuring standardization during the training and testing process.

Sources of the Data

The data was collected from four data collection devices:

1. Demographic questionnaire
2. Self-efficacy questionnaires
3. Knowledge tests
4. Training reaction and motivation survey

The data was collected from the participants two times during the study, before training and after training. The demographic questionnaire was completed before the first training activity. The training reaction and motivation survey was completed after the second training activity. The self-efficacy questionnaire and knowledge test was completed before the first training activity and after the second training activity.

Data Collection Devices

All the data collection devices used in this study, found in Appendices B through F, were surveys and knowledge tests based on data collection devices that have been used in the previous Ortiz et al. (2016) study. The surveys and knowledge test were edited for minor grammatical and formatting changes, but the content remained the same. The demographic questionnaire used in this study (Appendix B) included questions about the participants' information, such as their age, what pilot certificates and ratings they held, and under which regulations they received their flight training. Participants were also asked to provide details about their flight experience and training, specifically, total flight hours, years of flight experience, region of the U.S. where most of their flight experience occurred, total flight time in actual or simulated conditions, number of instrument approaches conducted, and number of instrument approaches where weather conditions required a missed approach to be flown. The self-efficacy questionnaire (Appendix C) asked the participants to rate their confidence level on a variety of statements on a scale of 0 to 100, with 0 being not confident and 100 being most confident. The statements pertained to the topic of instrument approaches, missed approaches, and interpreting weather information. The 17 statements were:

1. Skill at interpreting weather information (METAR)
2. Knowledge of how to perform a missed approach
3. Skill to successfully perform a missed approach
4. Interpreting approach plate information
5. Knowledge of how to perform a precision instrument approach
6. Skill to successfully perform a precision instrument approach
7. Knowledge of how to perform a non-precision instrument approach
8. Skill to successfully perform a non-precision instrument approach
9. Knowledge of visual decent points
10. Skill at calculating descent rates
11. Knowledge of landing requirements from an instrument approach under IFR
12. Knowledge of flight visibility and runway visual range definitions

13. Knowledge of approach categories on instrument approach procedure
14. Skill of selecting the correct minimums for an instrument approach
15. Knowledge of how to choose an instrument approach based on current weather conditions
16. Skill of choosing an instrument approach based on current weather conditions
17. Skill at selecting an airport based on current weather conditions

The pre-training knowledge test (Appendix D) and post-training knowledge test (Appendix E) posed questions on instrument knowledge relevant to IFR operations and missed approach procedures. Two versions of a 30-question pre-training and post-training knowledge test were used to allow comparison both within and between the three experimental groups. The pre-training and post-training knowledge tests were parallel versions of each other where each question in the pre-training knowledge test had a matching question in the post-training knowledge test that measured the same knowledge but written in a way that asked the question in a different way. Finally, the reaction and motivation survey (Appendix F) asked a series of questions using a 7-point Likert scale that asked participants to rate their reaction to the training and their motivation level during the training. The reaction questions were:

1. The overall quality of this training course.
2. The relevance to instrument flight.
3. The quality of the course materials.
4. The course materials were clear.
5. The amount of knowledge you gained from this course.
6. The course increased my knowledge to perform a missed approach.

The motivation questions were:

1. I tried my hardest to learn.
2. I did my best.
3. I paid full attention to the lesson.
4. I wanted to learn during this lesson.
5. I took this lesson seriously.

Instrument reliability. The Ortiz et al. (2016) study gave the various data collection devices to each of the 35 participants. Cronbach's alpha was calculated to determine the data collection device's reliability, where a value above 0.7 was considered to be reliable. The Cronbach's alpha scores were as follows: the knowledge test was 0.7, the self-efficacy survey was 0.95, the reaction survey was 0.73, and the motivation level was 0.8.

Instrument validity. The pre-training and post-training knowledge tests and self-efficacy survey were created in the Ortiz et al. (2016) study with the assistance of two subject matter experts (SMEs) that were current FAA certificated flight instructors that held a Flight Instructor Instrument rating. A different flight instructor SME reviewed all the data collection devices for content validity and face validity. Three additional questions were added to each knowledge test to compliment the original Ortiz et al. questions. These questions were aimed at measuring the sensitivity of the increased skill from the SBT lesson. The new questions were verified by two different flight instructor SMEs to ensure content and face validity.

Ethical considerations.

The experimental design involved human participants and therefore ethical considerations in terms of participant consent, harm, and privacy. An application to conduct research with human subjects was submitted and approved by the Institutional Review Board (IRB) at Embry-Riddle Aeronautical University (Appendix A). All participant participation in the research was voluntary. Participants were provided with an informed consent form that detailed the research purpose and design as to allow them to make a decision to participate in the research with informed consent.

The risk to the participants was comparable to a typical two-hour computer-based lesson or test which included slight levels of mental and cognitive stress as well as fatigue similar to that of using a desktop computer while seated at a desk. All participant information was kept confidential, and participant names, or any other identifying demographics, could not be matched. This confidentiality ensured that the participants were protected, and every effort was made to make them feel they could answer any questions truthfully.

Treatment of the Data

Demographic data and descriptive statistics. A demographic survey adapted from the Ortiz et al. (2016) study was used to capture demographic information from the three participant groups. Mean scores and standard deviations were calculated for the reaction and motivation survey. The results of these descriptive statistics were reported in Chapter IV.

Reliability testing. To determine reliability, a split-half reliability calculation with Cronbach’s alpha was calculated on the results of the pre-training knowledge test, the post-training knowledge tests, the pre-training self-efficacy questionnaire, the post-training self-efficacy questionnaire, the reaction survey, and the motivation survey. This divided the participant groups in half and compare them to each other. If needed, test questions were removed from the statistical analysis to ensure that a Cronbach's alpha was greater than or equal to .7.

Hypothesis testing. SPSS statistics software was used to conduct a two-way mixed ANOVA between the three experimental groups knowledge tests and self-efficacy scores. The ANOVA compared the means within and amongst the three participant groups in terms of the pre-training and post-training knowledge test scores and self-efficacy questionnaire. The knowledge test score consisted of a value between 0 and 30 where the total score was the number of questions answered correctly. The self-efficacy questionnaire score was a summated score of 17 statements, each rated on a scale of 0 to 100, with a score of 1700 being the maximum possible score. The analysis was used to determine instances where a confidence level of 95% ($p < 0.05$) exists. In this case, if the training increased knowledge scores and self-efficacy level and if the more active learning training type had a higher increase than the other less active learning types. Then a one-way ANOVA for participant motivation and reaction was used to determine instances where a confidence level of 95% ($p < 0.05$) exists. Specifically, if the groups receiving a more active learning had a more positive reaction to the training than the less active learning groups.

Summary

The study used a 3 x 2 design with three participants' groups with different types of training where a pre-test/post-test method was used to measure the effectiveness of three different types of training modules. The Read group received a passive training module, and the Fly Only and Fly and Decide groups received two different versions of an active training module with different levels of cognitive involvement. Knowledge tests and self-efficacy questionnaires were given to the participants both before and after the training modules. A two-way ANOVA was used to determine the effectiveness of the training both between groups and within groups. Additionally, an analysis was conducted to determine if a correlation exists between pilot knowledge and self-efficacy.

CHAPTER IV

RESULTS

Experimental data were collected over a three-month period from general aviation pilots who possessed an instrument rating on their pilot certificate and were not instrument current in accordance with 14 CFR 61.57. Advertisements for participants took place across central Florida and Illinois at the following airports: in Florida at Daytona Beach, Ormond Beach, Flagler, New Smyrna Beach, St. Augustine, Palatka, Spruce Creek, and Sanford; and in Illinois at Carbondale, Marion, Mattoon-Charleston, Champaign, Lewis-Romeoville, Kankakee, Lansing, Chicago Executive, and Rockford. Additionally, advertisements were made at Embry-Riddle Aeronautical University and other flight training schools around the Daytona Beach Metro Area including Phoenix East Aviation, Sunrise Aviation, Air America, and Epic Aviation. The solicitation process resulted in the recruitment of 62 participants. The participants demographic and flight experience information were used to implement a stratified random sampling method to ensure that participant age, certificate type, and flight hours were as consistent as possible among the three participant groups. The three groups were named Read, Fly Only, and Fly and Decide to coincide with the different training methods given to the participants. As described in Chapter III, the Read group received a passive training module, and the Fly Only and Fly and Decide groups received two different versions of an active training module with different levels of cognitive involvement. The Fly and Decide group was considered to receive the highest level of active learning training.

Two of the 62 participants held an ATP pilot certificate and had greater than 12,000 flight hours, with a majority of that flight time as Part 121 Air Carrier operations.

After initial data analysis, the data from these two participants were classified as outliers as they did not represent the general aviation pilot population and were removed from the dataset prior to further data analyses. This resulted in the analysis of data from 60 participants divided evenly into three groups of 20 participants.

Demographic Information

The demographic survey (Appendix B) was used to collect demographic data and to ensure that the participants met the requirements of the study. The sample consisted of 60 instrument rated pilots that were not instrument current, of which, 55 were male and 5 female, 19 (31.7%) held a private pilot certificate, 41 (68.3%) held a commercial pilot certificate, and 31 of the commercial pilots (51.7% of the total sample of 60 participants) also held a flight instructor certificate. The demographic breakdown of participants age and pilot certificate type by experimental group is shown in Table 3.

Table 3

Age and Pilot Certificate Type for Participants by Experimental Group

	Age		Pilot Certificate Type	
Group	Mean	SD	Private	Commercial
Read	34.40	16.089	6	14
Fly Only	38.65	22.302	7	13
Fly and Decide	36.35	18.602	6	14
Total	36.47	18.922	19	41

The participants ages ranged from 19 to 83, with an average age of 36.47 (SD = 18.922). The breakdown of the ages of all 60 participants is shown in Figure 5.

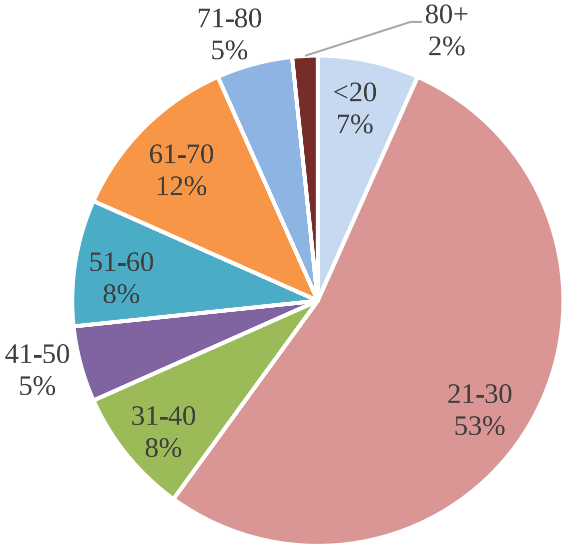

Figure 5. Participant age breakdown.

Figure 6 shows the participant age breakdown by experimental group. An ANOVA between the three experimental groups showed that there was not a significant difference in participant age, $F(1,57) = .246$, $p = .782$.

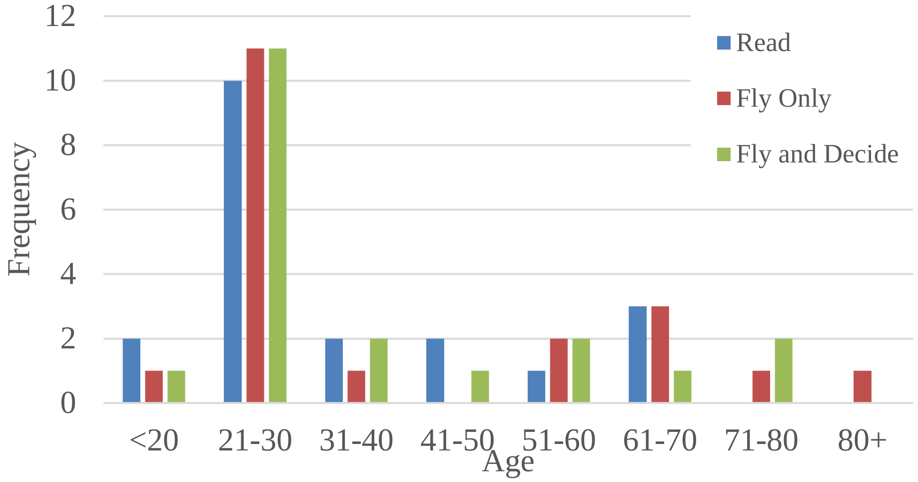

Figure 6. Participant age breakdown by experimental group.

The participants total flight hours ranged from 160 to 7250 hours, with an average of 1161.56 (SD = 1515.4748) and median of 347.5. Flight time was non-normally distributed with a skewness of 2.055 (SE = 0.309) and a kurtosis of 4.273 (SE = 0.608). A breakdown of participant total flight hours is shown in Figure 7.

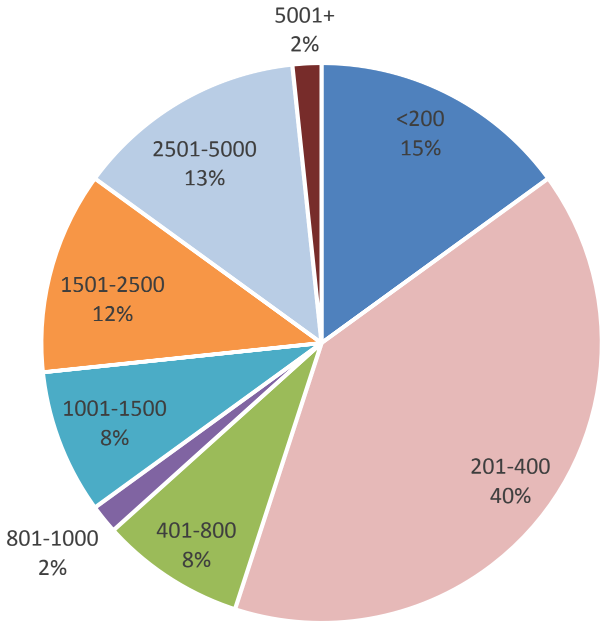

Figure 7. Participant flight hour breakdown.

Figure 8 shows the breakdown of participant flight hours by experimental group. An ANOVA between the three experimental groups showed that there was not a significant difference in total flight hours, *F*(1,57) = .026, *p* = .974.

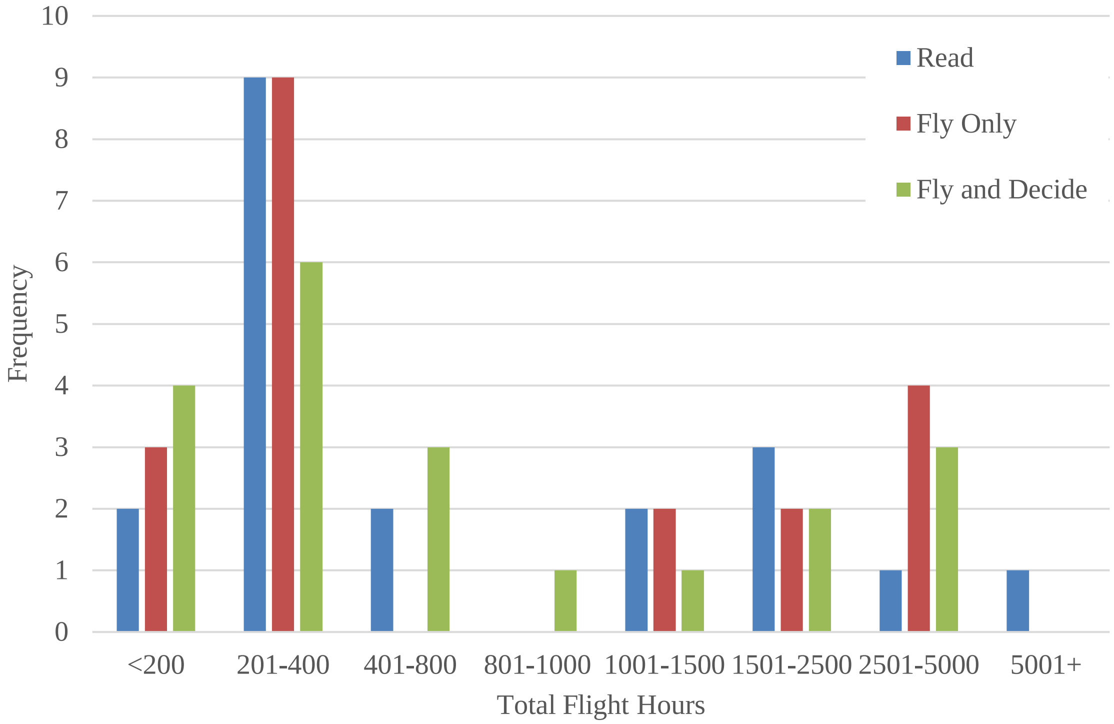

Figure 8. Participant flight hour breakdown by group.

The participants total flight experience in years ranged from 3 years to 50 years, with an average of 12.8 (SD = 12.7688) and a median of 5.0 years. A breakdown of participant total flight hours is shown in Figure 9.

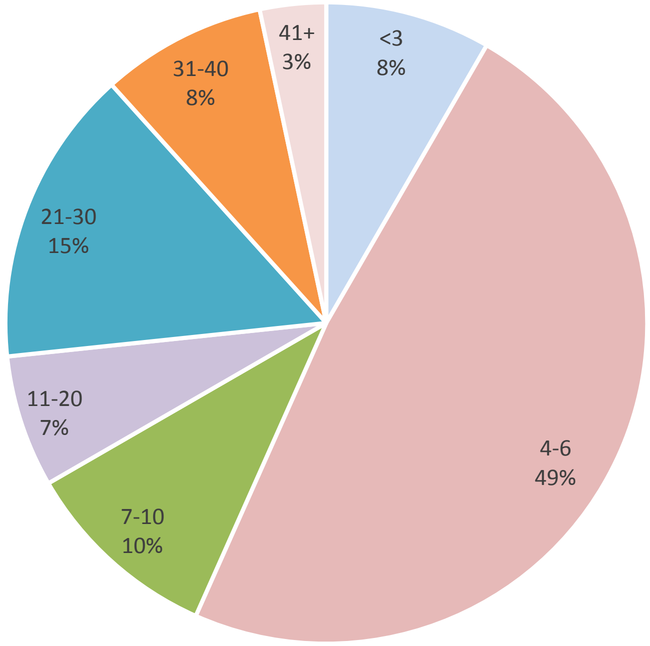

Figure 9. Participant flight hour breakdown by group.

A summary of participant flight hours and flight experience in years by experimental group is shown in Table 4 and Figure 10.

Table 4

Total Flight Hours and Flight Experience of Participants by Experimental Group

	Total Flight Time (Hours)			Flight Experience (Years)		
Group	Mean	Median	SD	Mean	Median	SD
Read	1166.24	345.9	1694.004	11.65	5.00	12.119
Fly Only	1214.75	335.0	1472.101	14.05	4.50	13.020
Fly and Decide	1103.70	420.0	1445.161	12.70	5.50	13.669
Total	1161.56	347.5	1515.475	12.80	5.00	12.769

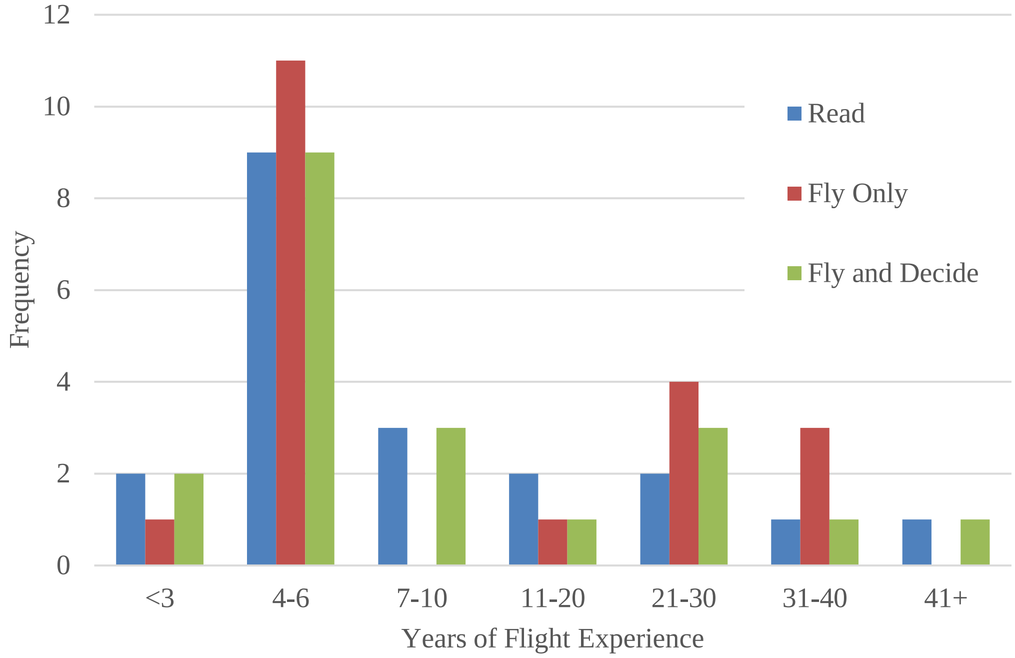

Figure 10. Participants' years of flight experience breakdown by group.

An ANOVA between the three experimental groups showed that there was not a significant difference in total years of flight experience, $F(1,57) = .173$, $p = .842$.

Twenty of the participants received flight training under 14 CFR 61, 38 received flight training under 14 CFR 141 pilot schools, and 2 received flight training from the U.S. Military. A majority 80% of the participant's flight experience occurred primarily in the southeast U.S. The other 20% of the participants reported their flight experience occurring in the northeast, east-central, southwest, and south-central U.S. A detailed breakdown of the location of participants flight experience is shown in Figure 11.

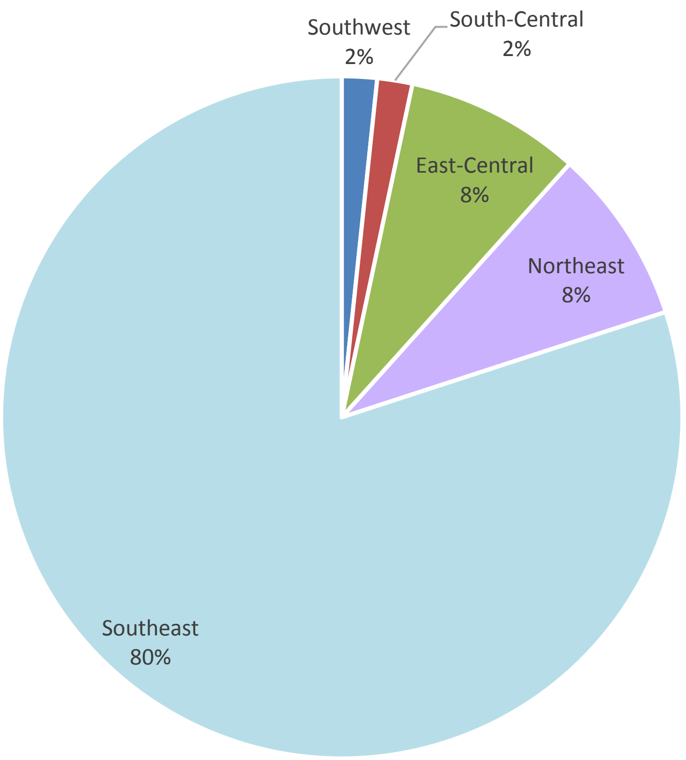

Figure 11. Primary region of participant flight experience.

Descriptive Statistics

Participant knowledge scores. The participant pre-training and post-training knowledge tests (Appendices D and E) consisted of 30 questions with possible scores ranging from 0 to 30, with one point given for each correct answer given. The pre-training knowledge test participant scores ranged from 15 to 27 with a mean score of 22 (SD = 2.732). The frequency distribution of pre-training knowledge score is shown in Figure 12.

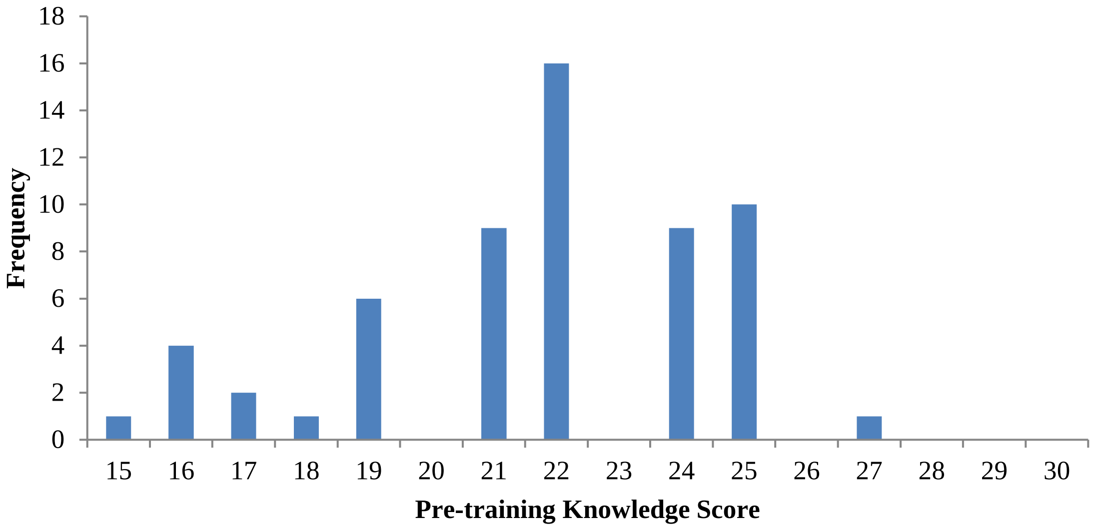

Figure 12. Pre-training knowledge score frequencies.

The post-training knowledge scores ranged from 19 to 30 with a mean score of 26 (SD = 2.023). The frequency distribution of post-training knowledge score is shown in Figure 13.

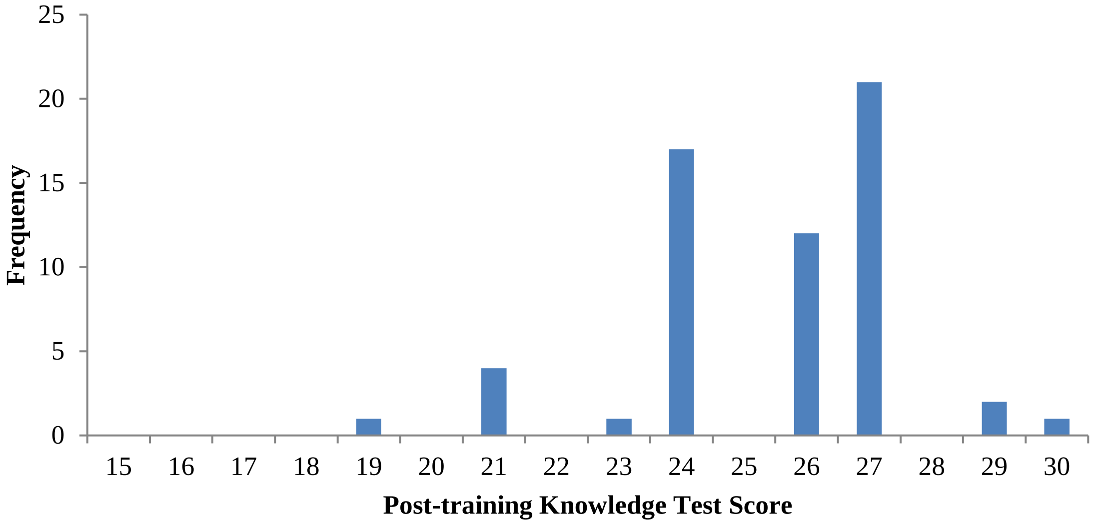

Figure 13. Post-training knowledge score frequencies.

Participant self-efficacy scores. The participant pre-training and post-training self-efficacy questionnaire survey (Appendix C) consisted of 17 statements that participants rated on a scale of 0 to 100. All 17 scores were then added to get an overall aggregate self-efficacy score. The pre-training self-efficacy scores ranged from 474 to 1660 with a mean of 1198.87 (SD = 329.424). The frequency distribution of pre-training self-efficacy score is shown in Figure 14.

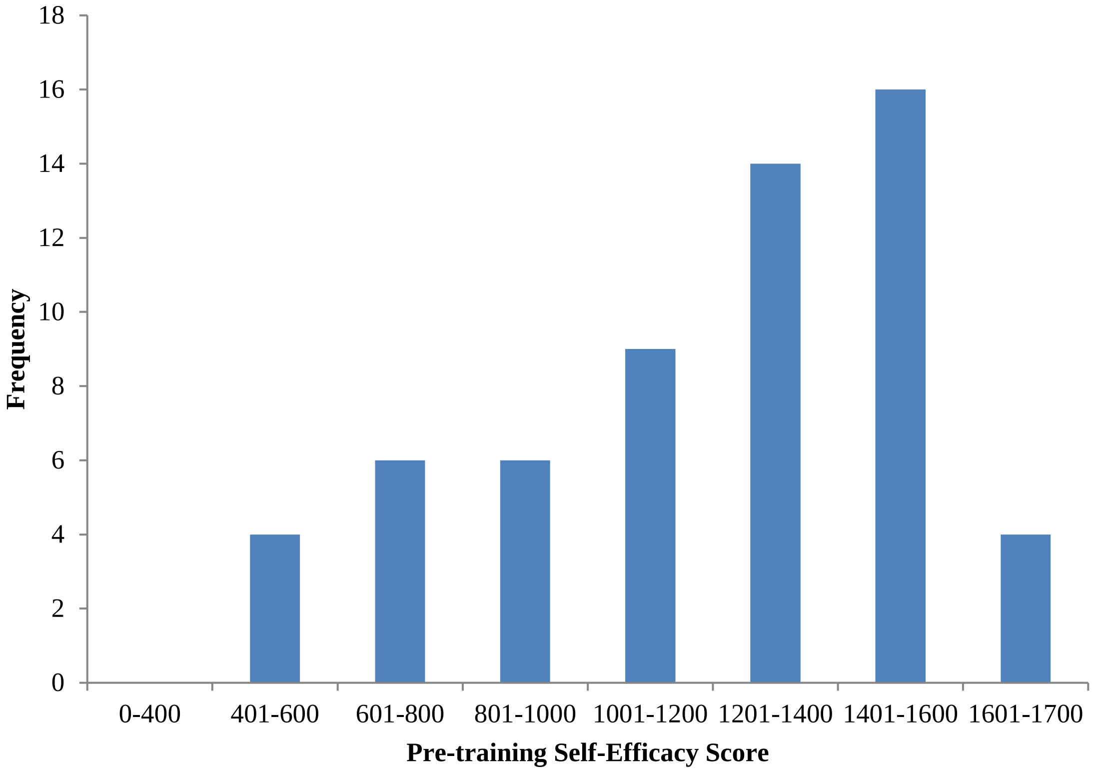

Figure 14. Pre-training self-efficacy score frequencies.

The post-training self-efficacy scores ranged from 760 to 1697 with a mean of 1350.13 (SD = 252.550). The frequency distribution of post-training self-efficacy score is shown in Figure 15.

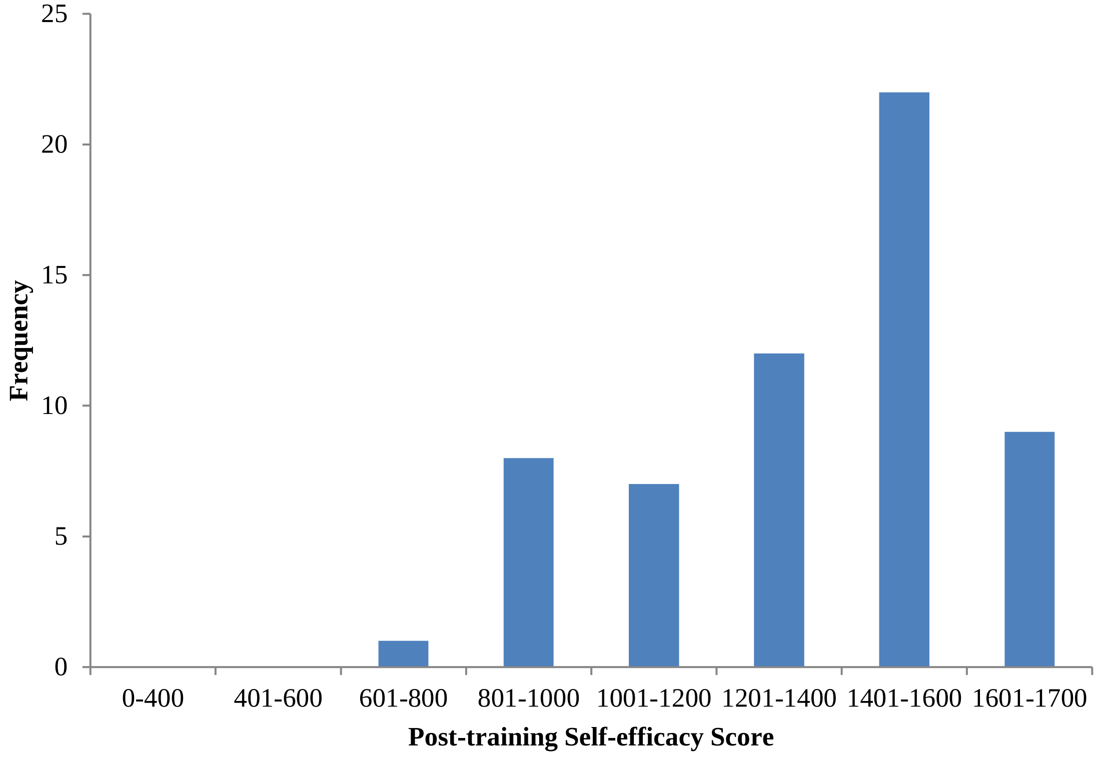

Figure 15. Post-training Self-efficacy score frequencies.

Participant reaction and motivation score. After training, each participant completed the reaction and motivation survey (Appendix F) and rated their reaction to the training by reading six statements and responding on a 7-point Likert scale where 1 was very low and 7 was very high. The reaction statements targeted the participants' overall course impression, relevance, quality, clarity, overall knowledge gain, and missed approach knowledge gain. The reaction scores were totaled to calculate a composite reaction score. The overall reaction to the training was positive, with the participants' mean overall score of 6.33 (SD = 0.184). Figure 16 breaks down the scores by group and details the participant reaction score.

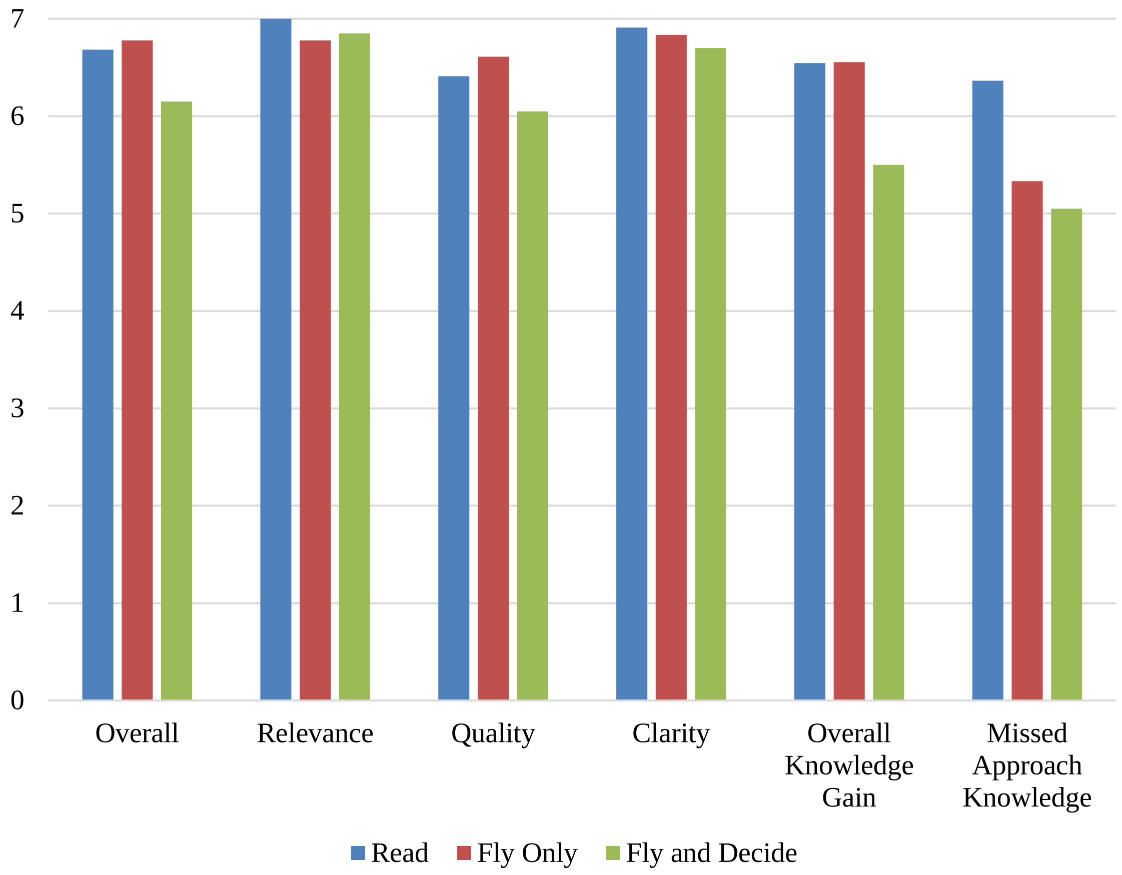

Figure 16.   Participant training reaction score by experimental group.

The five statements of the participant motivation survey targeted if the participants were motivated to pay attention to the lesson and tried to perform well on the knowledge tests. The scores from the five motivation statements were added together to create an overall participant motivation score. Figure 17 shows the motivation scores by group. The motivation mean was 6.48 (SD = 0.047) indicating that the participants had a high level of motivation during the training.

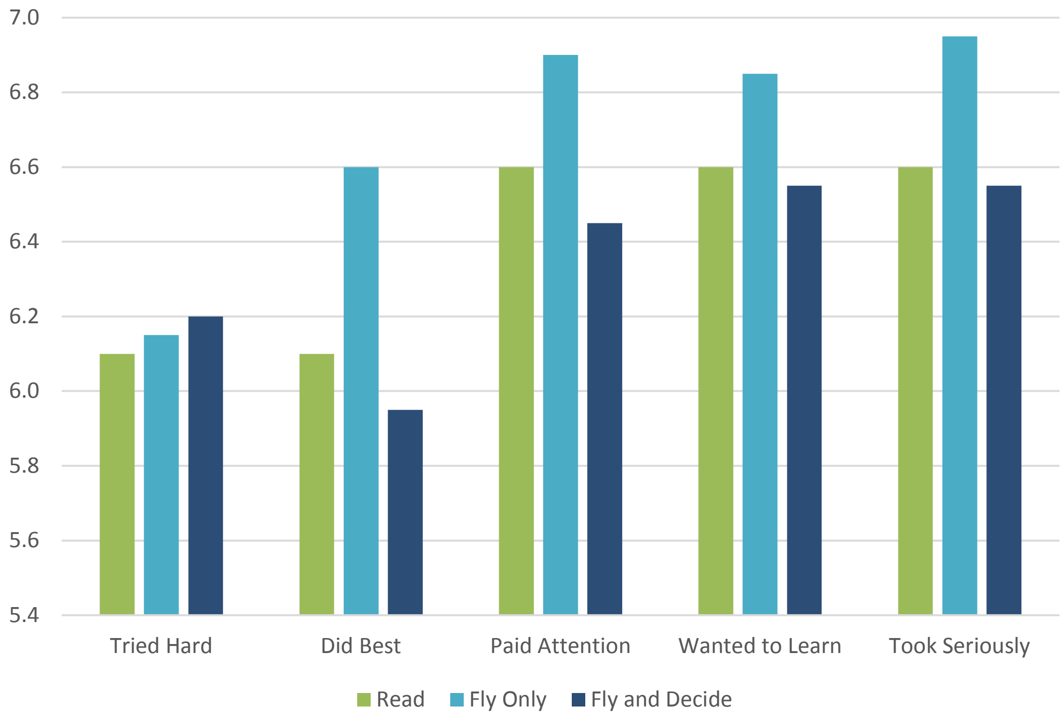

Figure 17. Participant motivation score by experimental group.

Reliability Testing

Reliability testing for the data collection devices was completed using a Cronbach's alpha calculation. The Cronbach's alpha for each of the six data collection devices is shown in Table 5. A Cronbach's alpha score greater than .7 was required to ensure that the data collection devices were considered reliable. All six Cronbach's alphas were greater than .7, and therefore the data collection devices were considered to have acceptable internal reliability. It was not necessary to remove any questions from data collection devices to reach the required .7 threshold. Additionally, the two self-efficacy questionnaires had a Cronbach's alpha score above .98 indicating a very strong level of reliability in those two data collection devices.

Table 5

Cronbach's Alpha Scores for the Data Collection Devices

Data Collection Device	Cronbach's Alpha
Pre-training Knowledge Test	.792
Post-training Knowledge Test	.760
Pre-training Self-efficacy Questionnaire	.987
Post-training Self-efficacy Questionnaire	.980
Participant Reaction Survey	.783
Participant Motivation Survey	.755

Hypothesis Testing

Two ANOVAs, an independent samples *t*-test, and correlations were calculated to test the hypotheses. If the probability value was 0.05 or less, the proposed hypothesis was accepted. If the probability value was above 0.05, the proposed hypothesis was rejected.

ANOVA assumption testing.

There are three assumptions of an ANOVA that were tested prior to completing the ANOVA calculation for hypothesis 1 through 4. The first assumption requires the data to be normally distributed. First, the skewness and kurtosis shown in Table 6 for each of the four dependent variables, pre-training knowledge test score, post-training knowledge test score, pre-training self-efficacy score, and post-training self-efficacy score was calculated.

Table 6

Skewness and Kurtosis for the Knowledge and Self-efficacy Scores

	Knowledge Test Score		Self-efficacy Score	
	Pre-training	Post-training	Pre-training	Post-training
Kurtosis	-0.1721	1.0051	-0.6870	-0.6532
Skewness	-0.5815	-0.8343	-0.5929	-0.6380

Next, Q-Q plots, shown in Figures 18, 19, 20, and 21, were created to show the observed values of the four dependent variables compared to an expected normal distribution. The values of skewness and kurtosis for each of the four dependent variables were not an exact normal distribution, however Q-Q plots show that the distribution of the four dependent variables are near normal. The near normal distribution and the sample size of 60 participants was enough to ensure a valid p-value in the ANOVA.

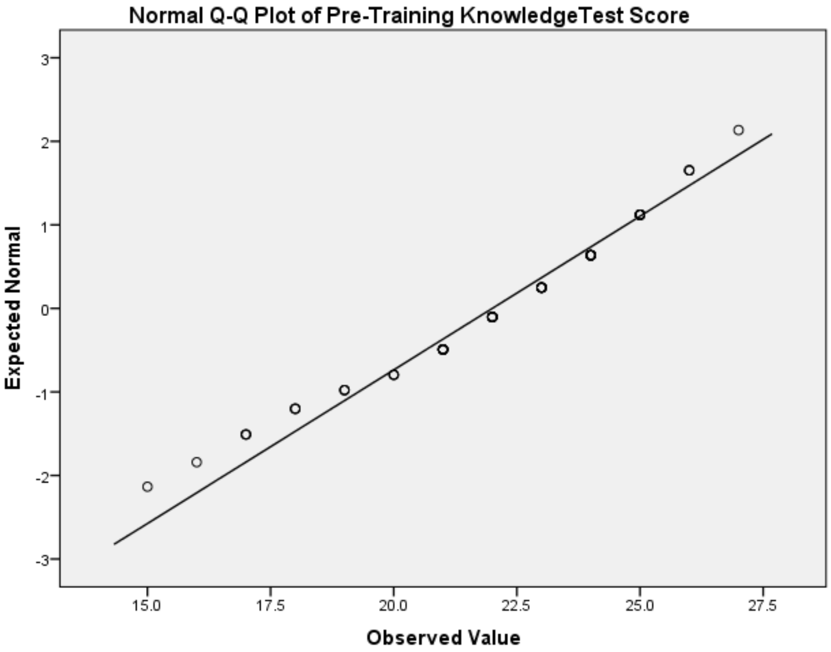

Figure 18. Normal Q-Q plot of pre-training knowledge test score.

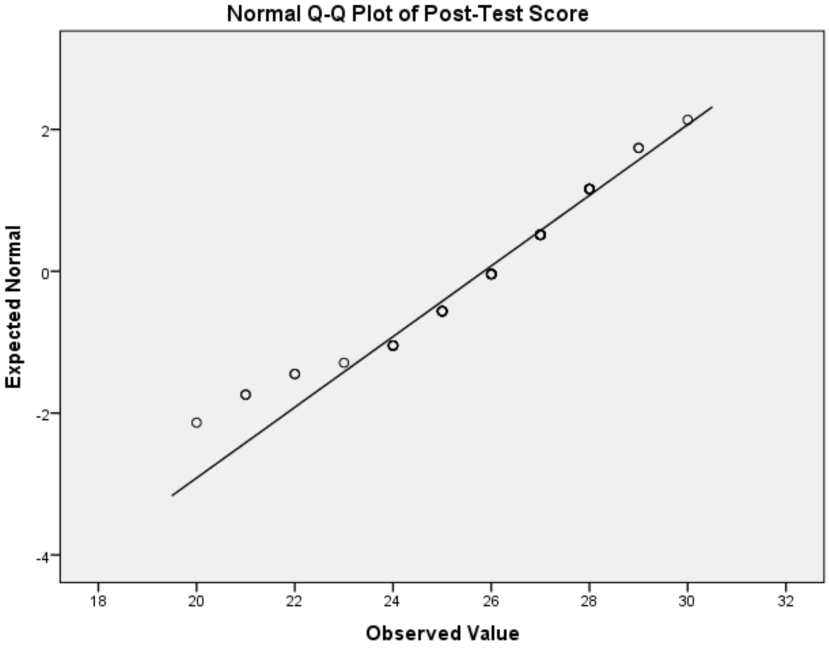

Figure 19. Normal Q-Q plot of post-training knowledge test score.

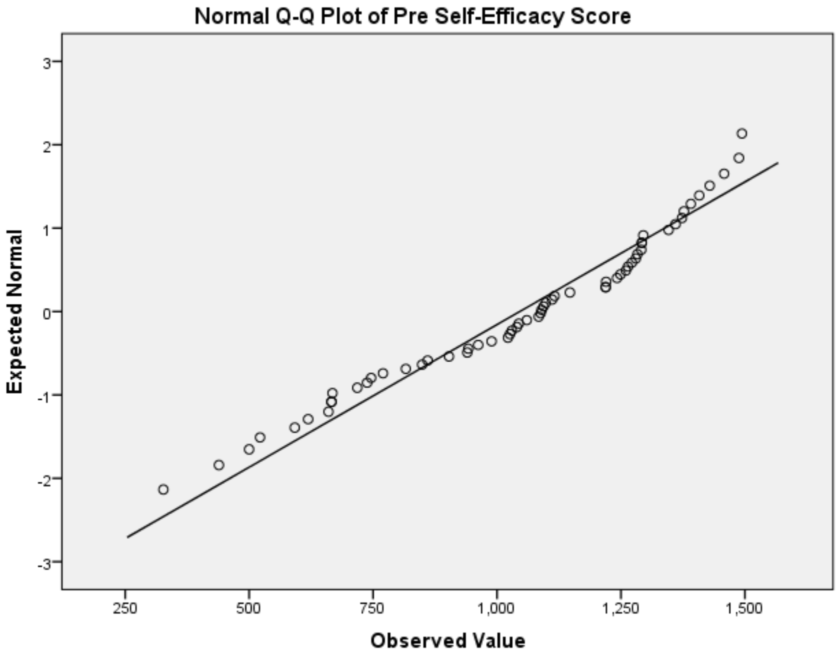

Figure 20. Normal Q-Q plot of pre-training self-efficacy score.

Figure 21. Normal Q-Q plot of post-training self-efficacy score.

The second assumption checked to determine if the error variance of the dependent variable was equal across the groups. To test this assumption, Levene’s test of equality error variances was conducted. The results of Levene’s test is shown in Table 7, with a p-value of .01 or less as the threshold to indicate significance.

Table 7

Levene's Test of Equality of Error Variances

Levene's Test of Equality of Error Variances				
	F	df1	df2	Sig.
Pre-training Knowledge Test Score	2.466	2	57	.094
Post-training Knowledge Test Score	3.645	2	57	.032
Pre-training Self-efficacy Score	1.678	2	57	.196
Post-training Self-efficacy Score	4.868	2	57	.011

All four of the Levene’s tests for Pre-training Knowledge Test Score, Post-training Knowledge Test Score, Pre-training Self-efficacy Score, and Post-training Self-efficacy Score were not significant, indicating that the error variance of the dependent variable was not significantly different across the three experimental groups. Therefore, the second assumption of the ANOVA was met.

The third assumption of the ANOVA is that there was an independence of observations. In this case, each participant was asked not to reveal any information about the experiment and the data collection instruments to any potential participants. Therefore, the scores for each participant knowledge test and self-efficacy questionnaire were not affected by any other participant and were classified as independent observations.

Hypotheses 1 and 2. A 3 x 2 mixed ANOVA was conducted to test Hypotheses 1 and 2 to evaluate the effect of the three different training types on knowledge test scores. The dependent variable was knowledge test scores, with values ranging from 0 to 30. The two independent variables were the three different training types: Read, Fly Only, and Fly and Decide and the time interval of pre-training and post-training.

Hypotheses 1 and 2 state:

1. After completing a lesson about IFR and missed approaches, participants will perform better on the post-training knowledge test than on the pre-training knowledge test.
2. Participants in the Fly and Decide group will perform better on an instrument knowledge test than participants in the Fly Only group, who will perform better on an instrument knowledge test than participants in the Read group after completing the lesson about IFR and missed approaches.

The ANOVA, shown in Table 8, determined that the main effect of training on knowledge scores between pre-training and post-training was significant $F(1,57) = 184.977$, $p < .001$, $\eta^2 = .764$. The interaction effect between training type and knowledge scores did not have a significant effect, $F(2, 57) = 2.038$, $p = 0.140$, $\eta^2 = .067$.

Table 8

Tests of Within-subjects Effects for Knowledge Test Scores

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Knowledge	Sphericity Assumed	444.675	1	444.675	184.977	.000
	Greenhouse-Geisser	444.675	1.000	444.675	184.977	.000
	Huynh-Feldt	444.675	1.000	444.675	184.977	.000
	Lower-bound	444.675	1.000	444.675	184.977	.000
Knowledge * Group	Sphericity Assumed	9.800	2	4.900	2.038	.140
	Greenhouse-Geisser	9.800	2.000	4.900	2.038	.140
	Huynh-Feldt	9.800	2.000	4.900	2.038	.140
	Lower-bound	9.800	2.000	4.900	2.038	.140
Error(knowledge)	Sphericity Assumed	137.025	57	2.404		
	Greenhouse-Geisser	137.025	57.000	2.404		
	Huynh-Feldt	137.025	57.000	2.404		
	Lower-bound	137.025	57.000	2.404		

Further analysis of the contrasts test of knowledge scores across groups, shown in Table 9, did not yield any significant differences between the three experimental groups.

Table 9

Contrast Test for Knowledge Test Scores Across Groups

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Bonferroni	Read	Fly	-.25	.662	1.000
		Decide	-1.10	.662	.307
	Fly Only	Read	.25	.662	1.000
		Decide	-.85	.662	.614
	Decide and Fly	Read	1.10	.662	.307
		Fly	.85	.662	.614
Games-Howell	Read	Fly	-.25	.759	.942
		Decide	-1.10	.546	.125
	Fly Only	Read	.25	.759	.942
		Decide	-.85	.665	.419
	Decide and Fly	Read	1.10	.546	.125
		Fly	.85	.665	.419

Table 10 and Figure 22 show the comparison between mean knowledge test score and different training type for each of the three experimental groups.

Table 10

Mean Knowledge Test Scores by Experimental Group

Group	Pre-training Knowledge	Post-training Knowledge	Difference
Read	21.40	25.55	4.15
Fly Only	21.55	25.90	4.35
Fly and Decide	23.05	26.10	3.05
Total	22.00	25.85	3.85

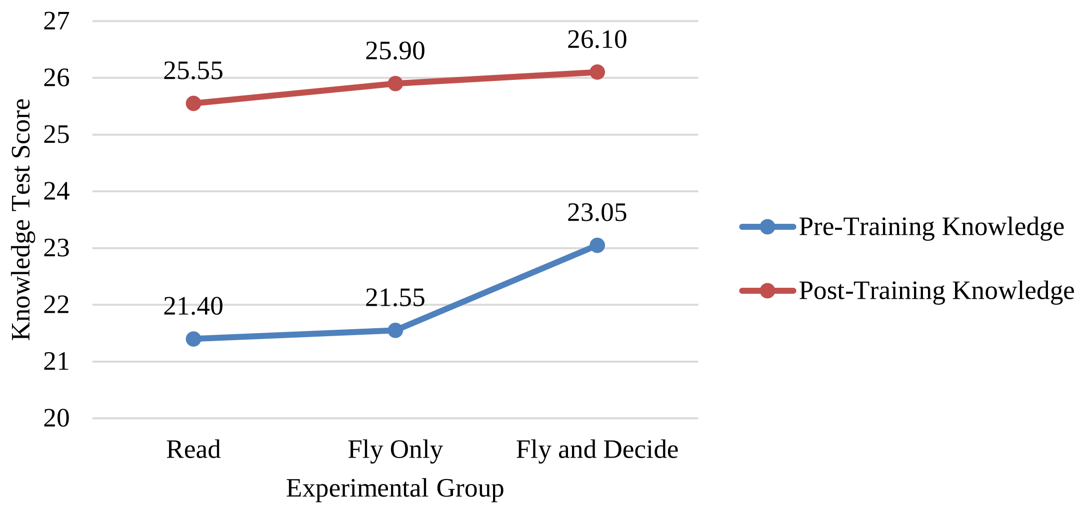

Figure 22. Knowledge test score vs experimental group.

All participants showed an improvement in test scores after training. Out of a maximum score of 30, the total mean knowledge scores increased from 22.00 to 25.85, an increase of 3.85 points which is an improvement of 12.8%. The ANOVA and contrast test indicate that the specific type of training given did not have a significant effect on improving participant knowledge scores. Therefore, Hypothesis 1 is supported, and Hypothesis 2 is rejected.

Hypotheses 3 and 4. A 3x2 ANOVA was conducted to test Hypotheses 3 and 4 to evaluate the effect of the three different training types on self-efficacy scores. The dependent variable was self-efficacy scores, with values ranging from 0 to 1700. The two independent variables were the experimental group of three different training types: Read, Fly Only, and Fly and Decide and the time interval of pre-training and post-training. Hypotheses 3 and 4 state: after completing a lesson about IFR and missed approaches, participants will have a higher self-efficacy pertaining to IFR operations when compared to their level of pre-training self-efficacy.

3. Participants in the Fly and Decide group will have a higher self-efficacy pertaining to IFR operations than participants in the Fly Only group, who will have a higher self-efficacy pertaining to IFR operations than participants in the Read group after completing the lesson about IFR and missed approaches.

The ANOVA result, shown in Table 11, for the main effect of training on self-efficacy score was significant, $F(1, 57) = 299.409$, $p < .001$, $\eta^2 = .840$, indicating that all three groups had a significant increase in self-efficacy after the training. The ANOVA interaction effect between training type and self-efficacy scores was also significant, $F(2, 57) = 7.883$, $p < .001$, $\eta^2 = .217$.

Table 11

Tests of Within-subjects Effects for Self-efficacy

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Self-Efficacy	Sphericity Assumed	2483714.133	1	2483714.133	299.409	.000	.840
	Greenhouse-Geisser	2483714.133	1.000	2483714.133	299.409	.000	.840
	Huynh-Feldt	2483714.133	1.000	2483714.133	299.409	.000	.840
	Lower-bound	2483714.133	1.000	2483714.133	299.409	.000	.840
Self-Efficacy * Group	Sphericity Assumed	130792.467	2	65396.233	7.883	.001	.217
	Greenhouse-Geisser	130792.467	2.000	65396.233	7.883	.001	.217
	Huynh-Feldt	130792.467	2.000	65396.233	7.883	.001	.217
	Lower-bound	130792.467	2.000	65396.233	7.883	.001	.217
Error(Self-Efficacy)	Sphericity Assumed	472837.400	57	8295.393			
	Greenhouse-Geisser	472837.400	57.000	8295.393			
	Huynh-Feldt	472837.400	57.000	8295.393			
	Lower-bound	472837.400	57.000	8295.393			

The contrast test for self-efficacy across groups, shown in Table 12, showed a significant difference in post-self-efficacy score improvement existed between the Read group and the Fly and Decide Group.

Table 12

Contrast Test for Self-efficacy Score Across Groups

Dependent Variable		(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Pre-Training Self-Efficacy Score	Bonferroni	Read	Fly	-17.500	94.016	1.000
			Decide	-13.950	94.016	1.000
		Fly Only	Read	17.500	94.016	1.000
			Decide	3.550	94.016	1.000
		Fly and Decide	Read	13.950	94.016	1.000
			Fly	-3.550	94.016	1.000
	Games-Howell	Read	Fly	-17.500	99.582	.983
			Decide	-13.950	86.899	.986
		Fly Only	Read	17.500	99.582	.983
			Decide	3.550	95.127	.999
		Fly and Decide	Read	13.950	86.899	.986
			Fly	-3.550	95.127	.999
Post-Training Self-Efficacy Score	Bonferroni	Read	Fly	-101.300	75.535	.556
			Decide	-175.650	75.535	.071
		Fly Only	Read	101.300	75.535	.556
			Decide	-74.350	75.535	.987
		Fly and Decide	Read	175.650	75.535	.071
			Fly	74.350	75.535	.987
	Games-Howell	Read	Fly	-101.300	83.791	.456
			Decide	-175.650*	66.198	.031
		Fly Only	Read	101.300	83.791	.456
			Decide	-74.350	75.588	.592
		Fly and Decide	Read	175.650*	66.198	.031
			Fly	74.350	75.588	.592

Note: * indicates the mean difference is significant at the 0.05 level.

Amongst all participants, the self-efficacy score, out of a maximum score of 1700, increased from 1045.73 before training to 1333.47 after training. This was an improvement of 287.73 or 16.9%. Table 13 and Figure 23 show the comparison between mean self-efficacy score and different training type for each of the three experimental groups.

Table 13

Mean Self-efficacy Scores by Group

Group	Pre-training Self-efficacy	Post-training Self-efficacy	Difference
Read	1035.25	1241.15	205.90
Fly Only	1052.75	1342.45	289.70
Fly and Decide	1049.20	1416.80	367.60
Total	1045.73	1333.47	287.73

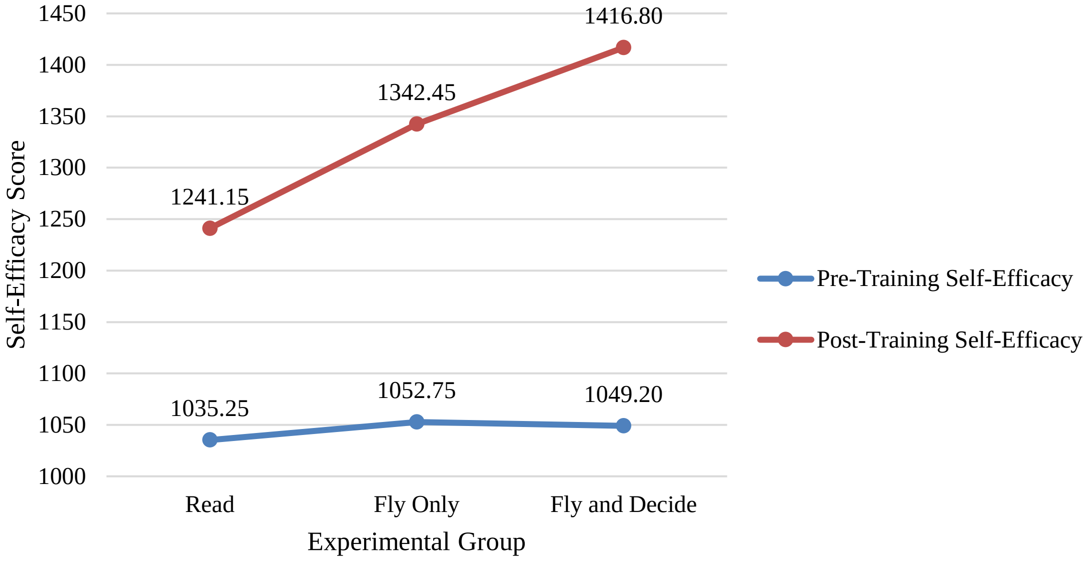

Figure 23. Self-efficacy score vs experimental group.

An independent samples t-test was conducted to follow up on the significant interaction between training type and self-efficacy score. A Bonferroni adjustment was applied to the p-value to account for the three t-tests that were performed. In this case, the original p-value of .05 was divided by 3, and a new p-value threshold of .017 was set to determine significance of the result.

The difference in the increase in self-efficacy score between the Read group (M = 1241.15, SD = 238.53, SE = 53.34) and the Fly Only group (M = 1342.45, SD = 289.0, SE = 64.62) was not significant, *t*(38) = -1.209, *p* = .230. The difference in the increase in self-efficacy score between the Read group (M = 1241.15, SD = 238.53, SE = 53.34) and the Fly and Decide group (M = 1416.80, SD = 175.36, SE = 39.21) was significant, *t*(38) = -2.653, *p* = .012, r = .395. The difference in the increase in self-efficacy score between the Fly Only group (M = 1342.45, SD = 289.0, SE = 64.62) and the Fly and Decide group (M = 1416.80, SD = 175.36, SE = 39.21) was not significant, *t*(38) = -.984, *p* = .333. Therefore, Hypothesis 3 is supported, and Hypothesis 4 is partially supported because only the difference in post-training self-efficacy scores between the Read group and the Fly and Decide group was significant.

Hypothesis 5. Hypothesis 5 states: Participants in the Fly Only and Fly and Decide group will have a higher satisfaction of training compared to participants in the Read group. A check of the assumptions of an ANOVA was conducted. The skewness and kurtosis were calculated to determine if the reaction score was normally distributed. The skewness of the motivation score was -0.998, and the kurtosis was 0.0002. This data was not normally distributed, but the sample size of 60 participants ensured a valid p-value in the ANOVA. Levene's test of equality of error variances was conducted, and the results were not significant, *F*(2,58) = 1.096, p = .355. This indicated that the error variance was not significantly different across all groups. Additionally, there was an independence of observations as each participant was asked not to reveal any information about the experiment and the data collection instruments to any potential participants. Therefore, the scores for each reaction and motivation survey were not affected by any other participant and were classified as independent observations.

With all assumptions accounted for, a one-way ANOVA was conducted to evaluate the relationship between the three groups of participants' ratings of their reaction to the training. The independent variable of training type contained three levels matching the three different experimental groups. The dependent variable was the average score of the six survey questions of the participants reaction to the training. The participants selected a value on a Likert scale between 1 and 7, with 1 being a negative reaction to the training and 7 being a positive reaction to the training. Table 14 shows the mean reaction score by experimental group.

Table 14

Mean and SD of Participant Reaction Scores by Group

Group	Mean	SD
Read	6.4333	0.180
Fly Only	6.4286	0.218
Fly and Decide	6.2000	0.231
Total	6.3258	0.184

The total mean reaction score was 6.32, which indicated that the participants of all groups had a positive reaction to the training. The ANOVA, shown in Table 15, showed that there was no significant difference in the reaction score between groups, *F*(2, 58) = .505, *p* = .612 (r = .050); therefore, Hypothesis 5 is rejected.

Table 15

Mean Reaction Score ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Mean Reaction Score	Between Groups	.290	2	.145	.505	.612
	Within Groups	5.459	58	.287		
	Total	5.749	60			

Additionally, a one-way ANOVA was conducted to evaluate the relationship between experimental group and participants' ratings of their motivation during the training. As before, a check of the assumptions of an ANOVA was conducted. The skewness and kurtosis were calculated to determine if the motivation score was normally distributed. The skewness of the motivation score was -0.217 and the kurtosis was -1.40. This data was not normally distributed, but the sample size of 60 participants ensured a valid p-value in the ANOVA. Levene’s test of equality of error variances was conducted, and the results were not significant, F(2,58) = .610, p = .553. This indicates that the error variance was not significantly different across all groups. Additionally, there was an independence of observations as each participant was asked not to reveal any information about the experiment and the data collection instruments to any potential participants. Therefore, the scores for each motivation survey were not affected by any other participant and were classified as independent observations.

The independent variable experimental group contained three levels matching the three different types of training. The dependent variable was the average score of the five survey questions of the participants’ motivation level during the training. The participants selected a value on a Likert scale between 1 to 7, with 1 relating to a low level of personal motivation during the training to 7 relating to a high level of personal motivation to learn during the training. Table 16 shows the mean motivation score by experimental group.

Table 16

Mean and SD of Participant Motivation Scores by Group

Group	Mean	SD
Read	6.6000	0.175
Fly Only	6.7429	0.152
Fly and Decide	6.4400	0.283
Total	6.5727	0.193

The ANOVA of motivation score between groups, shown in Table 17, was not significant, *F*(2, 58) = 1.149, *p* = .338 (r = .108), indicating that there was no difference in participant motivation between the experimental groups.

Table 17

Mean Motivation Score ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Mean Motivation Score	Between Groups	.382	2	.191	1.149	.338
	Within Groups	3.161	58	.166		
	Total	3.544	60			

Summary

The statistical analysis to test the five hypotheses revealed the effectiveness in the training across the three experimental groups. There was a statistically significant increase in knowledge gain between pre-training and post-training for all participants. However, there was no statistically significant difference in knowledge gain between the three experimental groups. All participants had an increase in self-efficacy between pre-training and post-training. Between experimental groups, the increase in self-efficacy score between the Read and Fly and Decide groups was statistically significant. Lastly, all participants reported a positive reaction to the training and high level of motivation during the training. There were no statistically significant differences in reaction or motivation score between the participants in the three experimental groups.

CHAPTER V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

A pilot's ability to maintain instrument approach and missed approach knowledge and self-efficacy at a high level is critical to the safety of flight. Ideally, pilots can use an airplane or an FAA approved simulator and training device for refresher training; however, that is not always possible. There are other ways pilots can maintain a high level of knowledge and self-efficacy in a study-at-home situation. A passive method of learning is when a pilot reads and reviews current FAA publications. One example of an active method of learning is using a personal computer and commercial off the shelf flight simulation software to fly instrument approach procedures. The key is to allow a pilot to use flight simulation software to maximize the benefit of active learning through SBT.

Active learning has been used to teach and enhance knowledge in learners in many different types of applications. SBT and the use of simulation in aviation training are common techniques used to facilitate active learning (Jones & Jones, 1998). The FAA recommends SBT to be used in support of flight training (FAA, 2008), and research has shown that SBT is an effective training method. (Blickensderfer, Strally, & Doherty, 2012; Fowlkes et al, 2009; Nicholson et al, 2009). Self-efficacy is the measure of one's own confidence and judgement to succeed in completing a given task (Kraiger, Ford, & Salas, 1993). Having a high self-efficacy on a task or topic will result in a positive correlation to successful performance of that task or an increase in knowledge gained (Bandura, 2000; Zimmerman, 2000; Zimmerman & Kitsantas, 2005).

Once training has taken place, a measurement of the training effectiveness is necessary. Two frameworks for measuring training effectiveness are the Kirkpatrick (2006) model and the Kraiger, Ford, and Salas (1993) model. The Kirkpatrick model measures training effectiveness by measuring four levels: learner reactions, the measurable knowledge gain that took place, learner behavior, and effective results. Kraiger, Ford, and Salas' model measures training effectiveness by evaluating the learners cognitive, skill-based, and affective outcomes. The data collection devices used in the study make use of the two frameworks to take measurements of knowledge gain and cognitive outcomes based on a knowledge test, learner behavior and effective outcomes based on a self-efficacy questionnaire and a learner reaction and motivation survey for participant reaction to the training.

Discussion

The study examined the effect of active learning on instrument rated pilots who were not instrument current. Sixty-two participants were recruited to produce a sample of 60 participants who represented the population of non-current instrument rated GA pilots in the U.S. The sample included only private and commercial pilots that held an instrument rating but were not instrument current, as defined by 14 CFR 61.57. The participants also had various flight training backgrounds and flight experience. The participants completed two training activities that varied in level of active learning to measure the change in participant instrument knowledge and self-efficacy before and after training.

Conducting a missed approach due to deteriorating weather conditions and selecting an alternative airport is a critical portion of a flight. While flying an instrument approach is a common occurrence, performing a missed approach due to weather conditions does not occur often. While pilots log the frequency of instrument approaches in their personal logbooks, the number of missed approaches conducted due to weather conditions is not often tracked. The 60 participants who completed the study reported flying a total of 17,566 instrument approaches in their entire flight experience. Only 11 of the participants performed a total of 123 missed approaches because weather conditions did not allow a landing. Only 0.7% of the total approaches flown by all 60 participants ended with a missed approach due to weather conditions. The low frequency of conducting weather induced missed approaches from this sample highlights the potential for a lack of pilot proficiency and, therefore, the need for refresher training on missed approaches and decision making.

The design of the training in this study simulated how pilots can practice instrument procedures and missed approaches on their own personal computer. Using the Kirkpatrick (2006) and Kraiger, Ford, and Salas (1993) models of measuring training effectiveness, the effectiveness of the training provided was completed using three measures:

1. The difference in participant knowledge pre-training vs post-training
2. The difference in participant self-efficacy pre-training vs post-training
3. The participants’ reaction to the training

The participants were a diverse sample of pilots from various backgrounds, certificate levels, total flight hours, and years of flying experience who represented the GA pilot population of the U.S.

Instrument reliability. The six data collection devices used in the study were evaluated with a Cronbach's alpha calculation to determine reliability for each. A threshold of .7 was established to determine if the data collection device was reliable. All six data collection devices used in the study had a Cronbach's alpha greater than .7 and were considered reliable data collection devices.

Instrument approach and missed approach knowledge. The training presented to the participants produced a significant increase in knowledge scores between the pre-training knowledge test and the post-training knowledge test across all participants. Mean test scores, with a maximum score of 30, increased from 22.0 to 25.85 amongst all participants, an increase of 12.8%. All three training types were effective in providing knowledge to GA pilots, and the effect size on the training was .764, indicating the training had a high level of effect on the participants. There was no significant difference between the knowledge test scores improvement by experimental group. The literature suggests that the more active learning the training possesses that training will be more effective. However, in this case, there was no significant effect on knowledge gain between the three groups, which conflicts with what the literature suggests would occur. The significant increase in knowledge across all participants highlights the effectiveness of the shared common training element of video-based instruction presented as the first-training activity. The differing levels of active learning in the second training activity did not influence knowledge score, indicating that the second training did not contain any elements that affected a participant's instrument knowledge. However, the increase in scores among all participants indicates that narrated computer-based training is effective for refresher training of GA pilots instrument knowledge.

Instrument approach and missed approach self-efficacy. The training presented to the participants produced a significant increase on self-efficacy score in relation to instrument approaches and missed approaches between the pre-training knowledge test and the post-training knowledge test across all participants. Mean self-efficacy scores, with a maximum value of 1700, increased 16.9% from 1045.73 to 1333.47 after training. The training had a large effect size of .840 on the participants. The increase in post-training self-efficacy was significantly different between the training types of the Read group and the Fly and Decide group. The Read group reported an increase in self-efficacy of 12.1%, while the Fly and Decide group reported an increase in self-efficacy of 21.6%. The Fly and Decide group increased their self-efficacy by 161.7 over the Read group, an increase of 9.5%.

The data show that all three training methods increased GA pilot self-efficacy in relation to instrument approaches and missed approaches. Furthermore, as the literature suggests, the most active type of training, flying approaches and making decisions during those approaches in a SBT format, resulted in the greatest increase in participant self-efficacy. Additionally, as the literature suggests, the increase in self-efficacy will result in improved pilot performance during instrument and missed approaches. The type of training provided in the Fly and Decide group was an effective way for a pilot using SBT on a personal computer to increase self-efficacy.

Interestingly, of the 60 participants, 6 reported a lower self-efficacy after the training. During the debriefing with the participants, some of the comments stated were “I didn’t realize how much I had forgotten” and “My memory isn’t as good as it used to be.” While ideally the training would improve self-efficacy, in some cases the training helped to reset the participant's self-efficacy to the correct level and reduce an over-confident state.

Reaction to training and motivation during training. The training was provided to the participants via a personal computer. Participants in the Fly Only and Fly and Decide group used Prepar3D and a yoke representative of a small GA airplane to complete the training scenarios. Participants in all groups reported having a positive reaction to the training. The participants rated their reaction to the training on a scale from 1 to 7, with 7 being the maximum positive reaction score. Overall, all participants' reaction score to the training was a mean score of 6.33 (SD = 0.184). The data indicated that there was no significant difference in the reaction scores between experimental groups, meaning that participants of all groups had a positive reaction to the training. Additionally, many of the participants felt that the personal computer-based simulation and scenarios were "realistic," "had enough detail to knock the rust off," and "the missed approaches were a good way to make me think what would come next." Several of the participants stated during the debrief that they wished more training of this type existed and wanted to find out more information about the flight simulation software and flight control system used in the study.

The three experimental groups all reported having a high level of motivation during the training. The participants rated their motivation level on a scale from 1 to 7, with 7 being the maximum positive motivation to complete the training. All participants had a mean motivation score of 6.57 (SD = 0.193). The data indicate that there was no significant difference in the motivation of the participants between groups, meaning that all participants were motivated to learn during the training.

Limitations. All participants in this study were familiar with personal computer operation and did not have any issues completing the training, knowledge tests, self-efficacy questionnaires, demographic survey, and reaction and motivation survey. While some participants did not have prior experience with desktop flight simulation software, the scenarios and interface were comparable enough to a real airplane that no negative impacts occurred during training. As a result, none of the participant's performance in the SBT lesson was poor enough to result in removing their data from the dataset.

Conclusions

This study validated the potential of at-home personal computer-based SBT to provide an instrument rated pilot a way to review and refresh their instrument knowledge and improve self-efficacy without the associated cost and availability of an airplane. A properly designed lesson was proven to increase knowledge in instrument rated pilots regardless of the level of active learning that took place. Additionally, the varying levels of active learning that participants experienced had a direct relationship to the increase in post-training self-efficacy.

The FAA has leveraged the use of simulation technology in flight training and maintaining currency; however, the scope of using personal computer-based SBT at home technologies toward pilot currency requirements has not been considered. At a minimum, this study has shown that personal computer-based SBT is effective and could be used as an additional training aid in conjunction with existing flight training curriculum and pilot currency requirements. The development of at-home SBT by educators and instructional designers targeting topics that student pilots historically find difficult has the potential to reduce training time and improve student understanding.

Outside of the flight training environment, unsafe trends that are identified in the GA flight environment could be the starting point for the creation of at-home SBT lessons to help improve GA safety overall.

Recommendations

The study took each participant approximately two hours to complete, and in some cases longer. Even though breaks were given to the participants as needed, the pre-training and post-training knowledge tests took a long time to complete. Developing shorter, all scenario-based tests that would still measure the same topical information but take less overall time for participants to complete would be ideal. Additionally, putting a maximum time limit in place to complete the knowledge tests would help ensure the process would not go beyond 2 hours. However, an effort must be made to ensure that this time limit does not create confounding variables from the different learning styles and abilities of participants.

While participants in all groups showed an increase in knowledge gained, the second training activity only had a differing effect on participant self-efficacy. Some redevelopment of the scenarios in the second training activity is recommended to incorporate active learning training methods that would enhance the level of instrument knowledge gain in addition to the gain of self-efficacy. Redevelopment should include some reinforcement of knowledge presented during training as well as having each scenario target a more specific aspect of knowledge relating to instrument approaches and missed approaches.

A recommendation and suggestion for future research would be to conduct the study in a similar manner with pre-training and post-training intervals but add a third interval a few weeks later. This would provide an opportunity to measure and compare participants' retention in the knowledge test and longer term self-efficacy. This would provide evidence as to the long-term effectiveness of this type of computer-based and personal computer-based scenario training. Additionally, counterbalancing the pre-training and post-training knowledge tests would serve as a further verification of knowledge effect on the participants. Next, as weather and flight conditions vary significantly around the U.S., a larger sample of pilots that includes participants from more diverse geographic locations and experiences backgrounds would further validate the different training methods used in this study.

The flight control setup that was utilized in this study was a close replica to what is in a common GA aircraft. Research is needed to determine if other devices like a joystick or equivalent flight control setup that is smaller in size and more cost effective would provide the same training effect. Furthermore, as was done in the past with PCATDs initial approval, a need to investigate how much pilot skill, in terms of pilot stick-and-rudder skill or adherence to FAA ACS standards, can be developed on at-home personal computer-based SBT and transferred to the real airplane. Finally, an investigation is recommended into how much fidelity and detail in the SBT flight scenario is needed to maximize the effectiveness of these types of scenarios and the connections to the real flight environment.

In conclusion, this study supports the approach of using active learning for refresher training of instrument rated pilots that are not instrument current. For those pilots who do not have access to an aircraft, the data show that the development of refresher training scenarios where decision making is involved would be an enjoyable and effective way to improve knowledge and self-efficacy. Increases in self-efficacy will result in improved pilot performance during instrument and missed approaches. In the future, further scenario development and an online repository of personal computer flight simulation scenario files could be created to allow pilots to download and fly instrument SBT at home on a regular basis to increase knowledge and self-efficacy at a high level.

REFERENCES

Air America. (2017). *Time builders: Aircraft cost.* Retrieved from http://airamericafc.com/time-builders/

Airplane Owners and Pilots Association (AOPA). (2016). *Air safety institute.* Retrieved from https://www.aopa.org/training-and-safety/air-safety-institute

Alessi, S. M. (1998). Fidelity in the design of instructional simulations. *Journal of computer based instruction, 15*(2), 40-47.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: Jossey-Bass.

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (Complete ed.). New York: Longman.

Baker, R., & Dwyer, F. (2005) Effect of instructional strategies and individual differences: A meta-analytic assessment. *International Journal of Instructional Media, 32*, 69-84.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191-215.

Bandura, A. (2000). Cultivate self-efficacy for personal and organizational effectiveness. In E. A. Locke (Ed.), *Handbook of principles of organization behavior* (pp. 120–136). Oxford, UK: Blackwell.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.*), Self-efficacy beliefs of adolescents* (pp. 307-337). Greenwich, Connecticut: Information Age Publishing.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology, 88,* 87-99. doi:10.1037/0021-9010.88.1.87

Baker, R., Dwyer, F. (2005) Effect of instructional strategies and individual differences: A meta-analytic assessment. *International Journal of Instructional Media, 32,* 69-84.

Barshi, I. (2015). From Healy's training principles to training specifications: The case of the comprehensive LOFT. *The American Journal of Psychology, 128*(2), 219.

Beckman, W. (2003). A evaluation of the perceived effect of personal computer aviation training devices for instrument flight training. *Journal of Aviation/Aerospace Education & Research, 12*(3), 53-64. Retrieved from http://commons.erau.edu/jaaer/vol12/iss3/1

Blickensderfer, E. L., Strally, S., & Doherty, S. (2012). The effects of scenario-based training on pilots' use of an emergency whole-plane parachute. *The International Journal of Aviation Psychology, 22*, 184-202. doi:10.1080/10508414.2012.663253

Bovier, C. (1993). *How a high-tech training system crashed and burned.* Minneapolis: Lakewood Media Group, LLC.

Brady, T., Stolzer, A., Muller, B., & Schaum, D. (2001). A comparison of the learning styles of aviation and non-aviation college students. *Journal of Aviation/Aerospace Education & Research, 11*(1). Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/1689466433?accountid=27203

Brown, L. (2014). Constructivist learning environments and defining the online learning community. *I-Manager's Journal on School Educational Technology, 9*(4), 1-6. Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/1544384175?accountid=27203

Bruner, J. (1996) *The culture of education.* Cambridge, MA: Harvard University Press.

Chi, M. T. H. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1*(1), 73-105. doi:10.1111/j.1756-8765.2008.01005.x

Clauson-Sells, H. (2014). The acculturation and self-efficacy of international college students (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3579041). Retrieved from http://search.proquest.com.ezproxy.libproxy. db.erau.edu/docview/1504643286?accountid=27203

Combs, A. (2001). The PCATD's role in the cognitive processes of flight training. *Journal of Aviation/Aerospace Education & Research, 10*(3).

Dale, E. (1969). *Audio-visual methods in teaching* (3rd ed.). New York: Holt, Rinehart & Winston.

Dwyer, F. (2010). Edgar Dale's cone of experience: A quasi-experimental analysis. *International Journal of Instructional Media, 37*(4), 431. Retrieved from http://go.galegroup.com.ezproxy.libproxy.db.erau.edu/ps/i.do?p=AONE&sw=w&u=embry&v=2.1&it=r&id=GALE%7CA273786647&sid=summon&asid=a4ceaac7ecae3af49184bb11c0f64c3a

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*, 1149-1160.

Federal Aviation Administration (FAA). (2016a). *2016 U.S. civil airmen statics*. Washington, D.C.: U.S. Department of Transportation. Retrieved from http://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics/

Federal Aviation Administration. (1992). *Airplane flight training device qualification. (Advisory Circular 120-45A).* Washington D.C.: U.S. Department of Transportation.

Federal Aviation Administration. (1991). *Airplane simulator qualification (Advisory Circular 120-40B).* Washington D.C.: U.S. Department of Transportation.

Federal Aviation Administration. (2008). *Aviation instructor's handbook.* Washington, D.C.: Department of Transportation.

Federal Aviation Administration. (2012a). *Currency requirements and guidance for the flight review and instrument proficiency check (Advisory Circular 61-98B).* Washington D.C.: U.S. Department of Transportation.

Federal Aviation Administration. (2014a). *FAA Approval of aviation training devices and their use for training and experience (Advisory circular 61-136A).* Washington D.C.: U.S. Department of Transportation.

Federal Aviation Administration. (2014b). *Handbooks & manuals.* Retrieved from http://www.faa.gov/regulations_policies/handbooks_manuals/

Federal Aviation Administration. (2012b). *Instrument flying handbook*. Washington D.C.: U.S. Department of Transportation.

Federal Aviation Administration. (2010). *Instrument proficiency check guidance.* Washington, D.C.: Department of Transportation. Retrieved from https://www.faa.gov/pilots/training/media/IPC_Guidance.pdf

Federal Aviation Administration. (2016b). *Instrument rating – airplane: Airmen certification standards. FAA-S-ACS-8.* Washington, D.C.: U.S. Department of Transportation. Retrieved from https://www.faa.gov/training_testing/testing/acs/media/instrument_rating_acs.pdf

Federal Aviation Administration Safety Team (FAAST). (2014). *DC Special flight rules area course overview*. Washington, D.C.: U.S. Department of Transportation. Retrieved from https://www.faasafety.gov/gslac/ALC/Course Landing.aspx?cID=405

Fowlkes, J., Norman, J. W., Schatz, S., & Stagl, K. C. (2009). Contrasting cases: A strategy for advanced learning using simulation-based training. *Human Factors and Ergonomics Society Annual Meeting Proceedings, 53*(26), 1935-1938. doi:10.1518/107118109X12524444844677

Frasca Flight Simulation. (2017). *Simulators for fixed wing aircraft.* Retrieved from http://www.frasca.com/fixed-wing-simulator-products/#eluid0300744c

Furman, N., and Sibthorp, J. (2013). Leveraging experiential learning techniques for transfer. *New Directions for Adult and Continuing Education, 2013,* 17–26. doi: 10.1002/ace.20041

Garrett, K. (2013). Flight school cost - how much does it cost to learn to fly? *Aviation Schools Online.* Retrieved from http://www.aviationschoolsonline.com/faqs/ article-how-much-does-flight-training-cost.php

Ginzburg, S., & Dar-El, E. (2000). Skill retention and relearning - a proposed cyclical model. *Journal of Workplace Learning, 12*(8), 327-332. Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/198419510?accountid=27203

Griffiths, O., Johnson, A. M., & Mitchell, C. J. (2011). Negative transfer in human associative learning. *Psychological Science, 22*(9), 1198-1204. doi:10.1177/0956797611419305

Henley, I. M. A. (2003). *Aviation education and training: Adult learning principles and teaching strategies*. Burlington, VT: Ashgate.

Instrument Rating Requirements, 14 C.F.R. § 61.65 (2016).

Jones, V. F., & Jones. L. S. (1998). *Comprehensive classroom management: Creating communities of support and solving problems.* Boston: Allyn & Bacon.

Kapp, K. M., & Defelice, R. A. (2009, August 31). Time to develop one hour of training. *Association for Talent Development.* Retrieved from https://www.td.org/Publications/Newsletters/Learning-Circuits/Learning-Circuits-Archives/2009/08/Time-to-Develop-One-Hour-of-Training

Kayes, D. C. (2002). Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning & Education*, *1*(2), 137-149. doi:10.5465/AMLE.2002.8509336

Kirkpatrick, D. L., & Kirkpatrick, J. D. (2006). *Evaluating training programs: The four levels* (Third ed.). San Francisco, CA: Berrett-Koehler.

Knowles, M. S., Holton III, E. F., & Swanson, R. A. (2005). *The adult learner* (6th ed.). Hoboken: Routledge. doi:10.4324/9780080481913

Kolb, D. A. 1984. *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Kontos, A. P. (2004). Perceived risk, risk taking, estimation of ability and injury among adolescent sport participants. *Journal of Pediatric Psychology, 29*, 447–455. http://dx.doi.org/10.1093/jpepsy/jsh048

Kraiger, K., Ford, J. K., & Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology, 78*(2), 311-328. doi:10.1037/0021-9010.78.2.311

Lane, J., & Lane, A. (2001). Self-efficacy and academic performance. *Social Behavior and Personality, 29*(7), 687. Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/209903960?accountid=27203

Liu, D., Macchiarella, N. D., & Vincenzi, D. A. (2009). Simulation to fidelity. In D. A. Vincenzi, J. A. Wise, M. Mouloua, & P. A. Hancock (Eds.), *Human factors in simulation and training* (pp. 61-74). Boca Raton, FL: CRC Press.

Lockheed Martin (2016). *Prepar3d product overview*. Retrieved from http://www.prepar3d.com/product-overview

Mayer, R. E. (2002). *The promise of educational psychology, volume 2: Teaching for meaningful learning*. Upper Saddle River, NJ: Merrill Prentice Hall.

McDermott, J. T. (2005). *A comparison of the effectiveness of a personal computer-based aircraft training device and a flight training device at improving pilot instrument proficiency: A case study in leading regulatory change in aviation education* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3193688). Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/305028534?accountid=27203

Menekse, M. (2012). *Interactive-constructive-active-passive: The relative effectiveness of differentiated activities on students' learning* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3518872). Retrieved from http://search.proquest.com.ezproxy.libproxy.db.erau.edu/docview/1034283822?accountid=27203

Meyers, C., & Jones, T. B., (1993). *Promoting active learning*. San Francisco, CA: Jossey-Bass Publishers.

Moore, P. J. (1997). *Aviation training: Learners, instruction, and organization.* Telfer, R., & Moore, P. J. (Eds.). Aldershot, UK; Brookfield, VT: Avebury Aviation.

Morris, S. B. (2007). Estimating effect sizes from pretest-posttest-control group designs. *Organizational Research Methods, 11*(2), 364-386. doi:10.1177/1094428106291059

Nicholson, D., Fiore, S., Vogel-Walcutt, J. J., & Schatz, S. (2009). Advancing the science of training in simulation-based training. *Human Factors and Ergonomics Society Annual Meeting Proceedings, 53*(26), 1932-1934. doi:10.1518/107118109X12524444844596

Olson, R., & Austin, J. (2005). A step toward early PC-based training that reduces risk: The effects of practicing an "instrument referenced" skill pattern on "visually referenced" performance of beginning flight students. *Journal of Aviation/Aerospace Education & Research, 14*(2).

Ortiz, Y., Blickensderfer, B., Thomas, R., Bois, R., Allen, M., & Mikail, S., Beattie, M. (2016, November). Flight simulation without an instructor: Teaching missed approaches. *Proceedings of the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC),* Orlando, FL.

Recent Flight Experience, 14 C.F.R. § 61.57 (2013).

Rehmann, A. J., Mitman, R. D., Reynolds, M. C., & Crew System Ergonomics Information Analysis Center, Wright-Patterson AFB, OH (CSERIAC). (1995). *A handbook of flight simulation fidelity requirements for human factors research.* Retrieved from https://ntl.bts.gov/lib/000/800/858/tn95_46.pdf

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs: General & Applied. 80*(1), 1–28. doi:10.1037/h0092976

Saitek. (n.d.). *Pro Flight Cessna yoke system for PC*. Retrieved from http://www.saitek.com/uk/prod/cessnayoke.html

Salanova, M., Lorente, L., & Martinez, I. M. (2012). The dark and bright sides of self-efficacy in predicting learning, innovative and risky performances. *Spanish Journal of Psychology, 15*(3), 1123. doi:10.5209/rev_SJOP.2012.v15.n3.39402

Scott, D., & Hargreaves, E. (2015). *The SAGE Handbook of learning*. London: SAGE Publications Ltd. doi: 10.4135/9781473915213

Sense, F., Behrens, F., Meijer, R. R., & Rijn, H. (2016). An individual's rate of forgetting is stable over time but differs across materials. *Topics in Cognitive Science, 8*(1), 305-321. doi:10.1111/tops.12183

Talleur, D. A., Taylor, H. L., Emanuel, T. W., Rantanen, E., & Bradshaw, G. L. (2003). Personal computer aviation training devices: Their effectiveness for maintaining instrument currency. *The International Journal of Aviation Psychology, 13*(4), 387-399. doi:10.1207/S15327108IJAP1304_04

Taylor, H. L., Lintern, G., Hulin, C. L., Talleur, D. A., Emanuel Jr, T. W., & Phillips, S. I. (1999). Transfer of training effectiveness of a personal computer aviation training device. *The International Journal of Aviation Psychology*, 9(4), 319-335. doi:10.1207/s15327108ijap0904_1

Taylor, H. L., Talleur, D. A., Bradshaw, G. L., Emanuel, T. W., Rantanen, E., Hulin, C. L., & Lendrum, L. (2003). *Effectiveness of personal computers to meet recency of experience requirements* (Report No. DOT/FAA/AM-03/3). Washington, D.C.: Government Printing Office.

Thorndike, E. L. (1898). Animal intelligence: An experimental study of the associative process in animals. *Psychological Review Series of Monograph Supplements, 2*(4), 1-107.

Thorndike, E. L. (1927). The law of effect. *American Journal of Psychology, 39*, 212-222.

Treichler, D. G. (1967). Are you missing the boat in training aids? *Film and Audio-Visual Communications (1)*.

Vancouver, J. B., Thomson, C. M., & Williams, A. A. (2001). The changing signs in the relationships among self-efficacy, personal goals and performance. *Journal of Applied Psychology, 86,* 605–620. http://dx.doi.org/10.1037//0021-9010.86.4.605

Watson, J. B. (1930). *Behaviorism.* New York: W. W. Norton and Company Inc.

Wingfield, S. S., & Black, G. S. (2005). Active versus passive course designs: The impact on student outcomes. *Journal of Education for Business, 81*(2), 119-123. doi:10.3200/JOEB.81.2.119-128

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82-91. doi:10.1006/ceps.1999.1016

Zimmerman, B. J., & Kitsantas, A. (2005). Homework practices and academic achievement: The mediating role of self-efficacy and perceived responsibility beliefs. *Contemporary Educational Psychology, 30*(4), 397-417. doi:10.1016/j.cedpsych.2005.05.003

APPENDIX A

Permission to Conduct Research

Embry-Riddle Aeronautical University Application for IRB Approval Exempt Determination

Principle Investigator: Robert Thomas
Other Investigators: Steven Hampton
Role: Faculty
Campus: Daytona Beach **College:** COA
Project Title: Effect of Active Learning Training on Instrument Rated Pilots' Knowledge and Self-Efficacy
Submission Date: 6/13/2017 **Determination Date:** 6/23/2017

Review Board Use Only

Initial Reviewer: Dr. Tim Holt/M.B. McLatchey

Exempt: Yes

Approved:

	M.B. McLatchey	June 15, 2017 Expires: June 14, 2018
Pre-Reviewer Signature	Chair of the IRB Signature	Date of Approval / Expiration Date

Brief Description: The purpose of this research is to demonstrate how a self-paced student experience delivered via technology-enhanced instruction using the simulation software P3D can foster knowledge and skills in general aviation pilots. More specifically, to demonstrate the training effectiveness of active training instructional delivery compared to a passive training module for fostering knowledge for a missed approach due to weather.

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.

☐(2) Research involving **only** the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures (of adults), interview procedures (of adults) or observation of public behavior. Participant information obtained will remain anonymous or confidential.

☐(3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s)

require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☐(4) Research involving the collection or study of **existing** data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

☐(5) Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

☐(6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

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.

IRB Proposal
Embry-Riddle Aeronautical University
Human Subject Protocol Application Form

Type of Project: Ph.D. Dissertation Research Project

Degree Level: Ph.D.

Project Title: EFFECT OF ACTIVE LEARNING TRAINING ON INSTRUMENT RATED PILOTS' KNOWLEDGE AND SELF-EFFICACY

Principal Investigator: Robert Thomas, Assistant Professor, Aeronautical Science Department

List all Other Investigators: Steven Hampton, Dissertation Chair, Doctoral Studies Department

Submission Date:

Beginning Date: **Expected End Date:**

Type of Project: Training effectiveness study

Type of Funding Support (if any):

1. Background and Purpose.

Using simulated, scenario-based methods to train learners how to perform various tasks is common in many different domains. Examples include healthcare, military operations, and aviation. One characteristic of these domains is that learners are developing knowledge and skills for using complex technology effectively. If the learner makes a mistake in a non-simulated situation, the results could be dire. In contrast, practicing a task in a simulated environment allows the learner to apply the knowledge and skills of that task in a safe environment that, in turn, helps prepare them for performance in the operational environment.

As technology continues to advance, scenario-based training continues to improve. Where previous simulations required expensive hardware and software as well as the presence of an instructor, today's technology brings scenario-based practice to the learner--wherever the learner can be found (e.g., home-study, work environment, and so on).

One example of the new accessibility of simulation software is *Prepar3D* (P3D) (www.prepar3d.com). Designed for aviators, P3D allows the learner to practice flight related skills using a desktop computer system. With any new training device, however, comes the question of whether training using that device provides effective learning.

Will students learn from this training within P3D? How well do students learn? Are there predictive qualities from this training that will transfer to pilot performance in actual flight? All of these questions can be addressed using an experimental approach.

The purpose of this research study is to demonstrate how a self-paced student experience delivered via technology-enhanced instruction using the simulation software P3D can foster knowledge and skills in general aviation pilots. More specifically, to demonstrate the training effectiveness of active training instructional delivery compared to a passive training module for fostering knowledge for a missed approach due to weather.

2. Design, Procedure, Materials, and Methods:

The experiment will be a 3 (2 Experimental Groups vs. Control Group) x 2 (Progression: Pre-module vs. Post-Module) Mixed Design

The 2 Experimental groups and Control group will both receive (unless specifically stated otherwise):

1. Informed Consent Form	5 minutes
2. Demographic Questionnaire	5 minutes
3. Pre-Training Self-Efficacy Questionnaire	5 minutes
4. Pre-Training Knowledge Test	30 minutes
5. First Training Activity	20 minutes
6. Optional Break	5 minutes
7. Second Training Activity a. *Control group only* – Control Activity Module b. *Experimental groups only* – P3D Training Module	20-40 minutes
8. Optional Break	5 minutes
9. Reaction Questionnaire	5 minutes
10. Post-Training Self-Efficacy Questionnaire	5 minutes
11. Post-Training Knowledge Test	30 minutes
Total	135 – 155 minutes

First Training Activity. The 2 experimental and control groups will receive the first training activity. The first training activity will be delivered using a web browser on a Microsoft Windows based computer. The lesson will consist of the participant looking at visuals in the form of a slide based presentation while listening to audio instruction.

The Training Module will highlight the fundamentals of missed approach. During the lesson, audio and visual instructions will instruct the participants on missed approach points, aspects of FAR 91.175, how to conduct missed approach procedures, and how to apply weather information for missed approach decisions and procedures.

Second Training Activity. The participants will be divided into three groups, the control group and 2 experimental groups. The Control Group's second training activity will be a passive learning module where they will be instructed to read the provided selection of several pages from FAA Handbooks. The first experiment group will use P3D desktop flight simulation to allow participants to fly four instrument approaches that end in a missed approach and landing. The second experimental group, using P3D desktop flight simulation, will fly four scenarios that will consist of flying four instrument approaches that end in a missed approach and landing. All of the scenarios will occur within the P3D desktop environment in a laboratory in the Human Factors department or the Advanced Flight Simulation Center at ERAU.

Figure 1. P3D participant desktop test-bed.

3. Measures and Observations:

Measurements: This study will utilize multiple measures. These measures will include: a) Demographic questionnaire, b) Self-Efficacy questionnaire, c) Training Reaction Questionnaire, and d) Knowledge Test (Two Versions: Pre- & Post-). Please see Appendix for examples of all measures.

a) Demographic Questionnaire. This questionnaire includes questions which ask for basic information from the participant including: age, pilot certificates and ratings held, flight experience and training, and amount of experience performing missed approach.

b) Self-efficacy. Self-efficacy is a person's belief in their ability to succeed in a specific task (Bandura, 2000). In the current study, self-efficacy is the degree to which participants feel confident in their knowledge of how to perform a missed approach procedure in addition to other aviation knowledge. We are assessing self-efficacy to gain an understanding of the diversity among the participants with respect to their confidence in their own aviation knowledge. The self-efficacy questionnaire is a 12-item assessment that asks participants to rate their self-confidence (from 0-100; 0 meaning not confident and 100 meaning most confident) with various aviation-related events, skills, and knowledge. More specifically, the items on this assessment refer to participant's confidence with a missed landing procedure.

c) Training Reaction Questionnaire. The purpose of this questionnaire is to obtain the students' opinions of using the Prepar3d flight simulation program for flight training. The questionnaire will contain six Likert-scaled items, and the students will be able to rate their reaction and experience from 1 (Low/Not) to 7 (High/Very).

d) Knowledge Test (Two versions: Pre- & Post-). The purpose of these will be to test the students' knowledge of identifying missed approach points, understanding aspects of FAR 91.175 (i.e., when you are allowed to descend from the minimum altitudes), conducting missed approach procedures, and applying updated weather information to make a decision on which airport and approach will allow landing given the current weather conditions.

The Pre-Test's purpose will be to assess the participants' prior knowledge of missed approach. The Post-Test's purpose will be to assess the participants' knowledge of missed approach after having received the training module.

All versions of the knowledge test will contain a series of questions related to missed approach in various question formats (i.e., multiple choice, True/False, answer matching, and fill-in blank).

4. Risks and Benefits.

Potential risks are comparable to a typical two-hour computer-based lesson or test which are slight levels of mental/cognitive stress and fatigue similar to that of using a desktop computer while seated at a desk.

Participants will gain the experience of having participated in a study that will improve the effectiveness of pilot training. The results of this study will benefit general aviation pilots as it will provide results as to whether or not computer SBT active learning training will increase the knowledge and self-efficacy of non-current instrument rated pilots. The could affect how future refresher training for pilots is developed.

5. Informed Consent.

The Informed Consent will be explained to the participants upon their arrival at the experimental site. It will be collected before the demographic questionnaire is distributed to ensure all participants have signed it prior to any research activities (see appendix).

A verbal debriefing will be given upon completion. The participants will be thanked for their time and asked if they have any questions. The researcher will give the full debriefing and ensure that all the participants' questions are answered.

6. Anonymity.

The participant information will be confidential (only the researcher will have access to participant information for verification of eligibility; however, names or any other identifying demographics cannot be matched). Confidentiality ensures that the participants will be protected and feel that they can answer any questions truthfully. Publication of data will not include any identifying information.

7. Privacy.

There will be no video or audio recordings. All data collected in the study will be kept under lock and key in the Aeronautical Science Department at Embry-Riddle Aeronautical University in Daytona Beach, FL. Each participant will be assigned a random participant ID number which will be listed on all testing and survey instruments.

Any data collected from participants that choose to opt out during the research will be deleted or destroyed as appropriate.

8. Participant Population and Recruitment Procedures.

Participants (N=48) will be recruited from Embry-Riddle Aeronautical University in Daytona Beach, FL, as well as other locations in Florida. To be eligible for the study, participants must be at least 18 years of age, hold a pilot certificate with an instrument rating, and not be instrument current according to 14 CFR 61.57.

Participants will be recruited using emails, posted flyers, website postings, and classroom visits. Emails will be sent to faculty members of the COA requesting if they could verbally announce and/or post an electronic message through CANVAS to their students.

9. Economic Considerations.

Participants that participate and complete the study will be entered in a drawing to win one of two iPads. The iPads will be purchased and provided by the Dean of the College of Aviation.

Participants who show up for the research but refuse informed consent will be thanked for their time but not entered in the drawing. Participants who start the research but fail to complete the research will be thanked for their time but not entered in the drawing.

No extra credit will be given for ERAU students who participate in this study.

10. Time.

It will take approximately 2 to 2 ½ hours to complete (includes optional 5 minute breaks as needed).

CONSENT FORM

I consent to participating in the research project entitled: EFFECT OF ACTIVE LEARNING TRAINING ON INSTRUMENT RATED PILOTS' KNOWLEDGE AND SELF-EFFICACY.

The purpose of this study is to examine GA pilots' understanding of missed approach procedures. Study participants will complete several written questionnaires and activities pertaining to missed approach procedures.

The study will have two parts: a pre- and a post-test. The total duration of the study will be approximately two to two and a half hours. Participants may not use any notes or electronics to help them answer any of the questions. Potential risks during the study are comparable to a typical two-hour computer-based lesson or test which are slight levels of mental/cognitive stress and fatigue similar to that of using a desktop computer while seated at a desk.

The eligibility requirement to participate in this study is: participants must be at least 18 years of age and currently hold a pilot certificate with an instrument rating and not be instrument current in accordance with 14 CFR 61.57.

If the researcher informed me that I am eligible to participate, I will be enrolled in a drawing to receive an iPad for my participation.

All participants are guaranteed confidentiality. Your name will not be on any questionnaire and/or associated with any experiment data or results. Only members of the research team will have access to the participant information. Your name will not be published in any results. All data collected in the study will be kept under lock and key in the Aeronautical Science Department at Embry-Riddle Aeronautical University in Daytona Beach, FL.

For more information about the study and the results please contact the *Principle Investigator (PI)*, Robert Thomas, at thomasr7@erau.edu, 386-226-6959.

The individuals above, or their research assistants, have explained the purpose of the study, the procedures to be followed, and the expected duration of my participation.

I acknowledge that I have had the opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my full satisfaction.

Furthermore I understand that I am free to withdraw consent at any time and to discontinue participation in the study without prejudice to me.

Finally I acknowledge that I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Name *(please print)*: ________________________________Date: _____________
(Participant)

Signed: ____
(Participant)

Signed: ____
(Researcher)

APPENDIX B

Demographic Survey

Participant Number: __________________

Demographic Survey

1. Which gender do you most closely identify with?
    a. Female
    b. Male
    c. Other
    d. Prefer not to answer
2. What is your current age?

3. What pilot certificate do you currently hold?
    a. Private
    b. Commercial
    c. ATP
4. Do you hold instrument rating? (If you are an ATP, please answer yes)
    a. Yes
    b. No
5. Do you hold a flight instructor certificate?
    a. Yes
    b. No

6. Where did you complete the majority of your flight training?
    a. Part 61 (e.g. Local FBO)
    b. Part 141/142 Collegiate Program
    c. Part 141/142 Non-Collegiate
    d. Military

7. Approximately what is your total flight time?

8. Which region did you complete the majority of your total flight hours (e.g., Northwest for Oregon; Southwest for Arizona)?
    a. **Northwest –** (Idaho, Montana, Oregon, Washington, Wyoming)
    b. **Southwest –** (Arizona, California, Colorado, Nevada, New Mexico, Utah)
    c. **North-Central –** (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota)
    d. **South-Central –** (Arkansas, Louisiana, Mississippi, Oklahoma, Texas)
    e. **East-Central** – (Illinois, Indiana, Michigan, Ohio, Wisconsin)
    f. **Northeast –** (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia)
    g. **Southeast –** (Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee)
    h. **Alaska**
    i. **Hawaii**
    j. **Not in the United States**
9. Approximately how many years have you been flying?

10. How many hours of dual received have you logged?

11. If you are a flight instructor, how many hours of dual given have you logged?

12. Within the past 90 days, approximately how many hours have you flown?

13. Do you meet the currency requirements to act as PIC of an aircraft (have a current flight review)?
    a. Yes
    b. No
14. Do you meet the currency requirements to act as PIC of an aircraft under instrument flight rules (instrument currency requirements)?
    a. Yes
    b. No

15. Approximate total number of flight hours under actual instrument conditions

16. Approximate total number of flight hours under simulated instrument conditions (i.e., under the hood)

17. Approximate total number of hours in a Flight Training Device toward instrument training

18. Approximate total number of instrument approaches conducted

19. Have you conducted a missed approach in actual instrument conditions because the weather conditions did not allow a legal landing at the airport?
    a. Yes
    b. No
20. If you answered yes, approximately how many missed approaches have you conducted because of weather conditions?

APPENDIX C

Self-efficacy Questionnaire

Self-efficacy Questionnaire

Participant #: ________________

This questionnaire is designed to help us get a better understanding of how pilots understand concepts and tasks associated with a missed approach. Please rate your degree of confidence by recording a number from 0 (cannot do) through 100 (certain can do) of how confident you think you are at the following items.

1. Skill at interpreting weather information (METAR)	
2. Knowledge of how to perform a missed approach	
3. Skill to successfully perform a missed approach	
4. Interpreting approach plate information	
5. Knowledge of how to perform a precision instrument approach	
6. Sill to successfully perform a precision instrument approach	
7. Knowledge of how to perform a non-precision instrument approach	
8. Skill to successfully perform a non-precision instrument approach	
9. Knowledge of visual decent points	
10. Skill at calculating descent rates	
11. Knowledge of landing requirements from an instrument approach under IFR	
12. Knowledge of flight visibility and runway visual range definitions	

13. Knowledge of approach categories on instrument approach procedure	
14. Skill of selecting the correct minimums for an instrument approach	
15. Knowledge of how to choose an instrument approach based on current weather conditions	
16. Skill of choosing an instrument approach based on current weather conditions	
17. Skill at selecting an airport based on current weather conditions	

APPENDIX D

Pre-training Knowledge Test

Pre-training Knowledge Test

1. The missed approach point on a precision instrument approach is called the __________.
    a. Minimum Descent Altitude
    b. Decision Altitude
    c. Visual Descent Point
    d. Touchdown Zone Elevation

2. The lowest altitude reached on a non-precision instrument approach is called the __________.
    a. Minimum Descent Altitude
    b. Decision Altitude
    c. Visual Descent Point
    d. Touchdown Zone Elevation

3. Which of the following requirements is needed in order to legally land from an instrument approach?
    a. Normal rate of descent
    b. Visibility required by the instrument approach
    c. Landing environment in sight
    d. All of the above

4. What is the lowest approach category an aircraft with a stall speed (Vso) of 60 kts could use?
    a. A
    b. B
    c. C
    d. D

5. What is the lowest approach category an aircraft with a stall speed (Vso) of 85 kts could use?
    a. A
    b. B
    c. C
    d. D

6. On the PDT ILS 25 approach chart, the required visibility for the ILS RWY 25 approach (in feet) for a category A aircraft is _________.
    a. 2400
    b. 1800
    c. 1300
    d. 4000

7. On the PDT RNAV 7 approach, the visual decent point is located ____________.
   a. 1.1 NM from the runway 7 threshold
   b. CESMI
   c. CIMAG
   d. Upon descending to 1763 feet

8. On the PDT RNAV 11 approach, what is the required visibility for a category A aircraft flying the LPV approach?
   a. 1 1/4 SM
   b. 1 SM
   c. 1 1/2 SM
   d. 1737 RVR

9. Refer to the PDT VOR RWY 7 approach, which of the following weather conditions would allow the pilot of a category A aircraft to land on RWY 7?
   a. Visibility 3/4 SM and ceiling overcast at 1900 feet
   b. Visibility 1/2 SM and ceiling overcast at 2100 feet
   c. Visibility 3/4 SM and ceiling overcast at 2100 feet
   d. Visibility 1/2 SM and ceiling overcast at 1900 feet

10. Refer to the SPI ILS 4 approach, the required visibility for the ILS RWY 4 approach (in feet) for a category A aircraft is _________.
    a. 792
    b. 980
    c. 2400
    d. 3500

11. Refer to the SPI RNAV 31 approach, the visual decent point is located ____________.
    a. At WOPEX
    b. 1.8 NM from the RWY 31 threshold
    c. When descending to 840 feet
    d. When directed by ATC

12. Refer to the SPI RNAV 31 approach, what is the required visibility for a category A aircraft?
    a. ¼ SM
    b. ½ SM
    c. ¾ SM
    d. 1 SM

13. Refer to the SPI VOR/DME RWY 13 approach, which of the following weather conditions would allow the pilot of a category B aircraft to land on RWY 13?
    a. Visibility ½ SM and Ceiling Overcast at 800
    b. Visibility 3/4 SM and Ceiling Overcast at 1000
    c. Visibility 1 SM and Ceiling Overcast at 800
    d. Visibility 1 SM and Ceiling Overcast at 1000

14. If a visual descent point is not given, the pilot can create one by taking the height above touchdown zone elevation and dividing it by _____ to determine a distance in nautical miles.
    a. 100
    b. 200
    c. 300
    d. 400

15. If the height above a runway's TDZE is 900 feet, the visual descent point should be approximately ____ NM away from the runway threshold.
    a. 1
    b. 2
    c. 3
    d. 4

16. Which of the following can NOT be used to determine appropriate visibility for an instrument approach?
    a. Flight visibility
    b. Runway visual range
    c. Tower visibility

17. A ____________ is the point at which, if the pilot were at the MDA and saw the runway, he or she would be stable to land.
    a. Minimum Descent Altitude
    b. Decision Altitude
    c. Visual Descent Point
    d. Normal rate of descent

18. While in flight, the distance the pilot is able to see outside the aircraft is _____________.
    a. Minimum Descent Altitude
    b. Decision Altitude
    c. Flight Visibility
    d. Runway Visual Range

19. Alternate airports must be within the plane’s ___________.
    a. visual range
    b. fuel range
    c. instrument range
    d. radar system

20. When the runway is in sight, the pilot can use excessive rates of descent in order to ensure landing.
    a. True
    b. False

21. A higher category airplane can fly a slower approach in order to use lower minimums from a different category.
    a. True
    b. False

22. Pilots should immediately execute the missed approach procedure if, when reaching the MAP, the runway environment is in sight.
    a. True
    b. False

23. See the provided TAF for Van Nuy's Airport (KVNY) below and the VNY ILS 16R approach. If you arrive at the airport at 21Z, would you expect the weather to allow you to land using that approach in a category A aircraft?

    KVNY 291133Z 2912/3012 VRB03KT 1 1/2SM OVC014
    FM292000 14009KT 1SM OVC014
    FM300000 28007KT 1 1/2SM BKN016
    FM300300 VRB03KT 2SM BKN018

    a. Yes
    b. No

24. You have just executed a missed approach due to weather conditions at Saranac Lake Airport (SLK). Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land given the weather conditions in a category A aircraft.

    KMSS 291130Z 2912/3012 21006KT 1/2SM OVC004 BKN012
    KPBG 291130Z 2912/3012 18005KT 1SM VCSH OVC005
    KOGS 291120Z 2912/3012 17006KT 3/4SM OVC005 FEW200

    a. MSS
    b. PBG
    c. OGS
    d. None of the above

25. You have just executed a missed approach due to weather conditions at Greenville Mid-Delta Airport (KGLH). Given the approach charts and weather information provided and that you have sufficient fuel on board, select an airport that would allow you the best chance to land given the weather conditions in a category A aircraft.

    KRNV 161735Z AUTO 02009KT 1/2SM BR OVC005 SCT022 SCT027 27/22 A2988 RMK AO2 LTG DSNT E T02700219
    KLLQ 161736Z 2918/3018 03007KT 3/4SM -RA OVC007FEW025
    KGWO 161738Z 2918/3018 01006KT 1SM VCSH OVC005 BKN015

    a. KRNV
    b. KLLQ
    c. KGWO
    d. None of the above

26. While flying an instrument approach with a 3.0-degree glide slope at a ground speed of 98 knots, what rate of descent should you aim for to maintain a stable approach?
    a. 98 feet/minute
    b. 980 feet/minute
    c. 490 feet/minute
    d. 650 feet/minute

27. Which instrument approach would you most likely land from given the current weather conditions for KBVY in a category A aircraft?

    KBVY 061338Z 2918/3018 16010KT 1SM OVC005 BKN015

    a. LOC RWY 16
    b. RNAV RWY 16
    c. VOR RWY 16
    d. None of the options listed above are viable.

28. You have just executed a missed approach from Kenosha Regional (KENW) due to low ceilings. Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category A aircraft.

    KMKE 251752Z 02011KT 3SM BKN003 FEW033 18/12 A2965 RMK AO2 SLP038 T01780117 10178 20128 50003
    KMWC 251745Z 36010KT 1SM BKN002 19/11 A2965
    KUES 251745Z 32009KT 3SM BKN002 SCT030 OVC041 17/11 A2966

    a. KMKE (ILS1L)
    b. KMWC (RNAV 4L)
    c. KUES (ILS 10)
    d. None of the options listed above are viable.

29. You have just executed a missed approach from Jesup-Wayne County Airport (KJES) due to low ceilings. You must now choose an alternate airport. Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category A aircraft.

    KBQK 251835Z AUTO 27011G18KT 1/4SM R07/ 1000FT BR OVC005 26/12 A2981 RMK AO2
    KSSI 251753Z AUTO 25012G20KT 1SM OVC005 26/11 A2980 RMK AO2 SLP093 T02560106 10261 20194 51007
    KAYS 251835Z AUTO 28010G20KT 250V320 M1/4SM R19/0800FT FG OVC035 27/12 A2982 RMK AO2 T02660123

    a. KBQK (ILS 7)
    b. KSSI (RNAV22)
    c. KAYS (ILS 19)
    d. None of the options listed above are viable.

30. Which instrument approach would allow you the best chance to land given the current weather conditions for KISP in a category A aircraft?

    KISP 251956Z 09011G18KT 1 1/2SM -DZ BR OVC003 15/15 A2957 RMK AO2 SFC VIS 2 DZE15B32RAB15E32 SLP013 P0000 T01500150

    a. LOC RWY 6
    b. RNAV RWY 6
    c. ILS RWY 24
    d. None of these approaches

APPENDIX E

Post-training Knowledge Test

Post-training Knowledge Test

1. The missed approach point on a precision instrument approach is called the ____________________.
   a. Decision Altitude
   b. Visual Descent Point
   c. Minimum Descent Altitude
   d. Touchdown Zone Elevation

2. The lowest altitude reached on a non-precision instrument approach is called the __________.
   a. Decision Altitude
   b. Minimum Descent Altitude
   c. Touchdown Zone Elevation
   d. Visual Descent Point

3. Which of the following requirements is not needed in order to legally land from an instrument approach.
   a. Normal rate of descent
   b. Visibility required by the instrument approach
   c. Landing environment in sight
   d. Rotating beacon in sight

4. An aircraft with a stall speed (Vso) of 60 knots flying an approach at a speed of 85 knots would be in which approach category?
   a. A
   b. B
   c. C
   d. D

5. What is the lowest approach category that an aircraft with a stall speed of 80 knots could use?
   a. A
   b. B
   c. C
   d. D

6. On the TEB LOC 6 approach, the required visibility (in feet) for a category A aircraft is _________.
   a. 3500
   b. 2320
   c. 1687
   d. 2400

7. On the TEB RNAV Y RWY 6 approach, the visual decent point is located ____________.
    a. Upon descending to 369 feet
    b. STICC
    c. RW06
    d. 2.3 NM from RW06

8. On the TEB RNAV Y 19 approach, the required visibility using LPV minimums for a category A aircraft is _________.
    a. 3/4 SM
    b. 1 1/2 SM
    c. 4 SM
    d. 4000 RVR

9. Refer to the TEB ILS RWY 19 approach, which of the following weather conditions would allow the pilot of a category A aircraft to land on RWY 19 with ILS minimums?
    a. Visibility 1/2 SM and ceiling overcast at 400 feet
    b. Visibility 1 SM and ceiling overcast at 200 feet
    c. Visibility 1/2 SM and ceiling overcast at 200 feet
    d. Visibility 1 SM and ceiling overcast at 400 feet

10. On the COS LOC 17L approach with one VOR receiver, the required visibility (in feet) for a category B aircraft is _________.
    a. 4000
    b. 1800
    c. 7020
    d. 5500

11. On the COS ILS 17L approach, the decision altitude (in feet) for a category C aircraft is _______.
    a. 8700
    b. 7540
    c. 6387
    d. 7020

12. Refer to the COS NDB RWY 35L approach. Which of the following weather conditions would allow the pilot of a category A aircraft to land on RWY 35L?
    a. Visibility 2400 RVR and ceiling overcast at 6500 feet
    b. Visibility 4000 RVR and ceiling overcast at 6700 feet
    c. Visibility 1/2 SM and ceiling overcast at 6500 feet
    d. Visibility 2400 RVR and ceiling 6700 feet

13. On the COS RNAV 31 straight-in approach, what is the required visibility for a category D aircraft?

a. 1 SM
b. 1 ¼ SM
c. 1 ½ SM
d. 2 SM

14. Pilots can calculate the Visual Descent Point for a given approach by dividing the _____________ by 300.
    a. TDZE
    b. MDA
    c. Decision Altitude
    d. height above the TDZE

15. If the height above a runway's TDZE is 600 feet, the visual descent point should be approximately ____ NM away from the runway threshold.
    a. 1
    b. 2
    c. 3
    d. 4

16. Which of the following can NOT be used to determine appropriate visibility for an instrument approach?
    a. Tower visibility
    b. Flight visibility
    c. Runway visual range

17. A ____________ is the point in at which, if the pilot were at the MDA and saw the runway, he or she would be stable to land.
    a. Visual Descent Point
    b. Minimum Descent Altitude
    c. Normal rate of descent
    d. Decision Altitude

18. While in flight, the distance the pilot is able to see outside the aircraft is _____________.
    a. Decision Altitude
    b. Runway Visual Range
    c. Minimum Descent Altitude
    d. Flight Visibility

19. Before descending below the MDA or DA, the pilot must see and identify the _________?
    a. control tower
    b. fuel range

c. landing environment
d. weather conditions

20. Visibility requirements vary based on the type of instrument approach and the approach speed of the aircraft.
    a. True
    b. False

21. Pilots should immediately execute the missed approach procedure if the positive course guidance is lost at any time during the approach.
    a. True
    b. False

22. Pilots should immediately execute the missed approach procedure if, after the missed approach point, the pilot maintains visual contact with the landing environment.
    a. True
    b. False

23. See the provided weather forecast for Dexter R. Florence Memorial Field (KADF). Given the approach charts and weather information provided and that you have sufficient of fuel on board, would you expect to land at KADF in a category A aircraft?

    KADF 291736Z 2918/3018 04008KT 1SM SCT010 OVC004

    a. Yes
    b. No

24. You have just executed a missed approach due to weather conditions at McNary Field (KSLE). Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category A aircraft.

    KOTH 291835Z 22004KT 1SM OVC003 13/12 A3001 RMK AO1
    KONP 291835Z AUTO 20010KT 3/4SM BR OVC002 12/11 A2998 RMK AO2
    KSLE 291756Z 30003KT 1/2SM OVC004 18/07 A2993 RMK AO2 SLP135 T01780067 10178 20067 51005

    a. KOTH
    b. KONP
    c. KSLE
    d. None of the above

25. You have just executed a missed approach due to weather conditions at Houston County Airport (KCHU). Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category A aircraft.

    KDEH 291915Z AUTO 35011KT ½SM OVC008 18/04 A3016 RMK AO2
    KLSE 291853Z 03008KT 3SM OVC010 18/04 A3018 RMK AO2 SLP215 T01780039
    KFKA 291912Z AUTO 03008KT ½SM OVC004 16/02 A3019 RMK AO2 T01610024

    a. KDEH
    b. KLSE
    c. KFKA
    d. None of the above

26. While flying an instrument approach with a 3.0-degree glide slope at a ground speed of 92 knots, what rate of descent should you aim for to maintain a stable approach?
    a. 500 feet/minute
    b. 46 feet/minute
    c. 920 feet/minute
    d. 460 feet/minute

27. Which instrument approach would you most likely land given the current weather conditions for KBVY?

    KBVY 061338Z 2918/3018 16010KT 1SM OVC005 BKN012

    a. LOC RWY 16
    b. RNAV RWY 16
    c. VOR RWY 16
    d. Neither of the options listed above are viable.

28. You have just executed a missed approach from San Francisco International (KSFO) due to low visibility. Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category A aircraft.

    KOAK 251853Z 22019KT 1/4SM R30/1000ft +FGRA OVC001 SCT024 OVC032 18/11 A2979 RMK AO2 SLP089 T01780111
    KHWD 251854Z 26006KT 1/2SM R12/4000ft BR OVC037 19/08 A2978 RMK AO2 SLP094 T01890083
    KHAF 251855Z AUTO 19011G15KT 3/4SM R30/5000FT FG SCT005 BKN013 12/11 A2982 RMK AO2

    a. KOAK (ILS 30)
    b. KHWD (RNAV 28L)
    c. KHAF (RNAV 12)
    d. None of the above

29. You have just executed a missed approach from Wilkes-Barre/Scranton International (KAVP) due to weather. Given the approach charts and weather information provided and that you have sufficient of fuel on board, select an airport that would allow you the best chance to land in a category B aircraft.

    KHZL 251915Z AUTO 09007G15KT 3SM BR OVC002 15/13 A2954 RMK AO2
    KABE 251858Z 07009KT 10SM OVC009 17/14 A2952 RMK AO2 T01720144
    KXLL 251915Z AUTO 07008KT 10SM OVC007 17/15 A2952 RMK AO2

    a. KHZL (RNAV 10)
    b. KABE (ILS6)
    c. KXLL (RNAV 7)
    d. None of the above

30. Which instrument approach would allow you the best chance to land given the current weather conditions for KLEX in a category A aircraft?

    KLEX 251954Z 28016G25KT 3/4SM R22/5000FT OVC008 15/13 A2962 RMK AO2 PK WND 28029/1935 RAE16 CIG 005V012 SLP026 P0002 T01500128 $

    a. ILS RWY 22
    b. RNAV RWY 22
    c. RNAV RWY 27
    d. None of these approaches

APPENDIX F

Reaction and Motivation Questionnaire

Reaction and Motivation Questionnaire

Participant #: ________________

Directions: Please rate your reactions to the following items in terms of your opinions of the training lesson you just participated in.

1. The overall quality of this training course.

Very	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Low								**High**

2. The relevance to instrument flight.

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Relevant								**Relevant**

3. The quality of the course materials.

Very	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Low								**High**

4. The course materials were clear.

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Clear								**Clear**

5. The amount of knowledge you gained from this course?

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Much								**Much**

6. The course increased my knowledge to perform a missed approach.

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Much								**Much**

7. I tried my hardest to learn.

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Hard								**Hard**

8. I did my best.

Low	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**High**

9. I paid full attention to the lesson.

Not	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very**
Much								**Much**

10. I wanted to learn during this lesson.

Not Much	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very Much**

11. I took this lesson seriously.

Not Seriously	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Very Seriously**