January 2015

UNEXPECTED TRANSITION FROM VFR TO IMC: AN EXAMINATION OF TRAINING PROTOCOLS TO MITIGATE PILOT GAPS IN KNOWLEDGE AND PERFORMANCE

Julius Keller
Purdue University

Graduate School Form 30
Updated 1/15/2015

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By Julius C. Keller

Entitled

UNEXPECTED TRANSITION FROM VFR TO IMC: AN EXAMINATION OF TRAINING PROTOCOLS TO MITIGATE PILOT GAPS IN KNOWLEDGE AND PERFORMANCE.

For the degree of Doctor of Philosophy

Is approved by the final examining committee:

Thomas Q. Carney, Ph.D.
Chair

Richard O. Fanjoy, Ph.D.

Sarah Hubbard, Ph.D.

James P. Greenan, Ph.D.

To the best of my knowledge and as understood by the student in the Thesis/Dissertation Agreement, Publication Delay, and Certification Disclaimer (Graduate School Form 32), this thesis/dissertation adheres to the provisions of Purdue University's "Policy of Integrity in Research" and the use of copyright material.

Approved by Major Professor(s): Thomas Q. Carney, Ph.D.

Approved by: Kathryne A. Newton, Ph.D. 11/17/2015

Head of the Departmental Graduate Program Date

UNEXPECTED TRANSITION FROM VFR TO IMC: AN EXAMINATION OF TRAINING PROTOCOLS TO MITIGATE PILOT GAPS IN KNOWLEDGE AND PERFORMANCE

A Dissertation

Submitted to the Faculty

of

Purdue University

by

Julius C. Keller

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

December 2015

Purdue University

West Lafayette, Indiana

Special thanks to my family, friends, and supporters. Without your unwavering support, encouragement, and love, accomplishing this goal would not be possible. I deeply love you all.

ACKNOWLEDGEMENTS

The faculty and staff at Purdue University provided an exceptional level of support and encouragement. I will always be grateful for the opportunity to conduct research and represent Purdue University. My committee members included Dr. Thomas Carney, Dr. Richard Fanjoy, Dr. Sarah Hubbard, and Dr. James Greenan. Dr. Carney fostered mentorship and friendship the first day we met. His character provides a model for inspiration. Dr. Richard Fanjoy, was an exceptional advocate and supporter. Throughout our discussions, he guided me on what being a PhD student/candidate was all about. Dr. Sarah Hubbard, motivated me to maximize my potential. Her caring, kind, and charismatic nature provided me with confidence throughout the dissertation process. Dr. James Greenan gave exceptional knowledge on instructional methods. His willingness to give his time and remarkable expertise, made this project more worthwhile. When these talented individuals met to discuss the project, I was always left amazed and encouraged by their collegiality. In addition to the committee, my research partner, Allen Xie, provided tremendous value to this project. His many talents are beyond his years; he truly is a remarkable person and has a very bright future. Many thanks to all of the PEGASAS team members including those at the FAA Technical Center, Frasca International, WMU, TAMU, and The Ohio State University. This section could go on infinitely expressing my gratitude to you folks.

TABLE OF CONTENTS

Page

Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACS-Airman Certification Standards

AOPA-Aircraft Owners Pilots Association

ASOS-Automated Surface Observation Station

ATIS-Automatic Terminal Information Service

AWOS-Automated Weather Observation Station

FAA-Federal Aviation Administration

FTD-Flight Training Device

GA-General Aviation

IFR-Instrument Flight Rules

IMC-Instrument Meteorological Conditions

NTSB-National Transportation Safety Board

VFR-Visual Flight Rules

VMC-Visual Meteorological Conditions

ABSTRACT

Keller, Julius C. Ph.D., Purdue University, December 2015. Unexpected transition from VFR into IMC: An evaluation of training protocol to mitigate pilot gaps in knowledge and performance. Major Professor: Thomas Q. Carney, Ph.D.

During the past ten years, there have been 264 aircraft accidents identified as Visual Flight Rules (VFR) into Instrument Meteorological Conditions (IMC). These accidents have a nearly 90% fatality rate and hundreds of people have been fatally injured (ASI, 2014a). The general aviation community, including the Federal Aviation Administration, has called for measures to reduce the accident rate. To accomplish this goal, data analyses, education and training, and collaboration are recommended practices. This research study sought to examine the effectiveness of two training protocols as well as pilot knowledge, skills, and abilities pertaining to VFR into IMC. Data were collected at two sites, the William J. Hughes Technical Center (FAA Technical Center) located in Atlantic City, New Jersey and Purdue University located in West Lafayette, Indiana. Participants were recruited from the surrounding areas of each location.

Researchers of the current study utilized a pretest and posttest experimental design. Furthermore, data were collected through researcher observation of pilot performance during flight training device (FTD) sessions. The only group to indicate a statistically-significant increase in posttest scores, was the control group from the FAA Technical Center dataset. The interactive online group had the highest frequency and percentage of decisions made to avoid instrument meteorological conditions (IMC) during flight scenarios, in both data sets. An examination of qualitative data revealed participants who decided to continue into instrument meteorological conditions did so because they misperceived the flight conditions and risks. Those who turned and/or diverted, did so because they perceived unsafe conditions and took action to mitigate the risks. Though the treatments did not appear to statistically distinguish posttest scores between groups or decision making, other notable results and lessons learned are discussed. Additionally, recommendations for future research are presented.

CHAPTER 1. INTRODUCTION

According to the AOPA Air Safety Institute (ASI) (2014a), 264 accidents were identified as continued visual flight rules (VFR) into instrument meteorological conditions (IMC) during 2004-2014. Eighty-nine percent of these accidents were fatal, causing hundreds of deaths. The Federal Aviation Administration (FAA) (2011) is focused on reducing general aviation's (GA) fatal accident rate by 10 percent over the next ten-year period. VFR into IMC is a top 10 leading cause for fatal accidents in general aviation. The FAA's plan of action for improving safety includes: data analysis, outreach and education, flight instructor training, collaboration with industry, and establishing committees to develop interventions based on research.

This study sought to evaluate pilot performance when faced with VFR into IMC situations. Two locations were selected to perform the experiment. The first location was at the William J. Hughes Technical Center located in Atlantic City, New Jersey. The second location was at Purdue University. Two ground-based flight training devices (FTD) were utilized at the first location. A simulator manufacturer and research partner, Frasca International, provided the mobile simulator unit used at the second location.

A pretest posttest experimental design with random assignment was utilized to evaluate the effectiveness of two training protocols. The experimental design consisted of three groups. The first group was a control group whose participants did not receive any treatment. The second group participated in an online interactive short course developed by project researchers. Participants were able to navigate the online course independently. The third group participated in a training workshop conducted by the principal investigator (PI). Treatments employed in this study were tailored in an attempt to boost participant aeronautical knowledge, skills, and abilities pertinent to weather and pilot decision-making. In addition to the evaluation of pretest and posttest scores, two flight training device scenarios were designed to simulate real-world VFR into IMC scenarios for further evaluation. This study is consistent with the FAA and general aviation community's goal of reducing the GA accident rate.

1.1 Scope

A pilot can be certified to operate an aircraft at one or more privilege levels. The levels are listed in order of increasing experience and/or privilege. FAA pilot certification includes: student pilot, sport pilot, recreational pilot, private pilot, commercial pilot and airline transport pilot. A pilot can add an instrument rating to the private and commercial pilot certificate. Doing so requires the pilot to receive additional knowledge, experience, and evaluation mandated by the FAA. An instrument rating allows a pilot to operate under instrument flight rules (IFR).

According to the Code of Federal Regulations (CFR) (2015), only instrument-rated pilots are allowed to operate in conditions that require sole reference to instruments. The ideal participant in this study was a pilot who held at least a private pilot certificate without an instrument rating. In theory, these pilots are supposed to operate clear of weather conditions that are not suitable for visual reference. The current study evaluated how selected pilots perform when encountering deteriorating weather conditions. The researchers desired to recruit 84 participants in total. To reach this number, some participants had higher certificates and/or instrument ratings.

Researchers of this study incorporated methods for instruction based on research pertaining to adult learning, memory recall, and engagement, for the experimental groups. The treatments used in this study were comprised of supplemental weather information provided by the FAA and educational material from the Aircraft Owners and Pilots Association (AOPA). Pretest and posttest questions were derived from FAA airmen testing standards. Flight scenario evaluations were based on three main concepts: perception, processing, and performance. A pilot should accurately perceive meteorological conditions by collecting preflight information accurately and observing conditions while in flight. A pilot should process the weather data and conditions to determine whether any hazards create risks. Lastly, a pilot should perform by acting to eliminate the danger or alleviate the risk(s).

The research methodology included both quantitative and qualitative methods. The quantitative method included an analysis of pretest-posttest scores and the type of decision made during the flight training device scenarios. The qualitative method included an examination of participant responses pertaining to decision- making. The combination of these methods provided an in-depth understanding of the decision-making process and performance of pilots when faced with deteriorating weather conditions.

1.2 Significance

This study provided an in-depth analysis of general aviation pilot knowledge, skills, and abilities pertaining to low visibility encounters. In addition to the evaluation of pilot performance, two training protocols were evaluated. Researchers of the current study accomplished data collection through a pretest, posttest, and post-posttest. Furthermore, data were collected by researcher observation of pilot performance during flight training device sessions.

As the general aviation community commits to improving safety, this study is in line with industry efforts. Based on the results of this study, the general aviation research community may have a clearer understanding with the complexity of how pilots perceive, process, and perform during low visibility encounters. Findings from this study may lead researchers to future efforts and a more focused direction of investigation.

1.3 Research Questions

This study had one main research question and several sub questions. The primary research question was: Can focused workshops or interactive weather training short-courses significantly affect GA pilot weather knowledge and flight behavior in VFR-into-IMC situations?

The following sub questions were also addressed in this study:

1. *Research Question 1*: Is there a statistically-significant difference in pre-and posttests between and within the control and experimental groups?

2. *Research Question 2*: Which group of participants had the highest frequency of avoiding instrument meteorological conditions during flight training device scenarios?

3. *Research Question 3*: How do participants perceive their decision-making when asked after flight training device sessions?

1.4 Assumptions

The assumptions of this study were:

1. Participants were trained in accordance with Federal Aviation Administration Regulations and were deemed fit to conduct pilot operations.
2. Participants were aware of how to read weather reports, make appropriate and safe decisions, recognize deteriorating conditions, and safely perform in the flight training device.
3. Participants would have experience operating a FTD.
4. Participants would perform as if they were conducting a real flight in accordance with Federal Aviation Regulations.
5. Participants were unaware of the dependent variables of this study.

1.5 Limitations

The limitations of this study are:

1. Flight training devices did not function properly 100 percent of the time.
2. Flawed video recordings made data verification difficult.
3. Not all 84 recruited participants completed the study in its entirety, creating a small sample size.
4. To increase the sample size some participants were allowed to participate even though they had higher certificates/ratings and hours than desired. For the FAA Technical Center participants, nine out of the sixteen control group subjects had higher qualifications than desired. The interactive online group also had nine

out of sixteen participants with higher qualifications. Ten out of the sixteen interactive workshop participants had higher qualifications than desired.

For the data collected at Purdue, none of the control group participants had higher qualifications than desired, one out the seven interactive online participants had higher qualifications, and one out of the eight interactive workshop members had higher qualifications than desired. The participants from the dataset collected at Purdue University were more representative of the desired participant profile.

1.6 Delimitations

The delimitations of this study are:

1. A convenient sampling method was used.
2. Data collection was conducted at two locations, Atlantic City, New Jersey and West Lafayette, Indiana.
3. The flight training devices used at the two locations were different representations of GA aircraft.
4. Different recruiting and scheduling procedures were used at the two locations.
5. Participants should be private pilots with less than 1000 total hours and less than five hours of instrument time.
6. The flight training devices had a single-engine configuration.
7. A period of one academic semester was used to conduct the data collection for the study.

1.7 Definition of Key Terms

Aeronautical Decision-making (ADM)-A systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. It is what a pilot intends to do based on the latest information he or she has (FAA, 2009a).

Flight Training Device (FTD)-A fixed-based device used for accomplishing certain required tasks, maneuvers, or procedures (FAA, 2014).

Instrument Flight Rules (IFR)-Rules governing the procedures for conducting instrument flight (FAA, 2013a).

Principal Investigator (PI) - A principal investigator is typically a member of the faculty who bears responsibility for the intellectual leadership of a project. He/she accepts overall responsibility for directing the research, financial oversight of the funding, as well as compliance with relevant University policies, federal regulations, and sponsor terms and conditions of an award. This includes research grants, cooperative agreements, training or service projects, clinical studies, and other sponsored projects (Purdue University, 2015).

Visual Flight Rules (VFR)-Rules that govern the procedures for conducting flight under visual meteorological conditions (VMC). The term is also used to indicate weather conditions that are equal to or greater than minimum VFR requirements (FAA, 2009a).

1.8 Summary

This chapter provided an introduction to the study. The scope, significance, research questions, assumptions, limitations, and delimitations of the study were covered. Finally, a definition list of key terms was included to assist the reader in understanding the meaning of unfamiliar terms.

CHAPTER 2. REVIEW OF LITERATURE

The following section serves as an overview of the literature on human factors concepts within general aviation. First, an accident report that highlights the problem is reviewed. Secondly, literature focused on visual flight rules (VFR) versus instrument flight rules (IFR), naturalistic decision-making, aeronautical decision-making (ADM), aeronautical decision-making mnemonics and operational pitfalls is presented. Finally, a review of previous research regarding VFR into instrument meteorological conditions (IMC) is examined.

2.1 VFR into IMC Accident

On November 26, 2011, the pilot of a Cirrus Design SR20 departed from Marion Regional Airport (MZZ), Marion, Indiana without filing a flight plan. The destination for the Part 91 flight was DuPage Airport (DPA) in West Chicago, Illinois. A non-instrument rated private pilot and three passengers were aboard the aircraft. Two miles from the intended destination airport, the pilot contacted the control tower. The tower air traffic controller communicated the current IFR conditions at DPA. By this time, the aircraft had flown over and past the airport. Subsequently, the air traffic controller advised the pilot to reverse course and cleared him to land. When the controller asked the pilot if he was instrument rated, the pilot responded, “IFR training and I let this get around me.” The controller advised the pilot that Chicago Executive Airport (PWK) was reporting VFR conditions and located 20 miles northeast. The pilot acknowledged the information and debated the decision with the controller as he did not want to get delayed at DuPage because of the weather. He eventually told the controller he would proceed to PWK and made contact with Chicago terminal radar approach control (TRACON) (ASI, 2014b).

The Chicago TRACON controller provided the pilot with weather conditions at airports in the vicinity. Three minutes later, the pilot advised the controller he would proceed to PWK and then he changed his mind. Subsequently, the controller approved a frequency change. This would be the last transmission from the pilot. According to radar data found within the accident report, the airplane was tracking on a northbound course at approximately 1,800 feet MSL. The airplane then entered a left turn and momentarily tracked a westbound course. Two minutes later, the airplane entered a right turn at 1,800 feet MSL. The right turn tightened and continued to a south course. The accident site was located approximately .4 miles southeast of the last radar point (ASI, 2014b).

The nearest weather reporting station, located 22 miles south of the accident site, reported 1-3/4SM visibility, light rain and mist. Weather conditions at Chicago Executive Airport located about 23 miles east of the accident site at the time of the accident, were 7SM visibility, overcast at 1,300AGL. An Airmen’s Meteorological (AIRMET) advisory indicated possible IFR conditions, valid during the time of the flight. The Terminal Area Forecast (TAF) at DPA indicated 6SM, light rain, mist, broken clouds at 2500AGL and overcast clouds at 3500AGL. It was amended to indicate a visibility of 5SM, light rain, drizzle, mist, overcast clouds at 800AGL. It is unclear if the amended TAF was issued before the airplane's departure. The current Area Forecast (FA) outlook was for IFR conditions due to low ceilings (ASI, 2014b).

Records indicated the pilot held a private pilot certificate and had logged 207 flight hours. Approximately 114 of the hours were in the accident aircraft. The pilot had also logged 3.1 hours of simulated instrument flight time and 28.6 hours of actual instrument time. However, the actual instrument time logged was found to be inaccurate. The actual instrument time was logged as the same amount as the total flight. This is against Federal Aviation Regulations, which mandate logging actual instrument time only when controlling the aircraft solely by reference to the flight instruments (ASI, 2014b). The National Transportation Board (NTSB) probable cause for this accident was continued visual flight rules into instrument meteorological conditions resulting in spatial disorientation.

2.2 Visual Flight Rules versus Instrument Flight Rules

Instrument Flight Rules (IFR) allow pilots to fly solely by reference to instruments. This means they have received extensive training to fly by reference to instruments. Instrument meteorological conditions (IMC) is the term generally used when there is no visual reference to the horizon. During these operations a pilot must file a flight plan so that Air Traffic Control (ATC) can provide guidance, assist in navigation, and with separation of aircraft (FAA, 2012).

In contrast, a pilot operating under VFR (Visual Flight Rules) is supposed to use outside references, such as terrain or the horizon to maintain spatial orientation. Weather conditions for this type of operation are often referred to as visual meteorological conditions (VMC). Flying VFR gives pilots the responsibility for separating themselves from other traffic, terrain and clouds. This type of operation requires fewer regulations, less training, and allows pilots more freedom to go where they want. VFR weather minimums can be found in Federal Aviation Regulations (FAR) Part 91.155 (U.S. GPO, 2014). In spite of explicit regulations, training and safety programs, some inexperienced or unqualified pilots decide to fly into IMC or deteriorating conditions. Table 2.1 shows VFR and IFR categories of weather: visual flight rules (VFR), marginal visual flight rules (MVFR), instrument flight rules (IFR), low instrument flight rules (LIFR) (FAA, 2009a). Ceiling is measured in feet above ground level (AGL) and visibility is given in statute miles (SM).

Table 2.1
VFR and IFR Weather Categories

Category	Ceiling (AGL)		Visibility (SM)
VFR	Greater than 3,000 feet AGL	and	Greater than 5 miles
MVFR	1,000 to 3,000 feet AGL	and/or	3 to 5 miles
IFR	500 to 999 feet AGL	and/or	1 mile to less than 3 miles
LIFR	Below 500 feet AGL	and/or	Less than 1 mile

Note: VFR and IFR weather categories adapted from “General aviation pilot’s guide to preflight weather planning, weather self-briefings, and weather decision-making” by Federal Aviation Administration, 2009, P. 29.

2.3 History of Decision-Making

Resnik (1987), defines decision theory as, “the product of the joining efforts of economists, mathematicians, philosophers, social scientists, and statistics toward making sense of how individuals and groups make or should make decisions” (p.3). According to Peterson (2009), decision theory can be categorized into three eras: the Old Period, Pioneering Period, and the Axiomatic Period. During the Old Period, the ancient Greeks established decision-making as an academic topic to be examined. A theory was not attached to the decision-making process during the Old Period. However, the Greeks were aware of correct and rational decision-making, but there has been little evidence to suspect there was a major movement or advances. Fifteen hundred years after the decline of the ancient Greeks, the Pioneering Period began. In 1654, Blaise Pascal and Pierre de Fermat were motivated by a question pertaining to the outcomes when rolling dice. This inquiry led to the foundation of probability theory.

During the Pioneering Period another major breakthrough occurred when Antoine Arnaulde published the book Port-Royal Logic. The title translates into English as Logic or the Art of Thinking. The Port-Royal Logic has four parts: the formulation of ideas, judging or judgment, reasoning, and organization of thoughts to produce knowledge. This philosophy and organization of understanding decisions was developed further by scholars, such as Daniel Bernoulli.

Modern decision theory has been reduced to a system of axioms, thus being called the Axiomatic Era. According to the Royal Institute of Technology (1994), decision theory has had contributions from many disciplines. These disciplines include philosophy, social and political scientists, psychologists, statisticians, and economists. Each discipline has its own understanding of decision theory, but there is overlap in the methodological approach. Scholars indicate there are two camps of decision theory: normative and descriptive. A normative decision theory is a theory that describes how decisions should be made. In contrast, a descriptive theory pertains to how the decision was actually made.

Zeleny (1982) posits two basic approaches to decision-making:

1. The outcome-oriented approach, based on the view that if one can correctly predict the outcome of the decision process, then one obviously understands the decision process. The decision outcome and its correct prediction are at the center of this approach. Normative decision analysis, single, and multi-attribute utility theories. etc., are examples of this orientation, which asks questions such as what and when, rather than how.
2. The process-orientated approach, based on the view that if one understands the decision process, one can correctly predict the outcome. Essentially descriptive, this approach has prescriptive and normative features as well. Knowing how decisions are made, teaches how they should be made; the reverse causal linkage, unfortunately, does not follow (p. 85).

2.4 Naturalistic Decision-Making

Several disciplines, including economics, psychology, philosophy, mathematics and statistics, use decision or decision-making theory. Therefore, each discipline may have a variation of the definition or concept (Zsambok & Klein, 2014). Flin (1997) states, "naturalistic decision-making is the way people use their previous experience to make decisions in the field" (p. 30). The term Naturalistic Decision-Making (NDM) was first used in 1989 at a conference for researchers who departed from the traditional decision models. These researchers began to investigate how people made decisions in their natural settings or simulations that kept key aspects of the natural setting. The first NDM conference included research studies that involved participants such as firefighters, pilots, organization executives, technicians, military officers and doctors (Zsambok & Klein, 2014). Researchers whose focus shifted from the traditional decision-making paradigm did so partly in response to the idea that most studies used inexperienced participants in highly-controlled lab settings. These studies were seen as flawed, because of the lack of context (Kahneman, Slovic, & Tversky1987; Ranyard, Crozier & Svenson 1997). Consequently, NDM studies have been limited to natural settings.

According to Klein (2008), at least nine models have been developed from NDM and used to evaluate decision-making. One of these models is the Recognition Primed Decision Model (RPD). This model combines instinct, intuition, and systematic methods, thus explaining how people can make good decisions when a plan has to be developed. The RPD model shows how people use their previous experience. These experiences indicate the principal factors operating in the situation. Patterns highlight important cognitive cues, provide expectancies, recognize desired goals, and suggest typical types of reactions. If expectations are violated a person should reassess the situation and seek more information. After assessing the situation and determining a form of action that will work, then it should be implemented (Klein, 2008). This looped process is similar to what GA pilots are taught when planning or conducting a flight, particularly when unexpected events happen.

2.5 Aeronautical Decision-Making

The Federal Aviation Administration (2009b) defines ADM as:

> A systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances. It is what a pilot intends to do based on the latest information he or she has (p. 5-1).

Previously, many researchers held that good ADM was an outcome of experience. However, research conducted by scholars and FAA found that ADM could be taught. Therefore, ADM was mandated and added to the flight training curriculum (FAA, 2009b). The FAA (2009b) pinpoints six steps for good decision-making:

1. Identifying personal attitudes hazardous to safe flight.
2. Learning behavior modification techniques.
3. Learning how to recognize and cope with stress.
4. Developing risk assessment skills
5. Using all available resources
6. Evaluating the effectiveness of one's ADM skills.

An illustration of the expanded ADM model shows the interactions of ADM steps and how the process can mitigate risks. The model starts with the recognition of change in the situation, and then an evaluation is followed by a decision to react or not to react while the results are gauged for effectiveness. ADM incorporates an awareness of attitudes, ability to use all available information, skills/procedures, and the motivation to select an appropriate response. The ADM model is shown in figure 2.1.

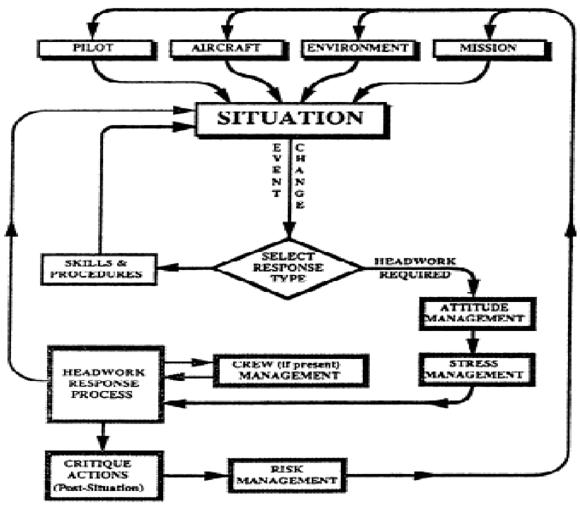


Figure 2.1 Aeronautical Decision-Making model adapted from "Advisory Circular 60-22" by Federal Aviation Administration, 1991, P. 2.

For the past 25 years the aviation research community has studied methods to improve safety. Aviation human factors research has shown that the use of appropriate mnemonics can help reduce error. Table 2.2 illustrates common mnemonics taught to GA pilots and is found in the Aeronautical Knowledge Handbook (FAA, 2009b).

Table 2.2
Common Mnemonics Used By General Aviation Pilots

PAVE	Pilot in command, Aircraft, enVironment, External pressures
DECIDE	Detect, Estimate, Choose, Identify, Do, Evaluate
OODA	Observe, Orient, Decide, Act
CARE	Consequences, Alternatives, Reality, External Factors

In 2009, the FAA published the General Aviation Pilot's Guide to Preflight Weather Planning, Weather Self-Briefings, and Weather Decision-Making. This guide outlined the use of the 3P model: process, perceive and perform. It is a simplified version of the ADM model. First, a pilot should accurately perceive meteorological conditions by collecting the information accurately. Secondly, a pilot should process the weather data to determine whether any hazards create risks. Lastly, a pilot should perform by acting to eliminate the danger or alleviate the risk(s). The 3P model is shown in Figure 2.2

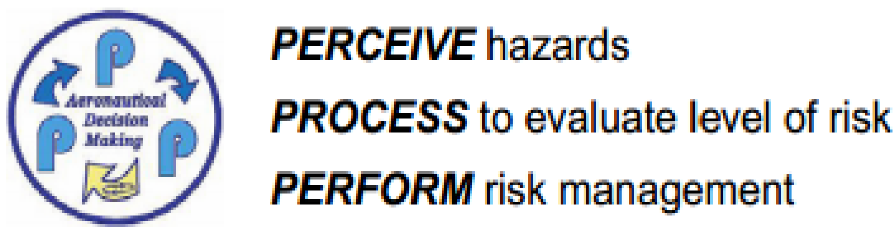


Figure 2.2 Perceive, Process, and Performance Model VFR and IFR weather categories adopted from "General aviation pilot's guide to preflight weather planning, weather self-briefings, and weather decision making" by Federal Aviation Administration, 2009, (P. 1).

As shown in the aforementioned case study, there can be operational pitfalls. According to the FAA (1991), operational deficiencies include:

> Behaviors that can negatively impact safe operations such as peer pressure, mindset, get-there-itis, duck under syndrome, scud running, getting behind the aircraft, loss of positional or situational awareness, operating without adequate fuel reserves, descent below the minimum enroute altitude, flying outside the envelope, neglect of flight planning, preflight inspections, checklists and continuing VFR into IMC (p. 3-4).

Peer pressure is poor decision-making based upon the emotional influence of peers, rather than an objective assessment. Mindset can be explained by the inability to identify and deal with unexpected changes in the original plan. Get-there-itis is the propensity for pilots to fixate on getting to the destination while disregarding any alternative plan. Duck-under syndrome is when pilots lower their altitude below minimums to check if they can see the runway environment when on an instrument approach. Pilots may be unwilling to execute a missed approach. Pilots who “scud run” attempt to maintain visual contact with the ground during low ceilings. This increases the risk of impacting the terrain and obstacles. Getting behind the aircraft means events have started to control the flight and the pilot is continuously surprised and/or trying to catch up with events. Not knowing where you are or an inability to recognize a changing environment is loss of positional or situational awareness. For example, pilots may disregard minimum fuel reserves and carry inadequate amounts. This can be caused by a disregard of regulations, overconfidence, and/or lack of flight planning.

Descent below the minimum enroute altitude is similar to the duck under syndrome, but occurs during the enroute segment. Flying outside the envelope involves the pilot operating the aircraft outside of its known limitations. Pilots sometimes rely on their short and long term memory and fail to follow the checklists, thereby potentially missing a vital step (FAA, 1991). Continued VFR flight into IMC often leads to spatial disorientation, which involves discrepancies in sensory stimuli. Spatial disorientation is cited in approximately 10% of all GA accidents, and approximately 90% of these accidents are fatal (FAA, *n.d.*).

In addition, to these pitfalls, the FAA has identified five hazardous attitudes that can decrease a pilot’s judgment. These five hazardous attitudes are: anti-authority, impulsivity, invulnerability, macho, and resignation. Along with the identification of these hazardous attitudes, the FAA prescribes antidotes.

These antidotal attitudes include: “follow the rules; they’re usually right,” “not so fast-think first,” “it could happen to me,” “taking chances is foolish,” “I’m not helpless” (AOPA, 1999).

2.6 VFR into IMC Empirical Research

Ohare and Owen (1999) used a one factor in-between subjects design to investigate pilot performance when encountering deteriorating weather conditions. The single factor between groups was duration of flight. Participants operated desktop personal computer aviation training devices and were evaluated on their situational awareness after their session. Questions regarding factors such as weather conditions, altitude, and airspeed were examined. Subjects who continued into IMC were less likely to seek alternative options. The authors asserted further investigation is needed to understand why pilots continue into deteriorating conditions. The proposed model was a direct result of the study that acknowledged the need for training.

Driskill, Weismuller, Quebe, Hand, Dittmar and Hunter (1997), evaluated 150 general aviation pilots to investigate the use of weather and ADM. The researchers employed 81 written scenarios designed to gain an understanding of how pilots perceive visibility, precipitation and terrain. Based on various conditions, pilots were questioned on confidence in safety. It was reported that pilot decision-making was consistent with expert assessment of the risks. However, it was noted that pilots varied in consistency when terrain was a factor. The majority of the subjects reported they had not operated in mountainous terrain.

Through either a cockpit mounted display panel or mobile device, automatic dependent surveillance-broadcast (ADS-B) offers an additional tool to increase situational awareness in GA pilots. The system works by receiving the flight information service-broadcast (FIS-B), this provides graphical based weather data from ground-based weather equipment. When working properly, a pilot should be able to receive, at a minimum, the local weather picture. Furthermore, FIS-B delivers pilot reports (PIREPs), significant meteorological information (SIGMET), special use airspace (SUA) status, terminal aerodrome forecasts (TAF), airmen's meteorological information (AIRMET), notices to airmen (NOTAM), aviation routine weather reports (METAR), and information direct to the cockpit (FAA, 2013b).

According to Ambs (2014), technologically-advanced weather systems in the cockpit have led aviation researchers to investigate pilot aeronautical decision-making and performance, particularly in adverse weather conditions. Ambs investigated literature pertaining to pilot decision-making and the influence of weather technology in the cockpit. The comprehensive literature analysis identified weather technology could be problematic based on training and experience. Improved decision-making and weather technology training can lead to safer operations.

Results from a study conducted by Stough, Watson and Jarrell (2006), indicated pilots examined in a ground training device were more likely to make accurate deviations when using weather technology. It was also noted pilots had greater awareness, reduced work load and made decisions sooner. In contrast, Johnson, Wiegmann and Wickens (2006), found pilots who used weather technology, specifically synthetic vision with weather on a moving map, failed to recognize deteriorating conditions. The pilots without weather technology initiated deviations at a significantly higher rate. Reasons for the difference were attributed to heads-down time by pilots with weather technology. The pilots who failed to deviate all made it to the destination and landed safely, though breaking regulations. Training was recommended to improve performance and decision making.

Vincent, Blickensderfer, Thomas, Smith and Lanicci (2013) evaluated a training module via lecture. This study specifically evaluated Next Generation Radar (NEXRAD). A pretest posttest experimental design was used to evaluate the training module. Participants were given paper-based scenarios to make decisions. Those who received the training indicated a significantly higher posttest score when compared to those who did not. Areas of improvement included knowledge, self-efficacy, and decision accuracy.

2.7 Summary

In this section, a background on human factors relating to aeronautical decision-making was provided. The review included discussion of operational pitfalls, common mnemonics and decision-making theory. In addition, there were empirical studies cited to show the need for further research in this area.

CHAPTER 3. METHODOLOGY

General Aviation (GA) pilots continue to be involved in accidents caused by continued flight operations under visual flight rules (VFR) into deteriorating instrument meteorological conditions (IMC). The GA community has sought to reduce these types of accident occurrences. The purpose of this research project was to examine and compare the effects of a workshop and an online interactive short course on general aviation pilot performance. In addition, the research investigated how selected general aviation pilots perceive and process weather information. This section discusses the quantitative and qualitative procedures used in this study. The discussion includes research design, population, sampling, data collection, procedures, apparatus, reliability, validity, and threats.

3.1 Research Design

According to McBurney and White (2009) features of a true experiment include: random assignment, a control group, and an experimental group. True experiments give researchers a high degree of control. A researcher is able to control the type of participants, group assignment, and manipulation of variables. True experiments assist in reducing confounding variables. Cause and effect relationships can be established. Engel and Schutt (2014) identify three types of true experiments: posttest only control group design, Solomon four-group design, and pretest posttest control group design.

According to Engel and Schutt (2014), a posttest control group design has a control group and at least one experimental group. A pretest is not administered because the researcher assumes the pretest scores would be similar due to random assignment. A limitation of the posttest only design is the inability of the researchers to compare a starting score of participants against an ending score.

The Solomon four-group design contains two additional control groups. It allows researchers to determine if pretest scores had an influence on participants. This experimental design is considered to be salient, because it alleviates internal validity issues. A limitation to this type of experiment is the complexity. Researchers must have resources including time and access to many participants.

The pretest posttest experimental design is the final type of true experiment (Engel & Schutt 2014). A pretest posttest experiment design is the preferred method for many researchers. It allows researchers to measure unit changes as a result of treatment or intervention. Pretest posttest experimental designs can employ one or more treatment groups. This research design addresses internal validity issues. Pretests can be compared to posttests. If the control group showed significant improvement, the researcher will need to investigate the reasons (Engel & Schutt 2014).

The pretest posttest experimental design was selected for this study because it requires fewer resources than the Solomon four group design. Additionally, it is more robust than a posttest only design. It also allows for more than one treatment group. This gave researchers the ability to investigate which training protocol influences pilot knowledge and behavior more effectively. Furthermore, pretest scores can serve as a covariate to the treatments (Engel & Schutt 2014). Figure 3.1 outlines the research design process. The present study was outlined as follows:

R--O_1-- X_C-- O_2—O_3
R--O_1--X_{TA}--O_2—O_3
R--O_1--X_{TB}--O_2—O_3

R=Random Assignment
O=Pretest
O_2=Posttests
$X_{a=}$Control Group A
X_{Tb}=Treatment B (Interactive Short Course)
XT_c=Treatment C (Workshop)

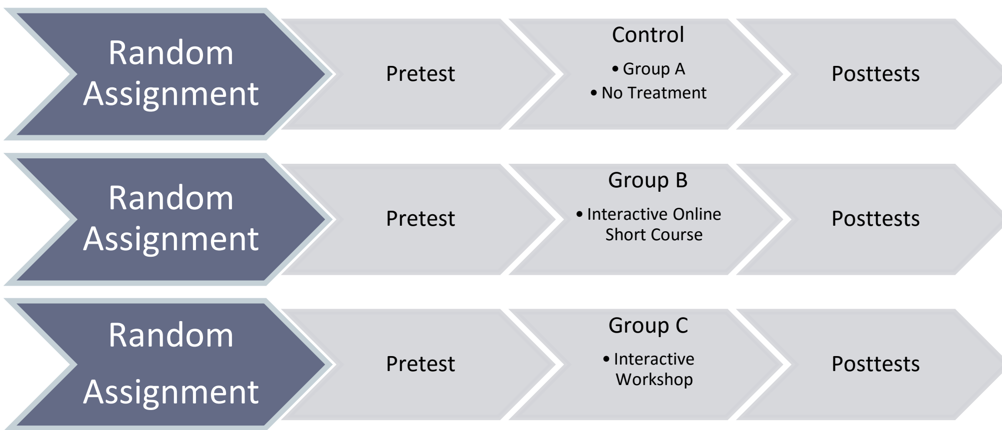


Figure 3.1. Research Design Process

In addition to the quantitative section, there was a qualitative section designed to understand participants' aeronautical decision-making. Participants were asked to provide typed responses pertaining to decisions made during the flight training device sessions.

3.2 Research Questions

This study had one main research question and several sub questions. The primary research question was: Can focused workshops or interactive weather training short-courses significantly affect GA pilot weather knowledge and decision-making in VFR-into-IMC situations?

The following sub questions were addressed in this study:

1. *Research Question 1*: Is there a statistically-significant difference in pre-and posttest performance between and within the control and experimental groups?
2. *Research Question 2*: Which group of participants had the highest frequency of avoiding instrument meteorological conditions during flight training device scenarios?
3. *Research Question 3*: How do participants perceive their decision-making when asked after completing flight training device sessions?

3.3 Population and Sample

The target population for this study was non-instrument rated private pilots with less than 1000 total flight hours, less than five hours actual instrument time, and at least 10 hours flown in the previous six months. The reason for the chosen population was because pilots outside of this group are likely to have either too much or too little training. Instrument-rated pilots are allowed to operate in weather conditions below visual flight rules minima. As a result, student pilots do not have enough training to operate outside of strict supervision of their instructor-authorized flight. Student pilots and pilots with instrument ratings tend to fall outside of the problem of continued VFR flight into IMC.

Using an appropriate sample size of participants is a method for researchers to conduct an experiment and make generalizations or conclusions about the population being investigated. Alpha level, beta level, and effect size each influence the necessary sample size. According to Gravetter and Forenzo (2015), alpha level is the probability of what is unlikely to happen by chance. Alpha level is also known as Type I error. Simply put, it is the chance (or likelihood) that researchers have concluded a treatment has worked when in fact it has not. Traditionally, researchers in social sciences use an alpha level of .05. However, it is not uncommon for researchers to use .10, .01, or .001. Researchers are able to choose the appropriate alpha level for the research project (Gravetter & Forzano, 2015). A *priori* alpha used in this study was .05.

According to Rubin (2012), beta level is also known as power and controls against type II errors. Type II error is in contrast to Type I error. A Type II error occurs when a researcher fails to reject a null hypothesis when it is false. The chance of this occurring depends on beta or power of the test. A suggested level of beta for social scientists is 0.8 (Rubin, 2012). Therefore, the current study assumed an 80 percent chance, or, $\beta = .8$ of discovering a significant difference between groups if one occurred.

According to Ellis (2010), effect size refers to the estimated magnitude of differences between the groups studied. Traditional effect sizes for small effects are .2, a medium effect is .5, and a large effect is .8. Effect size is generally used in research when the population is large. Typically, to determine effect size a researcher will seek an estimated effect size from previous similar studies (Ellis, 2010). For this study, an exhaustive search failed to find an appropriate effect size from previous research. Therefore, the estimate used is .5. Based on a priori Alpha level of .05, Beta level of .8 and Effect size of .5, it was determined a sample size of 42 was required to accurately detect at least a medium effect between the three groups. Table 3.1 shows the statistical software sample size calculation output.

Table 3.1

Sample Size Calculation

Analysis:	A priori: Compute required sample size		
Input:	Effect size f	=	.5
	α err prob	=	0.05
	Power (1-β err prob)	=	0.8
	Number of groups	=	3
Output:	Noncentrality parameter λ	=	10.5000000
	Critical F	=	3.2380961
	Numerator df	=	2
	Denominator df	=	39
	Total sample size	=	42
	Actual power	=	0.8034136

Note. Alpha=.05, Beta=.8, and estimated effect size=.5.

According to the Federal Aviation Administration (FAA) (2015a), there are 150,387 active Private and Commercial pilots without instrument ratings in the United States of America. The data do not indicate the experience level or flight times of these pilots. According to Gravetter and Lorenzo (2015), one of the most common sampling methods is convenience sampling. This type of sampling method is used, because it allows researchers an opportunity to recruit participants that are easy to recruit. Due to the time, scope and resources of this project, a convenience sampling method was used. By using this type of sampling method, threats were created. These threats will be discussed later. A Post-hoc power analysis will be discussed in the results section.

3.4 Variables

For the quantitative section, the independent variable (IV) was the training session completed by each participant in treatment group. One treatment group consisted of an online interactive short course in which participants completed independently. The other treatment group consisted of an interactive workshop facilitated by the principal investigator. The dependent variables (DV) were pretest/posttest scores and decisions made during the flight scenario sessions. Three decisions were available to participants, divert, execute a 180 degree turn away from deteriorating conditions, or continue into instrument meteorological conditions.

3.5 Procedures

An expedited Institutional Review Board (IRB) application was submitted to the Human Research Protection Program Office. Authorization to conduct research was approved for two locations. The first location was at the FAA William J. Hughes Technical Center in Atlantic City, NJ and the other at the Purdue University Airport located in West Lafayette, Indiana. Data collection took place between July 2015 and October 2015. See Appendix A for the research authorization document (#1506016169). Overall, the procedures were similar. However, due to the use of the use of two flight training devices at the FAA Technical Center, participants there completed the experiment in one day. At Purdue University there was only one flight training device used. Therefore, researchers had to split participant involvement at Purdue University into two days/sessions. The first session included intake, pretest, and treatment (if assigned). The second session included the flight training device scenarios and posttests. Each participant at Purdue University completed their participation within five days.

3.6 Recruitment

Recruitment at the FAA Technical Center was conducted by a third party contractor which used a database to contact potential participants. The contractor was given the desired pilot profile by researchers. Desirable participants were General

Aviation (GA) pilots, 18 years of age or older, holding a FAA Private Pilot Certificate without an instrument rating, and having flown at least 10 hours in the previous 6 months. The ideal participant would have accrued between 400 and 1000 hours of total flight experience. This pilot profile was determined by an extensive examination of accident reports. Participants were not compensated by Purdue University researchers. The contractor was able to recruit 60 general aviation pilots who closely matched the desired profile from the region.

Recruitment at Purdue University was conducted by the study researchers. An email invitation letter was sent to the local Fixed Based Operator (FBO) and local flying clubs. Please see Appendix B for the email invitation letter. The invitation letter was also posted at aviation facilities on the Lafayette airport complex. Participants interested in the study contacted the Principal Investigator (PI) for scheduling. The same desired pilot profile as in the first data collection phase was used. Desirable participants were GA pilots, 18 years of age or older, holding a FAA Private Pilot Certificate without an instrument rating, and had flown at least once in the previous 6 months. The ideal participant would have accrued between 400 to 1000 hours of total flight experience. This pilot profile was determined by an extensive examination of accident reports. Participants were not compensated by Purdue University researchers. Twenty four participants were recruited for this part of the study.

3.7 Intake of Participants

Similar intake procedures were used at both locations. Upon arrival and after receiving a welcome and information briefing, participants reviewed and signed the informed consent form (if they decided to participate). A member of the research team discussed the study with potential participants, and ensured all questions were answered. Researchers ensured participants fully understood the conditions of participation before signing the informed consent form. Informed consent statements described the study, foreseeable risks, and the rights and responsibilities of the participants, including a reminder that participation in the study was completely voluntary. The consent form also stated that the participant could withdraw from the study at any time without penalty. All of the information the participant provided, including Personally Identifiable Information (PII) was protected from release and only known by the researchers authorized in the study. Signing the form indicated the participant understood his or her rights as a participant and gave their consent to participate. All participants were given as much time as needed to review and ask the experimenters questions concerning the consent form. See Appendices C and D for the consent forms used. Each participant was randomly assigned to either the control group or one of the treatment groups by the use of an online program. According to Goodwin (2009), random assignment allows factors that can affect a study to be spread evenly throughout the various experimental groups. This allowed researchers a high level of confidence in the experimental results. Additionally, all participants were give a random six digit number for the purpose of de-identification.

3.8 Pretest

During the past four years, the FAA has been working closely with the aviation community to improve airmen testing standards. This effort has led to revisions of existing Practical Test Standards (PTS). Though the new Airmen Certification Standards (ACS) has not been officially implemented, the FAA plans to do so in the near future (FAA, 2015a). Each participant was asked to complete a pretest consisting of 24 weather-related knowledge, skills and ability questions from the ACS. For the pretest, participants were asked to log into an online program using their unique six digit identification number. All participants were presented with the same questions in the same order. Two practice questions were presented at the beginning of the pretest. Following that, demographic/flight experience information was requested. It took approximately 30 minutes for the participants to complete the pretest. Please see Appendix E for pretest questions. Once complete, participants proceeded to the next stage: flight device (Control/Group A), interactive online short course (Treatment/Group B) or interactive workshop (Treatment/Group C). Separate rooms were used for the facilitation of the interactive online short course and interactive workshop.

3.9 Interactive Online Short Course

The online short course was developed by researchers to allow participants to independently complete the subject matter. Topics for the interactive online short course were similar to those in the interactive workshop, and corresponded to the pretest posttest questions. Participants assigned to this treatment were asked to log in using identification numbers provided by the researchers. Once signed in, participants completed the course independently. The course guided participants through the listed topics. For each section, participants were given questions and feedback based on the answers chosen. A list of the topics is shown in Table 3.2. It took approximately one hour for participants to complete the online interactive short course.

Table 3.2

Interactive Online Course Topics

Extratropical cyclones, fronts, and air masses
Fog types, characteristics, and factors for development
Precipitation effects
Convective sources of low ceilings and low visibility
Weather Data Acquisition and Interpretation

3.10 Justification for using an Online Interactive Short Course

The utilization of online training courses has been investigated by researchers as technology has become readily available. However, the effectiveness of the ability to improve knowledge and/or behavior, particularly for complex topics such as weather and decision-making, has yielded mixed results. Wisher and Olson (2003), used an online database and searched for research articles pertaining to the effectiveness of web-based training modules on learning. Of the 47 articles found, 15 provided effect size data when comparing web-based instruction to traditional classroom presentation. Results indicated the average effect size was .24. This finding suggested the average student increased 10 percentage points. However, due to the small sample size there was large variability. Effect sizes ranged from -.4 to 1.6. Based on the overall results of this study, computer-based learning lead to an improvement of learning. The study reports broad categories of the field of study and does not report the complexity of the topics taught.

Silk, Perrault, Ladenson and Nazione (2015) conducted a study to evaluate the effectiveness of online, versus in-person instruction pertaining to searching for research articles. Participants in this study were college students. Results indicated 10% more students who participated in the online course were able to find research articles. This suggested the online instruction was more effective at improving student article search knowledge.

Sitzmann, Kraiger, Stewart and Wisher (2006) utilized meta-analytic methods to compare the effectiveness of web-based instruction and classroom instruction. Ninety-six research articles produced data from 19,331 trainees enrolled in 168 courses. Subject matter included technical writing, business, computer programming, engineering, and psychology. Trainees were undergraduate students, graduate students and employees. Results indicated web-based instruction was six percent more effective than classroom instruction when teaching declarative knowledge. However, web-based training was not more effective at teaching procedural knowledge. When web based instruction was used to supplement face-to-face instruction, results indicated a higher level of effectiveness in both declarative and procedural knowledge.

Few extant research studies regarding aviation-related topics have been completed. Knecht, Ball, and Lenz (2010), evaluated video training products pertaining to aviation weather-related knowledge and flight performance during deteriorating conditions. Fifty general aviation pilots participated in the study. Participants were assigned into two groups. The first group watched a 90 minute video that did not pertain to weather. The other group watched a 90 minute weather training video. Pretests and posttests were administered. Robust statistical analyses were conducted to determine the effectiveness of the weather-related training video. The researchers concluded the training videos were not effective, due to the complexity of weather and decision-making. Phase II of the aforementioned research study also concluded minimal effects and more research needed to be conducted.

3.11 Interactive Workshop

The interactive workshop was facilitated by the Principal Investigator, who holds the Ph.D. Degree in Atmospheric Science, and has extensive pilot and flight instructor experience. The workshop had six primary sections. These sections included the introduction, initial briefing, meteorological sources of low ceiling and low visibility events, aeronautical decision-making, weather data acquisition and interpretation, and conclusion. During the workshop, two-way discussion was facilitated by the Principal Investigator. Additionally, relevant accident case studies were examined. Moreover, videos obtained with permission from the Aircraft Owners and Pilots Association (AOPA) were used to highlight VFR into IMC events and decision-making. The interactive workshop lasted approximately two hours and fifteen minutes, with a 10 minute break. See Table 3.3 for the interactive workshop outline.

Table 3.3

Interactive Workshop Outline

1) **Workshop Introduction**
   a) Introductions
   b) Objectives and overview for the Workshop
2) **Meteorological Sources of Low Ceiling and Low Visibility Events, and Lessons from Related Accidents**
   a) Extratropical cyclones, fronts, and air masses
   b) Fog types, characteristics, and factors for development
      i) Accident Case Study 1—Fog/low ceilings
   c) Break
   d) Precipitation effects
      i) Accident Case Study 2—Precipitation effects
   e) Convective sources of low ceilings and low visibility
      i) Accident Case Study 3—Convective weather
   f) A Discussion on Aeronautical Decision Making
   g) A Review of Weather Data Acquisition and Interpretation
3) **Workshop Conclusion**
   a) Workshop Recap
   b) Discussion and Questions

3.12 Justification for using an Interactive Training Workshop

This subsection describes and justifies the selection of using a workshop for the treatment of this study. The Center for Teaching and Learning (2015) at the University of North Carolina suggests there are at least 150 instruction methods. These methods range from lectures to small brain-storming groups. “Seminar” and “workshops” are terms that are often interchanged. According to Brooks-Harris and Stock-Ward (1999), a workshop is typically a highly-interactive session facilitated by an expert, which can last from a half day to two days. Seminars are also facilitated by an expert and the focus is on one or two topics. When interactive instructional methods are employed during a seminar, the distinction between a workshop and seminar increasingly becomes convoluted. Workshops tend to be more interactive, while seminars tend to be one-way, facilitator-to-participants.

A workshop is an appropriate platform for this study because of the instructional material, number of participants, resources, learning preferences, and learning outcomes. According to Grave, Zanting, Mansvelder-Longayroux, and Molenaar (2014), workshops and seminars can be effective for individuals, groups or entire organizations. Learners are attracted by face-to-face delivery of training material and interactions among participants. In addition, instructional methods employed during a workshop can be varied. Combinations of instructional methods may enhance student understanding of a subject, improve communication, and positively affect different learning preferences. The application of the proper instructional method can make the learning process of participants more efficient (Guskey, 2014).

There are few extant research studies investigating the effectiveness of workshops in aviation training. This section will review literature from various fields geared towards adult learners. A study conducted by Rust (1998), sought to evaluate the effectiveness of workshops for educators. The purpose of the study was to determine if participants teaching practices would change. In addition, the researcher sought to understand attitudes towards the series of workshops. Workshop topics included, teaching large classes, assessments, curriculum, supervising post graduates, problem-based learning and teaching in higher education. The workshop included instructional and interactive methods. Five hundred participants responded to questionnaires before and after a series of workshops. Rust concluded that workshops can promote change in participants, provide encouragement, and increase confidence in using desired teaching methods.

Horrell, Goldsmith, Tylee, Schmidt, Murphy, Bonin and Brown (2014), used a randomized control trial to evaluate the effectiveness of workshops in reducing depression, anxiety and increasing self-esteem. A total of 459 individuals were randomized into either a control or experimental group. Follow-up data were collected from 381 participants. Results indicated that 12 weeks after the workshops, the experimental group showed significantly lower levels of anxiety and depression when compared to the control group. Additionally, the experimental group indicated significantly higher levels of self-esteem. Results indicated women benefited more from the workshops than men.

Occupational health professionals conducted a study to evaluate interactive fatigue management workshops for nurses. Research questionnaire items asked participants how confident they were at: diagnosing, managing, and discussing chronic fatigue. The questionnaires were distributed directly before and after the workshop. In addition, a questionnaire was sent four months after the workshop. Seventy-three participants completed all three questionnaires. In addition, participants were asked how satisfied they were with the workshop. Results provided support that knowledge can be enhanced by interactive workshops. Eighty-nine percent of participants rated their experience between five and seven on a seven-point Likert scale (Ali, Chalder and Madan 2014).

Dong, Li, Chen, Chang and Simon (2013), distributed questionnaires to 236 Chinese elderly adults who participated in health workshops focusing on depression, elder abuse, breast cancer and stroke. Before and after workshop analyses were conducted. Results indicated significant improvement in all five themes. The authors asserted workshops were beneficial and community policies should reflect the potential positive impact.

A study conducted by Pepin and King (2013), investigated the effectiveness of skills training workshops aimed at improving the well-being, coping and problem-solving skills of people caring for loved ones who had eating disorders. Each session lasted two and a half hours, one time per week for six weeks. Workshop topics included care-giver coping, emotional responses, role playing, problem-solving, and theoretical models pertaining to change. Results from 15 participants were analyzed. Findings indicated significant improvements in the care-giver's ability to cope with afflicted loved ones. Furthermore, results showed an increase in positive interactions.

Gilbody, Prasthofer, Ho and Costa (2011) investigated how workshops affect surgical trainees' perceptions. The researchers searched databases to find research articles that included a formal assessment of performance and/or trainee satisfaction. Eight articles met the criteria. Three studies indicated positive attitudes towards the workshops. One study indicated positive outcomes when trainees were tasked with simple procedures. One study indicated a negative outcome when trainees were tasked with complicated medical procedures. There was no indication on the remaining three articles. Based on the review of literature, the researchers concluded trainees and facilitators felt workshops improved knowledge and performance. The researchers noted the limitations of the study and asserted more research needed to be conducted.

Retrieval practice can be an effective strategy for learning complex material and can be implemented within a workshop. This strategy is when people are asked to recall certain learned information, even without feedback or correct answers (Roediger &

Butler, 2011). This strategy challenges the traditional viewpoint that learning is accomplished through studying. Retrieval practice can be a powerful strategy for long term learning and memory of information.

Karpicke and Blunt (2011) examined the effectiveness of retrieval practice compared to concept mapping, which is an elaborate way of studying and considered active learning. The researchers used a within-group experimental design with 120 undergraduates. One hundred and one students performed better on the final test when using retrieval practice methods. Retrieval practice methods can be incorporated into the workshop to enhance recall of complex concepts.

Developing and conducting a workshop requires attention to key details. These details include creating an atmosphere conducive to training, understanding experiences of participants, learning preferences, logical lesson structure, building and maintaining interest, interaction, and repetition (Jolles, 2011). Facilitators can create a non-intimidating environment by allowing participants to freely express their ideas, providing adequate breaks, considering appropriate snacks and beverages, and choose a safe physical environment without distractions. A knowledgeable expert facilitator can create instructional elements to capture the learning preferences of adult learners.

Learning styles or preferences have been studied by researchers for decades. Many theories have been developed and refined. Popular learning styles include; information processing-based, personality-based learning style, multidimensional/instructional-based learning, and experiential learning (Gerdon, 2012). According to Cassidy (2004), information processing-based style differentiates how students sense, perceive, solve problems, organize and remember information. Working and long term memory are the key focus when understanding learning and development. Personality- based learning is the evaluation of personality and its impact on learning. Multidimensional learning evaluates the type of learning student desire. Experiential learning is a popular learning theory developed by David Kolb and Roger Fry. The theory asserts students learn through a continuous process that includes concrete experience, reflective observation, abstract conceptualization and active experimentation. Simply put, learners experience, reflect, think, and do. Based on this process, learning styles are categorized into four styles; convergers, divergers, accommodators, and assimilators. Convergers have strong deductive reasoning skills and tend to be pragmatic. Divergers are imaginative and are keen at seeing the big picture or multiple viewpoints. Assimilators tend to desire more abstract reasoning while accommodators, tend to solve problems innately (Cassidy, 2004).

Kolb's learning theory offers an attractive theoretical model for selecting workshop teaching methods, because there is not a need to evaluate cognitive processes, personalities, or to survey the desires of students. Kolb (1984), Svinicki and Dixon (1987) suggest lectures, discussions, and case studies can be used to accommodate the four different learning styles.

Empirical evidence from multiple fields has shown workshops can be effective at changing knowledge, skills, abilities, and attitudes. Proper selection of instructional methods within a workshop can facilitate the learning styles of adult learners. Literature indicated well-planned workshops with lectures, reflective thinking, discussions and case studies can foster deep learning.

3.13 Apparatus and Flight Scenarios

The portion of the study performed at the William J. Hughes Technical Center utilized two GA cockpit simulators configured to simulate a Mooney Bravo single-engine aircraft. The study performed at Purdue University utilized a Frasca Cessna 172 Flight Training Device. See figure 3.1 for a picture of the flight training device at the FAA Technical Center. See figure 3.2 for a picture of the flight training device provided by Frasca International (outside and inside views).

Figure 3.1. Flight Training Device at the FAA Technical Center.

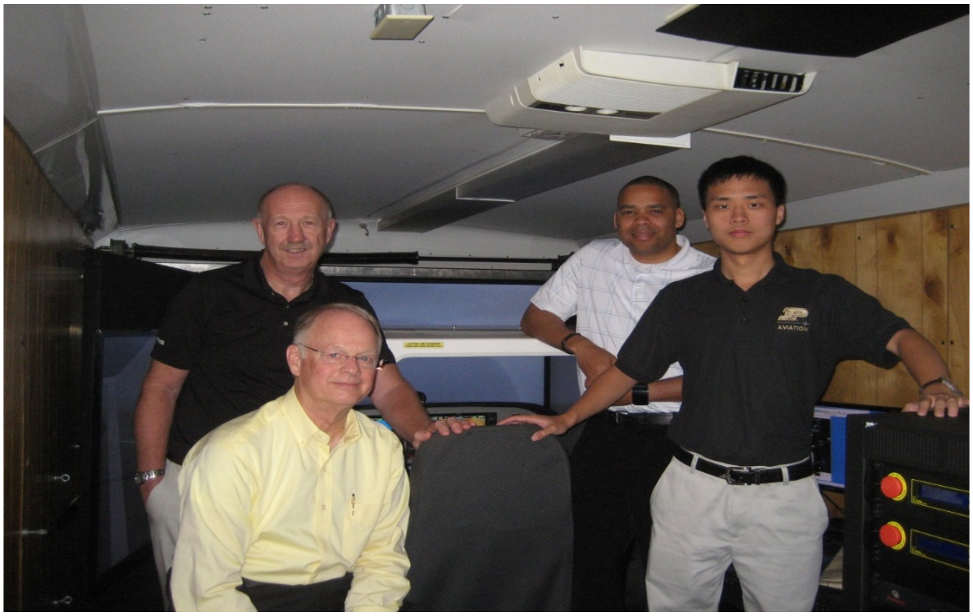


Figure 3.2. Mobile Flight Training Device.

Members of the research team were present throughout the experiment to observe and code participant behavior. Additionally, Certified Flight Instructors (CFIs) communicated instructions consistently, used appropriate terminology, conducted realistic pre-flight briefings, and assumed the role of an Air Traffic Controller (ATC), by reporting to, and requesting information from, the participants over the “radio” at various times during each flight. See Appendices F and G for examples of the ATC scripts for each flight scenario.

Each flight training scenario was tested and validated by building flight plans, weather, custom visuals based on the weather, writing realistic Air Traffic Control (ATC) scripts, creating potential alternates, and repeated test flying to determine if enroute timing and visual cues were consistent. Subject matter experts were used to evaluate the range of potential decisions pilots made during inadvertent encounters with adverse weather conditions within both scenarios. The scenarios were based on real-life accidents/challenging flight conditions in Alaska and New Mexico. Please see figures 3.3 and 3.4 for the flight routes. The figures show the point at which the visibility decreased. Moreover, weather information from Automatic Terminal Information (ATIS), Automated Surface Observing Station (ASOS), and Automated Weather Observing System (AWOS) was recorded, looped, and available to participants if the appropriate frequency was tuned in. Appendices H and I detail flight plan information for each scenario. Appendices J and K outline the scenario briefs for each scenario.

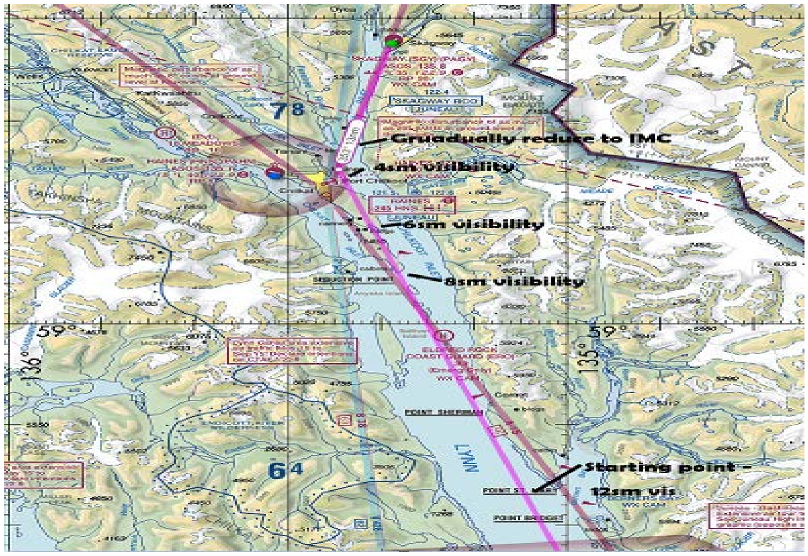


Figure 3.3. Alaska Scenario Flight Path and Deteriorating Visibilities.

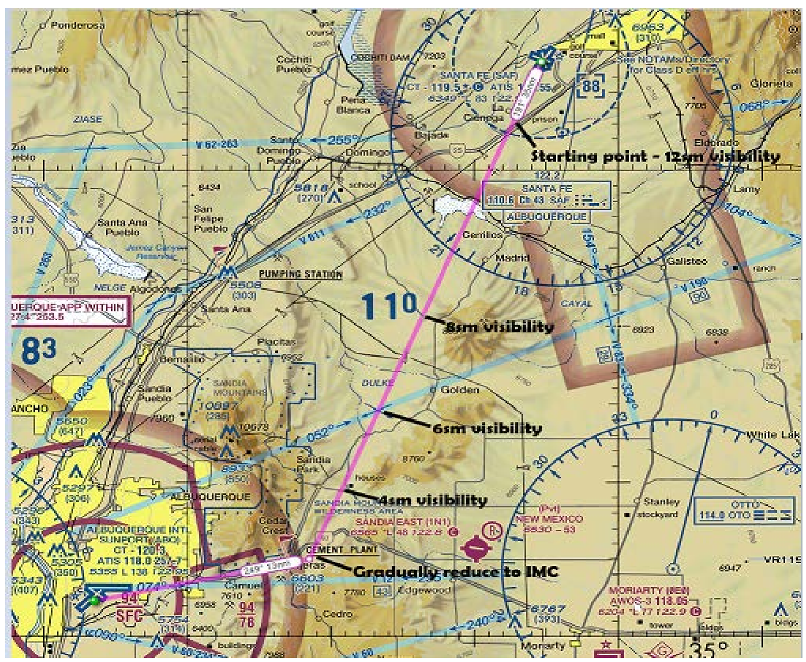


Figure 3.4. New Mexico Flight Path and Deteriorating Visibilities.

Prior to flying the research scenarios in the flight training device (FTD), participants were familiarized with the assigned FTD device and flew a baseline training scenario of basic flight maneuvers. This familiarization session lasted approximately 20 minutes. Participants were reminded to safely and effectively fly the aircraft according to Federal Aviation Regulations (FAR), as if it were a real flight. Additionally, participants were asked to verbalize thoughts only when doing so did not interfere with the primary task. Once the participants were ready, the flight scenarios began. Every participant flew the Alaska scenario first, followed by the New Mexico scenario. Each scenario lasted approximately 25 minutes and was both audio-and-video recorded. After both flight scenarios were completed, participants completed the posttest and answered post-flight questions regarding decision-making.

3.14 Posttest and Post-flight Questionnaire

Each participant was asked to complete a posttest and post-flight questionnaire immediately after completing the flight scenarios. The posttest utilized similar topics/questions as the pretest. Researchers came to a consensus and agreed on face and content validity. Simulator flights and posttests were completed the same day for all participants at the FAA Technical Center. Due to use of only flight training device at Purdue University and resulting scheduling, the researchers had no option but to split participants into two sessions. Participants who were assigned into either of the experimental groups completed the simulator flight posttest within two days after receiving the treatments. This is further explained in the limitations section. The post-flight questions were included in the first posttest. Participants were asked to type responses to questions pertaining to workload and decision-making.

In addition to the posttests completed at the research locations, participants were invited to complete a second electronic posttest related to aviation weather information. The invitation to complete the second posttest was emailed to FAA Tech Center participants after two months and to the Purdue University after one month of the initial data collection phase. This was due to the timing of the project. This project had a limited amount of time to collect and analyze the data. Participants who were evaluated at the FAA Technical Center, were invited to complete the posttest after two months. Appendix L lists the posttest questions.

3.15 Data Analysis

The statistical tests that were used to analyze the quantitative data for this experiment were a one-way Analysis of Variance (ANOVA) and a paired t-test. Pretest and posttest scores were used for the quantitative analyses. According to Vik (2013), an ANOVA is a robust statistical test to determine whether three or more means are equal. Six primary assumptions must be met before using an ANOVA. The six assumptions are: approximately normally-distributed data, homogeneity of variance, independence, continuous interval data points, two or more related groups, and no significant outliers (Vik, 2013).

The paired t-test has four primary assumptions. These assumptions are having a continuous level measurement, related groups, no significant outliers, and approximate normally-distributed data points (Vik, 2013). Descriptive data were collected from participants as part of the intake procedures and reported.

Post-flight questions pertaining to decision-making was analyzed using qualitative methods. According to Miles, Huberman, and Saldana (2013), there are several methods for analyzing qualitative data. These methods range from codes and categories to conversation analysis. An analysis was conducted on the post-flight questionnaire response through coding and themes, or categories. Codes are labels that give understanding to the data collected in the study. Typically, a code is a word or short phrase that captures the essence of sections obtained from transcripts, field notes, videos, documents, images, or historical artifacts. Categories are broader and can contain several codes. Themes and theories can be generated from the analysis. Simply put, themes are the result of coding, categorizing, and interpretation of the data (Miles, Huberman & Saldana, 2013). An analysis of post-flight questions regarding decision-making and workload was conducted. To increase reliability, researchers coded data separately and came to a consensus. Since the research was conducted at two locations, utilized different flight training devices, and had slightly different scheduling procedures, results were reported separately.

The primary research question was: Can focused workshops or interactive weather training short-courses significantly affect GA pilot weather knowledge and flight behavior in VFR-into-IMC situations?

The following sub questions were addressed in this study:

Research Question 1: Is there a statistically-significant difference in pre-and posttests performance between and within the control and experimental groups?

An ANOVA was used to determine if there was a significant difference between pre-test and post-test scores between the control and experimental groups. A paired t-test was used to determine if there was a significant difference in pretest and posttest scores within the three groups. The hypothesis was an improvement in scores for the experimental groups.

Research Question 2: *Which group of participants had the highest frequency of avoiding instrument meteorological conditions during flight training device scenarios?*

Descriptive statistics were used to determine frequency of instrument condition avoidance decisions.

Research Question 3: How do participants perceive their decision-making when asked after completing flight training device sessions?

Categories and codes were created, then themes were generated. Themes were defined, interpreted and discussed.

3.16 Threats to Internal and External Validity

Christensen, Johnson and Turner (2011), assert there are eight peripheral variables that threaten internal validity: history, maturation, testing, instrumentation, statistical regression, selection bias, experimental morality, and selection interaction. History refers to an event or condition that occurs during research involving human subjects. The event or condition can affect the results of the study. For example, a participant may receive additional flight training during a research project. This can influence the dependent variable. There were no known additional training events reported by participants or researchers.

Maturation of research can occur if the study takes place over an extended period of time. People, particularly children, tend to grow and develop quickly. Long-term studies are susceptible to maturation, particularly if the dependent variables do not involve time (Christensen, Johnson & Turner, 2011). At the FAA Technical Center, researchers collected data from each participant in one day. At Purdue University, researchers collected data from participants within four days. The data collection time period was minimal and maturation was not considered a threat for this study.

Testing refers to how research participants may do well on a posttest, simply because of the retention of knowledge during the pretest. Researchers used slightly different posttest questions to reduce the threat of testing. The posttest questions were from the topic area within the airmen certification standards test bank. Instrumentation can create a threat to internal validity by being changed throughout the study. This can happen with longitudinal studies. It is advised not to change the research instrument (Christensen, Johnson &Turner, 2011). Using three different flight training devices created a research instrument threat. Though each flight training device mimicked a single engine aircraft, control loading may have been different. Researchers used the same weather conditions, flight paths, and procedures to reduce this threat. Statistical regression is when measurements of extreme scores regresses towards the mean. One example of statistical regression is when a group of students who scored poorly on a pretest show greater progress on the posttest than average or higher-scoring groups.

Selection bias is a non-random factor. Typically, this happens when groups have important differences and cannot be assigned randomly into groups. This often occurs during quasi experimental research (Christensen, Johnson &Turner, 2011). The researchers used convenient sampling, and randomly assigned participants into each group by use of an online program. Convenience sampling creates a threat because participants were not randomly-selected. Due to resource constraints convenience sampling was utilized. Experimental morality is when a participant drops out during a study. Participants at the FAA Technical Center were deliberately cancelled from the study by researchers because of FTD hardware/software issues. This made the sample size much smaller than desired. Only one participant dropped out of the Purdue dataset. Selection maturation interaction occurs when highly-performing subjects do better than regulating performing subjects.

Experimental groups should be functionally similar during research studies (Yu & Ohlund, 2010). Some subjects outside of the desired pilot profile were allowed to participate in this study. The FAA Technical Center control group had nine pilots who held commercial-instrument certificates. Though the participants were randomly assigned, this group had more qualified pilots than the other groups, potentially effecting the results. Additional occurrences such as external threats to validity, can influence the generalizability of a study.

Researcher ability to generalize the results of a sample to the population is also influenced by external validity. Ary, Jacobs, Razavieh and Sorensen (2009) identify five threats to external validity: selection, setting, pretest, subject effects, and experimenter effects. Selection refers to the possibility that participants are not representative of the larger population (Ary, Jacobs, Razavieh & Sorensen, 2009). For example, if researchers are interested in evaluating training effects on all pilots, but use only airline transport pilots (ATP) for the sample tested. Results may be different when GA pilots are used. One treatment may work well on one group but not for the other. The present study identified a problem area for general aviation. Based on accident reports, a pilot profile was developed. Most of the pilots fit this profile. Demographics include flight experience of participants and are presented in the results section.

Setting refers to the location in which the study takes place. Laboratory settings may produce different results than what would occur in the “real world” (Ary, Jacobs, Razavieh & Sorensen, 2009). The present study utilized flight training devices. This may have influenced the performance of participants. To reduce this threat to external validity, researchers advised participants to operate as if the flight was real. Additionally, researchers followed rigorous protocols to make the flight training device scenarios as realistic as possible. Participants were provided flight plans, sectional charts, route briefings, air traffic control services, and weather information. Though there was consistency with research data collection protocols, the flight training devices had unique characteristics.

According to Ary, Jacobs, Razavieh and Sorensen (2009), use of a pretest can increase or decrease participant sensitivity to the dependent variable. This increased or decreased sensitivity may bring into question generalizability. Since the overall population has not been pretested generalization may become difficult. However, pretest and posttest experimental designs are thought to be rigorous and effective at establishing cause and effect.

Subject effects refers to the change in participant feelings and attitudes that may develop during an experiment. In addition, participants may attempt to pick up on demand characteristics. According to Rosenthal and Rosnow (1969), demand characteristics are cues within an experiment that can influence the way participants respond to research tasks. There are typically three roles a participant can take: good, negative, or apathetic. The good participant will attempt to provide the researcher with data that confirm the hypothesis. Contrary to the good participant, the negative participant will attempt to provide data that negate the hypothesis. Apathetic participants are indifferent and behave in a random manner. Demand characteristics may or may not be consistent with the expectations of the researcher. In addition, demand characteristics can develop anytime throughout a research study. Changes in participant behavior can affect the external validity of the study (Rosenthal & Rosnow, 1969). The researchers sought to minimize subject effects by concealing the dependent variables. Before the study was executed, researchers solicited individuals to participate in the mock experiment and provide feedback. This included the pretest, flight scenarios and posttest.

Lastly, experimenter effect refers to the potential bias of the research. Researchers may influence participant behavior consciously or unconsciously. These biases may manifest themselves in verbal or nonverbal cues (Ary, Jacobs, Razavieh & Sorensen, 2009). Experimenter effects can influence the generalizability of the results. To limit experimenter effects, researchers carefully followed research protocol and remained neutral throughout the data collection process.

3.17 Summary

This chapter addressed details of the research design and procedures to address the research questions. Additionally, the research samples were discussed. Moreover, justification for utilizing the treatments was discussed. Finally, threats to the validity of the study were addressed.

CHAPTER 4. RESULTS

This study sought to determine the effectiveness of two weather knowledge training modules on pilot skills and abilities when faced with deteriorating weather conditions. Participants completed the necessary Institutional Review Board (IRB) consent forms, and then completed a pretest. The pretest consisted of 24 weather-related knowledge questions adopted from the Federal Aviation Administration (FAA) Airman Certification Standards (ACS). Participants were then randomly-assigned into one of three groups: a control group, an interactive online course group, or an interactive workshop group. After participating in their assigned group, participants completed two flight training device scenarios created from real-life accident reports. Each participant was then asked to complete a posttest, including post-flight interview questions. Different questions from the same ACS topic area were selected for the posttest. Two months after the Federal Aviation Administration (FAA) William J. Hughes Technical Center (FAA Tech Center) participants completed the initial experiment, a posttest invitation was sent via email. Similarly, one month after the Purdue University participants completed the experiment, they were sent an invitation via email to complete the posttest. The second posttest was the same as the first posttest. Due to using two locations with slightly different procedures, simulators, and recruitment details, the results are reported separately in this chapter.

It was expected that participants in the treatment groups would have higher posttest scores and would avoid instrument meteorological conditions (IMC) at a higher frequency than the control group participants. Based on statistical comparisons of the three groups, the researchers sought to determine which training module was more effective at enhancing pilot skills, and abilities. Additionally, the post-flight training device questions were analyzed to ascertain pilot decision-making themes. Demographic information and statistical analyses pertaining to the research questions are discussed in this chapter.

4.1 Demographic Information for FAA Technical Center Participants

Participant demographic and flight experience information was collected as part of the experiment. This information included age, gender, total flight hours, accrued instrument time, and time flown in the previous six months. Demographic and flight experience information was sorted and depicted for each group, and these data are shown in Table 4.1. Table 4.2 shows participant flight experience information for each group, and Table 4.3 shows class of airplane most often flown and type of training received. Forty-eight participants started and completed the pretest and posttest (n = 48). However, not all participants completed the flight training device scenarios (n = 29). This was due to the flight training devices not functioning properly 100 percent of the time. Instead of having participants wait for technicians to correct the problem, affected participants were asked to complete the posttest. Flight training device results are discussed in the corresponding subsections.

Table 4.1

Demographic, Certificates, and Ratings

	Control group frequencies	Interactive online group frequencies	Interactive workshop group frequencies
Age			
18-25	3	3	2
26-35	4	2	3
36-45	1	0	2
46-55	2	3	2
56+	6	8	7
Total (n)	**16**	**16**	**16**
Gender			
Male	14	16	16
Female	2	0	0
Total (n)	**16**	**16**	**16**
Certifications/Ratings			
Private	7	7	6
Private Instrument	0	5	3
Commercial SE	0	1	0
Commercial ME	0	0	1
Commercial Instrument SE	5	0	1
Commercial Instrument ME	0	0	1
Commercial Instrument SE & ME	0	0	3
CFI	4	3	1
Total(n)	**16**	**16**	**16**

Note. SE = Single-Engine, ME = Multi-Engine, and CFI = Certified Flight Instructor.

Table 4.2

Participant Flight Hours

	Control group frequencies	Interactive online group frequencies	Interactive workshop group frequencies
Total Flight Hours Logged			
0-50	0	1	0
51-100	2	0	2
101-200	3	4	0
201-300	4	0	2
301+	7	11	12
Total (n)	**16**	**16**	**16**
Instrument Hours Logged			
0-50	9	10	7
51-100	4	2	4
101-200	1	2	3
201-300	2	1	0
301+	0	1	2
Total (n)	**16**	**16**	**16**
Flight Hours Logged In Previous 6 Months			
0-50	7	10	15
51-100	8	5	0
101-200	1	0	1
301+	0	1	0
Total (n)	**16**	**16**	**16**

Table 4.3

Class of Airplane Most Often Flown and Training Environment

	Control group frequencies	Interactive online group frequencies	Interactive workshop group frequencies
Class of Airplane			
Single Engine	16	14	15
Multi-Engine	0	0	1
Both	0	2	0
Total (n)	**16**	**16**	**16**
Training Environment			
Part 61	11	11	10
Part 141	3	2	3
Part 61 & Part 141	1	0	0
Collegiate Program	1	0	0
Military	0	0	2
Other	0	3	1
Total (n)	**16**	**16**	**16**

4.2 Research Questions

The following sections will outline and address the three research questions and provide in-depth statistical analyses. Multiple statistical analyses were completed with the use of Minitab 17. The *a priori* alpha level selected was .05 (α = .05). Forty-eight research participants completed the pretest and posttest (n = 48). Each group had 16 participants. Twenty participants (n = 20) completed the second posttest which was distributed two months after the initial data collection period. Eight were in the control group, eight in the interactive online group, and four in the interactive workshop group. Due to the unbalanced data collection points, only ANOVA was used to analyze the posttest two data.

4.3 Research Question 1: FAA Technical Center Participants

Research Question 1: Is there a statistically-significant difference in pre-and posttests results between and within the control and experimental groups?

According to the Federal Aviation Administration (FAA) (2015c) Airmen Certification Standards (ACS) were designed to replace the existing Practical Test Standards (PTS). Simply put, the ACS is an enhanced version of the PTS. The primary difference "is the addition of task specific knowledge and risk management elements. The result is a holistic, integrated presentation of specific knowledge, skills, and risk management." (p.3).

The test questions were sent through several rounds of vetting by the researchers and were deemed appropriate for the study. The final pretest and posttest assessment included twenty-four multiple choice questions. Pretests and posttests were given on the same day at the FAA Technical Center. The second posttest was distributed to participants two months after completion of the initial data collection. Descriptive statistics regarding the pretest, posttest, and post-posttest (Posttest Two) scores for each group can be found in Table 4.4.

A post hoc internal consistency item analysis was conducted for both the pretest and posttest using Minitab 17. Internal consistency quantifies the degree to which a measurement measures what it is supposed to measure (Furr & Bacharach, 2014). According to Clark and Watson (1995), clear rules of thumb from acceptable alpha levels no longer exist. However, previous acceptable alpha levels ranged from .60-.90. Pretest scores for each data set were combined. Therefore, the total count for the pretest was 72 while the posttest total count was 71. The Cronbach's alpha value for the pretest was

0.444 while the Cronbach's alpha value for the posttest was 0.682. When comparing these values to the rule of thumb, the pretest has low internal consistency, while the posttest has an acceptable level of internal consistency.

Table 4.4

Descriptive Statistics for the Pretest, Posttest, and Posttest Two

Group	n	Mean	Standard Deviation	Minimum	Maximum
Control Group Pretest	16	17.875	1.544	15	21
Control Group Posttest	16	19.375	2.680	15	24
Control Group Posttest II	8	20.125	1.959	16	22
Online Group Pretest	16	17.000	2.658	13	22
Online Group Posttest	16	17.19	4.050	11	24
Online Group Posttest II	8	19.13	3.360	12	23
Workshop Group Pretest	16	17.313	2.152	15	22
Workshop Group Posttest	16	16.188	2.228	13	20
Workshop Group Posttest II	4	19.000	2.450	17	22

Note. The mean was calculated from the number of correct answers.

A One-way Analysis of Variance (ANOVA) is the most appropriate statistical test for comparison of the three groups. A one-way ANOVA has six assumptions that need to be met before conducting the analysis. The six assumptions are having a dependent variable that is measured on a continuous interval, an independent variable such as treatment or control groups, independent observations, normal distribution, no significant outliers, and equal variance (Laerd Statistics, 2013a). The first three assumptions were met during the research design phase. Pretest and posttest scores were considered continuous interval. The independent variable includes a control group and two experimental groups. Participants completed the pretest, posttest, and posttest two independently; therefore, the independence assumption was met.

Before conducting a one-way ANOVA the data should be checked to ensure there are no significant outliers, the data are approximately normally distributed, and there is homogeneity of variances. For purpose of testing normality, the Kolmogorov-Smirnov (K-S) test was used. The K-S test hypothesizes there is no difference in normal distribution scores. If the result of the test is greater than .05, the null hypothesis cannot be rejected. Therefore, the result indicated normal distribution. The results of the K-S tests for the control and interactive online group indicated the data were normally distributed, $p > 0.150$ and $p > 0.135$, respectively. The K-S score for the interactive workshop group was, $p = 0.012$. An inspection of the corresponding histogram revealed the data were slightly skewed to the right. An ANOVA requires approximate normal distribution therefore, the remaining two assumptions were checked.

In regards to the posttest scores, the K-S tests indicated the control, interactive online, and interactive workshop group data were normally distributed. The K-S values were p > 0.150, $p > 0.150$, and $p > 0.078$, respectively. K- S values for the posttest two scores all indicated normal distribution, $p > 0.150$ (all three groups). Statistical output of the K-S tests for the pretest, posttest, and posttest two scores can be found in Appendix M.

For the purpose of checking for significant outliers, Grubb's test was used. According to Alfassi, Boger and Ronen (2005), Grubb's test calculates potential outliers from the mean in univariate data. When testing the three groups' pretest data, Grubb's tests indicated no significant outliers for any of the groups, $p = 0.495$, $p = 0.764$, and $p = 0.292$, respectively. All of the Grubb's tests indicated no significant outliers when examining the posttest scores, $p = 1.000$ (all three groups). When examining the Grubb's tests for the posttest two scores, the results indicted no significant outliers. The Grubb's tests for the control, interactive online, and workshop groups was, p = 0.059, $p = 0.052$, and $p = 0.734$, respectively. The statistical output for the outlier tests can be viewed in Appendix N.

The next required assumption was the test for equal variance. Homogeneity of variances should be statistically similar. To statistically compare variance among all of the groups' pretest scores, Levene's test was used. Levene's test is suggested when samples have fewer than 20 data points in any of the groups. It is also suggested to use Levene's test when data are skewed (Levene, 1960). Similar to the K-S test, Levene's test assumes that all variances are statistically equal. A *p*-value less than .05 indicated statistical differences in variation among the groups. After completing Levene's test on the pretest scores, the result indicated equal variance among the three groups, $p = 0.226$. In regards to the posttest scores, Levene's test indicated equal variance, $p = 0.051$. Levene's test for the posttest two scores also indicated equal variance, $p = 0.707$. Statistical output for the tests for equal variance can be viewed in Appendix O.

An ANOVA was used to test whether there was a significant difference between pretest scores. Results of the pretest one-way ANOVA indicated no significant difference between the pretest scores, $F(2, 45) = 0.67$, $p = 0.517$. The effect size calculation indicated a small effect value of $f = 0.234$. According to Cohen (1969), effect size is a measure of the magnitude of the relationship between variables. When using Cohen's f statistic, it is suggested to use 0.10, 0.25, and 0.40 as a rule of thumb for small, medium, and large effect sizes. Statistical output of the pretest scores' one-way ANOVA can be viewed in Appendix P.

When comparing the posttest scores, the data provided evidence that at least one mean was significantly different, $F(2, 45) = 4.46$, $p = 0.017$. The calculated effect size was, $f = 0.497$, which suggests a large effect size. After further examination of the statistical results, it was determined that the workshop posttest mean was significantly lower than the control group. In regards to posttest two, the ANOVA indicated no significance between groups, $F(2, 17) = 0.36$, $p = .702$. The effect size calculation was, $f = .02$, which indicates a small effect. Statistical output of the posttest and posttest two one-way ANOVAs can be viewed in Appendicies Q and R.

A paired t-test was used to determine if there was a significant difference within each group. There are four assumptions that need to be met before conducting a paired t-test. The four assumptions are having a continuous level dependent variable such as pretest and posttest scores, the independent variable should have two groups that are related to each other, no significant outliers present, and approximately normally-distributed data points (Laerd Statistics, 2013b).

The first two assumptions were met during the research design phase. The dependent variables are pretest and posttest scores, which are continuous. All of the data were approximately normally distributed and there were no significant outliers. The paired t-test for the control group indicated there was a significant difference between the pretest and posttest scores, $p = .007$; the posttest mean score was significantly higher. The calculated effect size was, $dz = 0.777$. However, the difference between the means was 1.5 and the 95% confidence interval was, (-2.530, -0.470). This may suggest a lack of practical significance. When the pretest and posttest scores were compared for the interactive online group, the paired t-test indicated no significant difference, $p = 0.80$.

The calculated effect size was *dz* = 0.064. Lastly, the paired t-test indicated no significant difference between the interactive workshop pretest and posttest mean scores, $p = 0.057$. The calculated effect size was *dz* = .514. The Statistical output for the paired t-test can be viewed in Appendix S.

4.4 Research Question 2: FAA Technical Center Participants

Research Question 2: *Which group of participants had the highest frequency of avoiding instrument meteorological conditions?*

Sixty pilots were recruited to participate in the study at the FAA Technical Center. However, the researchers had to cancel the first day (12 participants), because of technical issues with the two flight training devices that precluded flying the test scenarios. Of the remaining participants, only 29 were able to complete the flight training device scenarios, because of continuing technical issues with the flight training devices. Ten participants were assigned to the control group, ten to the interactive online group, and nine to the interactive workshop group. Demographic information and flight experience information for participants who completed the flight training device scenarios for each group is shown in Tables 4.5-4.7.

Table 4.5

Age, Gender, Certificates, and Ratings

	Control group frequencies	Interactive group frequencies	Workshop group frequencies
Age			
18-25	2	2	2
26-35	2	2	1
36-45	1	0	1
46-55	1	1	0
56+	4	5	5
Total (n)	**10**	**10**	**9**
Gender			
Male	9	10	9
Female	1	0	0
Total (n)	**10**	**10**	**9**
Certifications/Ratings			
Private	5	4	4
Private Instrument	0	4	2
Commercial SE	0	1	0
Commercial ME	0	0	0
Commercial Instrument SE	3	0	0
Commercial Instrument ME	0	0	1
Commercial Instrument SE & ME	0	0	1
CFI	2	1	1
Total (n)	**10**	**10**	**9**

Note. SE = Single-Engine, ME = Multi-Engine, and CFI = Certified Flight Instructor

Table 4.6

Flight Hours – FTD Participants

	Control group frequencies	Interactive online group frequencies	Interactive workshop group frequencies
Total Flight Hours Logged			
0-50	0	0	0
51-100	1	0	2
101-200	2	3	0
201-300	3	0	0
301+	4	7	7
Total (n)	**10**	**10**	**9**
Instrument Hours Logged			
0-50	6	6	5
51-100	2	1	1
101-200	1	1	2
201-300	1	1	0
301+	0	1	1
Total (n)	**10**	**10**	**9**
Flight Hours Logged in the Previous 6 Months			
0-50	4	7	9
51-100	6	2	0
101-200	0	0	0
301+	0	1	0
Total (n)	**10**	**10**	**9**

Table 4.7

Class of Airplane Most Often Flown and Training Environment

	Control group frequencies	Interactive online group frequencies	Interactive workshop group frequencies
Class of Airplane			
Single-Engine	10	8	8
Multi-Engine	0	0	1
Both	0	2	0
Total (n)	**10**	**10**	**9**
Training Environment			
Part 61	7	6	8
Part 141	1	1	1
Part 61 & Part 141	1	0	0
Collegiate Program	1	0	0
Military	0	0	0
Other	0	3	0
Total (n)	**10**	**10**	**9**

All participants were advised to make decisions based on a real visual flight rules (VFR) flight in accordance with FAA regulations. Pilots conducting VFR operations must make decisions early enough to avoid instrument flight rule (IFR) conditions, visibility below three statute miles and/or clouds lower than 1000 feet above ground level. Violation of this regulation may increase risks and lead to illegal operations, incidents or accidents. Furthermore, simply being legal is not always safe. Decisions must be made, based on pilot and aircraft capability. Participants were asked to fly two scenarios, one in Alaska and the other in New Mexico. During both scenarios the visibility was gradually decreased as the pilot flew closer to the destination. Each scenario had rising terrain to make the scenario more complex. Therefore, descending to a lower altitude was not the best option. The researchers reviewed the data collected during participant observations to ascertain each pilot's decision and when it was made. Participant behavior was recorded as continued into IMC, turned, and/or diverted. The visibility at the location of the decision was also recorded. It was expected the experimental group participants would avoid IFR conditions at a higher frequency than the control group.

Results indicated three (15%) decisions made by control group participants avoided instrument meteorological conditions when examining both scenarios together. Seven (35%) decisions made by interactive online group participants avoided instrument meteorological conditions. Two decisions (11%) made by interactive workshop group participants avoided instrument meteorological conditions. Even though the groups were not equal, the interactive online course group had a highest frequency of avoiding instrument meteorological conditions, seven (35%). The workshop group had the highest overall frequency of continuing towards the destination, 13 (72%). Control group participants had the highest overall frequency of entering instrument meteorological conditions then making a decision to turn or divert, five (25%). Table 4.8 shows a breakdown of the decision made by participants observed at the FAA Technical Center. Frequencies listed as 'Other' indicate when a participant either got lost, crashed or the flight training device failed.

Table 4.8

Decisions Made During Flight Scenarios

Group	Scenario	Diverted/Turned in VMC	Went into IFR then Diverted/Turn	Continued	Other
Control (n = 10)	Alaska	1(10%)	3 (30%)	6 (60%)	0
	New Mexico	2 (20%)	2 (20%)	6 (60%)	0
	Total=20	3 (15%) AK and NM	5 (25%) AK and NM	12 (60%) AK and NM	0
Online (n = 10)	**Scenario**	**Diverted/Turned in VMC**	**Went into IFR then Diverted**	**Continued**	**Other**
	Alaska	4 (40%)	0	4 (40%)	2 (20%)
	New Mexico	3 (30%)	2 (20%)	4 (40%)	1(10%)
	Total=20	7 (35%) AK and NM	2 (10%) AK and NM	8 (40%) AK and NM	3 (15%) AK and NM
	Scenario	**Diverted/Turned in VMC**	**Went in IFR then Diverted**	**Continued**	**Other**
Workshop (n = 9)	Alaska	1 (11%)	0.00%	7 (60%)	1(11%)
	New Mexico	1 (11%)	2 (22%)	6 (67%)	0
	Total=18	2 (11%) AK and NM	2 (11%) AK and NM	13 (72%) AK and NM	1(5%) AK and NM

Note. Other included the participant either crashed, got lost or the flight training device failed. Therefore, data was not documented. Percentages were rounded to the nearest whole number.

4.5 Research Question 3: FAA Technical Center Participants

Research Question 3: How do participants perceive their decision-making when asked after flight training device sessions?

After the flight training device scenarios, participants were requested to complete a posttest. At the end of the posttest, four identical post-flight questions were given for each scenario. One question pertained to the overall experience of the flight training device exercise. The first three post-flight questions will be used to address research question three. The post-flight questions were:

1. In the Alaska/New Mexico Simulation Scenario, did you divert, turn back or continue?

2. Why did you make the decision that you made?
3. Would you make the same decision again, and why?
4. Using a percentage, how much of your attention do you estimate was dedicated to maintaining the flight controls? And to maintaining situational awareness? (e.g., weather, traffic, etc.)
5. Is there anything you would like the researchers to know about your simulation experience today?

To address research question three, raw data were extracted from the Excel sheet output. The researchers started with the control group to determine how participants perceived their decision making. Ten control group participants answered all of the post-flight questions. Out of the 20 opportunities to make a decision to avoid degrading flight conditions, several participants entered instrument meteorological conditions then decided to divert and/or turn. Three responses indicated the decision to continue was “correct” and would do it again. One response from a participant who chose to continue during the Alaska scenario stated, “probably. Still felt there was adequate visibility.” Another response from a participant who chose to continue during the New Mexico scenario stated, “yes, because there wasn’t factors like low visibility, there are plenty of escape routes if things do go bad and the weather was decent.” Both scenarios had deteriorating conditions and rising terrain. These responses indicated a misperception of risk.

Responses that indicated the decision to continue were also attributed to the misperception of risks. A response from a participant who chose to continue during the New Mexico scenario stated, “Weather wasn’t bad enough to warrant turning around or diverting". Responses that indicated the decision to turn or divert did so to mitigate the risks. One participant stated, "VFR into IMC is one of the leading causes of fatalities, if you can't see the mountains and they are close, it's the perfect killing scenario." Many responses were similar to this assertion.

The interactive online group also had 20 opportunities to avoid deteriorating conditions. Several participants entered instrument meteorological conditions then made the decision to turn and/or divert. Three responses indicated the decision to continue was correct and would do it again. One response from a participant who chose to continue during the New Mexico scenario and had the willingness to make the same decision stated, "had the road in sight to follow to the airport." Additionally, a response from a participant who chose to continue during the Alaska scenario stated "was approaching the destination." These types of responses indicated the misperception of risks and the desire to arrive at the destination.

Responses from participants who chose to turn and/or divert did so because they perceived the risks and attempted to mitigate the risks. A response from a participant who diverted from deteriorating conditions during the Alaska scenario stated, "I knew the weather that was right in front of me. I did not know what the weather was like around the bend. I had a straight in scenario for the other airport." Several responses are similar to this response in regards to why the decision to turn and/or divert was made.

The interactive workshop participants had 18 opportunities to make decisions to avoid instrument meteorological conditions. Several participants entered instrument meteorological conditions then made the decision to turn and/or divert. Six responses indicated the decision was to continue and would make the same decision to continue again. A response from a participant who chose to continue during the Alaska scenario and would make the same decision again stated, “yes, I was away from the mountains and flight was VFR.” Another response from a participant who chose to continue during New Mexico scenario stated, “Yes. The end of the scenario when I was in IMC, I was stable and pointed straight at the airport. I would have been safe.” A response from a participant who chose to continue during the Alaska scenario stated, “I thought I would be safe because weather permits.” These responses indicated misperceptions of the flight conditions.

Responses from participants who chose to turn and/or divert away from degrading conditions did so because they were able to perceive risks and attempt to mitigate them. A participant who chose to divert during the New Mexico scenario stated, “I applied my normal decision making, I have done so in the past.” Another response from a participant who decided to turn away from degrading conditions during the New Mexico scenario stated, “I didn’t know the area well enough or have a good enough picture of where the weather was. Conditions seemed be worsening so I turned back.”

4.6 Demographic Information for Purdue Participants

Participant demographic and flight experience information was also collected as part of the experiment. This information included age, gender, total flight hours, instrument time, time flown in the previous six months, class of airplane most often flown, and training environment. Demographic and flight experience information was sorted and depicted for each group, and is shown in Tables 4.9-4.11. One participant assigned to the interactive online course group completed the pretest but failed to complete the entire experiment. This data point was removed in its entirety. Twenty-three participants started and completed the pretest and posttest (n = 23). There were eight participants in the control group, seven in the interactive online training group, and eight in the interactive workshop group. Flight training device results are discussed in the corresponding subsection.

Table 4.9

Demographics, Certificates and Ratings

	Control group frequencies	Interactive group frequencies	Workshop group frequencies
Age			
18-25	6	5	2
26-35	2	1	2
36-45	0	0	0
46-55	0	1	3
56+	0	0	1
Total (n)	**8**	**7**	**8**
Gender			
Male	8	6	8
Female	0	1	0
Total (n)	**8**	**7**	**8**
Certificates/Ratings			
Private	8	6	7
Private Instrument	0	0	1
Commercial SE	0	0	0
Commercial ME	0	0	0
Commercial Instrument SE	0	1	0
Commercial Instrument ME	0	0	0
Commercial Instrument SE & ME	0	0	0
CFI	0	0	0
Total (n)	**8**	**7**	**8**

Note. SE = Single-Engine, ME = Multi-Engine, and CFI = Certified Flight Instructor.

Table 4.10

Flight Hours and Experience

	Control group frequencies	Interactive group frequencies	Workshop group frequencies
Total Flight Hours Logged			
0-50	1	0	1
51-100	6	4	4
101-200	0	2	1
201-300	1	1	1
301+	0	0	1
Total (n)	**8**	**7**	**8**
Instrument Hours Logged			
0-50	8	7	8
51-100	0	0	0
101-200	0	0	0
201-300	0	0	0
301+	0	0	0
Total (n)	**8**	**7**	**8**
Flight Hours Logged In Past 6 Months			
0-50	8	4	6
51-100	0	3	2
101-200	0	0	0
301+	0	0	0
Total (n)	**8**	**7**	**8**

Table 4.11

Class of Airplane Most Often Flown and Training Environment

	Control group frequencies	Interactive group frequencies	Workshop group frequencies
Class of Airplane			
Single Engine	8	6	8
Multi-Engine	0	0	0
Both	0	1	0
Total (n)	**8**	**7**	**8**
Training Environment			
Part 61	6	5	7
Part 141	1	1	1
Part 61 & Part 141	1	0	0
Collegiate Program	0	1	0
Military	0	0	0
Other	0	0	0
Total (n)	**8**	**7**	**8**

4.7 Research Questions: Purdue University Participants

This section outlines and addresses the three research questions and provides in-depth statistical analyses for the data collected at Purdue University. Multiple statistical analyses were completed with the use of Minitab 17. *A priori* alpha level selected was $\alpha = .05$. Any p values below .05 were considered significant. Twenty-four participants were initially signed up to participate. Twenty-three participants completed the pretest and posttest (n = 23). A participant from the interactive online group did not complete flight training device scenario or the posttest; therefore, that person's pretest score was removed from the data.

4.8 Research Question 1: Purdue Participants

According to the Federal Aviation Administration (FAA) (2015c) Airmen Certification Standards (ACS) were designed to replace the existing Practical Standards (PTS). Simply put, the ACS is an enhanced version of the PTS. The primary difference "is the addition of task specific knowledge and risk management elements. The result is a holistic, integrated presentation of specific knowledge, skills, and risk management."(p.3). The questions were sent through several rounds of vetting by the researchers and were deemed appropriate for the study. The final pretest, posttest and, second posttest assessment included twenty-four multiple choice questions. Posttests were given to the Purdue participants within five days of taking the pretests. Descriptive statistics regarding pretest and posttest scores (number of correct answers) for each group can be found in Table 4.12. The test scores were calculated based on number of correct answers.

Table 4.12

Descriptive Statistics for Pretests, Posttests, and Posttest II

Group	n	Mean	Standard Deviation	Min	Max
Control Group Pretest	8	17.125	2.642	13	21
Control Group Posttest	8	15.13	4.49	7	21
Control Group Posttest II	1	18.00	0.00	18	18
Online Group Pretest	7	18.714	2.563	15	22
Online Group Posttest	7	17.857	1.464	15	19
Online Group Posttest II	2	18.00	0.00	18	18
Workshop Group Pretest	8	17.50	3.30	13	23
Workshop Group Posttest	8	17.00	4.24	9	21
Workshop Group Posttest II	2	20.00	2.83	18	22

Before conducting a one-way ANOVA the data should be checked to ensure it is normally distributed, there are no significant outliers, and there is homogeneity of variances. The results of the K-S tests revealed the data in each group were normally distributed, $p > 0.150$ (each group). In regards to the posttest data, the K-S tests for the control and interactive online group indicated normal distribution, $p = 0.050$ and $p > 0.150$, respectively. The K-S test for the interactive workshop group was $p < 0.010$. After examining the histogram, it was determined the data were slightly skewed to the left. Since the one-way ANOVA needs to only have approximate normally-distributed data, the two other assumptions were checked. Statistical output of the K-S tests for the Purdue university pretest and posttest scores can be found in Appendix T.

For the purpose of checking for significant outliers, Grubb's test was used. According to Alfassi, Boger and Ronen (2005), Grubb's test calculates potential outliers from the mean in univariate data. When testing the three groups, results of Grubb's test indicated no significant outliers for any of the groups, $p = 0.749$, $p = 0.857$, and $p = 0.533$ respectively. The Grubb's test results for the posttest scores were, $p = 0.312$, $p = 0.090$, and $p = 0.224$ respectively. Statistical output for the Grubb's tests can be viewed in Appendix U.

The next assumption that needed to be met was the test for equal variance. Homogeneity of variances should be statistically similar. For the purpose of statistically comparing variance among all of the groups' pretest scores, Levene's test was used. After completing Levene's test on the pretest scores, the result indicated equal variance among the three groups of pretest scores, $p = 0.840$. In regards to the posttest scores of the three groups, Levene's test indicated equal variance, $p = 0.350$. Statistical Output for the tests for equal variance can be viewed in Appendix V.

All of the assumptions were met; therefore, two one-way ANOVAs were used, one for the pretest and one for the posttests. Results of the one-way ANOVA for the pretest indicated no significant difference, $F(2, 20) = 0.62$, $p = .550$. The post-hoc effect size was, $f = 0.248$. In regards to the posttest scores among the three groups, the result of the one-way ANOVA indicated no significant difference between the groups $F(2, 20) = 1.06$, $p = 0.364$. The post hoc effect size was, $f = 0.253$. Statistical output of the one-way ANOVA for both pretest and posttest scores may be viewed in Appendix W.

The paired t-test for the control group indicated there was no significant difference between the pretest and posttest scores, $p = 0.249$. The calculated effect size was $dz = 0.511$. When the pretest and posttest were compared for the interactive online group, the paired t-test indicated no significant difference, $p = 0.457$. The calculated achieved effect size was $dz = 0.301$. Lastly, the paired t-test indicated no significant difference between the interactive workshop pretest and posttest mean scores $p = 0.743$. The calculated achieved effect size was $dz = 0.120$. Statistical output for the paired t-test can be viewed in Appendix X.

Five of the Purdue participants voluntarily completed the second posttest. Of these, one participant was assigned to the control group, two were assigned to the interactive online group, and two were assigned to the interactive workshop group. There were not enough data to conduct robust statistical testing. Thus, only descriptive statistics were reported, as shown in Table 4.12.

4.9 Research Question 2: Purdue Participants

Research Question 2: *Which group of participants had the highest frequency of avoiding instrument meteorological conditions?*

Twenty-four participants were recruited and signed up to participate in this study at Purdue University. However, 23 participants completed the flight training device scenarios. Eight participants were in the control group, seven in the interactive online group, and eight in the interactive workshop group. Demographic and flight experience information for the participants who completed the flight training device scenarios were the same as shown in the previous tables (4.9-4.11).

The researchers reviewed the data collected during participant observations to ascertain the decisions made and when they were made. Participant behavior was recorded as continued into IMC, turned, and/or diverted. The visibility at the location of the decision was also recorded. It was expected the experimental group participants would avoid IFR conditions at a higher frequency than the control group.

Results indicated seven (43.75%) decisions made by control group participants avoided instrument meteorological conditions when examining both scenarios together. Decisions made by seven (50%) by of the interactive online group participants avoided instrument meteorological conditions. Decisions made by six (37.5%) interactive workshop group participants avoided instrument meteorological conditions. Even though the groups were not equal, the interactive online course group had a higher frequency of avoiding instrument meteorological conditions. The control group had the highest overall frequency of continuing towards the destination, seven (43.75%). Interactive workshop participants had the highest overall frequency of entering instrument meteorological conditions then making a decision to turn and/or divert, four (25%). Table 4.13 shows a breakdown of the decision made by participants observed for the Purdue portion of the study.

Table 4.13

Decisions Made During Flight Training Device Scenarios-Purdue Participants

Group	Scenario	Diverted/Turned in VMC	Went into IFR then Diverted/Turn	Continued
Control (n = 8)	Alaska	3 (37.5%)	2 (25%)	3 (37.5%)
	New Mexico	4 (50%)	0	4 (50%)
	Total=16	7 (43.75) AK and NM	2 (12.5%) AK and NM	7 (43.75%) AK and NM
	Scenario	**Diverted/Turned in VMC**	**Went into IFR then Diverted/Turn**	**Continued**
Online (n = 7)	Alaska	4 (57.14%)	0	3 (42.8%)
	New Mexico	3 (42.86%)	2 (28.57%)	2 (28.57%)
	Total=14	7 (50%) AK and NM	2 (14.28%) AK and NM	5 (35.71) AK and NM
	Scenario	**Diverted/Turned in VMC**	**Went into IFR then Diverted/Turn**	**Continued**
Workshop (n = 8)	Alaska	4 (50%)	1 (12.5)%	3 (37.5%)
	New Mexico	2 (25%)	3 (37.5%)	3 (37.5%)
	Total=16	6 (37.5%) AK and NM	4 (25%) AK and NM	6 (37.5) AK and NM

Note. Percentages were rounded to nearest tenth.

4.10 Research Question 3: Purdue Participants

Research Question 3: How do participants perceive their decision-making, when asked after flight training device sessions?

After the flight training device scenarios, participants were asked to complete a posttest. At the end of the posttest, four identical post-flight questions were given for each scenario. One question pertained to the overall experience of the flight training device exercise. The first three post-flight questions will be used to address research question three. The post-flight scenario questions were:

1. In the Alaska/New Mexico Simulation Scenario, did you divert, turn back or continue?
2. Why did you make the decision that you made?
3. Would you make the same decision again, and why?
4. Using a percentage, how much of your attention do you estimate was dedicated to maintaining the flight controls? And to maintaining situational awareness? (e.g., weather, traffic, etc.)
5. Is there anything you would like the researchers to know about your simulation experience today?

To address research question three, raw data were extracted from the Excel sheet output. The researchers started with the control group to determine how participants perceived their decision-making. All of the control group participants (n = 8) answered all of the post-flight questions. The first responses indicated that of the 16 opportunities to turn and/or divert, participants claimed 11 decisions were made to turn or divert. However, observations showed only nine diverted or turned away from the deteriorating conditions. Even those who diverted, made late decisions and entered instrument meteorological conditions. At least, two of the participants indicated a turn or diversion away from deteriorating conditions, when in fact a decision to continue was observed.

Four participants in the control group indicated continuing to the destination was the right decision and would not change the decision if given another chance. One response from a participant who continued into instrument meteorological conditions during the Alaska scenario stated, “I have a GPS and already know the altimeter setting.” This type of response indicated the desire to arrive at the destination, even though attempting it was unsafe. The hazardous attitude “get-there-itis” is apparent. Another response, which indicated the decision to continue during the New Mexico scenario and willingness to do it again, stated “I never think about turning back since I think I was still on the right track. Also, the surface conditions is [sic] not mountains which makes me more comfortable. I am comfortable with the surface condition so I did not turn around.” This comment indicated a misperception of visibility and terrain. The peaks surrounding ABQ were 9000 feet MSL and visibility gradually reduced during the scenario to instrument meteorological conditions.

In contrast, for those who diverted or turned, the decision to do so was overwhelmingly because of safety. A response indicating the choice to divert/turn during the Alaska scenario stated, “Yes, there was another airport within a few minutes and it wasn’t worth risking it.” Another response, which indicated the decision to divert to a nearby airport during the New Mexico scenario and willingness to make the same decision, stated “Yes, because of poor visibility and proximity to the mountains.” These responses indicated the participants’ perceived changes in conditions, processed the information, and took action to mitigate the risks.

Participants in the control group who continued, learned from the situation. One participant who continued into instrument meteorological conditions during the New Mexico scenario stated, “NO. It’s dangerous”. Another participant response stated, “Definitely not. The visibility is very bad. I can rarely see anything. For safety, if it happens again, I will turn back to the original airport". These participant responses indicated recognition of unsafe decision-making and risks, albeit after the fact.

In regards to the interactive online group, some participants exhibited the same misperception of conditions and personal decision making. Participants indicated twice the decision to divert/turn was made but in fact the decision to continue was observed by the researchers. Additionally, serveral of the participants made late decisions to turn back or divert. None of the participants who chose to continue would make the same decision again. One participant who continued during the Alaska scenario, stated. "I probably would not because there were mountains in the area and you could easily crash into them." Another participant who continued during the New Mexico Scenario stated, "If I were to do this next time I would have diverted to another airport that was reporting VFR conditions. Flying in low visibility is not safe and it can be stressful." The participants who diverted did so overwhelmingly because of safety. None would have made a different decision.

The interactive workshop group had 14 opportunities for correct decisions. Nine participants indicated the decision to turn or divert; however, the researchers observed late decisions and participants were well into instrument meteorological conditions. Three participants continued and indicated willingness to make the same decision. A participant who continued during the Alaska Scenario and would do so again stated, "Yes. Altitude is high enough to ensure safety and we can still see the ground." The same participant had the same reasoning for continuing during the New Mexico scenario. These responses indicated a misperception of the conditions and regulations. All of the participants who indicated they turned and/or diverted and expressed willingness to make the same decision again. The overwhelming reason was safety. A participant expressed the need to decide earlier and stated, “I think I would turn back sooner. I did not realize the visibility was dropping that fast.” Participant responses to post-flight questions for both locations can be viewed in Appendices X and Y.

4.11 Summary of Results

This chapter provided an analysis of data obtained from participants observed at two locations, the William J. Hughes Technical Center and Purdue University. Forty-eight participants at the William J. Hughes Technical Center completed the pretest and posttest, while twenty-nine participants completed the flight training device scenarios and post-flight questions. Twenty participants completed the second posttest two months later.

Twenty-three participants completed the pretest, posttest, flight training device session, and post-flight questions at Purdue University. Statistical tests, descriptive statistics and qualitative analyses were used to answer the research questions for data collected at both locations. The first research question asked if there would be any differences in pretest and posttest scores between and within the three groups: control group, interactive online group, and interactive workshop group. The findings indicated there was no difference between the groups on the pretest scores for the FAA Technical Center participants. However, there was a statistically-significant result for the posttest scores. The control group posttest scores were significantly higher than the interactive workshop posttest scores. An examination of the posttest-two ANOVA revealed no significant difference between the three groups. In regards to the data collected at Purdue University, there was no significant difference found between or within the three groups including posttest two.

The second research question addressed the frequency of decisions made to avoid instrument flight rules conditions. Results of the data collected at the FAA Technical Center indicated the interactive online participants avoided IFR conditions at a higher frequency than the two other groups when examining both flight training device scenarios together. Results of the data collected at Purdue University indicated the control group and interactive online participants had the highest frequency of decisions to avoid IFR conditions when examining both scenarios together. However, the interactive online group had a higher percentage of decisions made to avoid IFR conditions.

The third research question asked how do participants perceive their decision-making after the flight training device scenarios. Three primary themes emerged from participant responses at both data collection sites. The first theme that became apparent to researchers was participants who chose to continue and/or would make the same decision had a misperception of the risks, which included degrading visibility and high terrain. Some participants indicated an overreliance on technology. Additionally, making it to the destination or “get there-itis” influenced participant decision making. Participants who continued, but indicated a change in decision if put in a similar situation, learned and recognized flaws in their decision making. Secondly, those who chose to turn and/or divert away from deteriorating conditions, did so overwhelmingly to mitigate risks. The participants were able to perceive the flight conditions and attempted to mitigate the risks. However, some still made the decision late. Ideally, decisions to turn and/or divert should be made prior to entering instrument meteorological conditions. Lastly, some participants indicated they continued but would not do so again if given another opportunity learned desired decision-making through the flight training devices scenarios.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

Chapter Four provided a detailed analysis of the data collected at the William J. Hughes Technical Center (FAA Technical Center) and Purdue University. This chapter summarizes the study, discusses the results, presents study limitations, provides recommendations, and suggests future research pertaining to Visual Flight Rules (VFR) operations into Instrument Meteorological Conditions (IMC).

5.1 Summary of Study

This study provided an in-depth analysis of general aviation pilot knowledge, skills, and abilities pertaining to low visibility encounters. In addition to the evaluation of pilot performance, two training protocols were evaluated. Researchers in the current study accomplished data collection through pretests, posttests, and post-posttests. Moreover, data were collected by researcher observation of pilot performance during flight training device (FTD) sessions. The foundation of this study was provided by previous research, which indicated training could address gaps in pilot knowledge and performance (Ambs, 2014; Johnson, Wiegmann & Wickens, 2006; Knecht & Ball, 2002; O'hare & Owens, 1999).

The current study recruited participants from the area surrounding Atlantic City, New Jersey, and from the West Lafayette, Indiana area. The desired participant was a private pilot with less than 1000 hours total time, no instrument rating, and had flown at least 10 hours in the previous six months. However, not all participants met these requirements, particularly within the FAA Technical Center group. Some pilots had additional certificates and/or ratings and had more hours. In regards to the FAA Technical Center participants, nine out of the sixteen control group subjects had higher qualifications than desired. Most of the demographic and flight experience was evenly distributed among the three groups. The control group had more commercial-instrument and Certified Flight Instructors (9) than the other groups. This could have potentially influenced the results for the FAA Technical Center dataset. The interactive online group also had nine out of sixteen participants with higher qualifications. Ten out of the sixteen interactive workshop participants had higher qualifications than desired. For the data collected at Purdue, none of the control group participants had higher qualifications than desired, two of the seven interactive online group participants had higher qualifications, and one of the eight interactive workshop members had higher qualifications than desired.

Participants were randomly assigned into either the control group, interactive online group, or interactive workshop group by use of an online program. Participants were asked to provide demographic and flight experience information. Each participant was given a 24-question pretest, which took approximately 30 minutes to complete. After completing the pretest, participants assigned to the interactive online group independently completed a self-paced online training module. It took these participants approximately 45 minutes to complete the short course.

Participants assigned to the interactive workshop group, engaged in a tailored discussion facilitated by the principal investigator (PI), a meteorology expert and professional pilot/Certified Flight Instructor.

The next phase of data collection was achieved by researcher observation of participant performance in flight training devices. At the FAA Technical Center, two flight training devices configured to mimic Mooney Bravo airplanes were used. The flight training device utilized at Purdue University simulated a Cessna 172. Participants were asked to fly two scenarios, one in Alaska and the other in New Mexico. Both scenarios were derived from real accident reports. Each scenario involved rising terrain and deteriorating visibility as the flight progressed. After the flight training device scenarios were completed, each participant was asked to complete a 24-question posttest (multiple choice) and post-flight questions. The posttest questions were similar to the pretest questions. Different questions from the same ACS topic area were chosen. Two months after the initial data collection at the FAA Technical Center, “posttest two” was distributed to participants via email. Posttest two had the exact same questions as the initial posttest. For the Purdue participants, one month after the initial data collection period, posttest two was distributed via email. Only descriptive statistics were used to report the Purdue posttest two data because only five participants responded.

The results of the study were analyzed to determine if the treatments had a significant impact on participant posttest scores and decision accuracy during the flight training device scenarios. Quantitative results were completed using the statistical software program Minitab 17. Additionally, post-flight questions were analyzed qualitatively.

From these analyses, the following primary results were produced from data collected at the FAA Technical Center:

1. The control group posttest scores significantly increased from the pretest values. This finding may indicate confounding variables. Training experience may have influenced the results. Nine of the control group participants had commercial certificates with instrument ratings and Certified Flight Instructor, whereas, the interactive online group did not have any. The interactive workshop group had five participants with commercial-instrument certificates or higher.
2. The interactive online course did not significantly increase posttest scores.
3. The interactive workshop did not significantly increase posttest scores. When the mean score was compared with the other groups, mean score for the workshop participants was significantly lower than the control group.
4. The interactive online participants avoided instrument meteorological conditions at a higher frequency and percentage than any other group. Interactive workshop participants continued into instrument meteorological conditions at a higher frequency and percentage than the other groups. However, it was found that the workshop participants had the least amount of time flown in the previous six months. All of the

participants in this group had 0-50 hours flown in the previous six months. This may have influenced the results.

5. Posttest Two scores were higher than the pretest and posttest scores but mean scores were not significantly different when comparing between groups. However, participants completed posttest two outside of the research environment limiting researcher control.
6. When examining the qualitative data, two major themes emerged. The first theme that emerged was participants who continued into instrument meteorological conditions misperceived the risks/flight conditions. Some over-relied on technology, while others were influenced by the overwhelming need to arrive at the destination or “get-there-itis”. Secondly, those who turned or diverted did so because they perceived the risks and performed to mitigate them. It should be noted some participants entered instrument meteorological conditions, then made the decision to turn and/or divert.

From the analyses, the following primary results were produced from data collected at Purdue University:

1. There was no significant difference between or within the three groups’ pretest and posttest scores.
2. The interactive online participants avoided instrument meteorological conditions at the same frequency as the control group but had a higher percentage of correct decisions made.

3. Only five participants responded to the second posttest. Therefore, only descriptive statistics were reported.
4. When examining the qualitative data, three major themes emerged. The first theme that emerged was participants who continued into instrument meteorological conditions misperceived the risks/flight conditions. Some over-relied on technology while others were influenced by the overwhelming need to arrive at the destination or "get-there-itis". Secondly, those who turned or diverted did so because they perceived the risks and performed to mitigate them. It should be noted some participants entered instrument meteorological conditions, then made the decision to turn and/or divert.
   Lastly, some participants indicated they continued but would not do so again if given another opportunity, indicating they learned desired decision-making through participating in the flight training devices scenarios.

5.2 <u>Discussion of Results</u>

The purpose of this study was to develop training modules that would enhance general aviation (GA) pilot knowledge, skills, and abilities pertaining to continued VFR into IMC. The treatments did not appear to significantly increase posttest scores within either of the groups at either location. Surprisingly, the control group posttest scores significantly increased among the FAA Technical Center participants. A review of the statistical analysis provided evidence that the difference in the mean was 1.5. The result may be statistically-significant, but may be not practically significant. However, researchers pursued other explanations. When examining demographic information, it was found the control group had more participants with commercial certificates with instrument ratings and Certified Flight Instructors. This additional training may have influenced the results. The pretest may have increased the testing effect among the control group participants more. It should also be noted the mean score difference was 1.5 which indicates non-practical significance.

In regards to flight experience, the way the demographic questionnaire was designed became a cause for concern and should be noted. Questions pertaining to flight hours accumulated did not allow participants to give an exact number. For instance, when asked total flight time, participants were given the options “0-50”, “51-100”, “101-200”, “201-300”, and “300+”. These types of options limited researcher ability to determine detailed differences among the participants. It is conceivable that participant flight time could have had large variation. The option “300+” could mean the participant had 350 hours or 4000 hours. In this study, specific flight time is unknown. The participants observed at Purdue met the desired pilot profile much more closely.

Though previous research has shown the effectiveness of interactive online training modules and workshops (Silk, Perrault, Ladenson & Nazione, 2015; Sitzmann, Kraiger, Stewart & Wisher, 2006), enhancing GA pilot knowledge, skills, and abilities in a short amount of time remains complex (Knecht, Ball & Lenz, 2010). The two training modules were not designed to “coach” participants, teach to the test questions, or reveal dependent variables within the flight training device scenarios. Perhaps more-focused training could improve pilot performance on tests and flight training device scenarios. Some responses from the qualitative data indicated participants recognized their decision-making was unsound. These participants learned through the flight training device scenarios. It may be possible that immersive training could assist in enhancing knowledge, skills, and abilities when dealing with VFR into IMC situations. Immersive training can include repetitive exposure to flight training device scenarios and/or modules with various instructional methods until there is a high level of competency. For example, computer-based programs can assist in providing participants with visual cues, multiple weather reports, and decision-making opportunities. Additionally, research protocol required observers to tell participants to fly according to FAA regulations and as if it were a real flight. It may have been ideal to tell participants the option to divert or execute a 180 degree turn was available.

Flight training devices can be effective tools, especially for training; however there are limitations, particularly for research. Flight simulators cannot provide totally realistic operations and pilots know there are no-life-or death consequences for their actions in simulators. Moreover, unlike training, there is no pass or fail. This can influence the motivation of pilots asked to participate in a research study. Hardware and software issues arose during the current research project and caused limitations.

Limitations of FTDs can manifest in physical attributes such as the feeling of flying and accurate control input sensitivity. Responses from participants at the FAA Technical Center indicated 55% of the scenarios required 70% or more of their attention to flight controls, leaving just 30% or less attention for situational awareness. This reported perception indicated participants had a difficult time controlling the simulators at the FAA Technical Center. Known flight training devices technical issues were noted by the researchers. It is possible fatigue and/or frustration influenced the performance of participants. The interactive workshop group subjects had the longest time commitment in the experiment. The workshop was approximately two hours and fifteen minutes in length, after which participants were asked to fly the scenarios, and then complete the posttest. Workshop participants thus gave approximately five hours of their time, whereas the control group gave approximately two hours, and the online group gave three hours of time. Therefore, it is reasonable to hypothesize human factors issues attributed to poorer performance on the posttest and flight scenarios for the FAA Technical Center workshop group. Responses from participants at Purdue University indicated lower perceived dedication to flight controls being required. There were no known FTD technical issues noted by the researchers. Only two responses indicated the need to dedicate more than 50% of their attention toward flight controls. Therefore, it is plausible the data collected at Purdue University may be more accurate. However, the sample size was smaller. The posttest scores of the workshop participants at Purdue University slightly decreased, similar to the FAA Technical Center control group participants. Human factors were not considered an issue because there was a gap in time between the interventions and the posttest. The experiment was split into two sessions, because there was only one flight training device at Purdue, whereas the FAA Technical Center had two running simultaneously.

A second posttest was distributed to participants two months after the initial data collection period. Twenty participants voluntarily responded within the two-week response period. The unbalanced responses made a paired t-test impractical. Therefore, only a one-way ANOVA test was used. The mean scores were higher than the pretest and posttest for all three groups. However, there was no significant difference between groups. The researchers were not able to control the testing environment; therefore, speculating why the scores increased may be unproductive. Participants could have looked up answers or felt more at ease outside of the research environment.

The interactive online group participants' posttest scores increased (not significantly), and they had a higher frequency and percentage of decisions made to turn or divert before entering instrument meteorological conditions. Though the frequencies or percentages were not much higher than the control group, the researchers believe there may be an aspect of the online module that may have influenced participant decision-making and posttest scores. The online module provided visualizations of deteriorating conditions. Furthermore, decision trees were utilized. This may have provided more structure to online group participant perceptions and performance.

5.3 Conclusions

This study examined two training protocols designed to ameliorate pilot gaps in knowledge and performance in relation to VFR into IMC. The researchers sought to identify: 1.) Were there significant differences between and within pretest and posttest scores? 2.) Which group had the highest frequency of decisions made to avoid instrument meteorological conditions? 3) What were participant perceptions of their decision making?

In regards to the posttest scores, the FAA Technical Center control group participants were the only group to demonstrate a significant increase. No group scored significantly better than the other at either location. The interactive online group had the highest frequency and percentage of decisions made to avoid instrument meteorological conditions during flight training device scenarios. Participants who decided to continue into instrument meteorological conditions did so because they misperceived the flight conditions and risks.

Those who turned and/or diverted did so because they perceived the risks and performed to mitigate them. It should be noted several participants entered instrument meteorological conditions and then decided to turn or divert. The treatments did not appear to significantly improve posttest scores or decision making. However, findings suggested the use of immersive and focused interactive online instruction, combined with immersive simulator training, may provide a more effective intervention in teaching pilots to avoid continued operations under VFR-into-IMC, and to make timely decisions.

Though each location had slightly different procedures, results were relatively consistent. Lessons were learned during and after this study, primarily, with research design (questionnaire), instructional methods/topics, complexity with using flight training devices, research protocol, and recruitment of desired participants.

5.4 Limitations of the Study

The current study had a number of limiting factors. These factors ranged from small sample size to flight training device technical difficulties. Researcher partners recruited sixty participants from the Atlantic City, New Jersey area. However, due to flight training device software and hardware issues, the first day of experimentation led to 12 participants being cancelled. Of the 48 remaining participants, only 29 completed the flight training device scenarios. The others completed the pretest and posttest without completing the flight training device scenarios. The reduction in participation led to a smaller sample size than desired. In addition, due to technical difficulties with the flight training devices, video recordings were also flawed. Not all of the data were verified as the researchers intended. Data collection spreadsheets were used and video recordings were reviewed when available.

The desired participant profile was a low-time, non-instrument rated private pilot; however, some participants had higher qualifications than desired. The researchers attempted to meet the sample size goal by allowing pilots with higher qualifications to participate. In regards to the FAA Technical Center participants, nine of the sixteen control group subjects had higher qualifications than desired. The interactive online group also had nine of sixteen participants with higher qualifications. Ten of the sixteen interactive workshop participants had higher qualifications than desired. The control group had more pilots with commercial certificates or higher. This may influenced the results.

For the data collected at Purdue, none of the control group participants had higher qualifications than desired, two of the seven interactive online group participants had higher qualifications, and one out of the eight interactive workshop members had higher qualifications than desired. Generalization is not recommended; however, the experimental design with random assignment is robust for determining cause and effect (Webster & Sell, 2014). There is evidence the treatment groups did not provide the desired outcome.

5.5 Recommendations for Practice

Though this study did not produce expected results, VFR pilots should consistently address VFR into IMC matters. Pilots should be encouraged to self-study VFR into IMC material which includes preflight planning, both preflight and inflight decision-making, operational pitfalls, the use of all available resources, and conditions conducive to low visibility weather events. Preflight decision making should include previous, current, and forecast weather reports. Go-no-go decisions must be made based on the capability of the pilot and aircraft. Pilots should appropriately file flight plans and use inflight weather services. Recognition of deteriorating conditions should be based on reports and/or visual cues. Decisions must be made in a timely manner to avoid illegal or less than desirable weather conditions.

Certified Flight Instructors play a vital role in the education/training of novice and expert pilots. During certificate training, flight instructors should introduce VFR into IMC material. Depending on the region of flying and/or flight school weather minimums, some pilots may not be introduced to low visibility conditions. Therefore, it may be difficult to show pilots actual visual cues. Other methods, such as existing online modules should be used to show various visibilities and corresponding factors. Decision-making should be discussed in detail. For pilots who already hold certificates, the flight review provides an opportunity for learning.

According to the Federal Aviation Administration (2013c), Part 61.56 details Flight Review requirements.

> A flight review consists of a minimum of 1 hour of flight training and 1 hour of ground training. The review must include:
>
> (1) A review of the current general operating and flight rules of part 91 of this chapter; and
>
> (2) A review of those maneuvers and procedures that, at the discretion of the person giving the review, are necessary for the pilot to demonstrate the safe exercise of the privileges of the pilot certificate (p.1).

It may be appropriate for flight review instructors to use part of the required time to discuss VFR into IMC topics along with other maneuvers and procedures. This may assist in keeping pilots up-to-date with current practices. Overall, pilots should explore available VFR into IMC self-study material and flight instructors should take advantage of opportunities to improve the competency of their clients.

5.6 Future Research Recommendations

The results of this study provided answers to the research questions; however, they also created additional questions that should be pursued in future research studies. The following are recommendations to continue this path of investigation.

1. Focused and immersive training should be used within training modules. Participants should be taught how to evaluate various weather reports and make go-no go decisions, particularly with marginal dynamic weather conditions. Visualization of various visibilities should be introduced to participants with subsequent testing. Aeronautical decision-making should be taught as a process, and operational pitfalls should be presented.
2. Significantly, the researchers believe that immersive, multi-session flight training device experiences and re-training between simulator sessions may have the greatest likelihood for teaching pilots to make consistently safe decisions.

VFR pilots should strive to reverse course and/or divert when weather conditions begin to degrade, prior to entering below-VFR conditions of ceiling and visibility.

3. Though there were not significant results, interactive online group participants had slightly higher posttest scores (FAA Technical Center) and percentage (both locations) of making appropriate decisions during flight training device scenarios. Consideration of using technology to teach general aviation pilots should be explored. The training should not be limited to online course modules but include devices such as personal computer, tablet, and aviation training devices.
4. Increasing the sample size in future experiments may provide a more definitive conclusion. If the sample size cannot be increased it is suggested to use two experiment groups, one control and one treatment.
5. Conducting a pilot test in addition to item analyses for the pretest and posttest questions prior to the experiment may increase the internal consistency of the instrument.

LIST OF REFERENCES

LIST OF REFERENCES

Aircraft Owners and Pilots Association. (1999). *Hazardous Attitudes.* Retrieved from http://flighttraining.aopa.org/magazine/1999/September/199909_Features_Hazardous_Attitudes.html

Air Safety Institute. (2014a). *Accident details*. Retrieved from http://www.aopa.org/asf/ntsb/narrative.cfm?ackey=1&evid=20111126X22009

Air Safety Institute. (2014b). *Accident analysis.* Retrieved from http://www.aopa.org/asf/ntsb/search_ntsb.cfm

Ali, S., Chalder, T., & Madan, I. (2014). Evaluating interactive fatigue management workshops for occupational health professionals in the United Kingdom. *Safety and Health at Work*, *5*(4), 191-197.

Ambs, K. M. (2014). The influence of cockpit weather automation on pilot perception and decision-making in severe weather conditions. *McNair Scholars Research Journal*, *7*(1), 1-17.

Ary, D., Jacobs, C., Razaieh, A., Sorensen, D. L. (2013). *Introduction to research in education*. Thousand Oaks, CA: Cengage Learning.

Brooks-Harris, J. E., & Stock-Ward, S. R. (1999). *Workshops: Designing and facilitating experiential learning*. Thousand Oaks, CA: Sage Publications.

Cassidy, S. (2004). Learning styles: An overview of theories, models, and measures. *Educational Psychology, 24*(4), 419-444.

Christensen, L. B., Johnson, B., & Turner, L. A. (2011). *Research methods, design, and analysis*. Upper Saddle: NY. Pearson Education, Inc.

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. Psychological Assessment, *7*(1), 309-319.

Code of Federal Regulations (2015). *Part 61-Certification: Pilots, flight instructors, and ground instructors.* Retrieved from http://www.ecfr.gov/cgi-bin/retrieveECFR?gp&r=PART&n=14y2.0.1.1.2#se14.2.61_13

Cohen, J. (1969). *Statistical power analysis for the behavioral sciences.* San Diego, CA: Academic Press.

Dong, X., Li, Y., Chen, R., Chang, E. S., & Simon, M. (2013). Evaluation of community health education workshops among Chinese older adults in Chicago: A community-based participatory research approach. *Journal of Education and Training Studies*, *1*(1), p170-181.

Driskill,W. E.,Weismuller, J. J., Quebe, J., Hand, D. K., Dittmar, M. J., & Hunter, D. R. (1997). *The use of weather information in aeronautical decision making* (Tech. Rep. No. NTIS DOT/FAA/AM-97/3). Washington, DC: Federal Aviation Administration.

Ellis, P. D. (2010). *The essential guide to effect sizes: Statistical power, meta-analysis, and the interpretation of research results*. New York, NY: Cambridge University Press.

Engel, R. J., & Schutt, R. K. (2014). *Fundamentals of social work research*. Thousand Oaks, CA: Sage Publications.

Federal Aviation Administration. (*n.d.) Spatial disorientation.* http://www.faa.gov/pilots/safety/pilotsafetybrochures/media/SpatialD.pdf

Federal Aviation Administration. (1991). *Aeronautical decision making*. Retrieved from http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_60-22.pdf

Federal Aviation Administration. (2009a). *General aviation pilot's guide to preflight weather planning, weather self-briefings, and weather decision making* Retrieved from http://www.faa.gov/pilots/safety/media/ga weather_decision_making.pdf

Federal Aviation Administration. (2009b). *Risk management handbook.* Retrieved from https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/risk_management_handbook/media/risk_management_handbook.pdf

Federal Aviation Administration (2011). *Fact sheet-general aviation safety.* Retrieved from http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=13103

Federal Aviation Administration. (2012). *Instrument flying handbook.* Retrieved from https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/media/FAA-H-8083-15B.pdf

Federal Aviation Administration. (2013a). *Definitions.* Retrieved from https://www.faa.gov/air_traffic/flight_info/aeronav/procedures/ifp_initiation/ifp_definitions/

Federal Aviation Administration. (2013b). *Weather technology.* Retrieved from http://www.faa.gov/news/safety_briefing/2013/media/SE_Topic_11_2013.pdf

Federal Aviation Administration. (2013c). *Code of Federal Regulations Part 61.56.* Retrieved from http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgFar.nsf/FARSBySectLookup/61.56

Federal Aviation Administration. (2014). *FAA approval of aviation training devices and their use for training and experience.* Retrieved from http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_61-136A.pdf

Federal Aviation Administration. (2015a). *U.S. Civil Airmen Statistics.* Retrieved from https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics

Federal Aviation Administration. (2015b). *What's new and upcoming in airmen testing?* Retrieved from https://www.faa.gov/training_testing/testing/media/whats_new_acs.pdf

Federal Aviation Administration. (2015c). *Update on the ACS.* Retrieved from https://www.faa.gov/training_testing/testing/media/acs_briefing.pdf

Flin, R. H. (1997). *Decision making under stress: Emerging themes and applications*. New York, NY: Gower Technical.

Furr, R. M., & Bacharach, V. R. (2013). *Psychometrics: An introduction*. Thousand Oaks, CA: Sage Publications.

Gerdon, E. (2012). *Quality online courses: A writer's guide.* Retrieved from http://www.learninghouse.com/wp-content/uploads/2013/08/Quality-Online-Courses-Download.pdf#page=18

Gilbody, J., Prasthofer, A. W., Ho, K., & Costa, M. L. (2011). The use and effectiveness of cadaveric workshops in higher surgical training: a systematic review. *Annals of the Royal College of Surgeons of England*, *93*(5), 347-352.

Goodwin, C. J. (2009). *Research in psychology: Methods and design*. Danvers, MA: John Wiley & Sons.

Grave, W., Zanting, A., Mansvelder-Longayroux, D. D., & Molenaar, W. M. (2014). Workshops and seminars: Enhancing effectiveness. In *Faculty Development in the Health Professions* (pp. 181-195). Springer Netherlands.

Gravetter, F., & Forzano, L. A. (2015). *Research methods for the behavioral sciences*. Independence, KY: Cengage Learning.

Guskey, T. R. (2014). Planning professional learning. *Learning*, *71*(8), 10-16.

Horrell, L., Goldsmith, K. A., Tylee, A. T., Schmidt, U. H., Murphy, C. L., Bonin, E. M., & Brown, J. S. (2014). One-day cognitive-behavioural therapy self-confidence workshops for people with depression: randomised controlled trial. *The British Journal of Psychiatry*, *204*(3), 222-233.

Johnson, N., Wiegmann, D., & Wickens, C. (2006). Effects of advanced cockpit displays on general aviation pilots' decisions to continue visual flight rules flight into instrument conditions. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 50*(1), 30-34.

Jolles, R. L. (2005). *How to run seminars and workshops: presentation skills for consultants, trainers, and teachers*. Hoboken, NJ: John Wiley & Sons.

Kahneman, D., Slovic, P., & Tversky, A. (1982). *Judgment under uncertainty: heuristics and biases*. Cambridge, MA: Cambridge University Press.

Karpicke, J. D., & Blunt, J. R. (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science*, *331*(6018), 772-775.

Knecht, W., Ball, J., Lenz, M. (2010). Effects of video weather training products, web-based preflight weather briefing, and local versus non-local pilots on general aviation pilot weather knowledge and flight behavior, phase I. *Federal Aviation Administration*, DOT/FAA/AM-10/1, Office of Aerospace Medicine, Washington DC. Retrieved from http://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2010s/media/201001.pdf

Klein, G. (2008). Naturalistic decision making. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*(3), 456-460.

Kolb, D. A. (1984). Experiential learning. *Experience as the source of learning and development. New Jersey*. *Prentice Hall*.

Laerd Statistics (2013a). *One-way ANOVA using Minitab.* Retrieved from https://statistics.laerd.com/minitab-tutorials/one-way-anova-using-minitab.php

Laerd Statistics (2013b). *Paired t-test using Minitab.* Retrieved from https://statistics.laerd.com/minitab-tutorials/paired-t-test-using-minitab.php

Levene, H. (1960). Robust tests for equality of variances1. *Contributions to probability and statistics: Essays in honor of Harold Hotelling*, *2*(1), 278-292.

McBurney, D., & White, T. (2009). *Research methods*. Thousand Oaks, CA: Cengage Learning.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2013). *Qualitative data analysis: A methods sourcebook*. Thousand Oaks, CA: Sage Publications.

O'Hare, D., & Owen, D. (1999). *Continued VFR into IMC: An empirical investigation of the possible causes*. Retrieved from https://www.hf.faa.gov/docs/508/docs/weatherReport.pdf

Pepin, G., & King, R. (2013). Collaborative care skills training workshops: Helping carers cope with eating disorders from the UK to Australia. *Social Psychiatry and Psychiatric Epidemiology*, *48*(5), 805-812.

Peterson, M. (2009). *An introduction to decision theory*. London, UK: Cambridge University Press.

Purdue University. (2015). *Principal investigator responsibility.* Retrieved from http://www.purdue.edu/business/sps/preaward/menu/1.gettingstarted/pi_role/index.html

Ranyard, R., Crozier, W. R., & Svenson, O. (1997). *Decision making: Cognitive models and explanations*. New York, NY: Taylor and Francis Group

Resnik, M. D. (1987). *Choices: An introduction to decision theory*. Twin Cities, MN: University of Minnesota Press.

Roediger, H. L., & Butler, A. C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, *15*(1), 20-27.

Rosenthal, R., & Rosnow, R. L. (1969). *Artifacts in behavioral research*. New York, NY: Academic Press.

Royal Institute of Technology. (1994). *Decision theory a brief introduction.* Retrieved from http://people.kth.se/~soh/decisiontheory.pdf

Rubin, A. (2012). *Statistics for evidence-based practice and evaluation*. Belmont, CA: Cengage Learning.

Rust, C. (1998). The impact of educational development workshops on teachers' practice. *The International Journal for Academic Development*, *3*(1), 72-80.

Silk, K. J., Perrault, E. K., Ladenson, S., & Nazione, S. A. (2015). The effectiveness of online versus in-person library instruction on finding empirical communication research. *The Journal of Academic Librarianship*, *41*(2), 149-154.

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology*, *59*(3), 623-664.

Stough, H. P., Watson, J. F., & Jarrell, M. A. (2006). *New technologies for reducing aviation weather-related accidents.* Retrieved from http://icas.org/ICAS_ARCHIVE/ICAS2006/PAPERS/394.PDF

Svinicki, M. D., & Dixon, N. M. (1987). The Kolb model modified for classroom activities. *College Teaching*, *35*(4), 141-146.

The Center for Teaching and Learning. (2015). *150 teaching methods.* Retrieved from http://teaching.uncc.edu/learning-resources/articles-books/best-practice/instructional-methods/150-teaching-methods

United States Government Printing Office. (2014). *Electronic code of federal regulations.* Retrieved from http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&sid=3efaad1b0a259d4e48f1150a34d1aa77&rgn=div5&view=text&node=14:2.0.1.3.10&idno=14#14:2.0.1.3.10.2.5.33

Vik, P. (2013). *Regression, ANOVA, and the general linear model: A statistics primer*. Thousand Oaks, CA: Sage Publications.

Vincent, M., Blickensderfer, E., Thomas, R., Smith, M., & Lanicci, J. (2013). In-Cockpit NEXRAD Products Training General Aviation Pilots. *In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 57*(1), 81-55.

Webster, M., & Sell, J. (2014). *Laboratory experiments in the social sciences*. San Diego, CA: Elsevier.

Yu, C. H., & Ohlund, B. (2010). *Threats to validity of research design.* Retrieved from http://www.creative-wisdom.com/teaching/WBI/threat.shtml

Zeleny, M. (1982). *Multiple criteria decision making*. Retrieved from http://classwebs.spea.indiana.edu/kenricha/Oxford/Archives/Oxford%202006/Courses/Decision%20Making/Articles/Zeleny,%20Ch.%203.pdf

Zsambok, C. E., & Klein, G. (2014). *Naturalistic decision making*. New York, NY: Psychology Press.

APPENDICES

Appendix A: Institutional Review Board Approval Letter

Date:	07/09/2015
Committee Action:	**Approval**
IRB Action Date	07/09/2015
IRB Protocol #	1506016169
Study Title	[Blocked] VFR/VMC to IMC Transition & GA MET Information Optimization Phase 2
Expiration Date	07/08/2016

Following review by the Institutional Review Board (IRB), the above-referenced protocol has been approved. This approval permits you to recruit subjects up to the number indicated on the application form and to conduct the research as it is approved. The IRB-stamped and dated consent, assent, and/or information form(s) approved for this protocol are enclosed. Please make copies from these document(s) both for subjects to sign should they choose to enroll in your study and for subjects to keep for their records. Information forms should not be signed. Researchers should keep all consent/assent forms for a period no less than three (3) years following closure of the protocol.

Revisions/Amendments: If you wish to change any aspect of this study, please submit the requested changes to the IRB using the appropriate form. IRB approval must be obtained before implementing any changes unless the change is to remove an immediate hazard to subjects in which case the IRB should be immediately informed following the change.

Continuing Review: It is the Principal Investigator's responsibility to obtain continuing review and approval for this protocol prior to the expiration date noted above. Please allow sufficient time for continued review and approval. No research activity of any sort may continue beyond the expiration date. Failure to receive approval for continuation before the expiration date will result in the approval's expiration on the expiration date. Data collected following the expiration date is unapproved research and cannot be used for research purposes including reporting or publishing as research data.

Unanticipated Problems/Adverse Events: Researchers must report unanticipated problems and/or adverse events to the IRB. If the problem/adverse event is serious, or is expected but occurs with unexpected severity or frequency, or the problem/even is unanticipated, it must be reported to the IRB within 48 hours of learning of the event and a written report submitted within five (5) business days. All other problems/events should be reported at the time of Continuing Review.

We wish you good luck with your work. Please retain copy of this letter for your records.

Ernest C. Young Hall, 10th Floor - 155 S. Grant St. - West Lafayette, IN 47907-2114 - (765) 494-5942 - Fax: (765) 494-9911

Appendix B: Invitation Email

August 4, 2015

Email subject line: GA pilots needed for flight simulator study

Dear Prospective Participant:

You are invited to participate in a flight simulation study as part of research being conducted by researchers from Purdue University and Western Michigan University. This project is sponsored by the Federal Aviation Administration.

The current research project is focused on the decision-making processes of General Aviation (GA) pilots, an evaluation of training protocols to mitigate pilot gaps in knowledge, and how cockpit workload affects these processes. This experiment will involve flying challenging GA aircraft scenarios in a flight simulator or Flight Training Device (FTD) and verbally explaining your thought processes as you gather information and make flight-related decisions. Participants will be randomly-assigned to one of 3 groups. The first group will take an electronic pre-test, fly the simulator/FTD scenarios, and then complete an electronic post-test. Both the pre-test and the post-test are made up of multiple choice questions. The second group will have the same experiences as the first group, but in addition they will participate in a workshop covering topics in weather and aeronautical decision-making, prior to flying the simulator. The third group will also have the same simulator and pre-test/post-test experiences, but in addition they will complete a set of weather knowledge interactive short courses, prior to flying the simulator. Participants will fly the scenarios in a single engine land aircraft simulator. Prior to flying the scenario, participants will be given time to become acclimated to the device.

Data will be collected through the use of video recordings and by direct observations of the researchers. Your identity will remain completely anonymous and your participation is completely voluntary. If you choose, you may opt out of the study at any time, without any negative consequences.

You are eligible to participate in this study if you are at least 18 years old, have a valid private pilot certificate and have flown in the last 6 months.

If you have any questions, are interested in learning more, or would like to schedule a time to participate, please contact Dr. Thomas Carney at 765-494-9954, or .

Sincerely,

Dr. Thomas Carney, Principal Investigator

Appendix C: William J. Hughes Technical Center Participant Consent Form

RESEARCH PARTICIPANT CONSENT FORM
Unexpected Transition from VFR to IMC : Evaluation of Training Protocol to Mitigate Pilot Gaps in Knowledge

Thomas Carney, Ph.D.
Department of Aviation Technology
Purdue University

Purpose of study: This experiment is part of a larger effort to understand general aviation (GA) pilot performance. A clearer understanding of pilot performance can lead to improvements in general aviation safety. This study may be beneficial to the general aviation community by improving training and standards. Electronic examination and simulator performance measures will be taken. This research project is in collaboration with researchers from Western Michigan University and sponsored by the Federal Aviation Administration.

WHAT WILL PARTICIPATION INVOLVE?: You will be asked to complete a short background questionnaire. You will also be asked to complete an electronic pre-test on aviation weather knowledge. You will be randomly-assigned by computer to either a control group (the group of participants who will only fly the simulator scenarios) or one of two treatment groups (composed of the participants who will receive one of the two (workshop, or interactive short course) training experiences). The odds of your being assigned to a particular group are 1 in 3, or 33.3%. If you are assigned to the control group, you will go directly to the simulator/FTD. If you are assigned to one of the treatment groups, you will go to a classroom and/or part-task trainer to receive specialized training related to aviation weather topics, aeronautical decision making, and related aviation topics. Then you will be introduced to the flight simulator and other equipment that will be used during the experiment, as well as the tasks you will be asked to complete in the simulator. A brief training session will follow to further familiarize you with the verbal protocol (explaining your thought processes aloud) and interactions in the flight simulator.

During the experiment, you will complete two flight scenarios, each of which will take approximately 30-45 minutes. Pre-flight briefings will give you all the necessary details about each flight. As for any flight, all FARs are to be followed and flight safety is the highest priority. The scenarios will additionally include normal conversations with Air Traffic Control (ATC). As an aid to data collection on workload and decision-making, you will be asked to talk through all actions and thought processes during your flight. However, this “talk-aloud” procedure is secondary to the safety of the flight and will not be required if it detracts from your flying or decision-making ability.

Data will be collected related to your thought processes and decision-making during each flight. Additionally the timeliness, correctness, and completeness of your responses to flight situation and/or ATC instructions will be recorded. Observers from the experimental team will also “code” your verbal descriptions for how they relate to various scenario-related factors. There will also be video recording of your interactions and verbal descriptions in the simulator; these will be viewed by a second set of experimenters and coded independently for comparison. At the completion of the simulator/FTD session, you will also be asked to fill out a questionnaire regarding your experiences encountered and the effects of workload on decision-making, and you will be asked to complete an electronic post-test with questions about aviation weather knowledge. You will be asked to complete (electronically) a final post-test on aviation weather knowledge, 2 to 3 months after your simulator/FTD session.

The entire duration of participation (except for the final post-test), including training, completing the scenarios, and filling out the questionnaires is expected to take approximately 2-4 hours.

How long will I be in the study?: Each participant will be asked to complete all of the experiences described above for their assigned research group. The amount of time required for those experiences is estimated to vary between 2 hours and 4 hours, depending on the group assigned. For all 3 groups, the commitment of time will occur during one day at the FAA Hughes Technical Center. In addition, all participants will be asked to complete (electronically) a final multiple choice test, approximately 2 to 3 months after the activities at the Hughes Technical Center.

What are the possible risks or discomforts?: With regard to your safety, the risk is minimal: no more risk exists than the amount encountered in everyday life. You may experience some minor physical fatigue, or stress when you are performing in the simulator. To offset this, you will not begin the next flight in the session until you are ready. The flight scenarios are chosen to be challenging with regard to decision-making under varying workload conditions, and safely piloting the aircraft may be difficult. There is a chance that these simulation scenarios could require deviating from the prescribed flight plan. If you experience frustration or undue stress from these occurrences or otherwise, please keep in mind that you can leave the experiment at any time without consequence by informing the experimenter that you wish to stop the study.

Are there any potential benefits?: You may improve your flight skills by flying the scenarios. You may also learn more about your decision making and workload abilities. The information obtained from the study may suggest ways to improve the flight training of GA pilots.

We hope that the benefits to society will be a greater understanding of pilot decision making under varying workload, and the implications for displays and cognitive aids that may better support decision making.

Will information about me and my participation be kept confidential?: All data collected from you will remain anonymous. To prevent any link between your identifying information and performance, all forms with your information will be kept in a separate file from the data collected. Identifying information will not be used in the data analysis or in any subsequent presentation or document. You will be assigned a computer-generated code number, known only to the researchers that will be used for tracking your research data. No other identifying information will be linked to the data, making all research data anonymous. All data will be stored in a locked cabinet and destroyed one year after the last participant has been tested. Researchers at Purdue University, Western Michigan University, and the Federal Aviation Administration will have access to the research records.

The research records of this project may be reviewed by principle investigators or co-investigators involved in the management and administration of this study. Findings from this study may be published and presented in a scientific journal or conference. In addition any departments responsible for regulatory and research oversight may also review records from this project.

What are my rights if I take part in this study?: Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Who can I contact if I have questions about the study?:

For research-related problems or questions regarding your rights as a research participant, you can contact the Principal Investigator, Dr. Thomas Carney, Department of Aviation Technology, Purdue University, at 765-494-9954 or tcarney@purdue.edu. You may also contact the Purdue University Human Research Protection Program (HRPP), at (765) 494-5942, or via email at irb@purdue.edu, ort representatives of Western Michigan University's IRB. The Chair of the Human Subjects Institutional Review Board for WMU can be reached at 269-387-8293 or the Vice President for Research for WMU at 269-387-8298.

Signature for video recording: Video recordings will be used during the study. If you are not willing to be videotaped, then you cannot participate in this study. These recordings will be analyzed by research team members to infer actions and thought processes that are not captured by the simulation software. The video recordings will be destroyed after analysis and no later than 1 year after the recording date. Please sign below if you are willing to be videotaped during the simulator scenarios.

____
Participant's Signature Date

____
Participant's Name

____
Researcher's Signature Date

Documentation of Informed Consent: I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will be offered a copy of this consent form after I sign it.

____

Participant’s Signature Date

____

Participant’s Name

____

Researcher’s Signature Date

Appendix D: Purdue University Participant Consent Form

For participants at Purdue University:

RESEARCH PARTICIPANT CONSENT FORM
General Aviation Aeronautical Decision Making and Pilot Performance

Thomas Carney, Ph.D.
Department of Aviation Technology
Purdue University

<u>Purpose of study:</u> This experiment is part of a larger effort to understand general aviation (GA) pilot performance. A clearer understanding of pilot performance can lead to improvements in general aviation safety. This study may be beneficial to the general aviation community by improving training and standards. Electronic examination and simulator performance measures will be taken. This research project is in collaboration with researchers from Western Michigan University and sponsored by the Federal Aviation Administration.

<u>WHAT WILL PARTICIPATION INVOLVE?:</u> You will be asked to complete a short background questionnaire. You will also be asked to complete an electronic pre-test on aviation weather knowledge. You will be randomly-assigned by computer to either a control group (the group of participants who will only fly the simulator scenarios) or one of two treatment groups (composed of the participants who will receive one of the two (workshop, or interactive short course) training experiences). The odds of your being assigned to a particular group are 1 in 3, or 33.3%. If you are assigned to the control group, you will go directly to the simulator/FTD. If you are assigned to one of the treatment groups, you will go to a classroom and/or part-task trainer to receive specialized training related to aviation weather topics, aeronautical decision making, and related aviation topics. Then you will be introduced to the flight simulator and other equipment that will be used during the experiment, as well as the tasks you will be asked to complete in the simulator. A brief training session will follow to further familiarize you with the verbal protocol (explaining your thought processes aloud) and interactions in the flight simulator.

During the experiment, you will complete two flight scenarios, each of which will take approximately 30-45 minutes. Pre-flight briefings will give you all the necessary details about each flight. As for any flight, all FARs are to be followed and flight safety is the highest priority. The scenarios will additionally include normal conversations with Air Traffic Control (ATC). As an aid to data collection on workload and decision-making, you will be asked to talk through all actions and thought processes during your flight. However, this “talk-aloud” procedure is secondary to the safety of the flight and will not be required if it detracts from your flying or decision-making ability.

Data will be collected related to your thought processes and decision-making during each flight. Additionally the timeliness, correctness, and completeness of your responses to flight situation and/or ATC instructions will be recorded. Observers from the experimental team will also “code” your verbal descriptions for how they relate to various scenario-related factors. There will also be video recording of your interactions and verbal descriptions in the simulator; these will be viewed by a second set of experimenters and coded independently for comparison. At the completion of the simulator/FTD session, you will also be asked to fill out a questionnaire regarding your experiences encountered and the effects of workload on decision-making, and you will be asked to complete an electronic post-test with questions about aviation weather knowledge. You will be asked to complete (electronically) a final post-test on aviation weather knowledge, 2 to 3 months after your simulator/FTD session.

The entire duration of participation (except for the final post-test), including training, completing the scenarios, and filling out the questionnaires is expected to take approximately 2-4 hours.

How long will I be in the study?: Each participant will be asked to complete all of the experiences described above for their assigned research group. The amount of time required for those experiences is estimated to vary between 2 hours and 4 hours, depending on the group assigned. For all 3 groups, the commitment of time will occur during one or two days at Purdue University, Department of Aviation Technology, at the Purdue University Airport. In addition, all participants will be asked to complete (electronically) a final multiple choice test, approximately 2 to 3 months after the activities at Purdue.

What are the possible risks or discomforts?: With regard to your safety, the risk is minimal: no more risk exists than the amount encountered in everyday life. You may experience some minor physical fatigue, or stress when you are performing in the simulator. To offset this, you will not begin the next flight in the session until you are ready. The flight scenarios are chosen to be challenging with regard to decision-making under varying workload conditions, and safely piloting the aircraft may be difficult. There is a chance that these simulation scenarios could require deviating from the prescribed flight plan. If you experience frustration or undue stress from these occurrences or otherwise, please keep in mind that you can leave the experiment at any time without consequence by informing the experimenter that you wish to stop the study.

Are there any potential benefits?: You may improve your flight skills by flying the scenarios. You may also learn more about your decision making and workload abilities. The information obtained from the study may suggest ways to improve the flight training of GA pilots.

We hope that the benefits to society will be a greater understanding of pilot decision making under varying workload, and the implications for displays and cognitive aids that may better support decision making.

Will I receive payment or other incentive?: You will not receive monetary payment for your participation. However, you may be eligible to receive one of several pilot-related prizes by random drawing, after your participation and at the conclusion of the research at Purdue. The approximate odds of winning any of these prizes is 1 in 24 (4.2%)

Will information about me and my participation be kept confidential?: All data collected from you will remain anonymous. To prevent any link between your identifying information and performance, all forms with your information will be kept in a separate file from the data collected. Identifying information will not be used in the data analysis or in any subsequent presentation or document. You will be assigned a computer-generated code number, known only to the researchers that will be used for tracking your research data. No other identifying information will be linked to the data, making all research data anonymous. All data will be stored in a locked cabinet and destroyed one year after the last participant has been tested. Researchers at Purdue University, Western Michigan University, and the Federal Aviation Administration will have access to the research records.

The research records of this project may be reviewed by principle investigators or co-investigators involved in the management and administration of this study. Findings from this study may be published and presented in a scientific journal or conference. In addition any departments responsible for regulatory and research oversight may also review records from this project.

What are my rights if I take part in this study?: Your participation in this study is voluntary. You may choose not to participate or, if you agree to participate, you can withdraw your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Who can I contact if I have questions about the study?:

For research-related problems or questions regarding your rights as a research participant, you can contact the Principal Investigator, Dr. Thomas Carney, Department of Aviation Technology, Purdue University, at 765-494-9954 or tcarney@purdue.edu. You may also contact the Purdue University Human Research Protection Program (HRPP), at (765) 494-5942, or via email at irb@purdue.edu, or representatives of Western Michigan University's IRB. The Chair of the Human Subjects Institutional Review Board for WMU can be reached at 269-387-8293 or the Vice President for Research for WMU at 269-387-8298.

Signature for video recording: Video recordings will be used during the study. If you are not willing to be videotaped, then you cannot participate in this study. These recordings will be analyzed by research team members to infer actions and thought processes that are not captured by the simulation software. The video recordings will be destroyed after analysis and no later than 1 year after the recording date. Please sign below if you are willing to be videotaped during the simulator scenarios.

____

Participant's Signature Date

____

Participant's Name

____

Researcher's Signature Date

Documentation of Informed Consent: I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research study, and my questions have been answered. I am prepared to participate in the research study described above. I will be offered a copy of this consent form after I sign it.

____

Participant’s Signature Date

____

Participant’s Name

____

Researcher’s Signature Date

Appendix E: Pretest

socrative
by MasteryConnect

Name: ____________________ **Date:** __________

Quiz name: PreTest Weather

1. PRACTICE QUESTION #1. A stable air mass is most likely to have which characteristic?
   - (A) Showery precipitation.
   - (B) Turbulent air.
   - (C) Poor surface visibility.

2. PRACTICE QUESTION #2. Interpret the weather symbol depicted in Utah on the 12-hour Significant Weather Prognostic Chart (Refer to Figure 20.)
   - (A) Moderate turbulence, surface to 18,000 feet.
   - (B) Base of clear air turbulence, 18,000 feet.
   - (C) Thunderstorm tops at 18,000 feet.

3. What is your biological sex?
   - (A) Male
   - (B) Female

4. What is your age?
   - (A) 17-25
   - (B) 26-35
   - (C) 36-45
   - (D) 46-55
   - (E) 56+

5. How many total flight hours have you logged?
   - (A) 0-50
   - (B) 51-100
   - (C) 101-200
   - (D) 201-300
   - (E) 301+

6. How many total instrument hours have you logged?
   - (A) 0-50
   - (B) 51-100
   - (C) 101-200
   - (D) 201-300
   - (E) 301+

7. Please list all ratings/certificates held.
   - (A) Private

- (B) Instrument
- (C) Commerical-Single Engine
- (D) Commercial Multi
- (E) CFI

---

8. Which type of airplane do you currently fly most often?
- (A) Single Engine
- (B) Multi Engine
- (C) Both

---

9. Which training environment did you achieve your private pilot certificate?
- (A) Part 61
- (B) Part 141
- (C) Four Year Collegiate Aviation Program
- (D) Military
- (E) Other

---

10. What weather products do you use for pre-flight and in-flight information?

____

____

____

____

____

---

11. How many total flight hours have you logged in the past 6 months?
- (A) 0-50
- (B) 51-100
- (C) 101-200
- (D) 201-300
- (E) 301+

---

12. (PA.I.C.K4l) How will frost on the wings of an airplane affect takeoff performance?
- (A) Frost will disrupt the smooth flow of air over the wing, adversely affecting its lifting capability.
- (B) Frost will change the camber of the wing, increasing its lifting capability.
- (C) Frost will cause the airplane to become airborne with a higher angle of attack, decreasing the stall speed.

---

13. (PA.I.C.K4f) If an unstable air mass is forced upward, what type clouds can be expected?
- (A) Stratus clouds with little vertical development.
- (B) Stratus clouds with considerable associated turbulence.
- (C) Clouds with considerable vertical development and associated turbulence.

---

14. (PA.I.C.K4f) An almond or lens-shaped cloud which appears stationary, but which may contain winds of 50 knots or more, is referred to as
- (A) an inactive frontal cloud.

(B) a funnel cloud.
(C) a lenticular cloud.

---

15. (PA.I.C.K4e) One weather phenomenon which will always occur when flying across a front is a change in the
(A) wind direction.
(B) type of precipitation.
(C) stability of the air mass.

---

16. (PA.I.C.K4g) Possible mountain wave turbulence could be anticipated when winds of 40 knots or greater blow
(A) across a mountain ridge, and the air is stable.
(B) down a mountain valley, and the air is unstable.
(C) parallel to a mountain peak, and the air is stable.

---

17. (PA.I.C.K4j) One in-flight condition necessary for structural icing to form is
(A) small temperature/dewpoint spread.
(B) stratiform clouds.
(C) visible moisture.

---

18. (PA.I.C.K4f) The conditions necessary for the formation of cumulonimbus clouds are a lifting action and
(A) unstable air containing an excess of condensation nuclei.
(B) unstable, moist air.
(C) either stable or unstable air.

---

19. (PA.I.C.K4k) If the temperature/dewpoint spread is small and decreasing, and the temperature is 62°F, what type weather is most likely to develop?
(A) Freezing precipitation.
(B) Thunderstorms.
(C) Fog or low clouds.

---

20. (PA.I.C.K4k) Low-level turbulence can occur and icing can become hazardous in which type of fog?
(A) Rain-induced fog.
(B) Upslope fog.
(C) Steam fog.

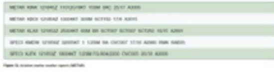
---

21. (PA.I.C.K4j) During an IFR cross-country flight you picked up rime icing which you estimate is 1/2" thick on the leading edge of the wings. You are now below the clouds at 2000 feet AGL and are approaching your destination airport under VFR. Visibility under the clouds is more than 10 miles, winds at the destination airport are 8 knots right down the runway, and the surface temperature is 3 degrees Celsius. You decide to
(A) use a faster than normal approach and landing speed.
(B) approach and land at your normal speed since the ice is not thick enough to have any noticeable effect.
(C) fly your approach slower than normal to lessen the 'wind chill' effect and break up the ice.

---

22. (PA.I.C.S1) Which of the reporting stations have VFR weather? (Refer to Figure 12.)

- Ⓐ All.
- Ⓑ KINK, KBOI, and KJFK.
- Ⓒ KINK, KBOI, and KLAX.



23. (PA.I.C.S1) What are the wind conditions at Wink, Texas (KINK)? (Refer to Figure 12).

- Ⓐ Calm.
- Ⓑ 110° at 12 knots, gusts 18 knots.
- Ⓒ 111° at 2 knots, gusts 18 knots.

24. (PA.I.C.S1) The base and tops of the overcast layer reported by a pilot are (Refer to Figure 14.)

- Ⓐ 1,800 feet MSL and 5,500 feet MSL.
- Ⓑ 5,500 feet AGL and 7,200 feet MSL.
- Ⓒ 7,200 feet MSL and 8,900 feet MSL.

25. (PA.I.C.S1) If the terrain elevation is 1,295 feet MSL, what is the height above ground level of the base of the ceiling? (Refer to Figure 14.)

- Ⓐ 505 feet AGL.
- Ⓑ 1,295 feet AGL.
- Ⓒ 6,586 feet AGL.

26. (PA.I.C.S2) From which primary source should information be obtained regarding expected weather at the estimated time of arrival if your destination has no Terminal Forecast?

- Ⓐ Low-Level Prognostic Chart.
- Ⓑ Weather Depiction Chart.
- Ⓒ Area Forecast.

27. (PA.I.C.S5) Between 1000Z and 1200Z the visibility at KMEM is forecast to be (refer to Figure 15).

- Ⓐ 1/2 statute mile
- Ⓑ 3 statute miles
- Ⓒ 6 statute miles

28. (PA.I.C.S5) What is the forecast wind for KMEM from 1600Z until the end of the forecast (refer to Figure 15)?

- Ⓐ No significant wind
- Ⓑ Variable in direction at 4 knots
- Ⓒ Variable in direction at 6 knots

29. (PA.I.C.S1) What is the outlook for the southern half of Indiana after 0700Z? (Refer to Figure 16.)

- Ⓐ VFR.
- Ⓑ Scattered clouds at 3,000 feet AGL.
- Ⓒ Scattered clouds at 10,000 feet.

30. (PA.I.C.S1) The Chicago FA forecast section is valid until the twenty-fifth at (Refer to Figure 16.)

(A) 1945Z.

(B) 0800Z.

(C) 1400Z.

31. (PA.I.C.S5) What is indicated when a current CONVECTIVE SIGMET forecasts thunderstorms?

(A) Moderate thunderstorms covering 30 percent of the area.

(B) Moderate or severe turbulence.

(C) Thunderstorms obscured by massive cloud layers.

32. (PA.I.C.S4) Which in-flight advisory would contain information on severe icing not associated with thunderstorms?

(A) Convective SIGMET.

(B) SIGMET.

(C) AIRMET.

33. (PA.I.C.S1) What is the status of the front that extends from Nebraska through the upper peninsula of Michigan?(Refer to Figure 18.)

(A) Cold.

(B) Warm.

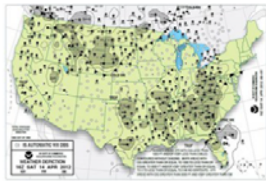
(C) Stationary.

34. (PA.I.C.S1) What weather phenomenon is causing IFR conditions in central Oklahoma? (Refer to Figure 18.)

(A) Low visibility only.

(B) Heavy rain showers.

(C) Low ceilings and visibility.



35. (PA.I.C.S1) What weather is forecast for the Florida area just ahead of the stationary front during the first 12 hours? (Refer to Figure 20.)

(A) Ceiling 1,000 to 3,000 feet and/or visibility 3 to 5 miles with intermittent precipitation.

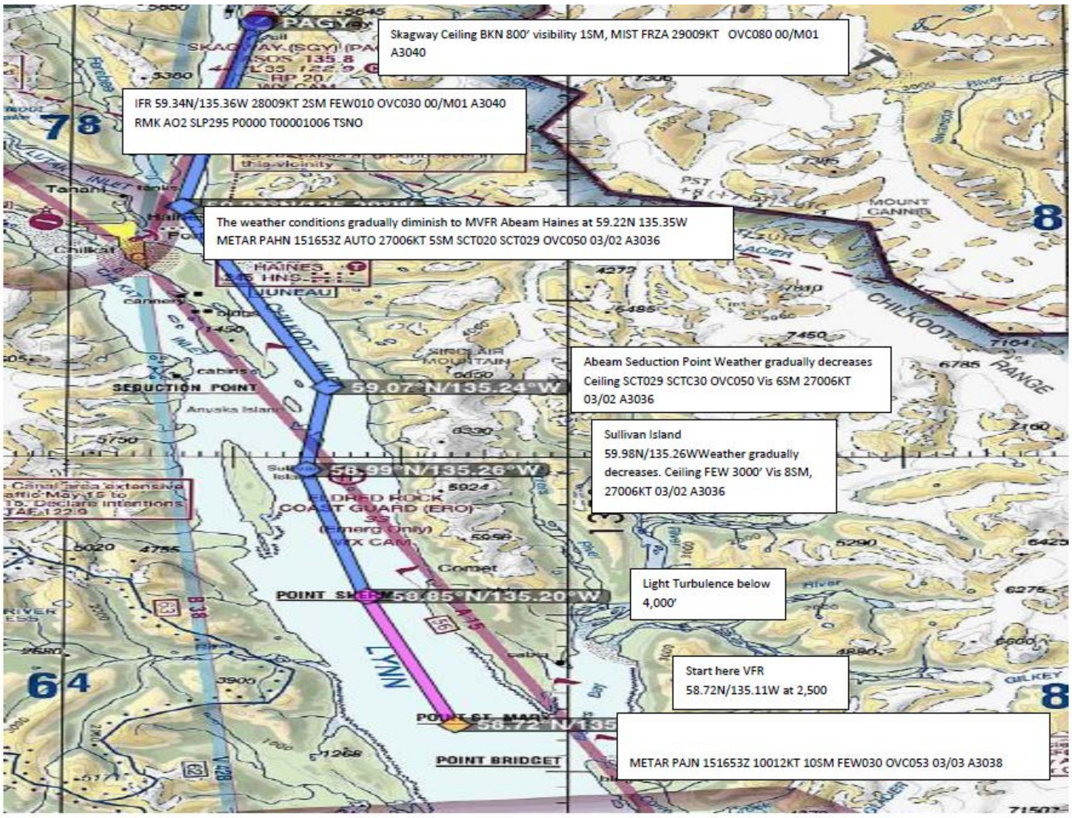
(B) Ceiling 1,000 to 3,000 feet and/or visibility 3 to 5 miles with continuous precipitation.

(C) Ceiling less than 1,000 feet and/or visibility less than 3 miles with continuous precipitation.

Appendix F: ATC Script for Alaska Scenario

Air Traffic Control Script: Alaska Scenario Team B [Juneau to Skagway]

Time (min)	ATC	Subject Response	Weather/Position/Simulation
	START 1700Z: **Point St Mary 2'500** 58.72N/135.11W	**Subject** will verbalize (self-announce) on CTAF 122.9 when abeam Point Sherman, Sullivan Island, Seduction Point, East of Haines with intentions (such as " at north in the Lynn Canal-Chilkoot Inlet, Taiya Inlet-landing Skagway, level at 2,500").	Scenario starts VFR (daylight) in the air at Point St Mary 2'500 at 58.72N/135.11W Juneau international airport information Uniform, time 1653 zulu weather, winds 100 at 12, visibility 10, sky condition few 3000 feet, overcast 3300 feet, temperature 3, dewpoint 3, altimeter 3038. Visual approach to runway eight in use - landing and departing runway eight. Notice to airmen-taxiway hotel east taxiway Charlie one and west taxiway echo one CLOSED to aircraft wingspan more than seventy-nine feet. Readback all hold short instructions. Advise on initial contact you have received Juneau international airport information Uniform." METAR PAJN 151653Z 10012KT 10SM FEW030 OVC033 03/03 A3038 RMK AO2 SLP286 T00280028



Time (min) Start 1700Z 0800AST	ATC	Subject Response	Weather/position/Simulation
Start 1700Z 0+30	Juneau ATC-"N6JW, extensive air traffic in the Lynn Canal-monitor CTAF 122.9 and state intentions as appropriate, good day."	"6JW-roger, monitoring CTAF"-or similar response.	**METAR PAJN 151653Z 10012KT 10SM FEW030 OVC053 03/03 A3038 RMK AO2 SLP286 T00280028**
1+45	Traffic in Lynn Canal on CTAF-"Any aircraft within 10 nautical miles of Point St. Mary-say altitude and if experiencing turbulence."	"This is 6JW-currently 10 miles south of Point St. Mary-northbound at 2,500-negative turbulence"	
2+15	**PIREP** **JNU UA/ OV 25SSE HNS /TM 1702/ FL025/ TP PA32 /SK SCT 550/ WX FV 10SM/LGT TURB BLO- 040/ RM PT SHERMAN VCNTY**		
3+50		"6JW at Sherman point 2,500 experiencing light turbulence" They may climb to 4,500'	Sherman Point 58.85N/135.20W Simulation insert light turbulence at Sherman Point at 2500-3000 feet at 58.85N/135.20W
7+07		" 6JW Abeam Sullivan Island" on CTAF	Sullivan Island 59.98N/135.26WWeather gradually decreases. Ceiling FEW 3000' Vis 8SM, 27006KT 03/02 A3036
9+30	Traffic in Lynn Canal on CTAF-"Float plane 12Mike is10 nm north of Chilkat Inlet landing Chilkat --Any aircraft within Chilkat inlet-say position and current flight conditions"	"This is 6WJM-currently abeam Seduction point -enroute to Skagway northbound at [altitude-dependent on action from turbulence encounter] **Note: Participant may turn around if they get the ASOS and realize they will enter MVFR conditions reported at Haines**	**Abeam Seduction Point Weather gradually decreases Ceiling SCT029 SCTC30 OVC050 Vis 6SM 27006KT 03/02 A3036** PAHN ASOS 135.7 "Haines Airport automated weather observation 1654Z. Wind two seven zero at zero six ; visibility five, sky condition, scattered at two thousand, overcast five thousand; temperature, 03 Celsius, dew point 02 Celsius, altimeter three-zero point three six . Remarks unknown precipitation, rain began 1641Z, Thunderstorm information not available."

Time (min)	**ATC | Weather Products** [AIRMET S&Z | CWA | ATIS]	**Subject Response**	**Weather/Position/Simulation**
15+10		"Abeam Haines" Note: Participant may turn around	Taiya Inlet MVFR METAR PAHN 151653Z AUTO 27006KT 5SM SCT020 SCT029 OVC050 03/02 A3036 The weather conditions gradually diminish to MVFR Abeam Haines at 59.22N 135.35W South of Taiya Inlet about 10 miles south of Skagway
16+45		Pilot continues towards destination in MVFR and possible ICING. Subject elects to land at alternate airport [PAHN]. Reverses course and returns to PAJN.	METAR PAGY 151654Z AUTO 29009KT 5SM FEW020 OVC030 00/M01 A3040 RMK AO2 SLP295 P0000 T00001006 TSNO
17+45	PIREP JNU UUA/ OV AGY /TM 1710/ FL010/ TP C206 /SK BKN 08/ WX FV 01SM BR/RM FRZA TAIYA INLET.	Pilot continues towards destination and enters IFR and ICING. Subject elects to land at alternate airport [PAHN] which is MVFR. Reverses course and returns to PAJN.	IFR at 59.34N/135.36W IFR 59.34N/135.36W 28009KT 2SM FEW010 OVC030 00/M01 A3040 RMK AO2 SLP295 P0000 T00001006 TSNO At 1710Z Skagway Ceiling BKN 800' visibility 1SM, MIST FRZA 29009KT OVC080 00/M01 A3040
Experimenter terminates the scenario prior to MVFR or upon entering IMC. The intent is to protect the emotional integrity of the subject from actually experiencing a controlled flight into terrain trauma event-r crashing the aircraft.			

Appendix G: ATC Script for New Mexico

Air Traffic Control Script Team B : New Mexico Scenario [Santa Fe to Albuquerque]

Time (min)	ATC	Subject Response	Weather/Simulation
Start 1700Z 1100 MDT	**6JW Departure Runway: 20** Scenario starts at 8,500' level flight a mile out from KSAF heading 195.		Start Scenario in the air at 8,500' at 35.59N/106.09W on heading 195 degrees ATIS- Santa Fe international airport information delta, time 1653 zulu weather, wind 270 at 16 gust 24, visibility 10, sky condition few 4 thousand 7 hundred, overcast 7 thousand, temperature 12, dewpoint minus 2, altimeter 2995. Visual approach to runway 20 in use-landing and departing runway 20. Notice to airmen-taxiway delta closed between runway 10/28 and runway 2/20. IFR departures contact clearance delivery on the ground frequency 121.7. VFR departures advise your location, direction of flight, and requested altitude on the ground frequency. Readback all hold short instructions. Advise on initial contact you have received Santa Fe Airport information delta. KSAF 201653Z 27016G24KT 10SM FEW047 OVC070 12/M02 A2995 RMK AO2 SLP095 T01171022

Time (min)	ATC | Weather Products [AIRMET S&Z | CWA | ATIS]	Subject Response	Weather/position
Start 2+00	SAF TWR: "6JW traffic is a bonanza inbound from the south-continue on course---state your altitude."	Subject should relay his/her altitude	
2+30	"6JW, traffic no longer a factor, when able, contact Albuquerque Center 132.8 for flight following, good day sir."	"6JW, roger-switching"-or similar response	
3+00		"Albuquerque Center-November 440AM with you 37 miles north of Albuquerque level at 8,500 requesting flight following to Albuquerque"-or similar response	
3+30	"November 440AM, Albuquerque Center, maintain VFR, Albuquerque altimeter 3000 (if necessary add "say destination")."	"6JW, roger-3000 in the box"-or similar response If requested by pilot AFSS 122.5 will provide METAR, area weather , SIGMET, AIRMET PIREP etc.	
4+00	"6JW, radar contact, 30 miles north-north east of the Albuquerque airport, advise prior to altitude change.		Weather gradually decreasing to 29019G27KT 8SM SCT50 OVC070 12/M02 A2997 Visibility, 8, sky condition scattered 5 thousand At 35.35N/106.23W
NLT 8+15			Moriarty airport information uniform, time 1655 zulu weather, wind 300 at 19 gust 29, visibility, 10, sky condition scattered 5 thousand, temperature 14, dewpoint minus 3, altimeter 2998.
10+00			**Over DULKE simulation input light Turbulence at Dulke Intersection below 9,000' at 35.24N/106.28W, gradually decreasing to 27016G24KT 6SM SCT45 OVC070 12/M02 A2997**

Time (min)	ATC	Subject Response	Weather
10+05	"6JW-a Cessna 402 reported light to moderate turbulence at 8,500-with smooth air above 9,000 in your area near Sandia"	**Intended response**-Subject requests a climb to 10,500.	KABQ UA/OV K1N1/TM 1705/FL085/TP C402/ SKC/TB/ LGT-MOD TURB BLO 090
10+15	"6JW climb and maintain VFR at one zero thousand five hundred"	[Subject response dependent upon subject's decision making skills] (Note-subject may opt to stay at 8,500 in the turbulence)	
11+00	"6JW- state your position and flight conditions."	[Subject should verify squawk code and relay his/her position	
11+30	"6JW, radar contact lost-stay on your assigned squawk code-Albuquerque Approach is expecting your call when reaching interstate 40-recent pilot reports indicate VFR arrivals are reaching Albuquerque from the east."	"6JW roger, we'll stay on our code and call approach at M40 Interstate"-or similar response.	Albuquerque international airport information tango, time 1716 zulu weather, wind 290 at 7, visibility 6, scattered 6 thousand, broken 8 thousand, temperature 14 dewpoint minus 2, altimeter 2998, Mountain obscuration NE. KABQ 201716Z 29007KT 5SM SCT060 BKN080 14/M02 A2998 RMK AO2 MTN TOPS OBSC SLP110 T01391017 10150 20067 58004
13+15	.	Subject elects to land at alternate airport [1N1-Sandia East] or [0E0 – Moriarty] or return to SAF-Santa Fe]. Subject continues in MVFR to IFR	MVFR due to reported mountain obscuration in the area at cement plant 35.09N/106.37W . 30019G27KT 3SM SCT45 OVC070 12/M02
13+50		Subject continues in IFR	IFR at 35.07N/106.42W 2SM SCT45 BKN 50 OVC070 AIRMET SIERRA ABQS WA 1710Z MTN OBSCN VALID UNTIL 1900Z 201710 TO ABQ201900 CONDS ENDG 1900. ZAB CWA 201710 ZAB CWA101 VALID UNTIL 1900 ISOLD SVR TSTM OVER ABQ MOVG SSE 10 KTS
NLT 14+00	**IMC35.07N/106.42W Experimenter terminates the scenario upon entering IMC or when the decision has been made.** **The intent is to protect the emotional integrity of the subject from actually experiencing a controlled flight into terrain trauma event-or crashing the aircraft.**		

Appendix H: Flight Plan for Alaska Scenario

Check Points (Fixes)	VOR Ident / Freq. / Z TIME	Magnetic Course (Route)	Altitude	Wind Dir.	Wind Vel. / Temp	CAS / TAS	TC / -L / +R WCA	TH / -E / +W Var.	MH / ± Dev.	CH	Dist. Leg / Rem.	GS Est. / Act.	Time Off ETE / ATE	ETA / ATA	GPH 8.5 Fuel / Rem.
Point Sherman Right 1nm	Z TIME														
		333	2500	100	10	116	355	360	338	338	9	118	:05		1
Sullivan Island Abeam Left 3.5nm					3		5	-22	0		43		:23		39
	1703.54z	329	2500	100	10	116	351	355	333	333	9	123	:05		1
Seduction Point Abeam Left 1nm					3		4	-22	0		34		:18		38
	1707.32z	321	2500	100	10	116	343	339	320	320	8	120	:04		1
Abeam Haines PAHN Left 5nm					3		4	-22	0		26		:14		37
	1709.49z	321	2500	100	10	116	343	339	320	320	13	120	:07		1
PAGY					3		4	-22	0		13		:07		36
	1715.11z	347	2500	100	10	116	9	14	352	352	13	116	:07		1
					3		5	-22	0		0		:00		35
	1720.17z														
	1720.43z														
										Totals »	52		28		5

Flight Plan and Weather Log on Reverse Side

Airport & ATIS Advisories

Departure		Destination
PAJN	ATIS Code	PAGY
033 / 10	Ceiling & Visibility	30 / 5
100 / 12	Wind	290 /9
30.38	Altimeter	30.40
	Approach	
10	Runway	
	Time Check	

Airport Frequencies

Departure		Destination	
PAJN		PAGY	
ATIS	135.2	ATIS	135.8
Ground	121.9	Approach	-
Tower	118.7	Tower	-
Departure	133.9	Ground	-
CTAF	118.7	CTAF	122.9
FSS	122.15	FSS	122.4
UNICOM	122.95	UNICOM	-
Field Elev	25	Field Elev	44
Block In		Log Time	
Block Out			

Appendix I: Flight Plan for New Mexico Scenario

VFR NAVIGATION LOG

Aircraft Number | | Notes Fuel burn 8.5 gph 2650 RPM

After T/O contact Albuquerque Center 132.8 Time to Leave the Delta: 1622

Top Of Climb **Time:** 5 **Fuel:** 1.0 **Distance:** 8 NM SW of KSAF **Distance With Wind:** 9 NM

Dulke is off the 198 Radial from SAF at a DME of 21. It is also off the 289 Radial from OTO at a Distance of 20nm

Hwy 40 point is off the 258 Radial from OTO at a Distance of 22nm. It is located at an intersection of Hwy 40 and another road and there is a cement plant.

Check Points (Fixes)	VOR Ident / Freq.	Magnetic Course (Route)	Altitude	Wind Dir.	Wind Vel. / Temp	CAS / TAS	TC / -L / +R WCA	TH / -E / +W Var.	MH / ± Dev.	CH	Dist. Leg / Rem.	GS Est. / Act.	Time Off ETE / ATE	ETA / ATA	GPH 11.5 Fuel / Rem.
	SAF														
DULKE Intersection	110.6	196	8,500	280	16	122	205	212	209	209	16	117	:09		2
HWY 40 35.09N 106.36W Cement Plant	OTO			13			7	-9	0		22		:12		38
	114.0	196	8,500	280	16	122	205	212	209	209	11	117	:06		1
KABQ	ABQ			13			7	-9	0		11		:06		37
	113.2	251	8,500	280	16	122	260	263	254	254	11	107	:06		1
				13			3	-9	0		0		:00		36
						Totals »					38		:21		4

Airport & ATIS Advisories

Departure		Destination
KSAF	ATIS Code	KABQ
070/10	Ceiling & Visibility	080/5
270@16G24	Wind	290@7
29.95	Altimeter	29.98
-	Approach	-
20	Runway	26
	Time Check	

Airport Frequencies

Departure		Destination	
KSAF		KABQ	
ATIS	128.55	ATIS	118.00
Ground	121.70	Approach	127.40
Tower	119.50	Tower	120.30
Departure	132.80	Ground	121.90
CTAF	119.50	CTAF	-
FSS	122.20	FSS	122.55
UNICOM	122.95	UNICOM	122.95
Field Elev	6348	Field Elev	5354
Block In		Log Time	
Block Out			

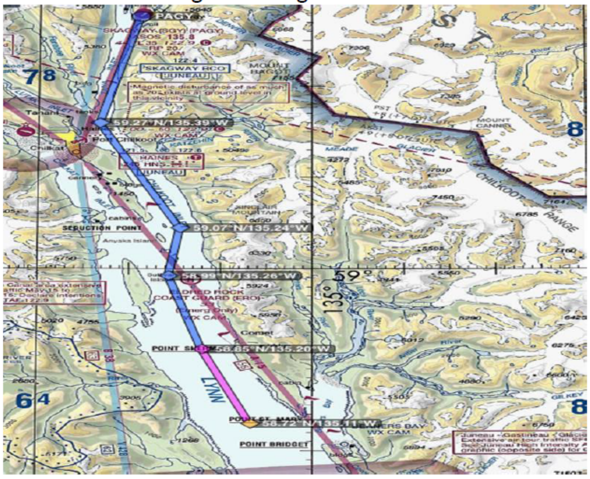
Flight Plan and Weather Log on Reverse Side

Appendix J: Alaska Flight Scenario Briefing

Juneau (PAJN) to Skagway (PAGY)

Alaska Flight Briefing PAJN to PAJY

Time: 0800 AST 1700Z Daylight 11 January
Aircraft: C172
ETE: 20:43 min
Distance: 53 NM
Altitude: 2500'
Course: 320 degrees
Average: TAS _________ knots at _______ MAP ________
Route: Top of Climb Start 2,500' abeam Point St. Mary (58.73N, 135.18W), abeam Point Sherman (58.85N, 135.18W),abeam Sullivan Island, abeam Seduction Point (59.10N, 135.25W)abeam Haines PAHN (59.26N, 135.39W), Taiya inlet, PAGY
Alaska Weather Flight Briefing PAJN to PAJY



PAJN…PAGY
PAJN ATIS 135.2
Juneau international airport information Uniform, time one-six-five-three zulu weather, winds one-zer-zero at one-two, visibility one-zero, sky condition few Three thousand-five hundred, overcast three thousand-three hundred', temperature three, dewpoint three, altimeter three zero three eight. Visual approach to runway eight in use -landing and departing runway eight. Notice to airmen-taxiway hotel east taxiway Charlie one and west taxiway echo one CLOSED to aircraft wingspan more than seventy-nine feet. Readback all hold short instructions. Advise on initial contact you have received Juneau international airport information Uniform."

Adverse conditions

AIRMET for mountain obscuration, mountains obscured in clouds and precipitation, no change; 1,200 feet scattered, 3,500 feet broken, 5,000 feet overcast, merging layers, tops at 25,000 feet. Occasionally, 700 feet scattered, 1,000 feet broken to overcast, 3,500 feet overcast; visibility, 3 statute miles in light rain and mist; From 0900, 1,200 feet broken, 2,500 feet overcast, tops at 25,000 feet, visibility, 4 statute miles in light rain and mist. Surface wind from the southeast with gusts to 25 knots.
AIRMET

WA7O
JNUS WA 111700
AIRMET SIERRA FOR MT OBSC VALID UNTIL 1122000
TAIYA INLET AND MOUNT BAGOT
MTS OCNL OBSC IN CLDS/PCPN.
OTLK VALID 111700-112000.

VFR Flight Recommended

Flight Synopsis,
Valid until 2400; a 1012 milibar low near Middleton Island, Alaska, moves to north of Burwash, Canada, by 1800 and southeast of Whitehorse, Canada, by 2400. An associated front over the western gulf of Alaska moves northeast to be over the northeast gulf coast by 0900, and completely across the southeast panhandle by 2100. A new ridge builds over the eastern gulf of Alaska by 2400. TAIYA INLET, Lynn Canal and MOUNT BAGOT, valid until 1800.

Current Weather METAR for entire route of flight
METAR PAHN 151653Z AUTO 27006KT 5SM SCT020 SCT029 OVC050 03/02 A3036 RMK AO2 SLP279 T00330017 TSNO
METAR PAGY 151654Z AUTO 29009KT 5SM FEW020 OVC030 00/M01 A3040 RMK AO2 SLP295 P0000 T00001006 TSNO
METAR PAJN 151653Z 10012KT 10SM FEW030 OVC033 03/03 A3038 RMK AO2 SLP286 T00280028

Forecast Weather for the route of flight
TAF PAJN 1501336Z 1512/1612 07008KT P6SM OVC033
FM151700 10012KT P6SM FEW005 OVC033
FM152300 11015KT P6SM –RA FEW007 SCT016 OVC041
FM160400 13010KT P6SM FEW009 SCT023

TAF PAGY 150232 1503/1603 22015 P6SM OVC050
TEMPO FM0300 4SM –RA OVC020
FM0900 20010 5SM SCT020 OVC030
TEMPO FM0900 3SM –RA BR OVC015
FM1500 20018G28 P6SM –SHRA OVC030
FM2100 VAR03 P6SM SCT030 BKN040 OVC060

Notices to Airmen
Juneau
Taxiway B, B1, B2 closed 3Aug03 14:00 until 28Aug03 14:00.

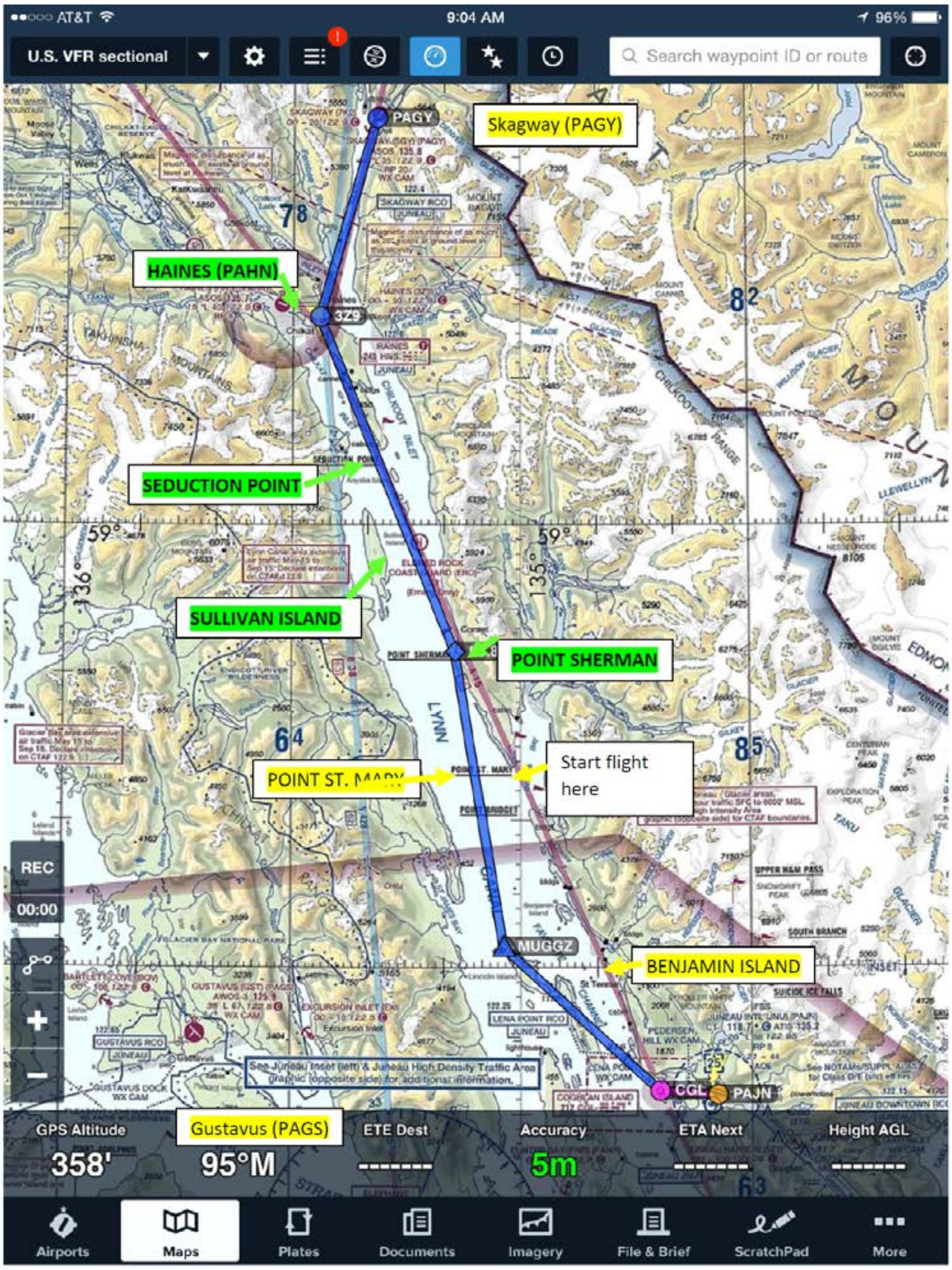
Obstruction/Obstacle tower light (ASR 1287767) 582006.10N1343933 (2.91 SW JNU) 322FT (155FT ABOVE GROUND LEVEL) OUT OF SERVICE.

Skagway
None

2

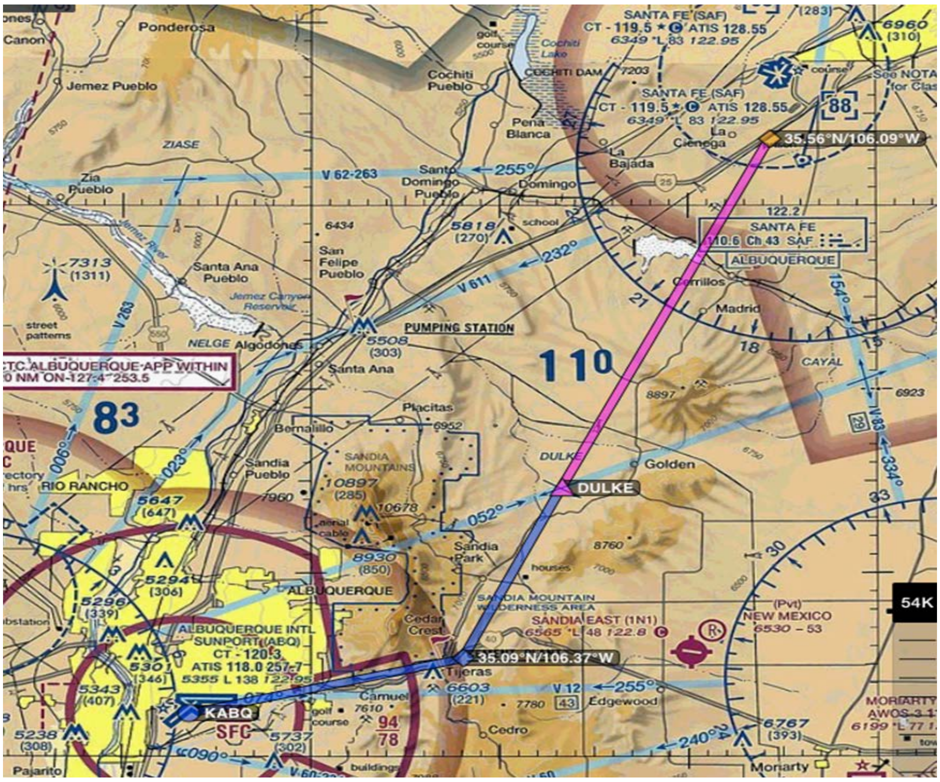
DATA BASED ON 151200Z
VALID 151300Z FOR USE 1300-2300Z. TEMPS NEG ABV 6000

FT	3000	6000	9000	12000	18000	24000
JNU	1010	1717-05	2222-10	262615	253620	255325


Skagway (PAGY)
HAINES (PAHN)
SEDUCTION POINT
SULLIVAN ISLAND
POINT SHERMAN
POINT ST. MARY
Start flight here
BENJAMIN ISLAND
Gustavus (PAGS)
U.S. VFR sectional
Search waypoint ID or route
PAGY
3Z9
MUGGZ
CGL
PAJN
REC
00:00
GPS Altitude
358'
95°M
ETE Dest
Accuracy
5m
ETA Next
Height AGL
Airports
Maps
Plates
Documents
Imagery
File & Brief
ScratchPad
More

Appendix K: New Mexico Flight Scenario Briefing

NM Scenario briefing
KABQ…DULKE…Hwy 40…ABQ 8.500' ETD 1700Z
Santa Fe (KSAF) to Albuquerque (KABQ) 5/20 1100MDT 1700Z.
This is an en-route scenario -pilot does not take off or land, starts airborne enroute having departed SAF Runway 20 heading 195 at 8,500'.
ATIS (relayed by ATC in this scenario). Pilots need to contact ABQ Center 132.8 for flight following when reaching top of climb.
ATIS: ATIS- Santa Fe international airport information delta, time 1653 zulu weather, wind 270 at 16 gust 24, visibility 10, sky condition few 4 thousand 7 hundred, overcast 7 thousand, temperature 12, dewpoint minus 2, altimeter 2995. Visual approach to runway 20 in use-landing and departing runway 20. Notice to airmen-taxiway delta closed between runway 10/28 and runway 2/20. IFR departures contact clearance delivery on the ground frequency 121.7. VFR departures advise your location, direction of flight, and requested altitude on the ground frequency. Readback all hold short instructions. Advise on initial contact you have received Santa Fe Airport information delta.
Departure: KSAF
Destination: KABQ
Aircraft: C172
DATE: May 20 1700Z 1100 MDT
ETE: 21 min
Distance: 43 NM
Altitude: 8,500'
Course: 195 degrees
Average TAS: _________NM at "_________ MAP at ______ RPM
Route: KSAF….DULKE Intersection…..Highway 40 (35.09N 106.36W)….
KABQ



Adverse conditions
NONE

VFR flight recommended.

Weather synopsis
There is a low pressure system dominant over the area. This will be bringing winds and a cold front to the area. Possible thunderstorm and mountain obscuration near Albuquerque.

Current Weather METAR for the route of flight
K0E0 201555Z AUTO 27016G22KT 10SM SCT047 11/M01 A2998 RMK AO2
K0E0 201615Z AUTO 28014G24KT 10SM SCT045 11/M02 A2998 RMK AO2
K0E0 201655Z AUTO 30016G24KT 10SM BKN047 BKN055 12/M02 A2998 RMK AO2
KABQ 201556Z 26007KT 10SM SCT050 BKN090 12/M01 A2999 RMK AO2 SLP114 T01171006
KABQ 201656Z 31009KT 5SM BKN055 BKN075 13/M01 A2998 RMK AO2 SLP112 T01331006
KAXX 201535Z AUTO 25009KT 10SM SCT022 SCT030 OVC036 02/00 A2998 RMK AO2
KAXX 201555Z AUTO 26010KT 10SM SCT038 OVC048 02/M01 A2998 RMK AO2
KAXX 201655Z AUTO 00000KT 10SM SCT037 BKN044 OVC050 02/M01 A2999 RMK AO2

KCQC 201453Z AUTO 29023G29KT 10SM CLR 08/M02 A2995 RMK AO2 PK WND 30029/1453 SLP098 T00781017 53012 TSNO
KCQC 201553Z AUTO 28024G31KT 10SM FEW035 09/M02 A2994 RMK AO2 PK WND 29034/1517 SLP094 T00891017 TSNO
KCQC 201653Z AUTO 30025G30KT 10SM BKN043 BKN050 11/M03 A2995 RMK AO2 PK WND 29032/1612 SLP097 T01061028 TSNO
KE80 201555Z AUTO 01004KT 10SM SCT055 OVC100 13/M02 A2999 RMK AO2 T01321016
KE80 201655Z AUTO 28010G22KT 10SM BKN065 BKN075 16/M02 A2997 RMK AO2 T01551024
KGNT 201553Z AUTO 29014G20KT 09/00 A3002 RMK AO2 SLP128 T00940000 PWINO TSNO
KGNT 201653Z AUTO 30014G21KT 12/00 A3002 RMK AO2 PK WND 30027/1631 SLP123 T01170000 PWINO TSNO
KLAM 201610Z AUTO 01003KT 10SM BKN038 BKN075 08/00 A2998 RMK AO2
KLAM 201630Z AUTO 25008KT 10SM SCT040 SCT048 OVC065 09/M01 A2998 RMK AO2
KLAM 201650Z AUTO 24012G21KT 201V271 10SM BKN048 BKN050 OVC065 10/M02 A2998 RMK AO2
KLVS 201653Z AUTO VRB03KT 10SM BKN060 OVC075 12/M05 A2991 RMK AO2 SLP071 T01171050
KONM 201555Z AUTO 30010G16KT 270V330 10SM SCT090 16/M03 A2998 RMK AO2
KONM 201655Z AUTO 31015G18KT 10SM SCT090 18/M05 A2997 RMK AO2
KSAF 201553Z 27010G20KT 10SM BKN040 BKN070 10/M02 A2996 RMK AO2 SLP095 T01001017
KSAF 201653Z 27016G24KT 10SM FEW047 OVC070 12/M02 A2995 RMK AO2 SLP095 T01171022
KSKX 201555Z AUTO 29004KT 10SM FEW028 OVC065 07/M01 A2997 RMK AO1
KSKX 201655Z AUTO 21013G16KT 10SM OVC040 08/M02 A2996 RMK AO1
KAEG 201550Z 28009G15KT 10SM SCT050 BKN075 09/M02 A3000
KAEG 201650Z 32010KT 10SM FEW045 BKN075 10/M02 A2999

Forecast weather for the route of flight

TAF KSAF 201136Z 2012/2112 30010KT P6SM BKN045
FM201700 28010G18KT P6SM FEW120
FM201900 28016G26KT P6SM VCSH SCT040CB BKN090
FM210200 31008KT P6SM SCT100

TAF KABQ 201136Z 2012/2112 VRB05KT P6SM FEW050
FM201700 28011KT 5SM FEW20 BKN 30 OVC 50
FM201900 29011G21 P6SM VCSH SCT060CB BKN100
FM210200 31010KT P6SM BKN110
FM210700 VRB06KT P6SM SCT110

Notices to airmen

Santa Fe

Contact ABQ Center 132.8 for flight following when reaching top of climb.

Visual approach to runway 20 in use-landing and departing runway 20. Notice to airmen-taxiway delta closed between runway 10/28 and runway 2/20. IFR departures contact clearance delivery on the ground frequency 121.7. VFR departures advise your location, direction of flight, and requested altitude on the ground frequency. Readback all hold short instructions. Advise on initial contact you have received Santa Fe Airport information delta.

Once you reach the mountains, radar contact will be lost.

Albuquerque

Albuquerque Approach is expecting your call when reaching interstate 40. Recent pilot reports indicate VFR arrivals are reaching Albuquerque from the east.

Landing and departing runway 21. Notice to airmen, taxiway A between Taxiway A8 and taxiway A12 closed. Pavement replacement lighted and barricaded. Taxiway A12 closed except Air National Guard aircraft. Lighted and barricaded.

Obstruction/Obstacle tower light (ASR 1057825)
350403.80N 1063307.50W (3.3NM ENE ABQ) 5586.0FT (165.0FT ABOVE GROUND LEVEL) OUT OF SERVICE. 10MAY 20:10 2011 UNTIL 30MAY 21:00 2011. CREATED 10 MAY 20:10 2011.

DATA BASED ON 201200Z
VALID 201500 FOR USE 1400-2100Z. TEMPS NEGATIVE ABOVE 12000

	3000	6000	9000	12000	18000	24000	30000	34000	39000
ABQ			9900+13	3513+5	3111-05	3010-16	320731	361041	350654
FMN			9900+19	3212+13	2911-05	2908-16	330931	330942	311054
TCC		1305	2709+18	2914+09	3215-06	3217-15	341830	341841	352552

Appendix L: Posttest and Post-Flight Questions

socrative by MasteryConnect

Name: ______________________ **Date:** __________

Quiz name: Post Test Weather

1. PRACTICE QUESTION #1. A stable air mass is most likely to have which characteristic?
   - (A) Showery precipitation
   - (B) Turbulent air
   - (C) Poor surface visibility

2. PRACTICE QUESTION #2. Interpret the weather symbol depicted in Utah on the 12-hour Significant Weather Prognostic Chart (Refer to Figure 20).
   - (A) Moderate turbulence, surface to 18,000 feet
   - (B) Base of clear air turbulence, 18,000 feet
   - (C) Thunderstorm tops at 18,000 feet

3. What is your biological sex?
   - (A) Male
   - (B) Female

4. What is your age?
   - (A) 17-25
   - (B) 26-35
   - (C) 36-45
   - (D) 46-55
   - (E) 56+

5. How many total flight hours have you logged?
   - (A) 0-50
   - (B) 51-100
   - (C) 101-200
   - (D) 201-300
   - (E) 301+

6. How many total instrument hours have you logged?
   - (A) 0-50
   - (B) 51-100
   - (C) 101-200
   - (D) 201-300
   - (E) 301+

7. Please list all ratings/certificates held.
   - (A) Private

- (B) Instrument
- (C) Commerical-Single Engine
- (D) Commercial Multi
- (E) CFI

8. Which type of airplane do you currently fly most often?
- (A) Single Engine
- (B) Multi Engine
- (C) Both

9. Which training environment did you achieve your private pilot certificate?
- (A) Part 61
- (B) Part 141
- (C) Four Year Collegiate Aviation Program
- (D) Military
- (E) Other

10. What weather products do you use for pre-flight and in-flight information?

____

____

____

____

____

11. How many total flight hours have you logged in the past 6 months?
- (A) 0-50
- (B) 51-100
- (C) 101-200
- (D) 201-300
- (E) 301+

12. (PA.I.C.K4l) Why is frost considered hazardous to flight?
- (A) Frost changes the basic aerodynamic shape of the airfoils, thereby decreasing lift
- (B) Frost slows the airflow over the airfoils, thereby increasing control effectiveness
- (C) Frost spoils the smooth flow of air over the wings, thereby decreasing lifting capability

13. (PA.I.C.K4f) What are characteristics of a moist, unstable air mass?
- (A) Cumuliform clouds and showery precipitation
- (B) Poor visibility and smooth air
- (C) Stratiform clouds and showery precipitation

14. (PA.I.C.K4f) Crests of standing mountain waves may be marked by stationary, lens-shaped clouds known as
- (A) mammatocumulus clouds.
- (B) standing lenticular clouds.

Ⓒ roll clouds.

15. (PA.I.C.K4e) Steady precipitation preceding a front is an indication of

Ⓐ stratiform clouds with moderate turbulence.

Ⓑ cumuliform clouds with little or no turbulence.

Ⓒ stratiform clouds with little or no turbulence.

16. (PA.I.C.K4i) Where does wind shear occur?

Ⓐ Only at higher altitudes.

Ⓑ Only at lower altitudes.

Ⓒ At all altitudes, in all directions.

17. (PA.I.C.K4j) In which environment is aircraft structural ice most likely to have the highest accumulation rate?

Ⓐ Cumulus clouds with below freezing temperatures.

Ⓑ Freezing drizzle.

Ⓒ Freezing rain.

18. (PA.I.C.K4h) What conditions are necessary for the formation of thunderstorms?

Ⓐ High humidity, lifting force, and unstable conditions.

Ⓑ High humidity, high temperature, and cumulus clouds.

Ⓒ Lifting force, moist air, and extensive cloud cover.

19. (PA.I.C.K4k) In which situation is advection fog most likely to form?

Ⓐ A warm, moist air mass on the windward side of mountains

Ⓑ An air mass moving inland from the coast in winter.

Ⓒ A light breeze blowing colder air out to sea.

20. (PA.I.C.K4k) Low-level turbulence can occur and icing can become hazardous in which type of fog?

Ⓐ Rain-induced fog.

Ⓑ Upslope fog.

Ⓒ Steam fog.

21. (PA.I.C.K4j) During an IFR cross-country flight you picked up rime icing which you estimate is 1/2" thick on the leading edge of the wings. You are now below the clouds at 2000 feet AGL and are approaching your destination airport under VFR. Visibility under the clouds is more than 10 miles, winds at the destination airport are 8 knots right down the runway, and the surface temperature is 3 degrees Celsius. You decide to

Ⓐ use faster than normal approach and landing speed.

Ⓑ approach and land at your normal speed since the ice is not think enough to have any noticeable effect.

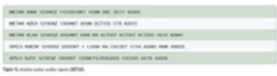
Ⓒ fly your approach slower than normal to lessen the 'wind chill' effect and break up the ice.

22. (PA.I.C.S1) The wind direction and velocity at KJFK is from (Refer to Figure 12.)

Ⓐ 180° true at 4 knots.

Ⓑ 180° magnetic at 4 knots.

Ⓒ 040° true at 18 knots.

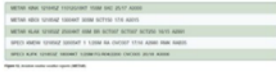


23. (PA.I.C.S1) The remarks section for KMDW has RAB35 listed. This entry means (Refer to Figure 12.)

Ⓐ blowing mist has reduced the visibility to 1-1/2 SM.

Ⓑ rain began at 1835Z.

Ⓒ the barometer has risen .35" Hg.



24. (PA.I.C.S1) The wind and temperature at 12,000 feet MSL as reported by a pilot are (Refer to Figure 14).

Ⓐ 090° at 21 MPH and -9 °F.

Ⓑ 090° at 21 knots and -9 °C.

Ⓒ 080° at 21 knots and -7°C.

25. (PA.I.C.S1) The intensity of the turbulence reported at a specific altitude is (refer to Figure 14).

Ⓐ moderate from 5,500 feet to 7,200 feet.

Ⓑ moderate at 5,500 feet and at 7,200 feet.

Ⓒ light from 5,500 feet to 7,200 feet.

26. (PA.I.C.S2) From which primary source should information be obtained regarding expected weather at the estimated time of arrival if your destination has no Terminal Forecast?

Ⓐ Low-level Prognostic Chart

Ⓑ Weather Depiction Chart

Ⓒ Area Forecast

27. (PA.I.C.S5) In the TAF from KOKC, the "FM (FROM) Group" is forecast for the hours from 1600Z to 2200Z with the wind from (Refer to Figure 15.)

Ⓐ 160° at 10 knots.

Ⓑ 180° at 10 knots, becoming 200° at 13 knots.

Ⓒ 180° at 10 knots.

28. (PA.I.C.S5) In the TAF from KOKC, the clear sky becomes (Refer to Figure 15.)

Ⓐ overcast at 2,000 feet during the forecast period between 2200Z and 2400Z.

Ⓑ overcast at 200 feet with a 40% probability of becoming overcast at 600 feet during the forecast period between 2200Z and 2400Z.

Ⓒ overcast at 200 feet with the probability of becoming overcast at 400 feet during the forecast period between 2200Z and 2400Z.

29. (PA.I.C.S3, S1) What sky condition and visibility are forecast for upper Michigan in the eastern portions after 2300Z? (Refer to Figure 16).

Ⓐ Ceiling 100 feet overcast and 3 to 5 statute miles visibility.

Ⓑ Ceiling 1,000 feet overcast and 3 to 5 nautical miles visibility.

Ⓒ Ceiling 1,000 feet overcast and 3 to 5 statute miles visibility.

30. (PA.I.C.S1) What sky condition and type obstructions to vision are forecast for upper Michigan in the western portions from 0200Z until 0500Z? (Refer to Figure 16).

(A) Ceiling becoming 1,000 feet overcast with visibility 3 to 5 statute miles in mist.

(B) Ceiling becoming 100 feet overcast with visibility 3 to 5 statute miles in mist.

(C) Ceiling becoming 1,000 feet overcast with visibility 3 to 5 nautical miles in mist.

---

31. (PA.I.C.S5) What information is contained in a CONVECTIVE SIGMET?

(A) Tornadoes, embedded thunderstorms, and hail 3/4 inch or greater in diameter.

(B) Severe icing, severe turbulence, or widespread dust storms lowering visibility to less than 3 miles.

(C) Surface winds greater than 40 knots or thunderstorms equal to or greater than video integrator processor (VIP) level 4.

---

32. (PA.I.C.S4) Which in-flight advisory would contain information on severe icing not associated with thunderstorms?

(A) Convective SIGMET.

(B) SIGMET.

(C) AIRMET.

---

33. (PA.I.C.S1) The IFR weather in northern Texas is due to (Refer to Figure 18)

(A) dust devils.

(B) low ceilings.

(C) intermittent rain.

---

34. (PA.I.C.S1) According to the Weather Depiction Chart, the weather for a flight from southern Michigan to north Indiana is ceilings (Refer to Figure 18).

(A) 1,000 to 3,000 feet and/or visibility 3 to 5 miles.

(B) less than 1,000 feet and/or visibility less than 3 miles.

(C) greater than 3, 000 feet and visibility greater than 5 miles.

---

35. (PA.I.C.S5) The enclosed shaded area associated with the low pressure system over northern Utah is forecast to have (Refer to Figure 20).

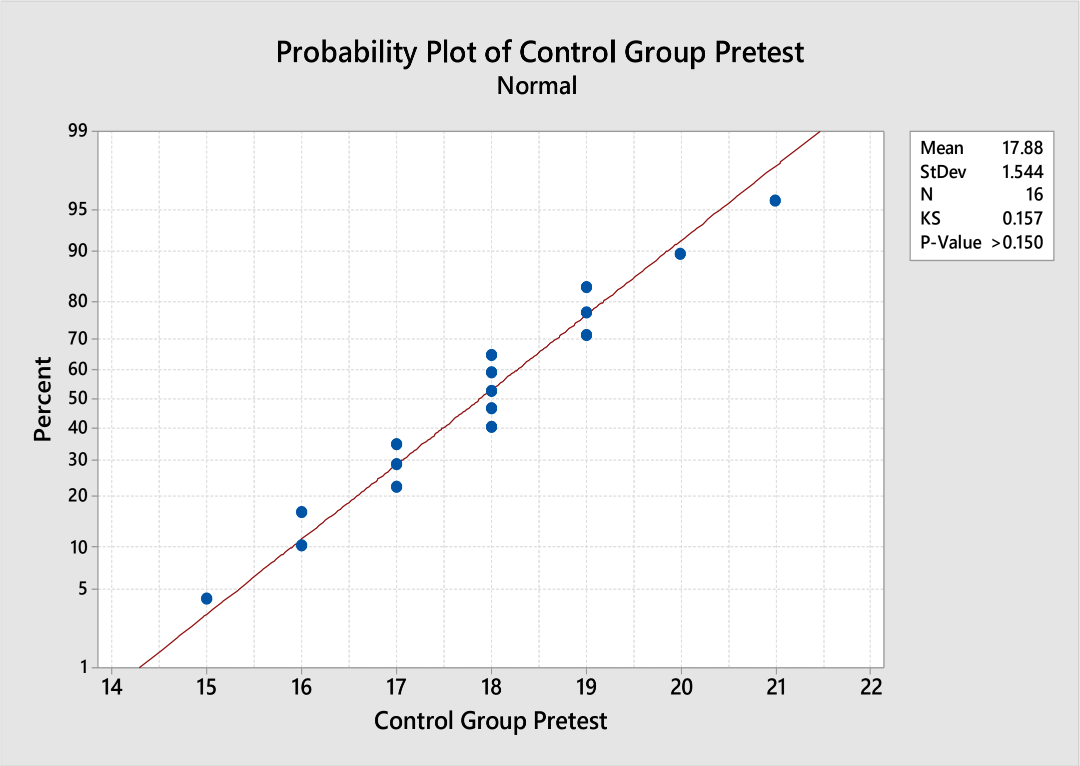
(A) continuous snow.

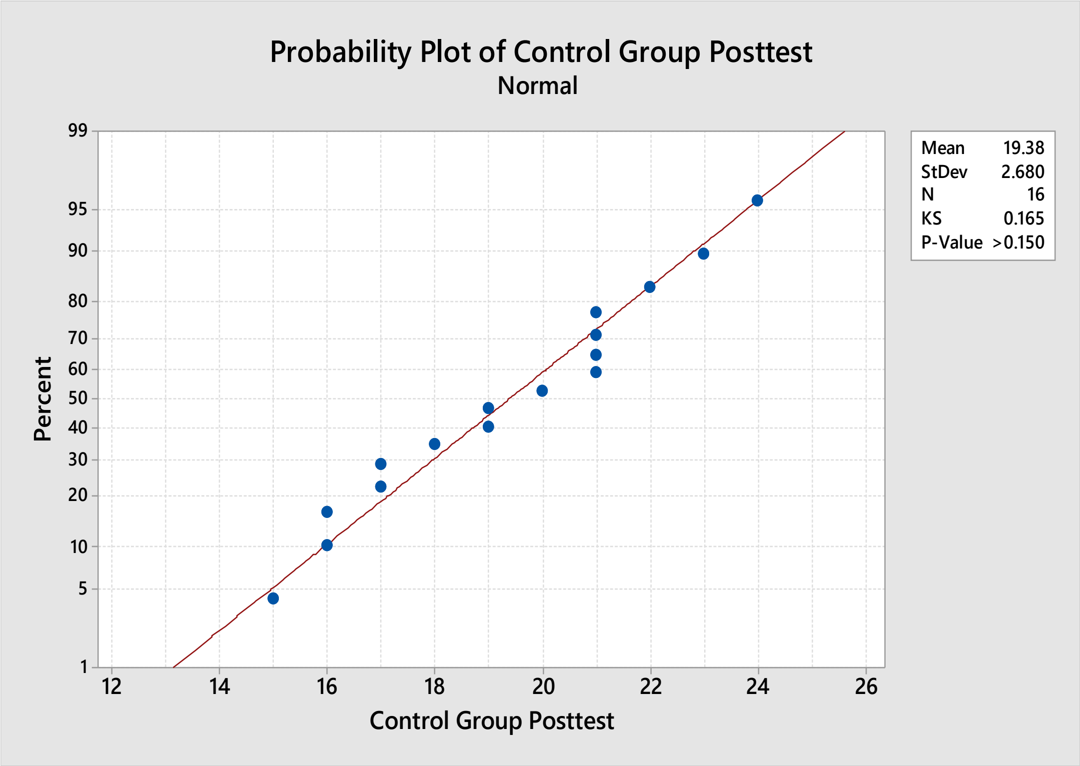
(B) intermittent snow.

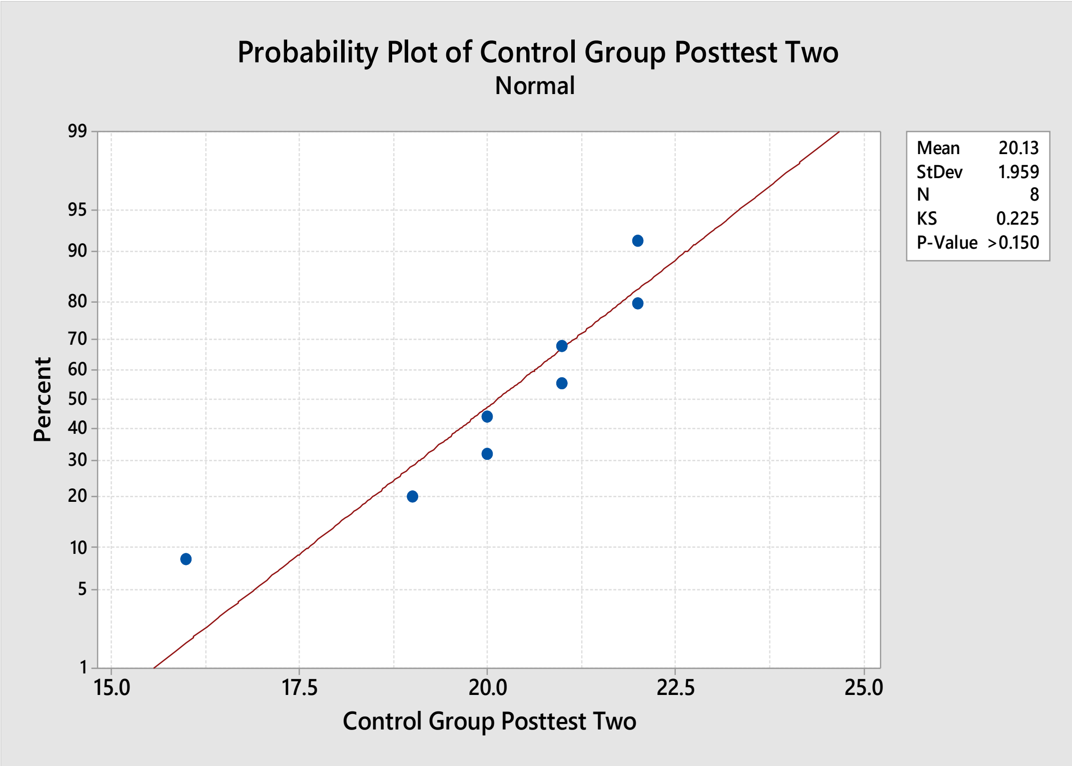
(C) continuous snow showers.

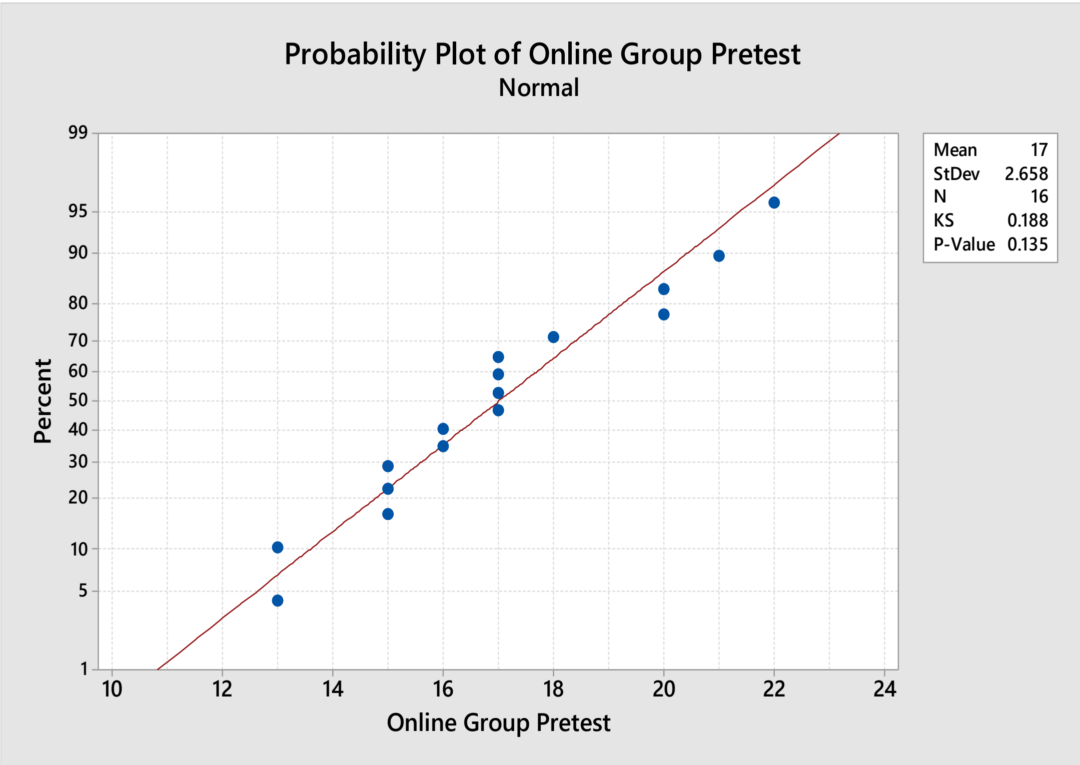
1. In the Alaska/New Mexico Simulation Scenario, did you divert, turn back or continue?
2. Why did you make the decision that you made?
3. Would you make the same decision again, and why?
4. Using a percentage, how much of your attention do you estimate was dedicated to maintaining the flight controls? And to maintaining situational awareness? (e.g., weather, traffic, etc.)
5. Is there anything you would like the researchers to know about your simulation experience today?

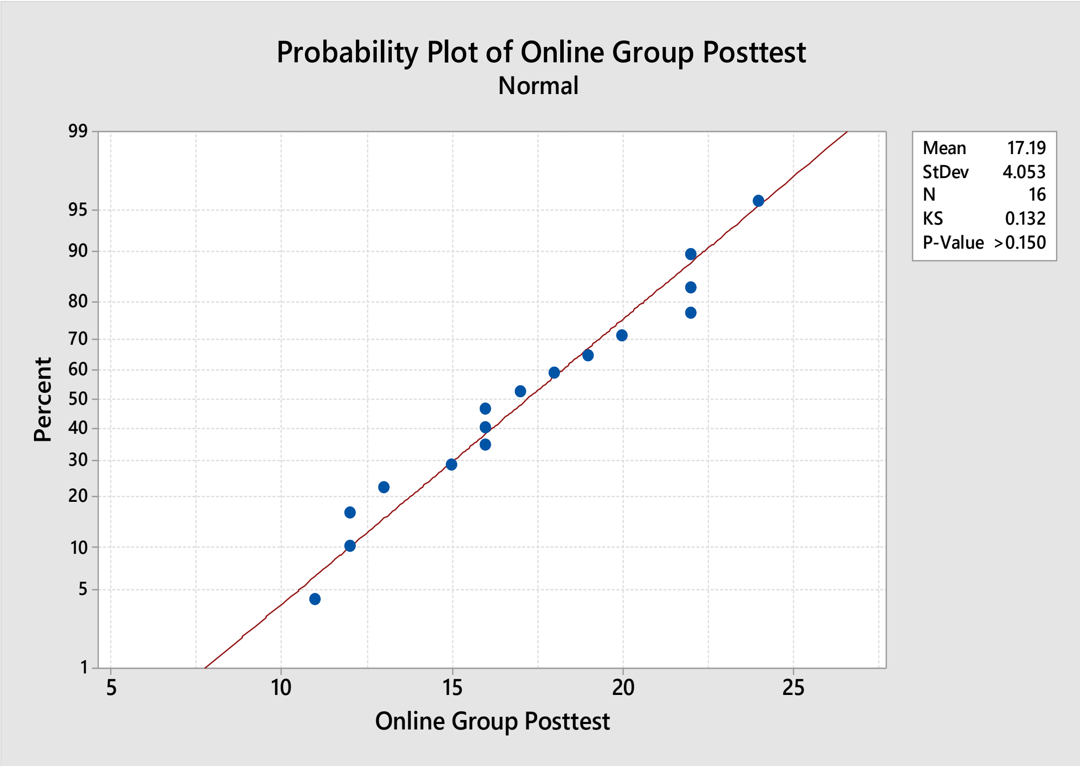
Appendix M: K–S Test Output for FAA Tech Center Participants

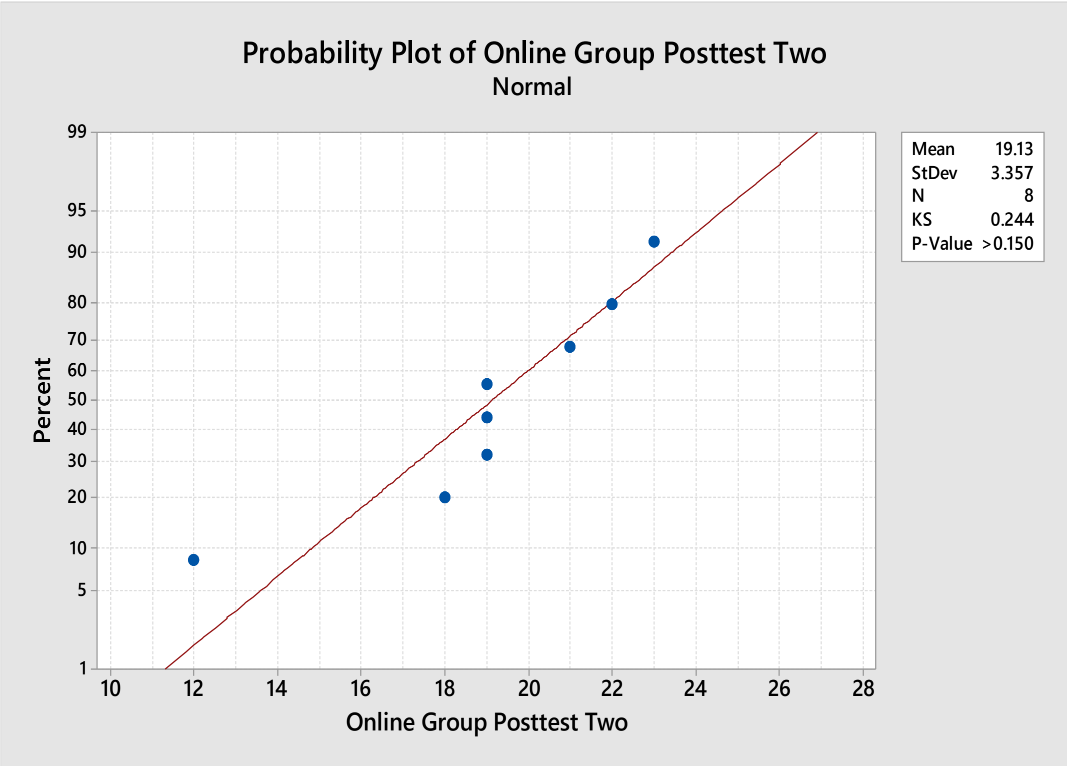


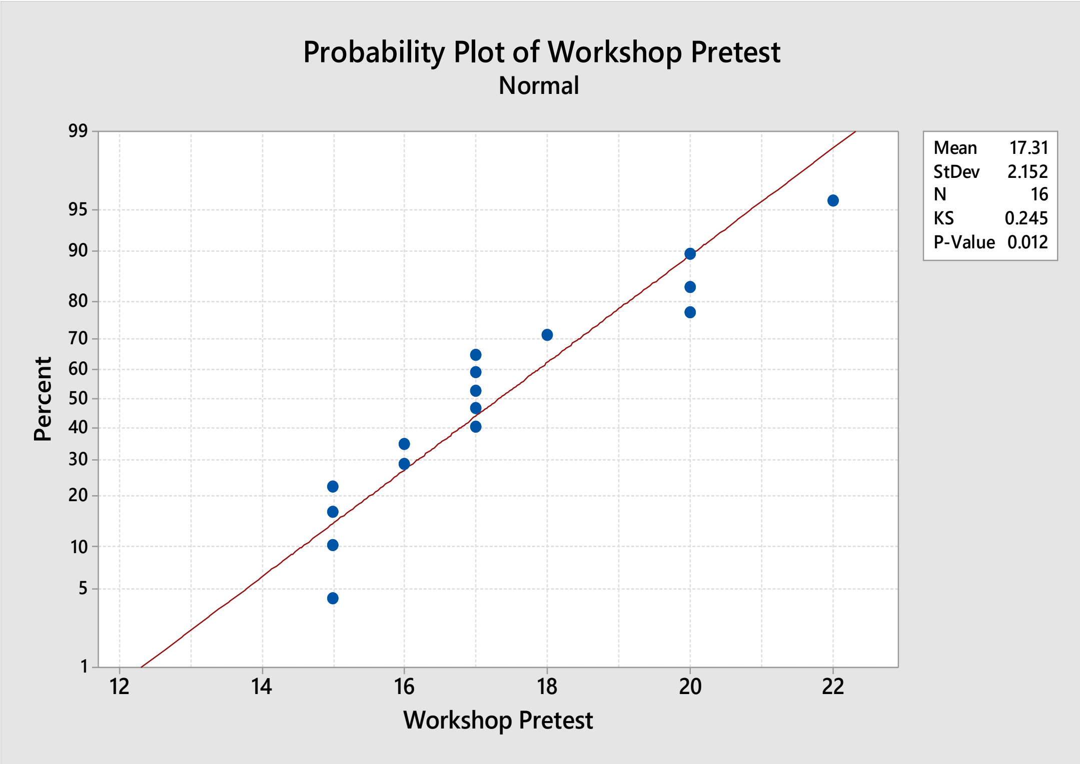



Probability Plot of Control Group Posttest Two
Normal
Percent
Control Group Posttest Two
99
95
90
80
70
60
50
40
30
20
10
5
1
15.0
17.5
20.0
22.5
25.0
Mean 20.13
StDev 1.959
N 8
KS 0.225
P-Value >0.150

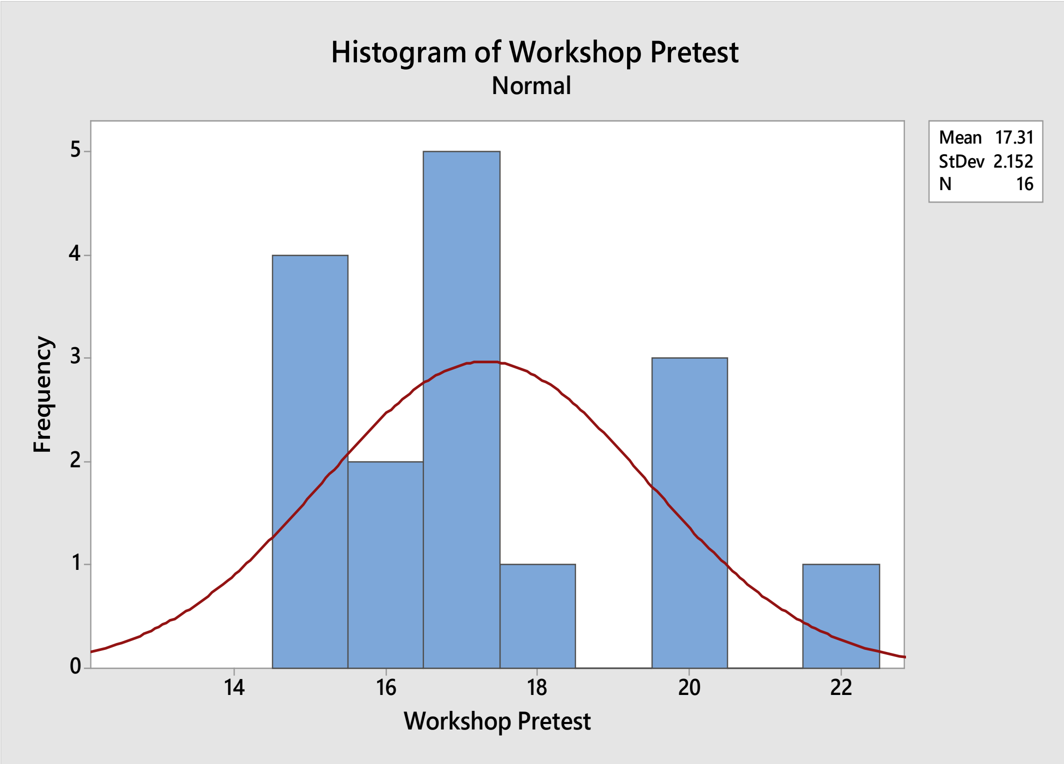

Probability Plot of Online Group Pretest
Normal
Percent
Online Group Pretest
99
95
90
80
70
60
50
40
30
20
10
5
1
10
12
14
16
18
20
22
24
Mean 17
StDev 2.658
N 16
KS 0.188
P-Value 0.135

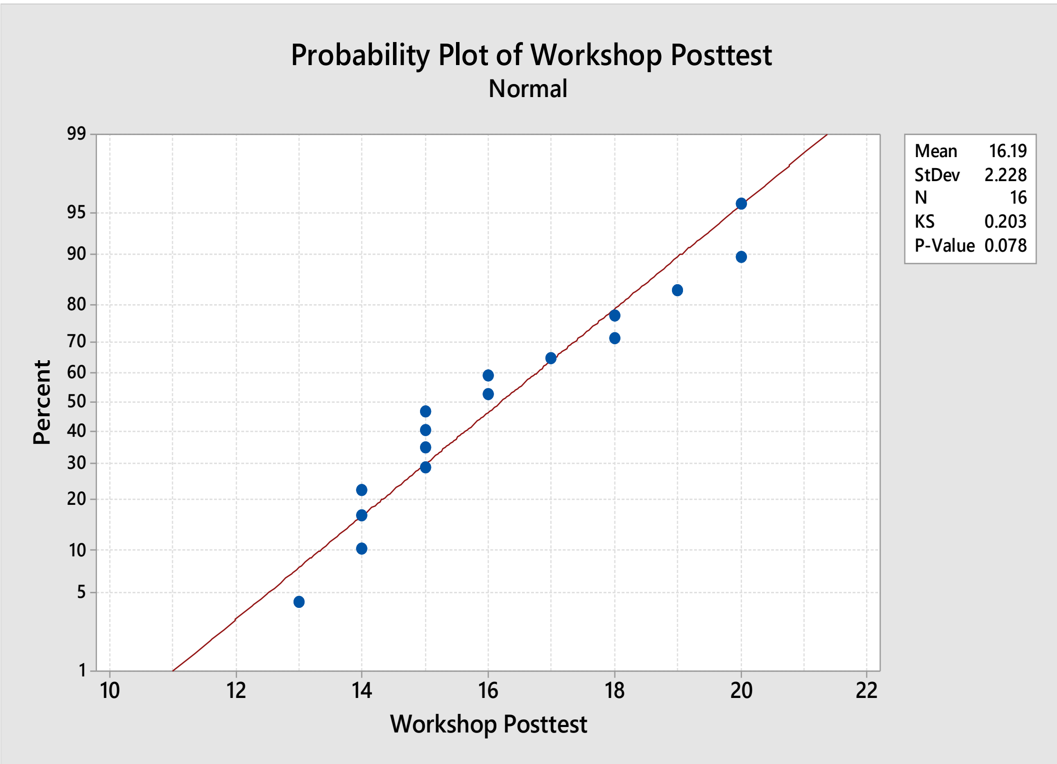

Probability Plot of Online Group Posttest
Normal
Mean 17.19
StDev 4.053
N 16
KS 0.132
P-Value >0.150
Percent
Online Group Posttest

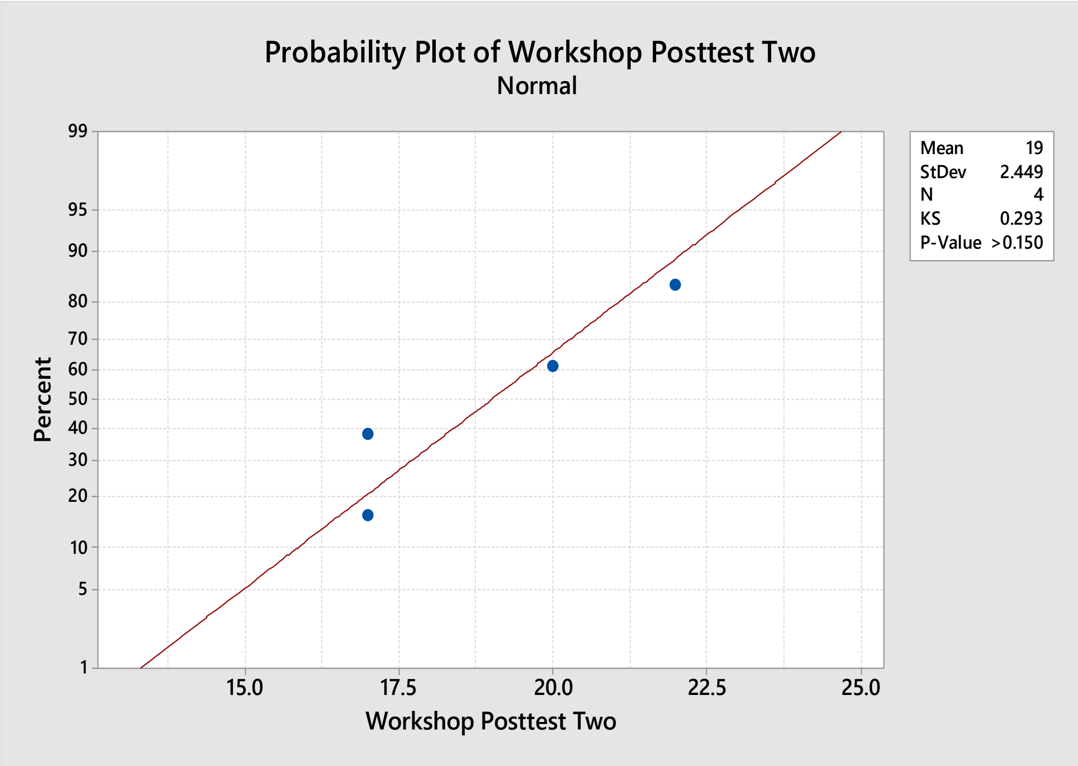

Probability Plot of Online Group Posttest Two
Normal
Mean 19.13
StDev 3.357
N 8
KS 0.244
P-Value >0.150
Percent
Online Group Posttest Two



Probability Plot of Workshop Pretest
Normal
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
12
14
16
18
20
22
Workshop Pretest
Mean 17.31
StDev 2.152
N 16
KS 0.245
P-Value 0.012


Histogram of Workshop Pretest
Normal
Mean 17.31
StDev 2.152
N 16
Frequency
0
1
2
3
4
5
14
16
18
20
22
Workshop Pretest


Probability Plot of Workshop Posttest
Normal
Mean 16.19
StDev 2.228
N 16
KS 0.203
P-Value 0.078
Percent
1
5
10
20
30
40
50
60
70
80
90
95
99
10
12
14
16
18
20
22
Workshop Posttest


Probability Plot of Workshop Posttest Two
Normal
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
15.0
17.5
20.0
22.5
25.0
Workshop Posttest Two
Mean 19
StDev 2.449
N 4
KS 0.293
P-Value >0.150

Appendix N: Grubb's Outlier Test for FAA Tech Center Participants

Outlier Test:

Method

Null hypothesis	All data values come from the same normal population
Alternative hypothesis	Smallest or largest data value is an outlier
Significance level	α = 0.05

Grubbs' Test

Variable	N	Mean	StDev	Min	Max	G	P
Control Group Pretest	16	17.875	1.544	15.000	21.000	2.02	0.495
Control Group Posttest	16	19.375	2.680	15.000	24.000	1.73	1.000
Control Group PosttestII	8	20.125	1.959	16.000	22.000	2.11	0.059
Online Group Pretest	16	17.000	2.658	13.000	22.000	1.88	0.764
Online Group Posttest	16	17.19	4.05	11.00	24.00	1.68	1.000
Online Group Posttest II	8	19.13	3.36	12.00	23.00	2.12	0.052
Workshop Pretest	16	17.313	2.152	15.000	22.000	2.18	0.292
Workshop Posttest	16	16.188	2.228	13.000	20.000	1.71	1.000
Workshop Posttest II	4	19.00	2.45	17.00	22.00	1.22	0.734

* NOTE * No outlier at the 5% level of significance

Appendix O: Test for Equal Variance –FAA Tech Center Participants

Test for Equal Variances: Control Group Pretest, Online Group Pretest, Workshop Pretest

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

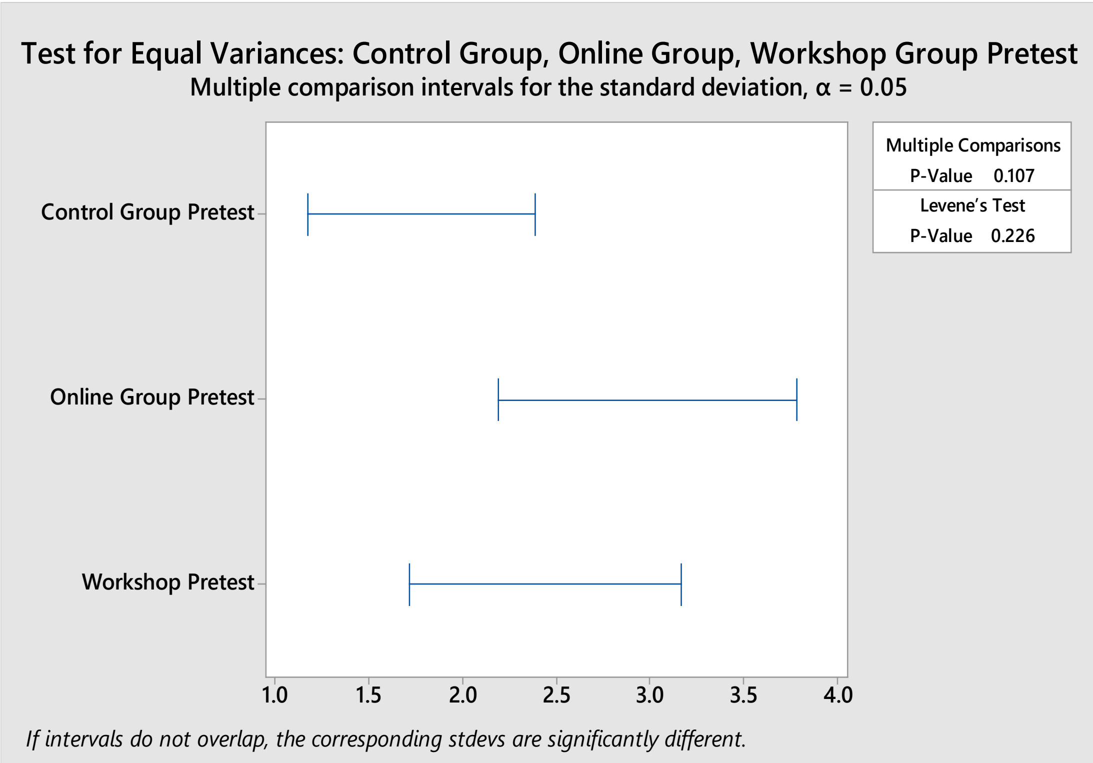
95% Bonferroni Confidence Intervals for Standard Deviations

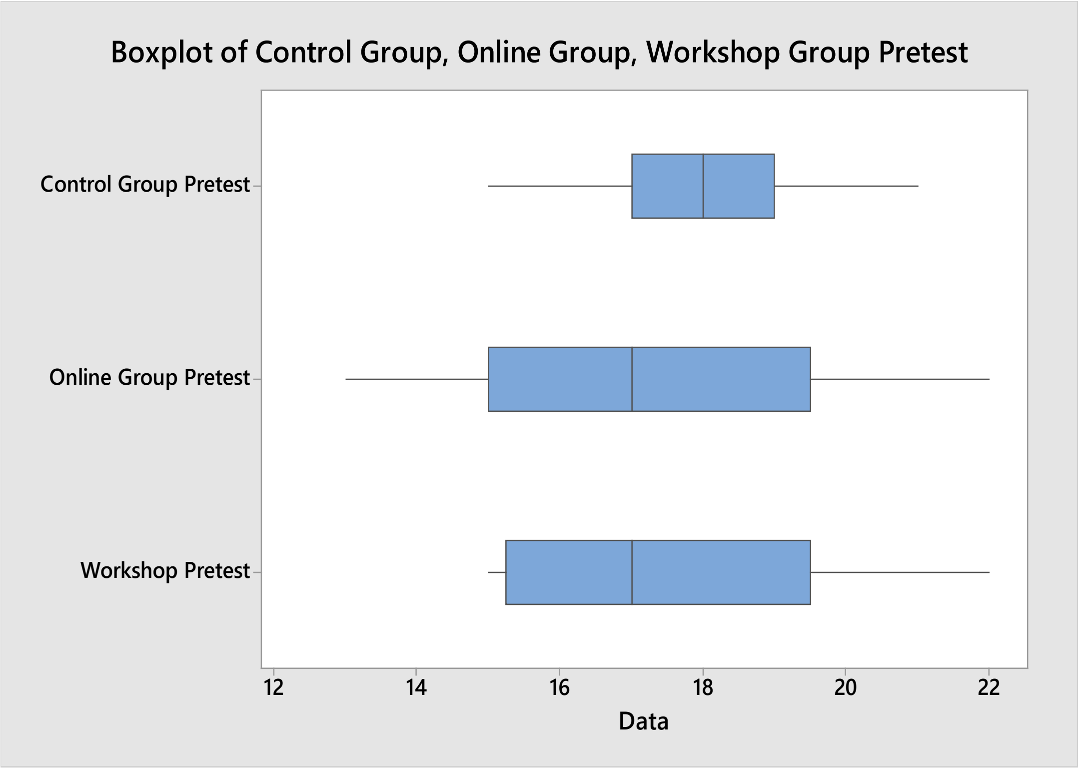
Sample	N	StDev	CI
Control Group Pretest	16	1.54380	(1.01556, 2.75974)
Online Group Pretest	16	2.65832	(1.83478, 4.52918)
Workshop Pretest	16	2.15155	(1.36829, 3.97843)

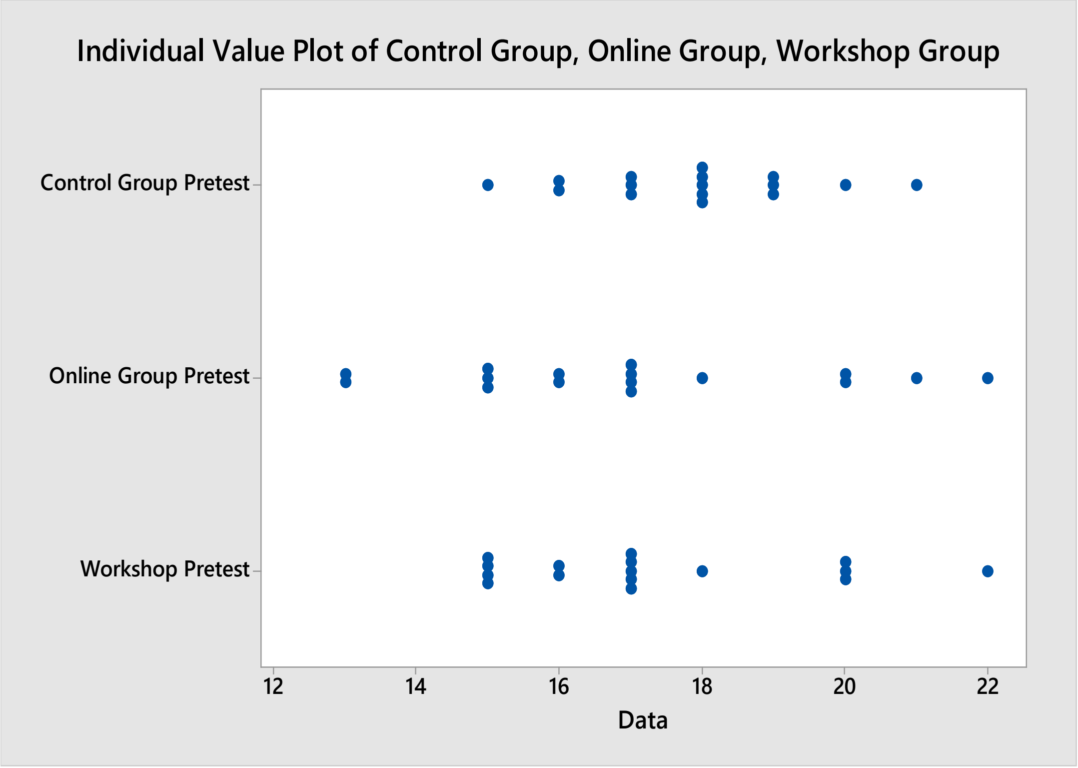
Individual confidence level = 98.3333%

Tests

Method	Test Statistic	P-Value
Multiple comparisons	—	0.107
Levene	1.54	0.226




Boxplot of Control Group, Online Group, Workshop Group Pretest
Control Group Pretest
Online Group Pretest
Workshop Pretest
12
14
16
18
20
22
Data


Individual Value Plot of Control Group, Online Group, Workshop Group
Control Group Pretest
Online Group Pretest
Workshop Pretest
12
14
16
18
20
22
Data

Test for Equal Variances: Control Group Posttest, Online Group Posttest, Workshop Posttest

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

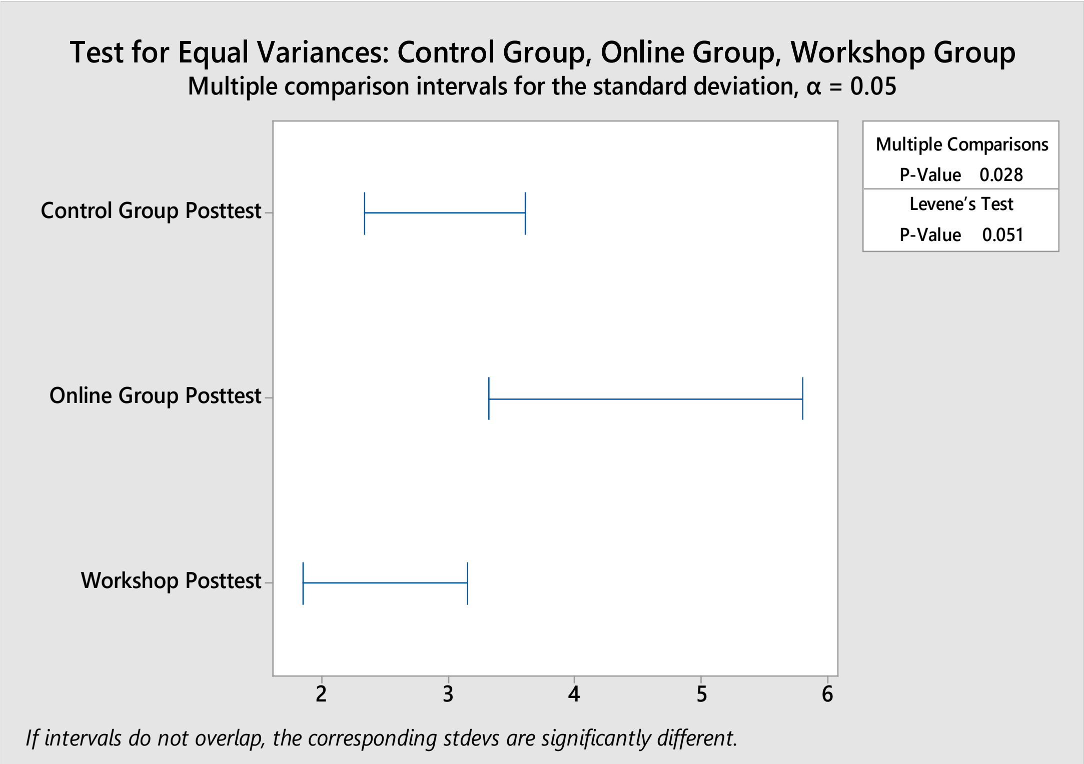
95% Bonferroni Confidence Intervals for Standard Deviations

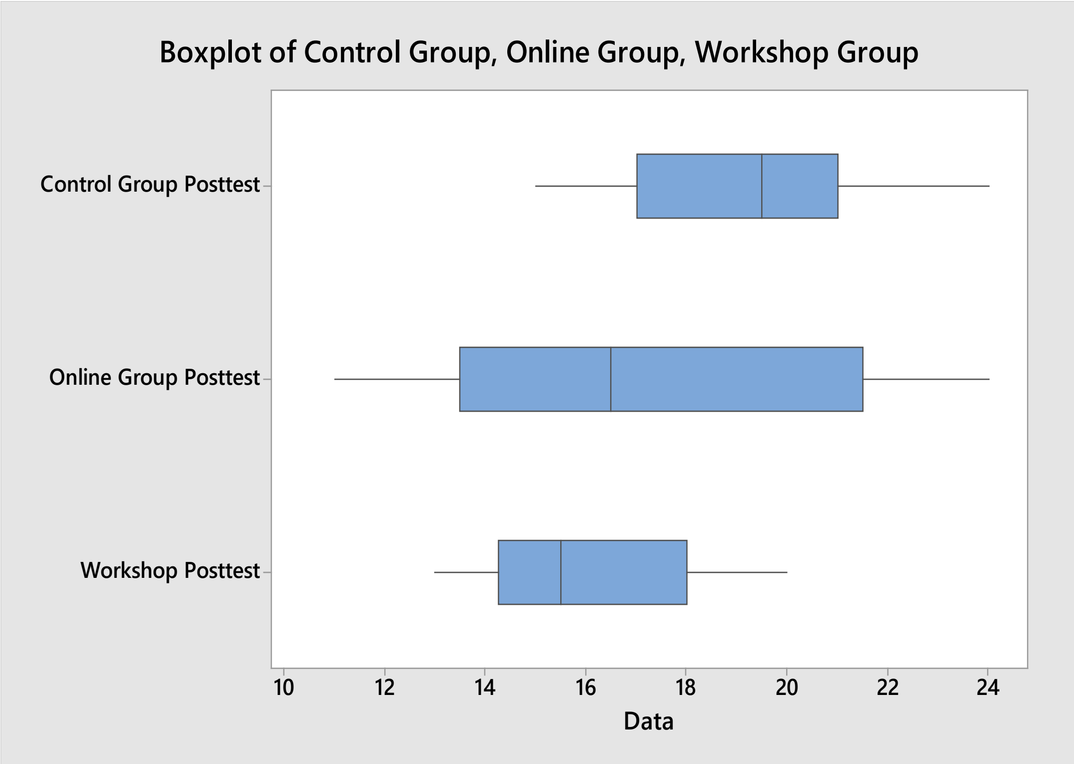
Sample	N	StDev	CI
Control Group Posttest	16	2.68017	(1.98019, 4.26587)
Online Group Posttest	16	4.05329	(3.02572, 6.38522)
Workshop Posttest	16	2.22767	(1.56734, 3.72329)

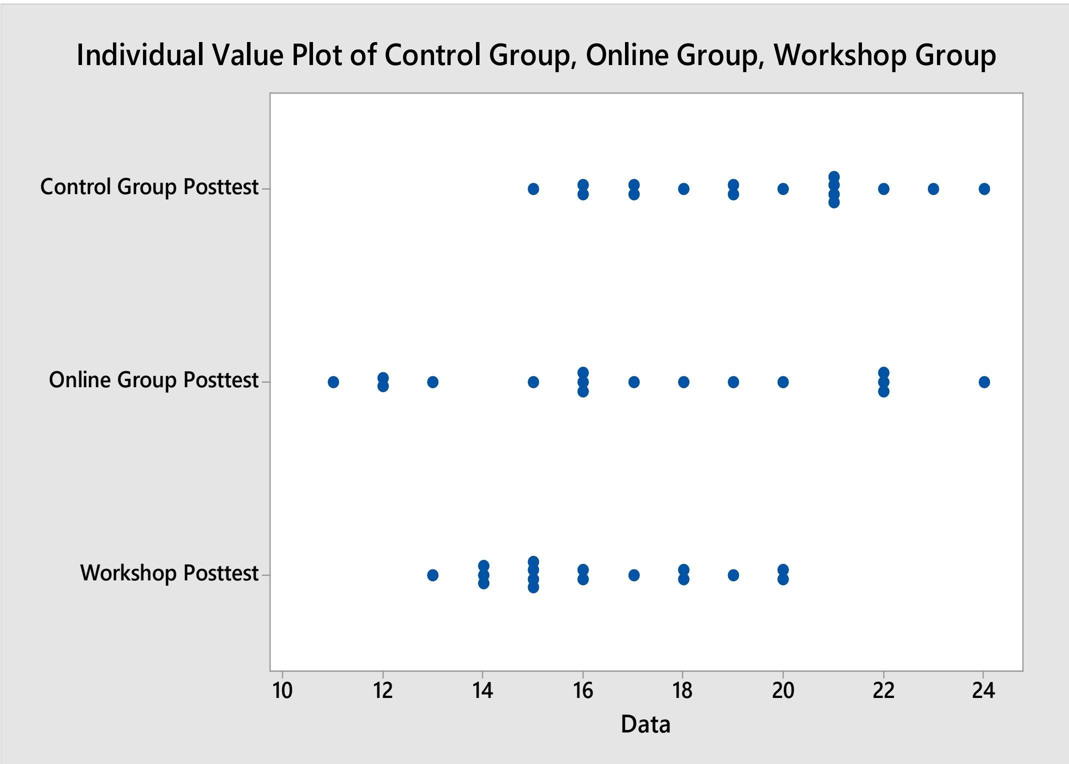
Individual confidence level = 98.3333%

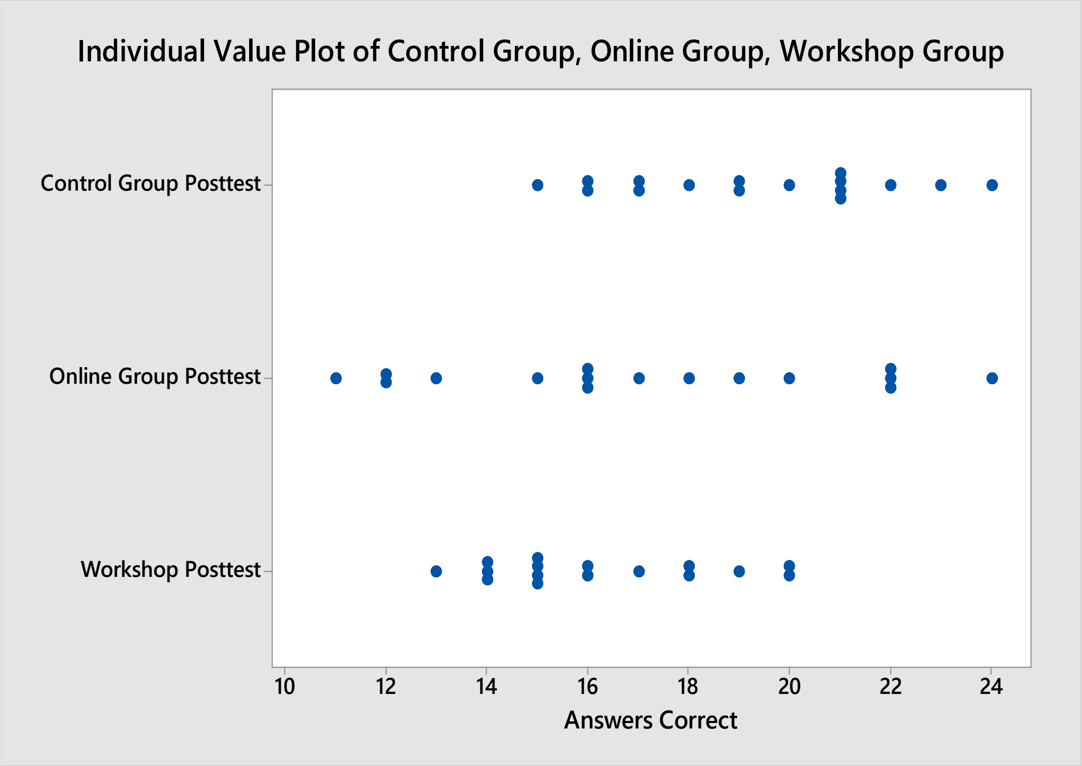
Tests

Method	Test Statistic	P-Value
Multiple comparisons	—	0.028
Levene	3.18	0.051




Boxplot of Control Group, Online Group, Workshop Group
Control Group Posttest
Online Group Posttest
Workshop Posttest
10
12
14
16
18
20
22
24
Data


Individual Value Plot of Control Group, Online Group, Workshop Group
Control Group Posttest
Online Group Posttest
Workshop Posttest
10
12
14
16
18
20
22
24
Data



Test for Equal Variances: Posttest Two

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	$\alpha = 0.05$

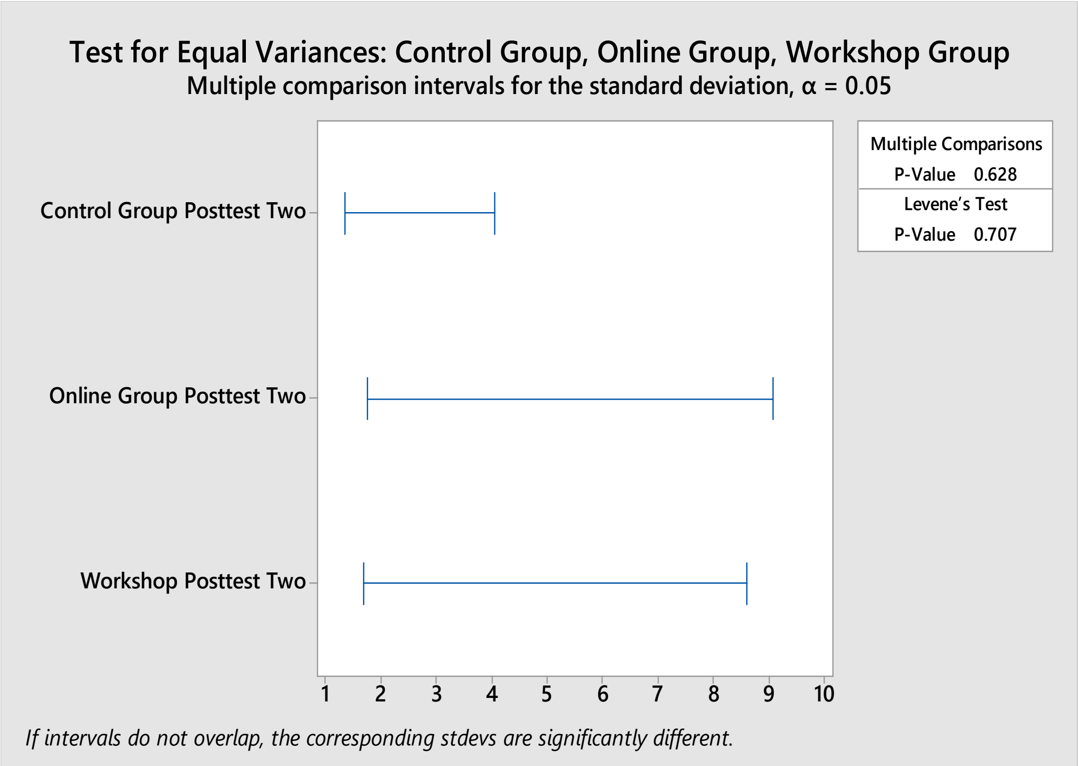
95% Bonferroni Confidence Intervals for Standard Deviations

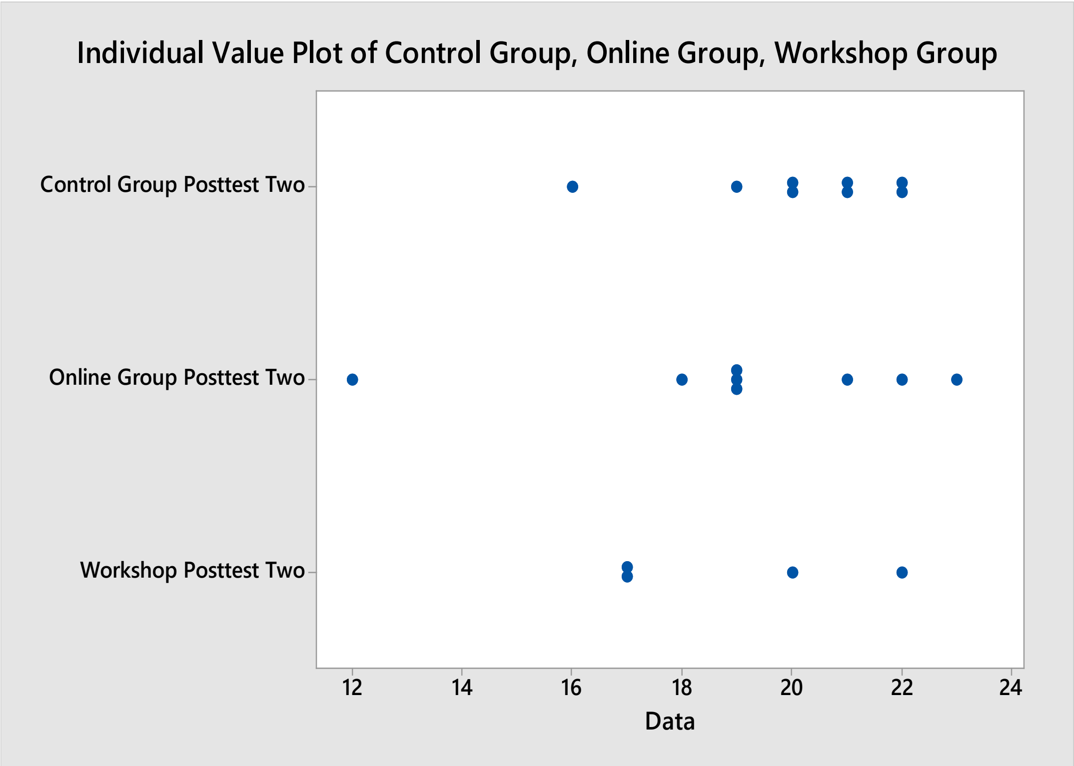
Sample	N	StDev	CI
Control Group Posttest Two	8	1.95941	(0.63450, 8.6348)
Online Group Posttest Two	8	3.35676	(1.15821, 13.8832)
Workshop Posttest Two	4	2.44949	(0.60677, 24.6283)

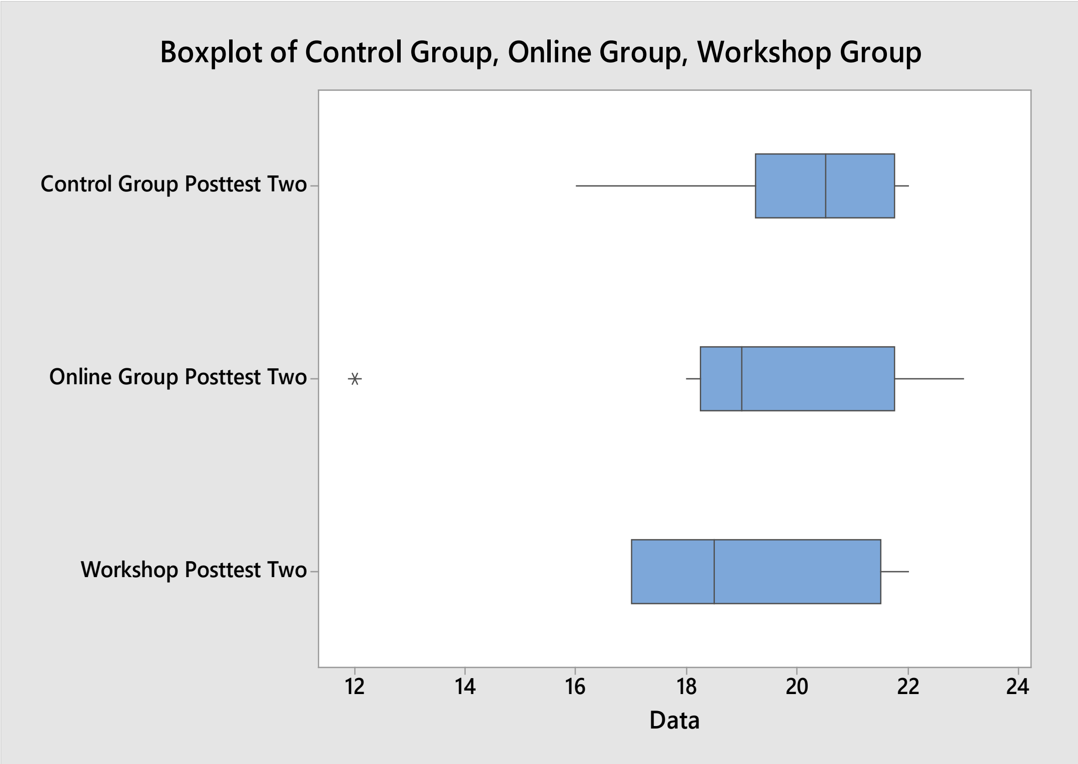
Individual confidence level = 98.3333%

Tests

Method	Test Statistic	P-Value
Multiple comparisons	–	0.628
Levene	0.35	0.707


Test for Equal Variances: Control Group, Online Group, Workshop Group
Multiple comparison intervals for the standard deviation, α = 0.05
Multiple Comparisons
P-Value 0.628
Levene's Test
P-Value 0.707
Control Group Posttest Two
Online Group Posttest Two
Workshop Posttest Two
1 2 3 4 5 6 7 8 9 10
If intervals do not overlap, the corresponding stdevs are significantly different.


Individual Value Plot of Control Group, Online Group, Workshop Group
Control Group Posttest Two
Online Group Posttest Two
Workshop Posttest Two
12 14 16 18 20 22 24
Data


Boxplot of Control Group, Online Group, Workshop Group
Control Group Posttest Two
Online Group Posttest Two
Workshop Posttest Two
12
14
16
18
20
22
24
Data

Appendix P: Pretest One-Way ANOVA-FAA Tech Center Participants

One-way ANOVA: Control Group Pretest, Online Group Pretest, Workshop Pretest

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Control Group Pretest, Online Group Pretest, Workshop Pretest

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	6.292	3.146	0.67	0.517
Error	45	211.188	4.693		
Total	47	217.479			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.16635	2.89%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Control Group Pretest	16	17.875	1.544	(16.784, 18.966)
Online Group Pretest	16	17.000	2.658	(15.909, 18.091)
Workshop Pretest	16	17.313	2.152	(16.222, 18.403)

Pooled StDev = 2.16635

Dunnett Multiple Comparisons with a Control

Grouping Information Using the Dunnett Method and 95% Confidence

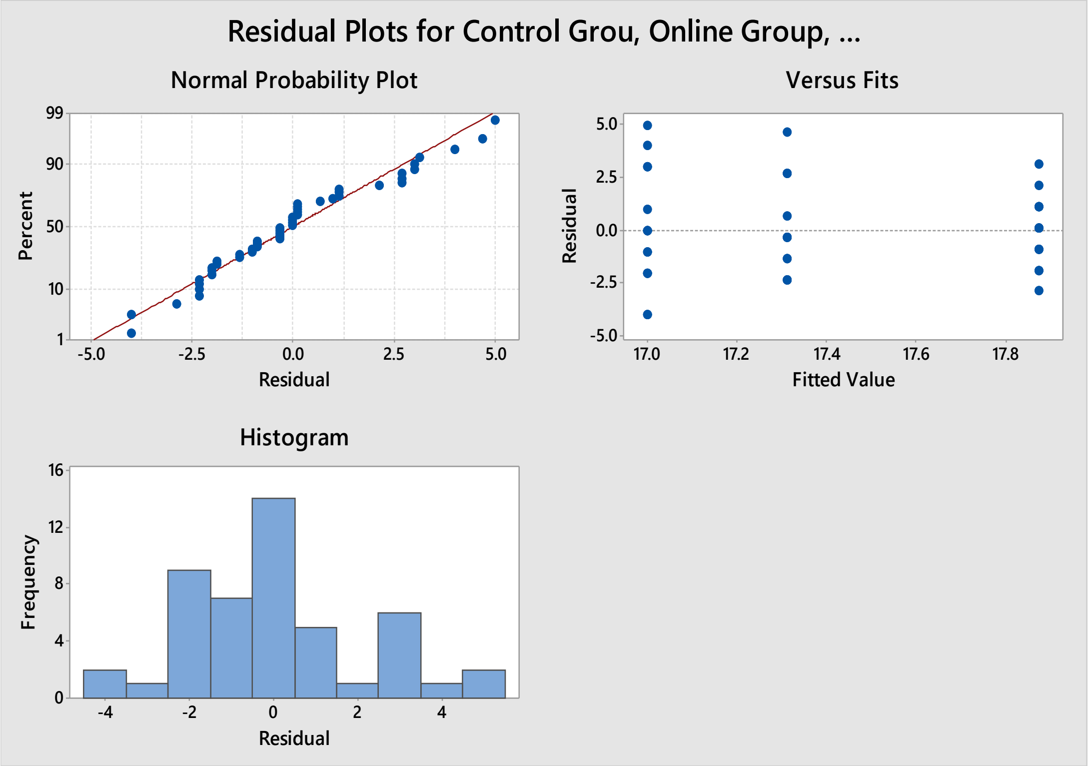
Factor	N	Mean	Grouping
Control Group Pretest (control)	16	17.875	A
Workshop Pretest	16	17.313	A
Online Group Pretest	16	17.000	A

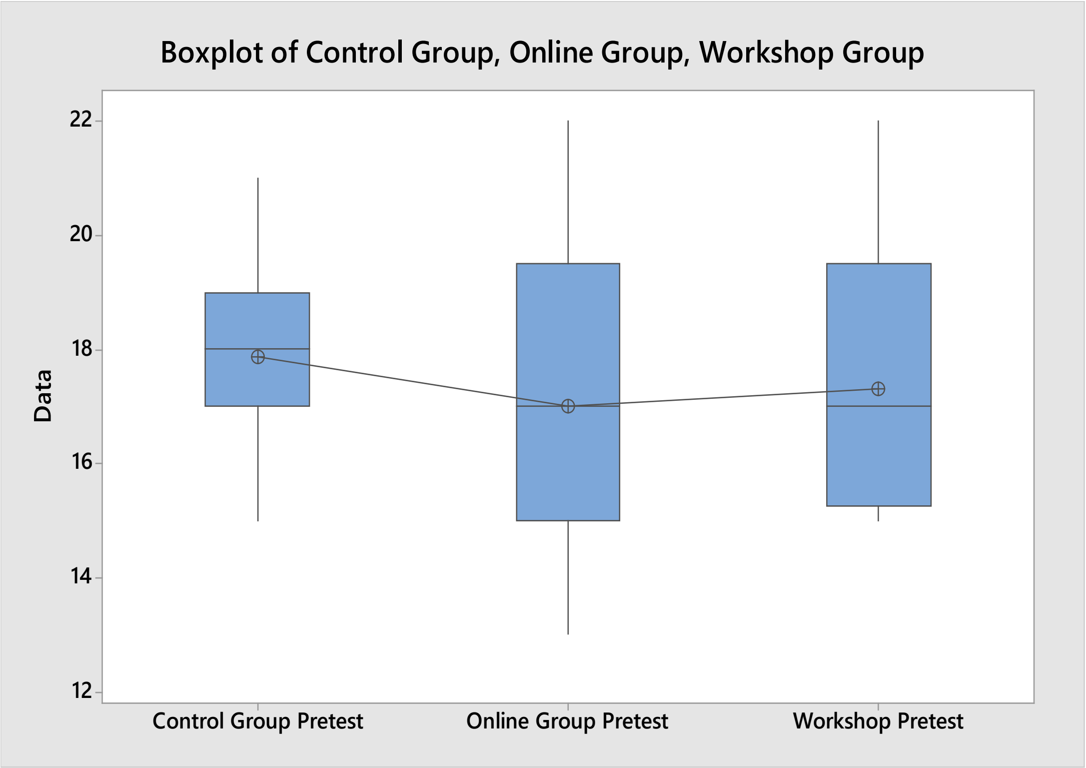
Means not labeled with the letter A are significantly different from the control level mean.

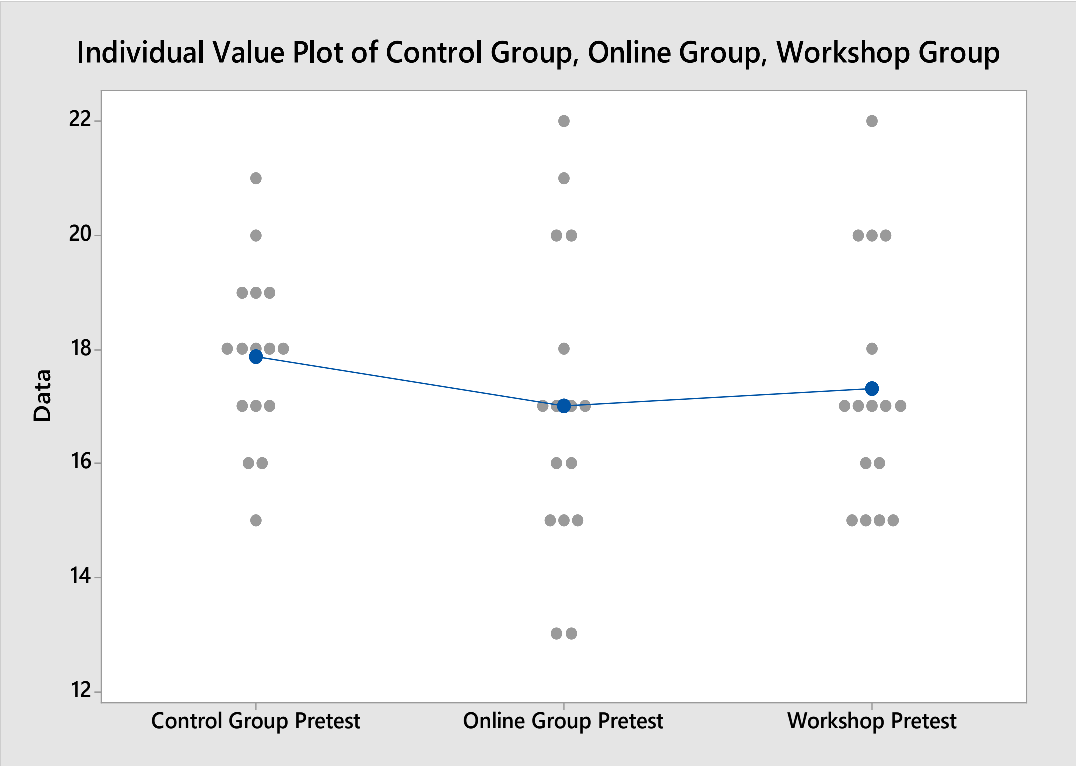
Dunnett Simultaneous Tests for Level Mean - Control Mean

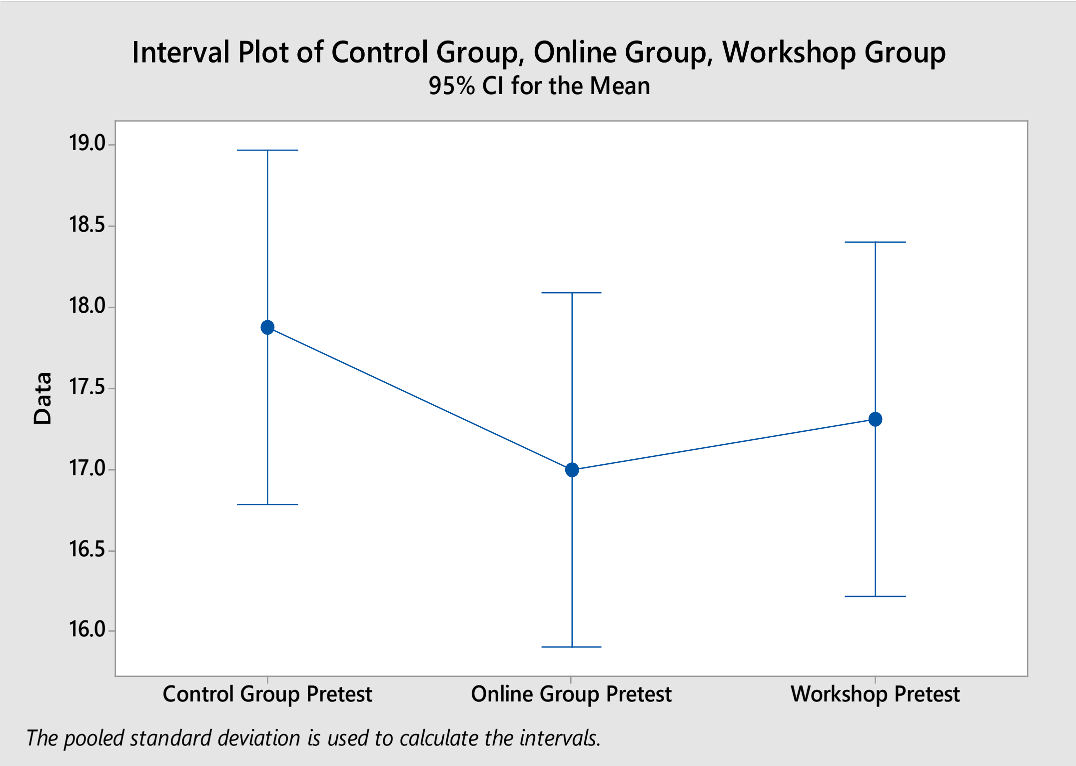
Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value

```
Online Group - Control Group      -0.875      0.766  (-2.624, 0.874)    -
1.14      0.419
Workshop Pre - Control Group      -0.563      0.766  (-2.312, 1.187)    -
0.73      0.685

Individual confidence level = 97.28%
```






Individual Value Plot of Control Group, Online Group, Workshop Group
Data
22
20
18
16
14
12
Control Group Pretest
Online Group Pretest
Workshop Pretest


Interval Plot of Control Group, Online Group, Workshop Group
95% CI for the Mean
Data
19.0
18.5
18.0
17.5
17.0
16.5
16.0
Control Group Pretest
Online Group Pretest
Workshop Pretest
The pooled standard deviation is used to calculate the intervals.

Appendix Q: Posttest One-Way ANOVA-FAA Tech Center Participants

One-way ANOVA: Control Group Posttest, Online Group Posttest, Workshop Posttest

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	$\alpha = 0.05$

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Control Group Posttest, Online Group Posttest, Workshop Posttest

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	85.04	42.521	4.46	0.017
Error	45	428.63	9.525		
Total	47	513.67			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.08626	16.56%	12.85%	5.06%

Means

Factor	N	Mean	StDev	95% CI
Control Group Posttest	16	19.375	2.680	(17.821, 20.929)
Online Group Posttest	16	17.19	4.05	(15.63, 18.74)
Workshop Posttest	16	16.188	2.228	(14.633, 17.742)

Pooled StDev = 3.08626

Dunnett Multiple Comparisons with a Control

Grouping Information Using the Dunnett Method and 95% Confidence

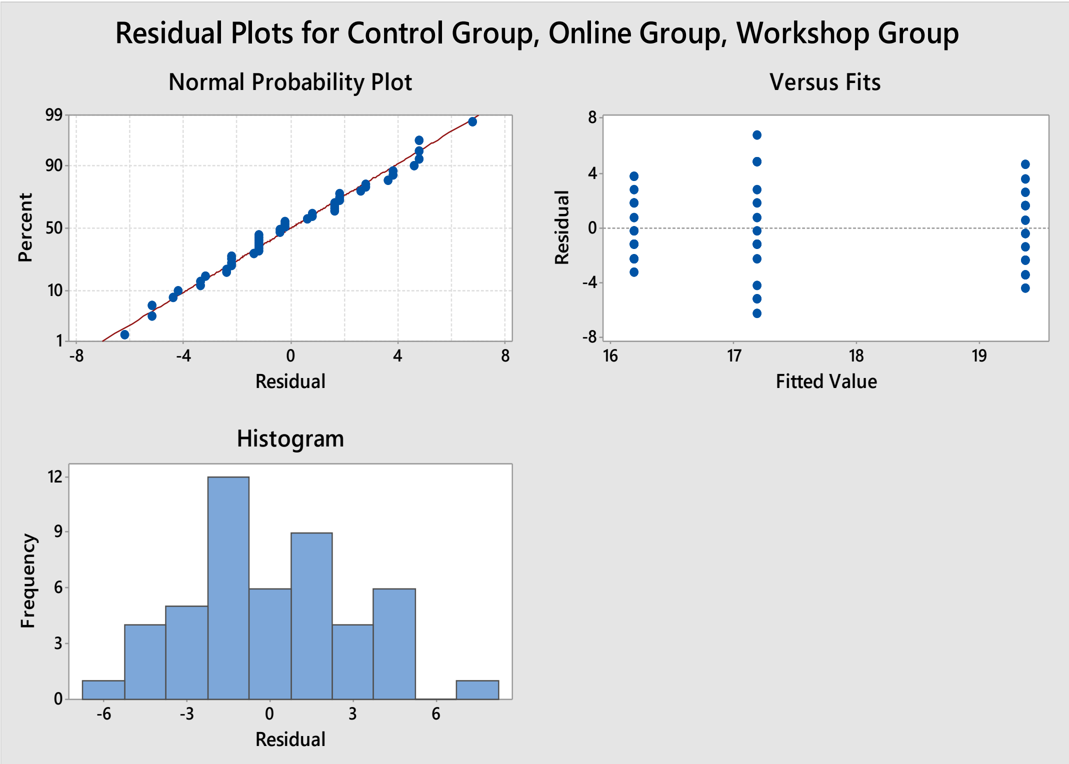
Factor	N	Mean	Grouping
Control Group Posttest (control)	16	19.375	A
Online Group Posttest	16	17.19	A
Workshop Posttest	16	16.188	

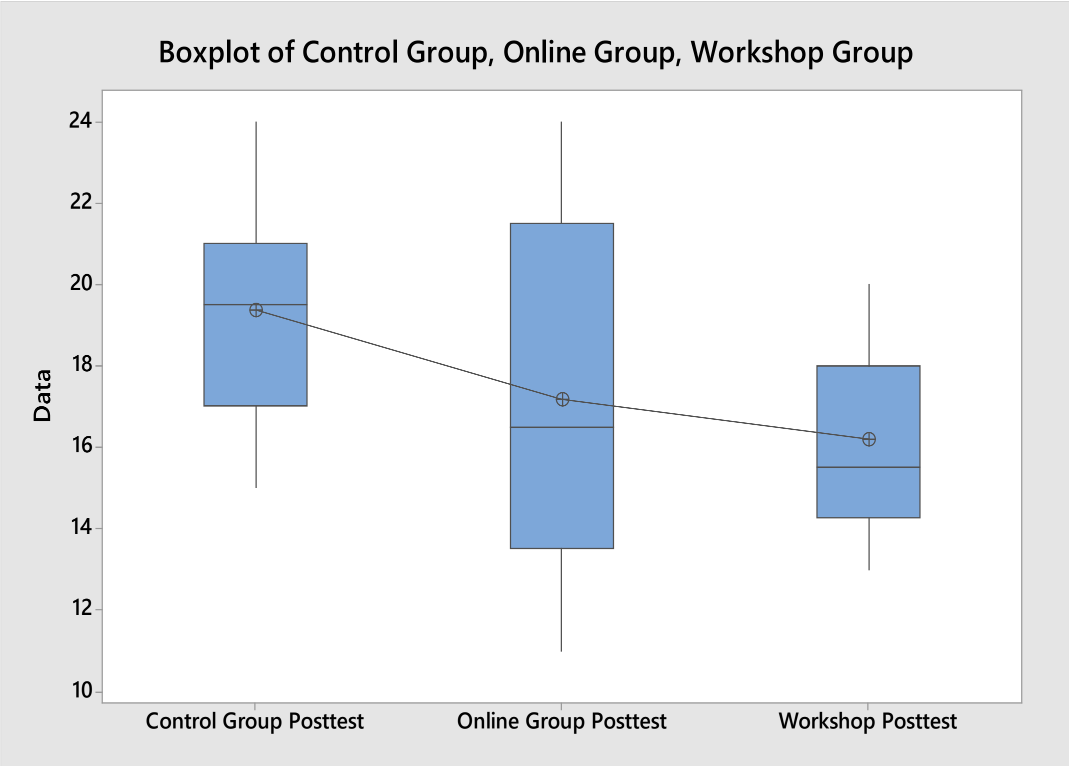
Means not labeled with the letter A are significantly different from the control level mean.

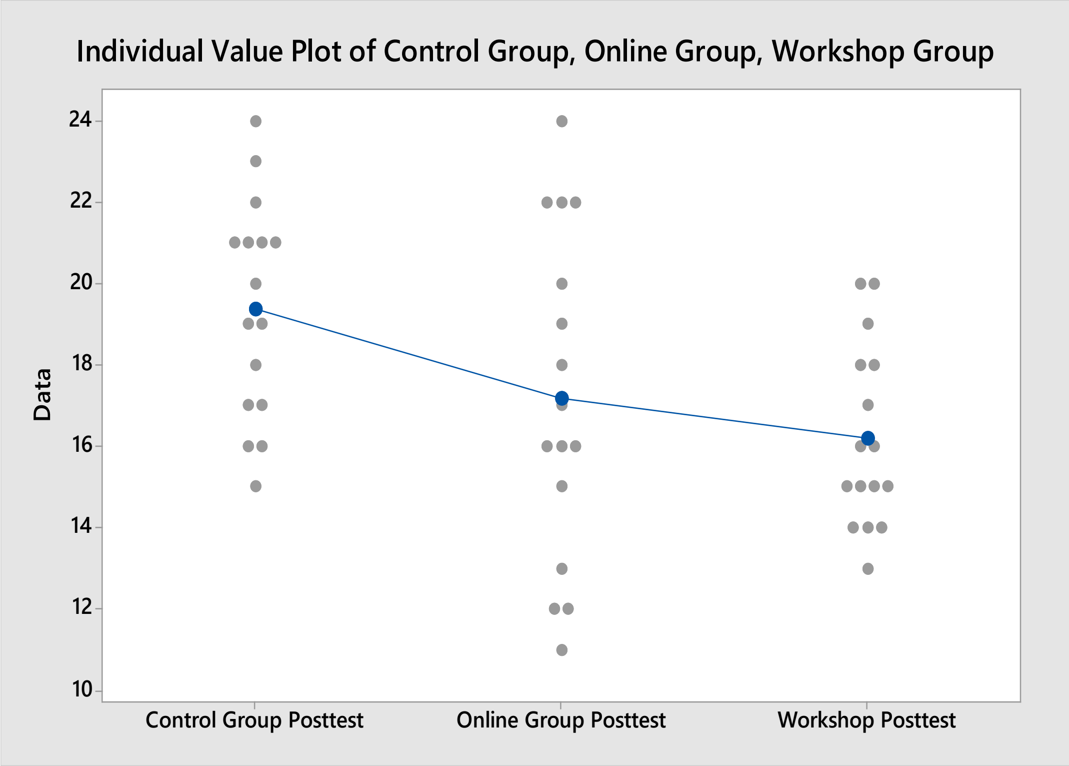
Dunnett Simultaneous Tests for Level Mean - Control Mean

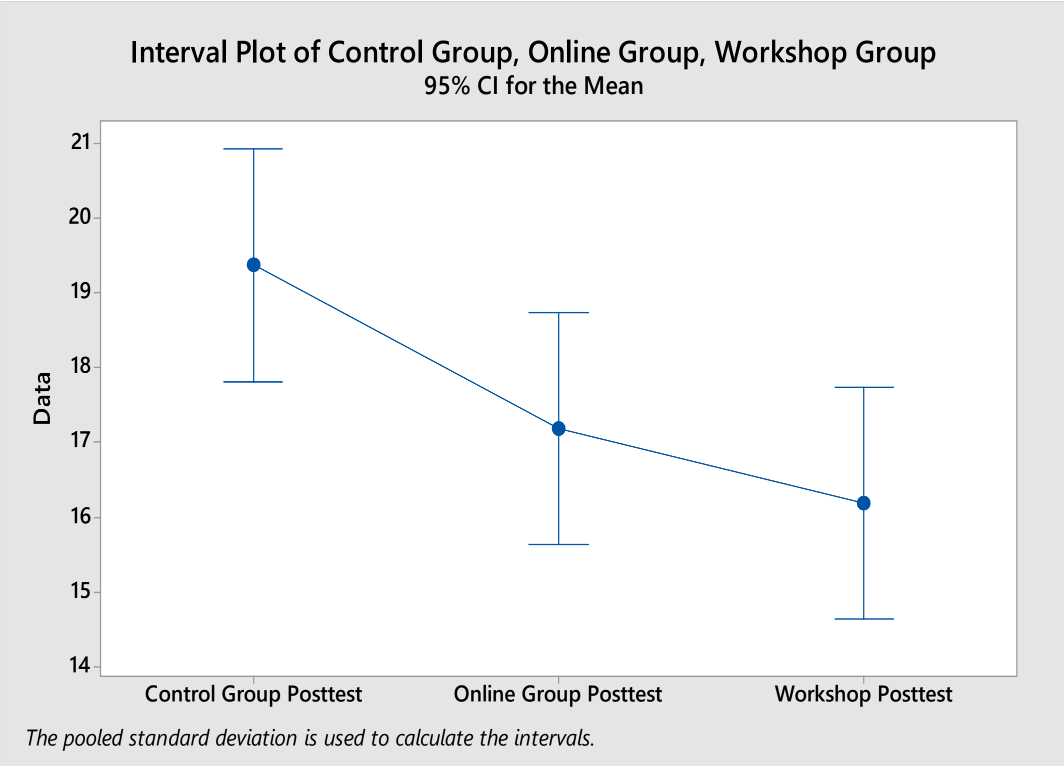
Difference SE of
Adjusted

```
Difference of Levels           of Means  Difference       95% CI       T-Value
P-Value
Online Group - Control Grou       -2.19        1.09  (-4.68,  0.30)     -2.00
0.092
Workshop Pos - Control Grou       -3.19        1.09  (-5.68, -0.70)     -2.92
0.010
```




Boxplot of Control Group, Online Group, Workshop Group
Data
24
22
20
18
16
14
12
10
Control Group Posttest
Online Group Posttest
Workshop Posttest


Individual Value Plot of Control Group, Online Group, Workshop Group
Data
24
22
20
18
16
14
12
10
Control Group Posttest
Online Group Posttest
Workshop Posttest


Interval Plot of Control Group, Online Group, Workshop Group
95% CI for the Mean
Data
21
20
19
18
17
16
15
14
Control Group Posttest
Online Group Posttest
Workshop Posttest
The pooled standard deviation is used to calculate the intervals.

Appendix R: Posttest Two One-Way ANOVA-FAA Tech Center Participants

One-way ANOVA: Control Group Posttest Two, Online Group Posttest Two, Workshop Posttest Two

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05
Rows unused	20

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Control Group Posttest Two, Online Group Posttest Two, Workshop Posttest Two

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	5.250	2.625	0.36	0.702
Error	17	123.750	7.279		
Total	19	129.000			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.69804	4.07%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Control Group Posttest Two	8	20.125	1.959	(18.112, 22.138)
Online Group Posttest Two	8	19.13	3.36	(17.11, 21.14)
Workshop Posttest Two	4	19.00	2.45	(16.15, 21.85)

Pooled StDev = 2.69804

Dunnett Multiple Comparisons with a Control

Grouping Information Using the Dunnett Method and 95% Confidence

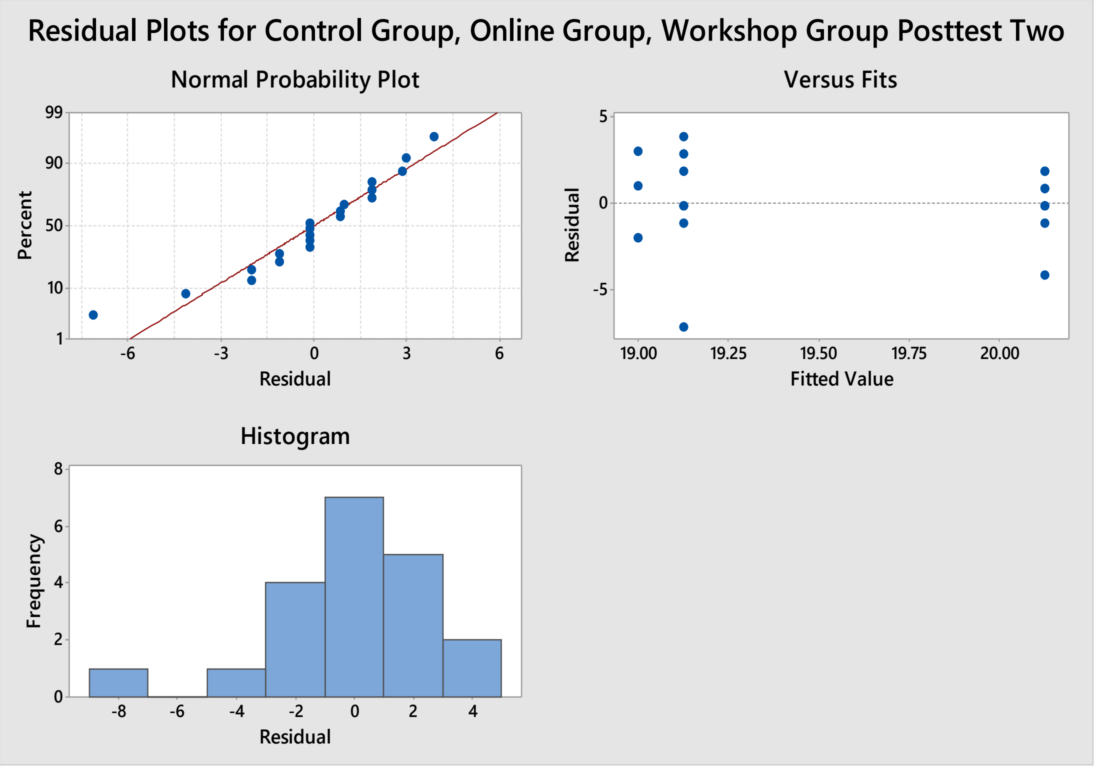
Factor	N	Mean	Grouping
Control Group Posttest Two (control)	8	20.125	A
Online Group Posttest Two	8	19.13	A
Workshop Posttest Two	4	19.00	A

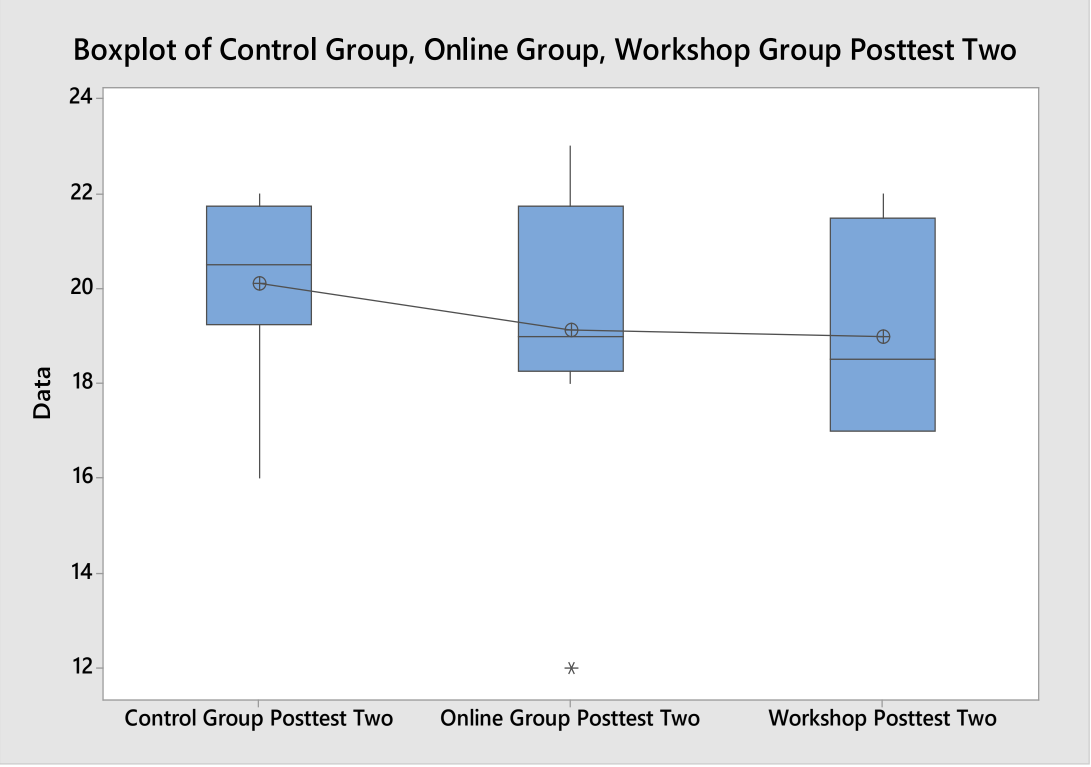
Means not labeled with the letter A are significantly different from the control level mean.

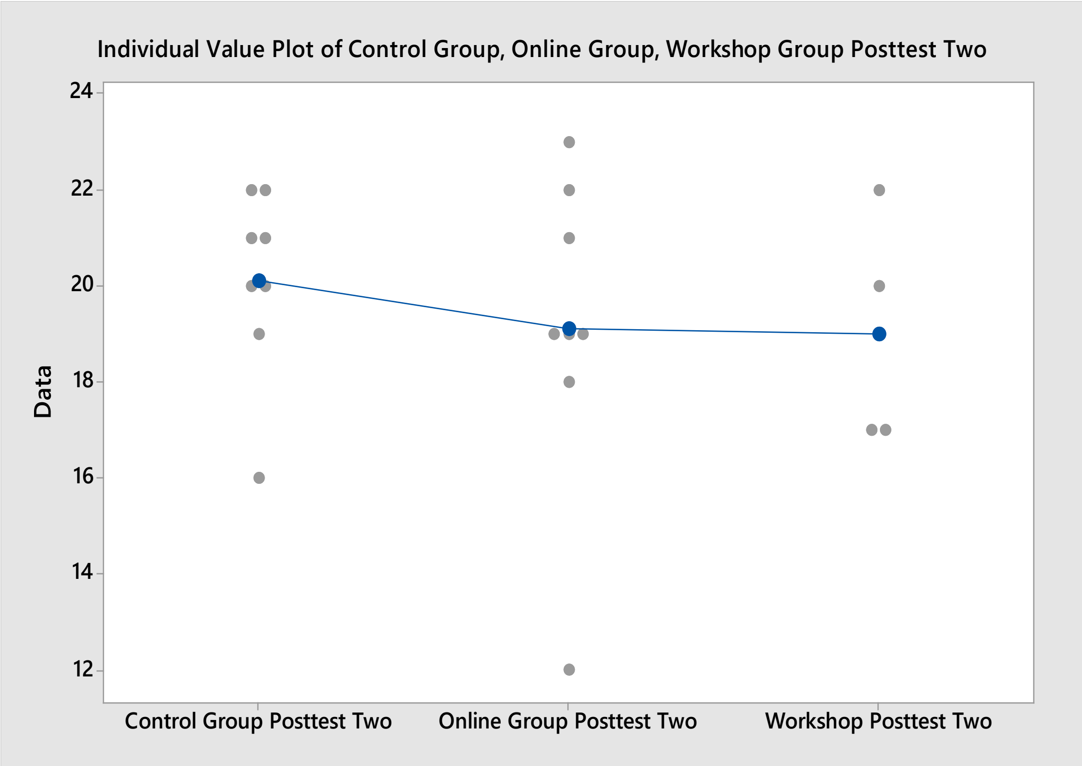
Dunnett Simultaneous Tests for Level Mean - Control Mean

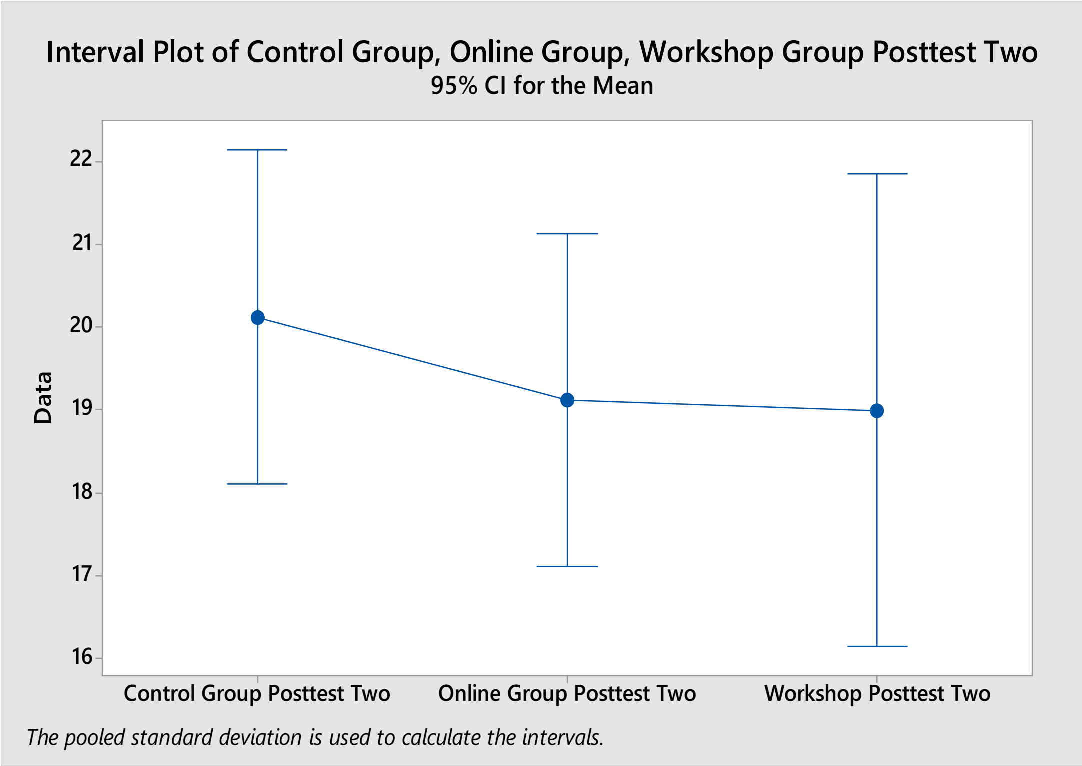
Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Online Group - Control Group	-1.00	1.35	(-4.27, 2.27)	-0.74	0.694
Workshop Pos - Control Group	-1.13	1.65	(-5.13, 2.88)	-0.68	0.733

Individual confidence level = 97.31%





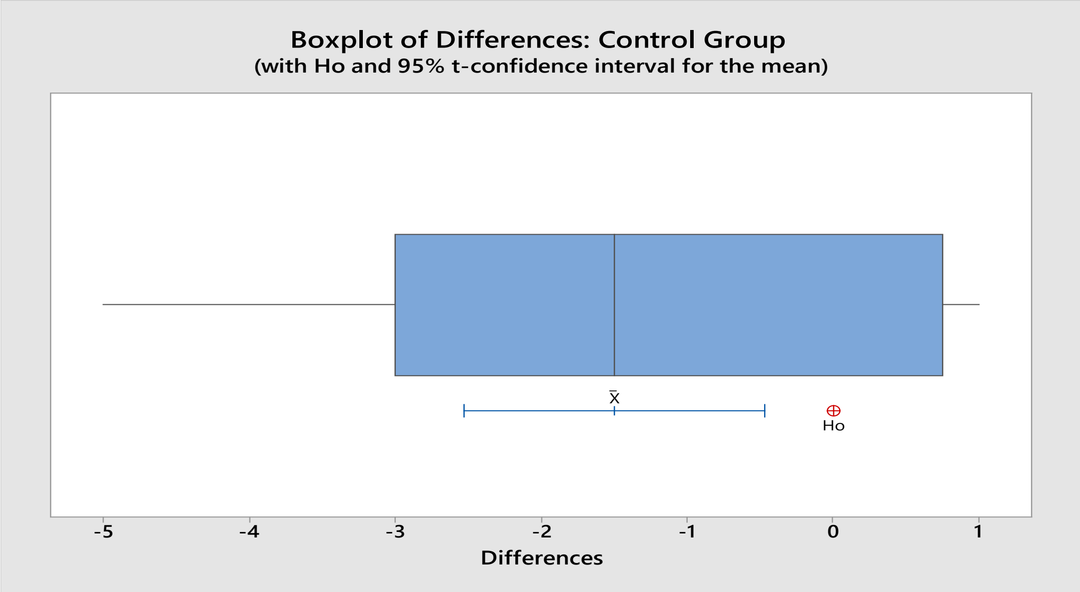

Individual Value Plot of Control Group, Online Group, Workshop Group Posttest Two
Data
24
22
20
18
16
14
12
Control Group Posttest Two
Online Group Posttest Two
Workshop Posttest Two

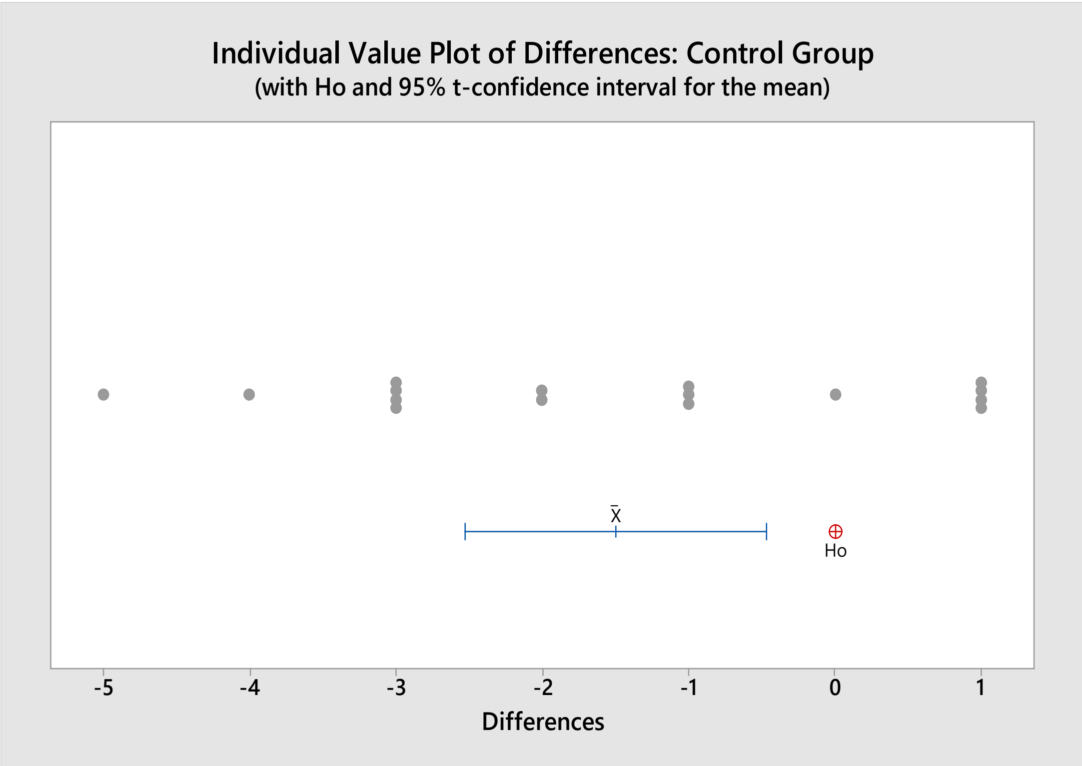

Interval Plot of Control Group, Online Group, Workshop Group Posttest Two
95% CI for the Mean
Data
22
21
20
19
18
17
16
Control Group Posttest Two
Online Group Posttest Two
Workshop Posttest Two
The pooled standard deviation is used to calculate the intervals.

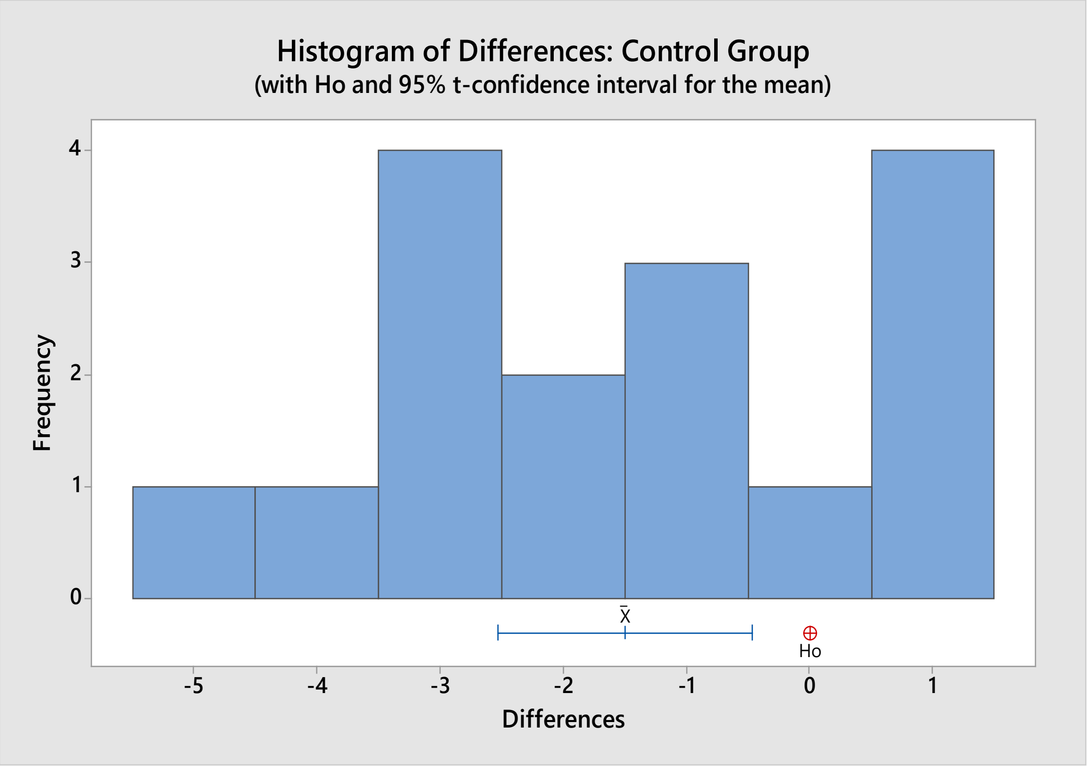
Appendix S: Paired t-tests for All Groups-FAA Tech Center Participants

Paired T-Test and CI: Control Group Pretest, Control Group Posttest

```
Paired T for Control Group Pretest - Control Group Posttest

                        N    Mean  StDev  SE Mean
Control Group Pretest   16  17.875  1.544    0.386
Control Group Posttest  16  19.375  2.680    0.670
Difference              16  -1.500  1.932    0.483

95% CI for mean difference: (-2.530, -0.470)T-Test of mean difference = 0 (vs
≠ 0): T-Value = -3.11  P-Value = 0.007
```





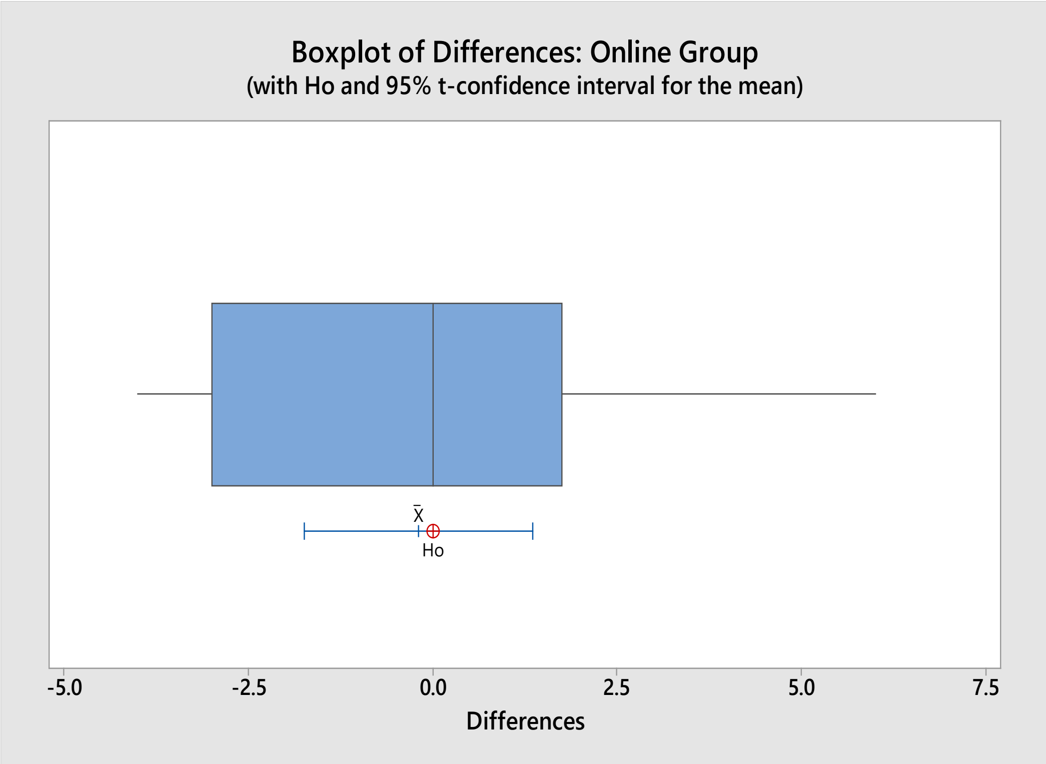


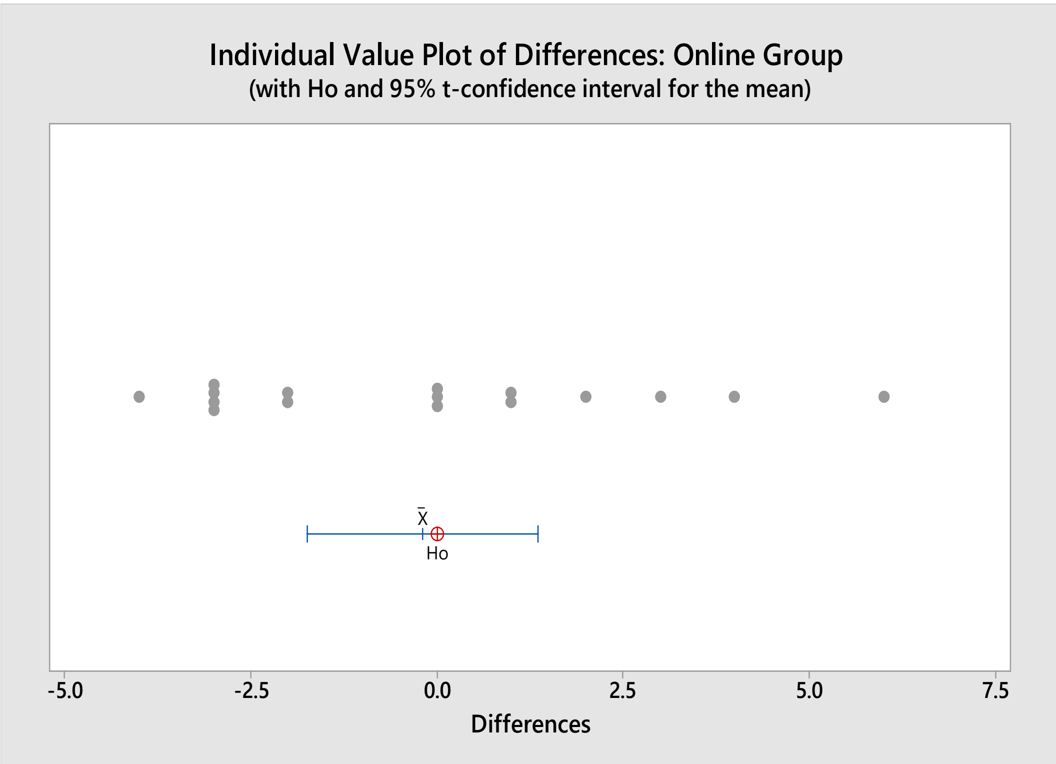
Paired T-Test and CI: Online Group Pretest, Online Group Posttest

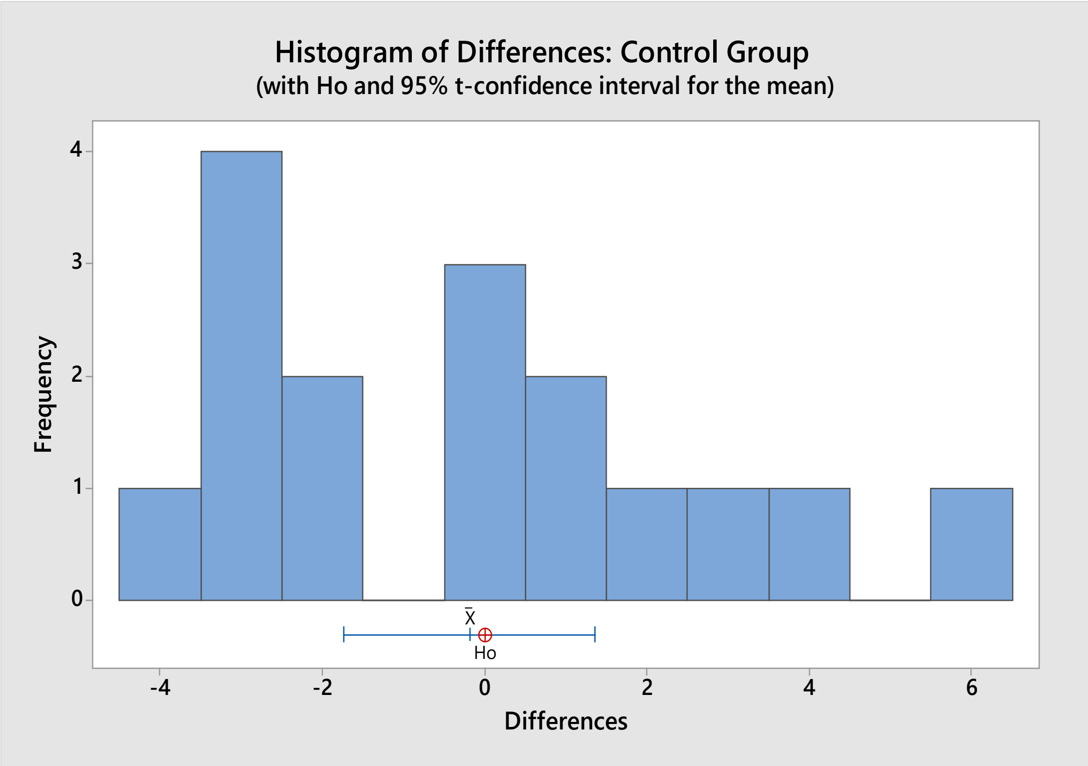
Paired T for Online Group Pretest - Online Group Posttest

	N	Mean	StDev	SE Mean
Online Group Pretest	16	17.00	2.66	0.66
Online Group Posttest	16	17.19	4.05	1.01
Difference	16	-0.188	2.903	0.726

95% CI for mean difference: (-1.735, 1.360)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = -0.26 P-Value = 0.800

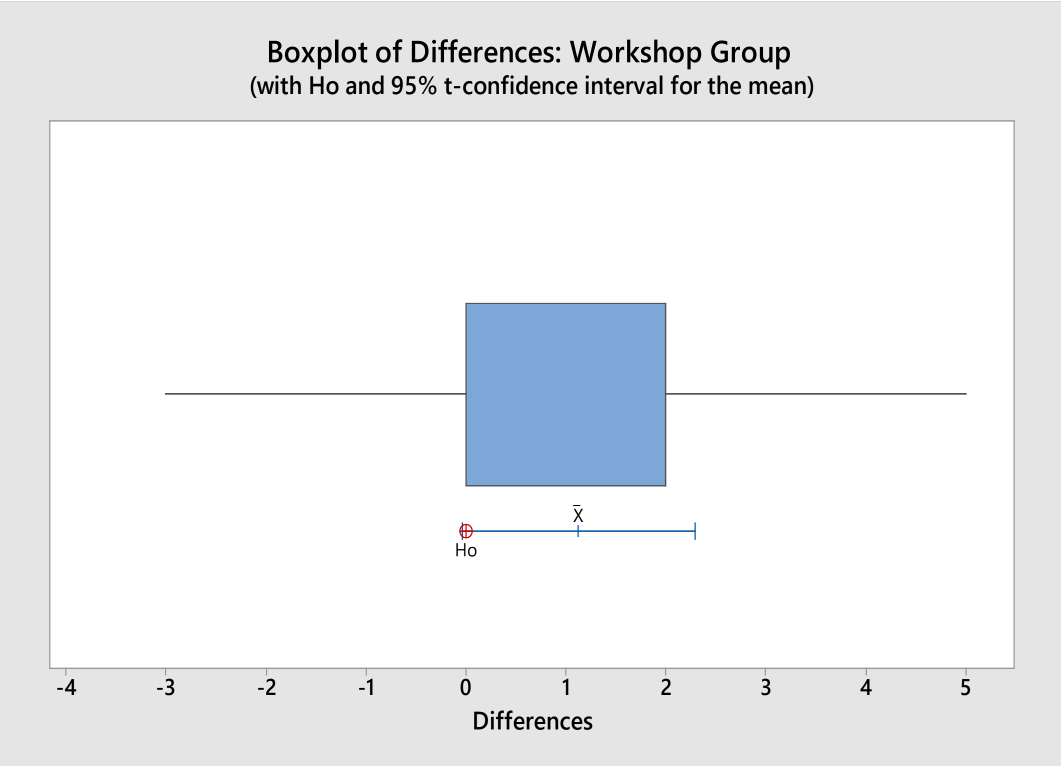

Boxplot of Differences: Online Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
Differences

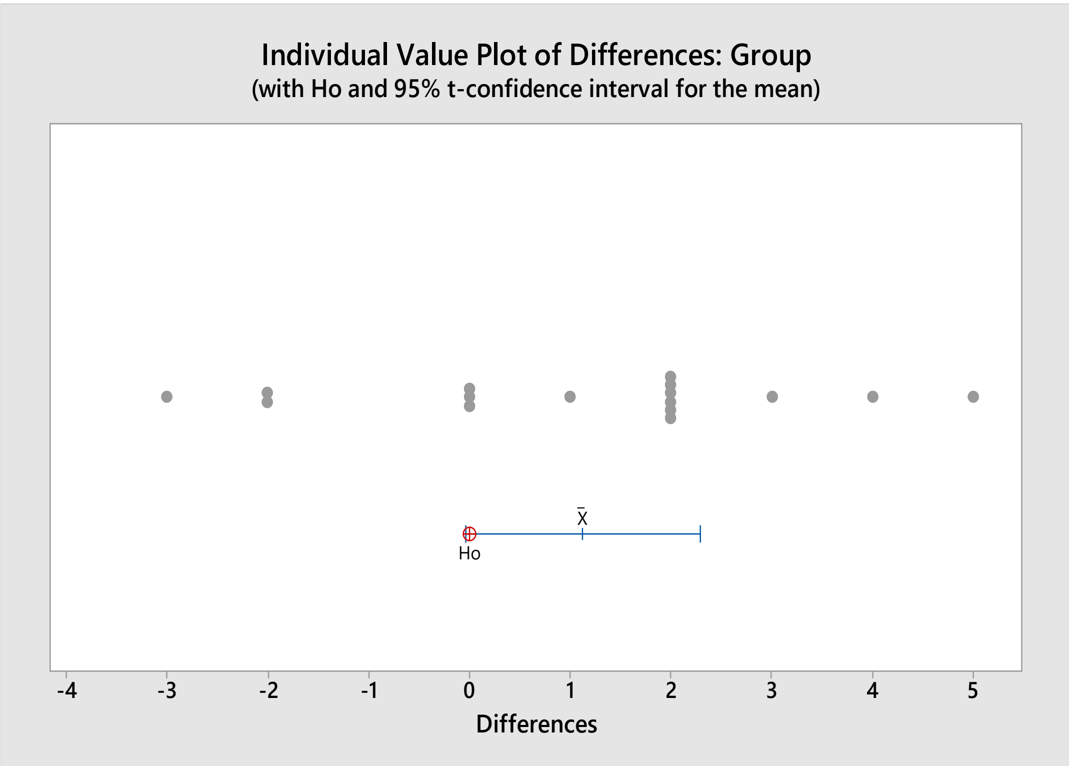

Individual Value Plot of Differences: Online Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
Differences

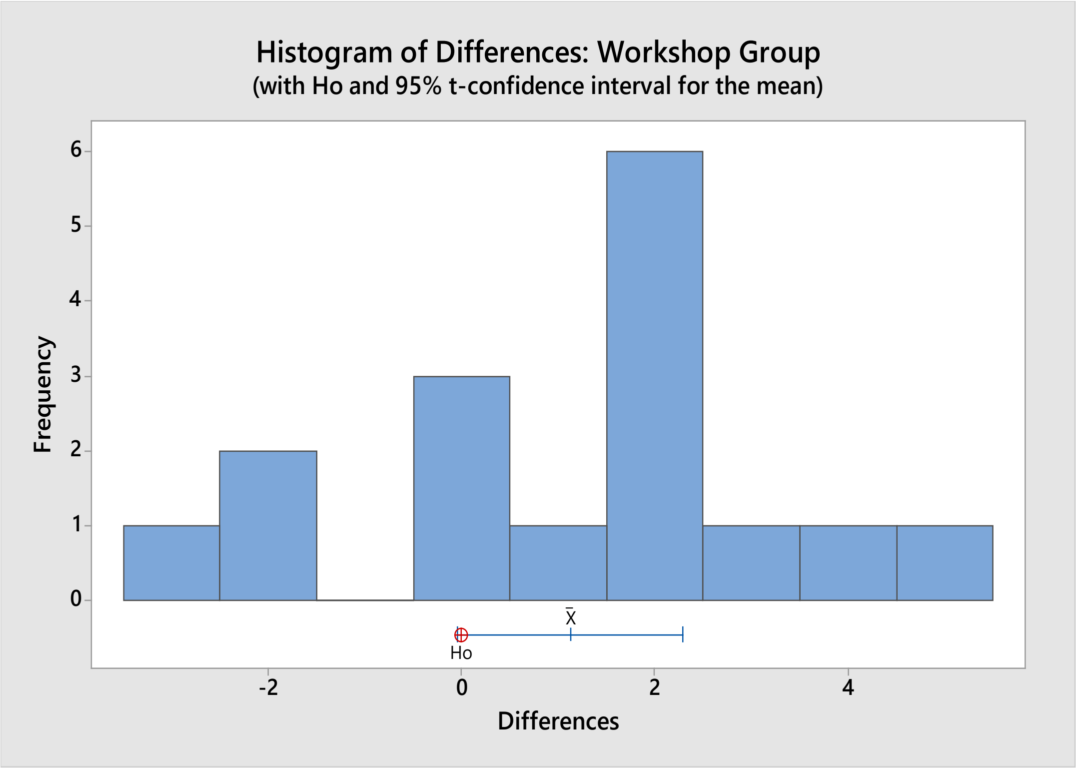


Paired T-Test and CI: Workshop Pretest, Workshop Posttest

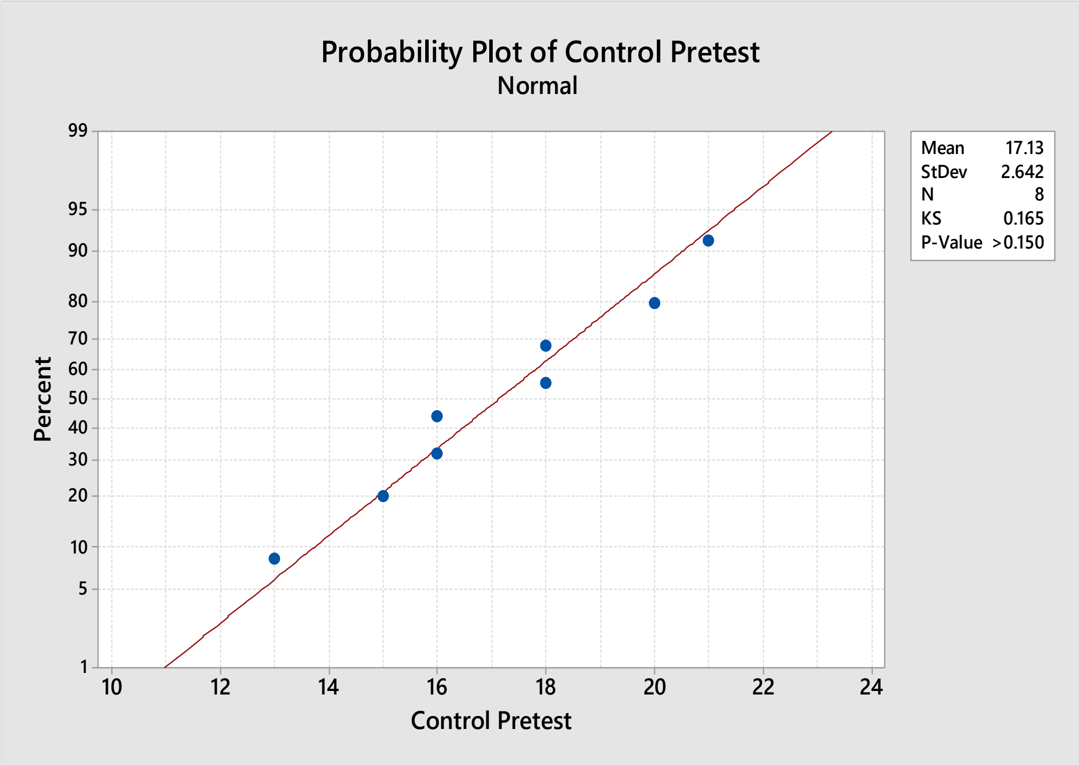
```
Paired T for Workshop Pretest - Workshop Posttest

                    N    Mean  StDev  SE Mean
Workshop Pretest   16  17.313  2.152    0.538
Workshop Posttest  16  16.188  2.228    0.557
Difference         16   1.125  2.187    0.547


95% CI for mean difference: (-0.040, 2.290)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 2.06  P-Value = 0.057
```

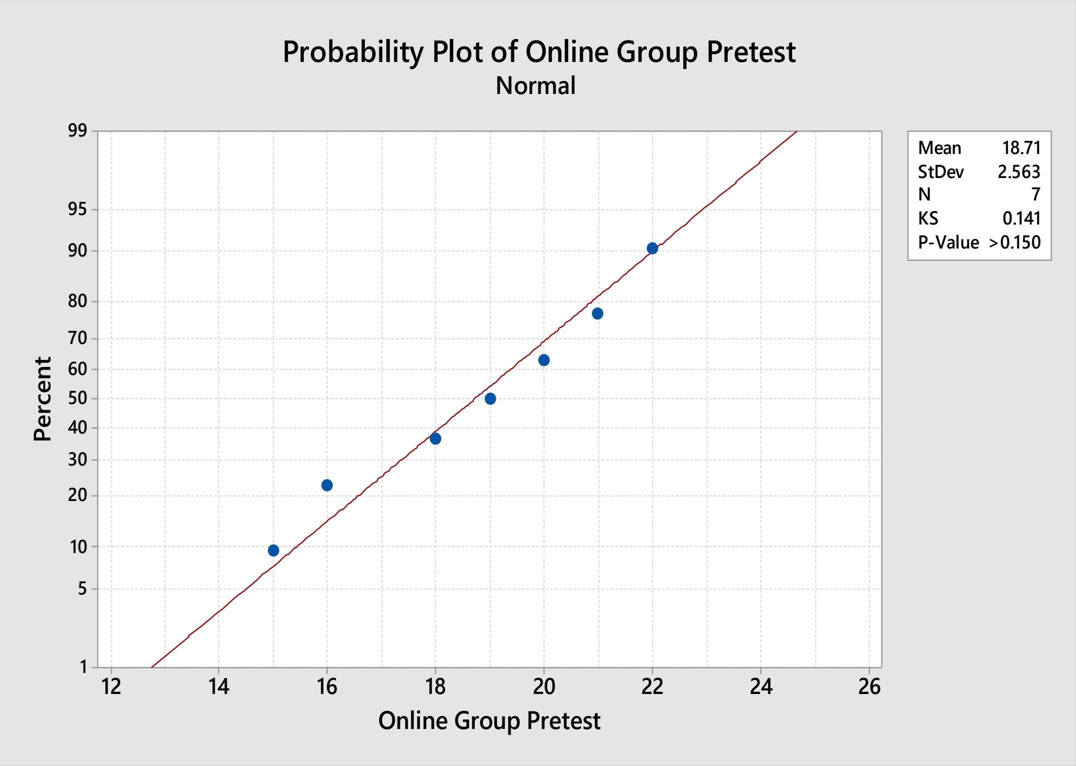

Boxplot of Differences: Workshop Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-4
-3
-2
-1
0
1
2
3
4
5
Differences

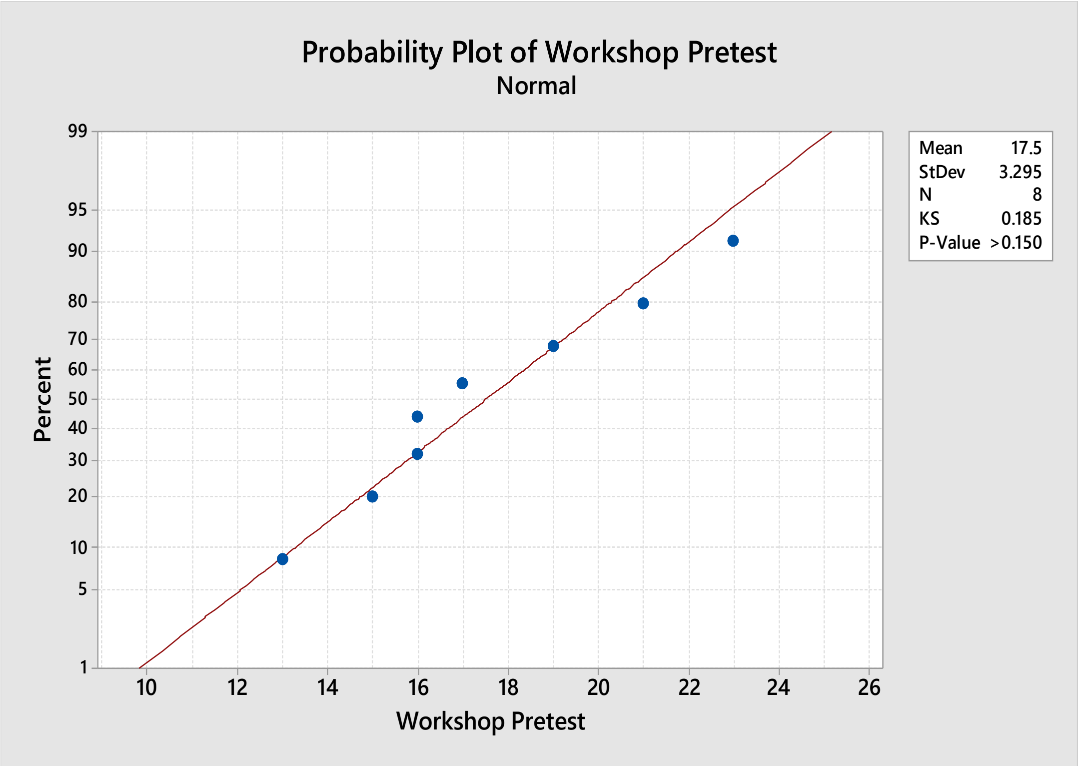

Individual Value Plot of Differences: Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-4
-3
-2
-1
0
1
2
3
4
5
Differences

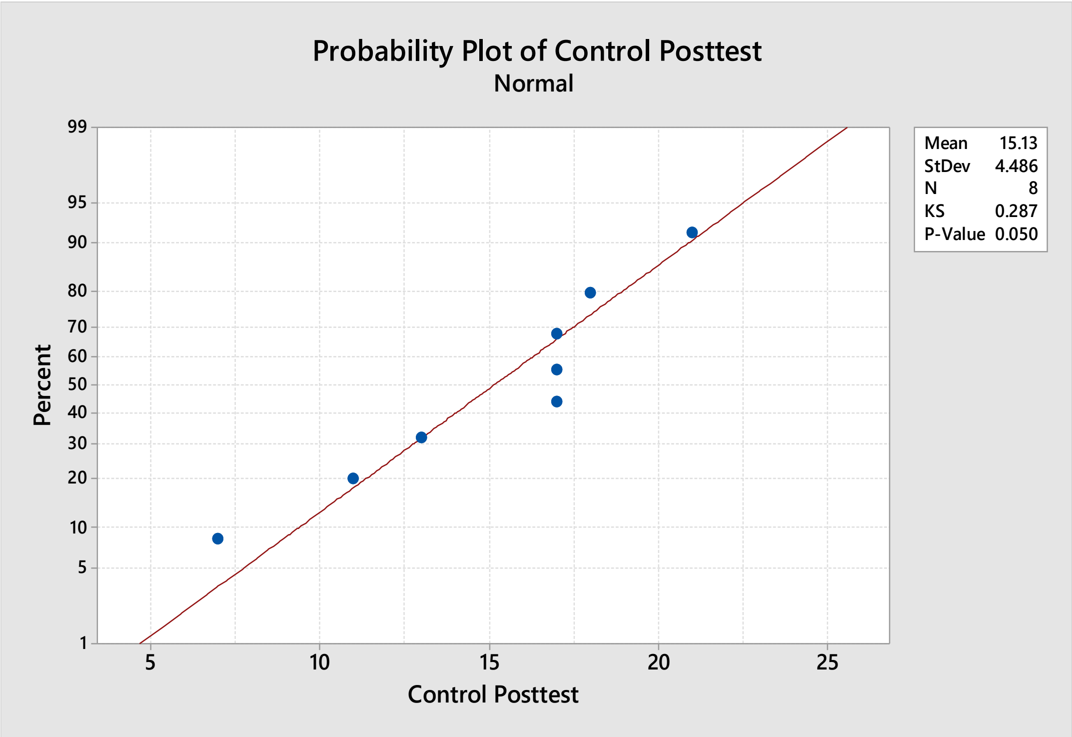

Histogram of Differences: Workshop Group
(with Ho and 95% t-confidence interval for the mean)
Frequency
0
1
2
3
4
5
6
X̄
Ho
-2
0
2
4
Differences

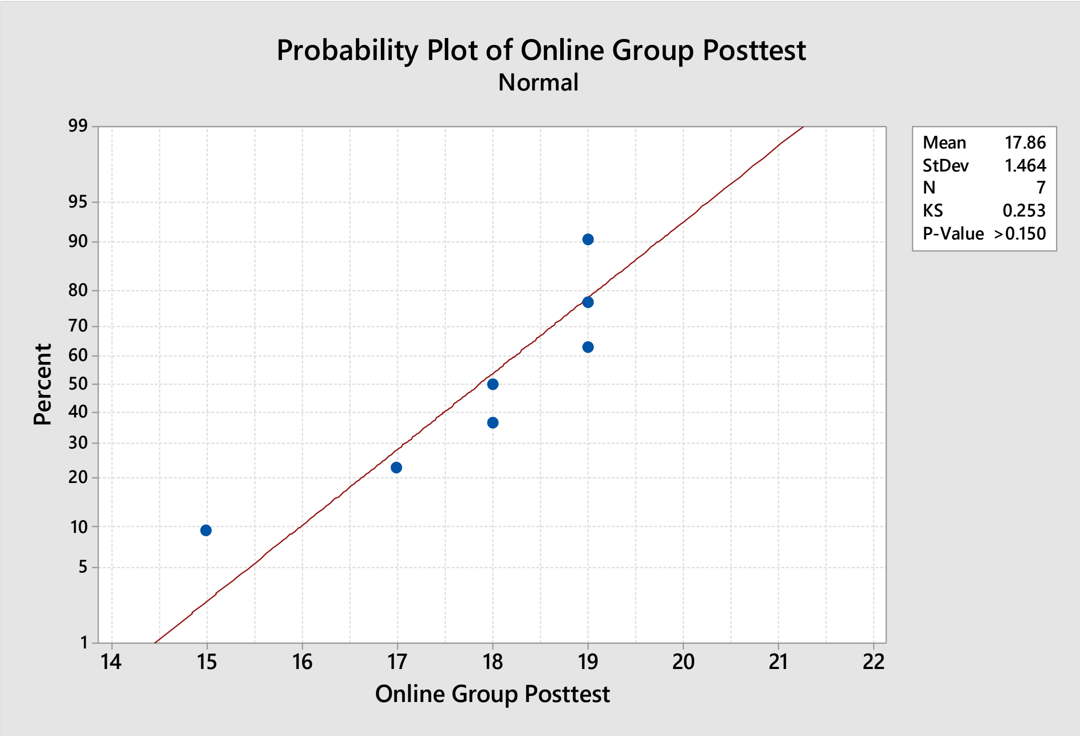
Appendix T: K-S Normality Tests-Purdue Participants

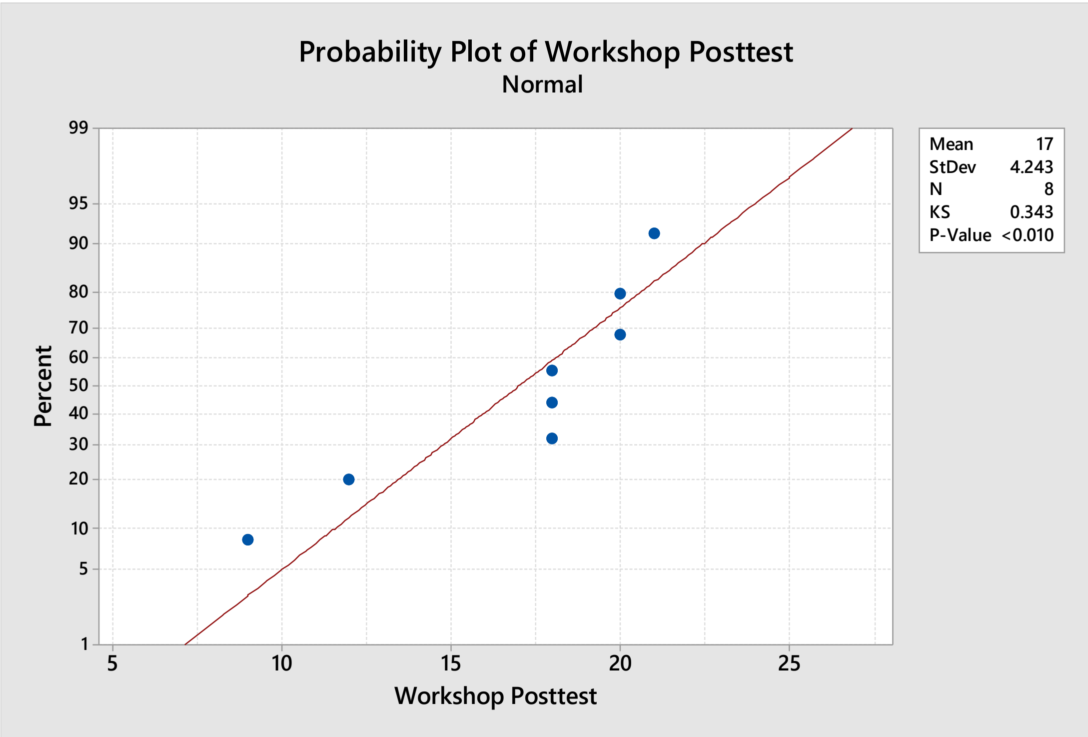


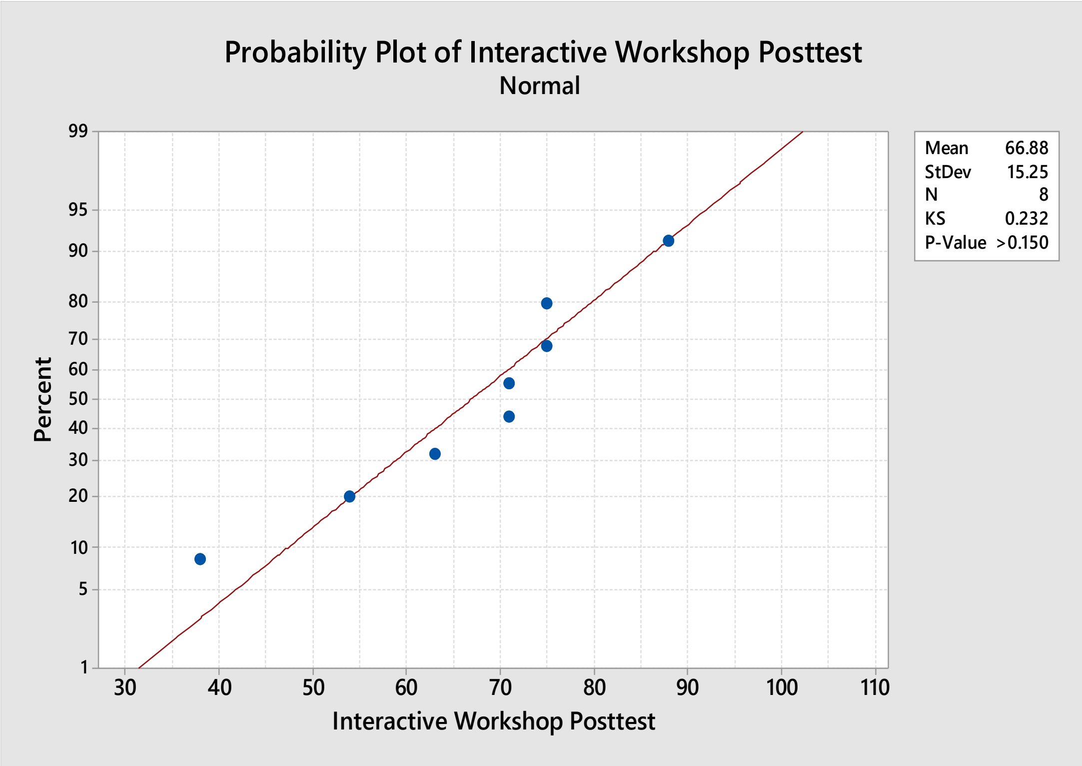


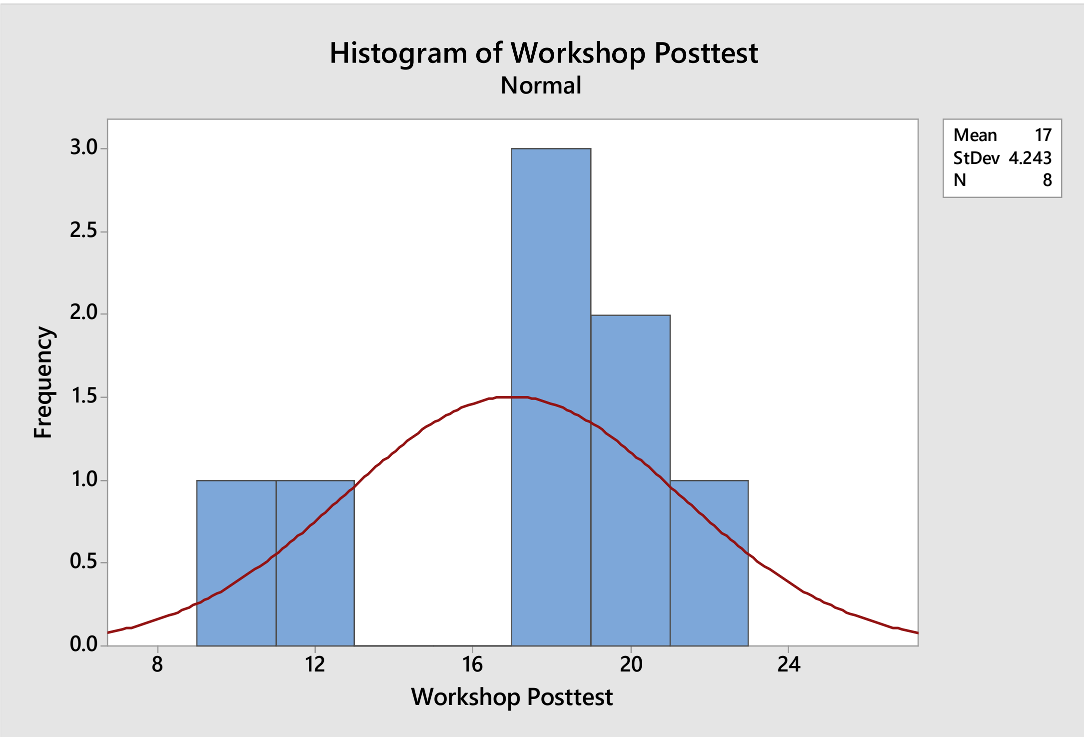

Probability Plot of Workshop Pretest
Normal
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
10
12
14
16
18
20
22
24
26
Workshop Pretest
Mean 17.5
StDev 3.295
N 8
KS 0.185
P-Value >0.150


Probability Plot of Control Posttest
Normal
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
5
10
15
20
25
Control Posttest
Mean 15.13
StDev 4.486
N 8
KS 0.287
P-Value 0.050


Probability Plot of Online Group Posttest
Normal
Mean 17.86
StDev 1.464
N 7
KS 0.253
P-Value >0.150
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
14
15
16
17
18
19
20
21
22
Online Group Posttest


Probability Plot of Workshop Posttest
Normal
Mean 17
StDev 4.243
N 8
KS 0.343
P-Value <0.010
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
5
10
15
20
25
Workshop Posttest


Probability Plot of Interactive Workshop Posttest
Normal
Percent
99
95
90
80
70
60
50
40
30
20
10
5
1
30
40
50
60
70
80
90
100
110
Interactive Workshop Posttest
Mean 66.88
StDev 15.25
N 8
KS 0.232
P-Value >0.150


Histogram of Workshop Posttest
Normal
Frequency
3.0
2.5
2.0
1.5
1.0
0.5
0.0
8
12
16
20
24
Workshop Posttest
Mean 17
StDev 4.243
N 8

Appendix U: Grubb's Outlier Tests-Purdue Participants

Outlier Test: Control Group Pretest, Control Group Posttest, Online Group Pretest, Online Group

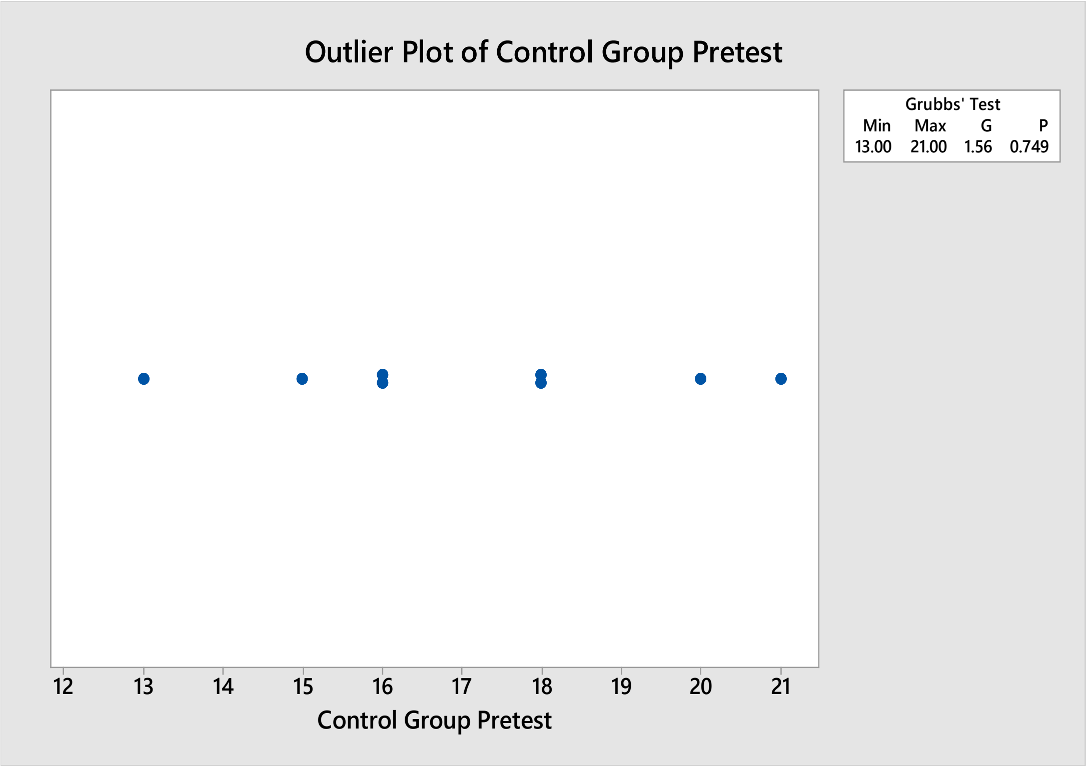
Method

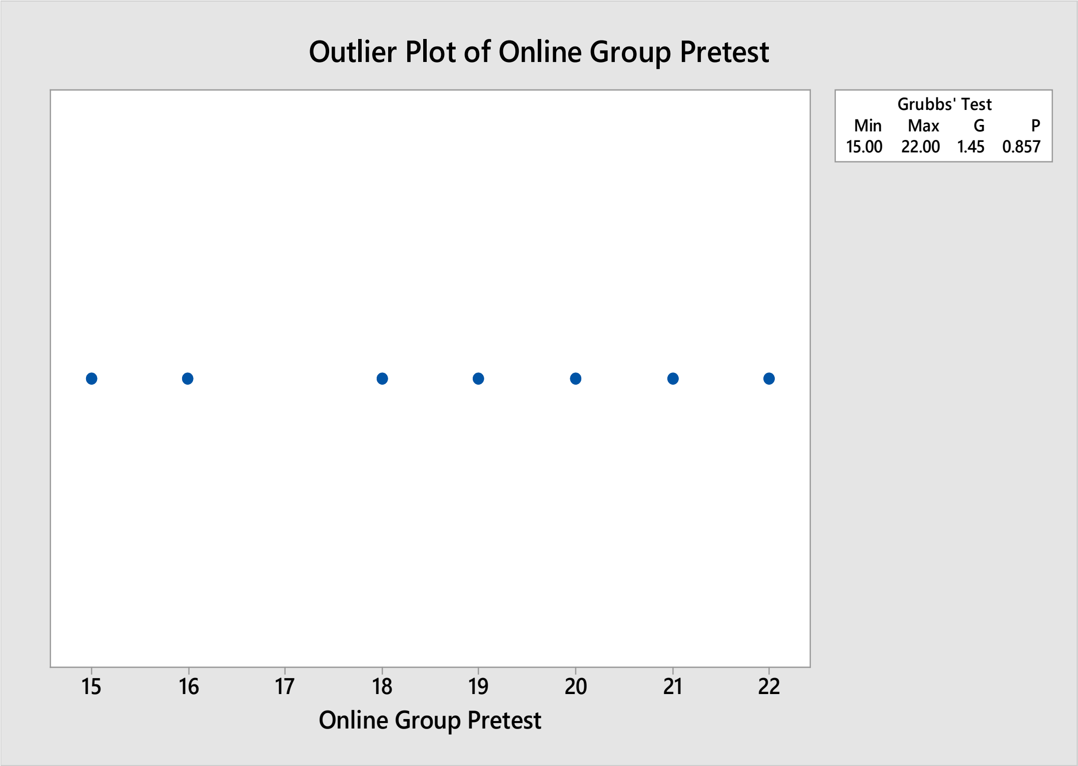
Null hypothesis	All data values come from the same normal population
Alternative hypothesis	Smallest or largest data value is an outlier
Significance level	α = 0.05

Grubbs' Test

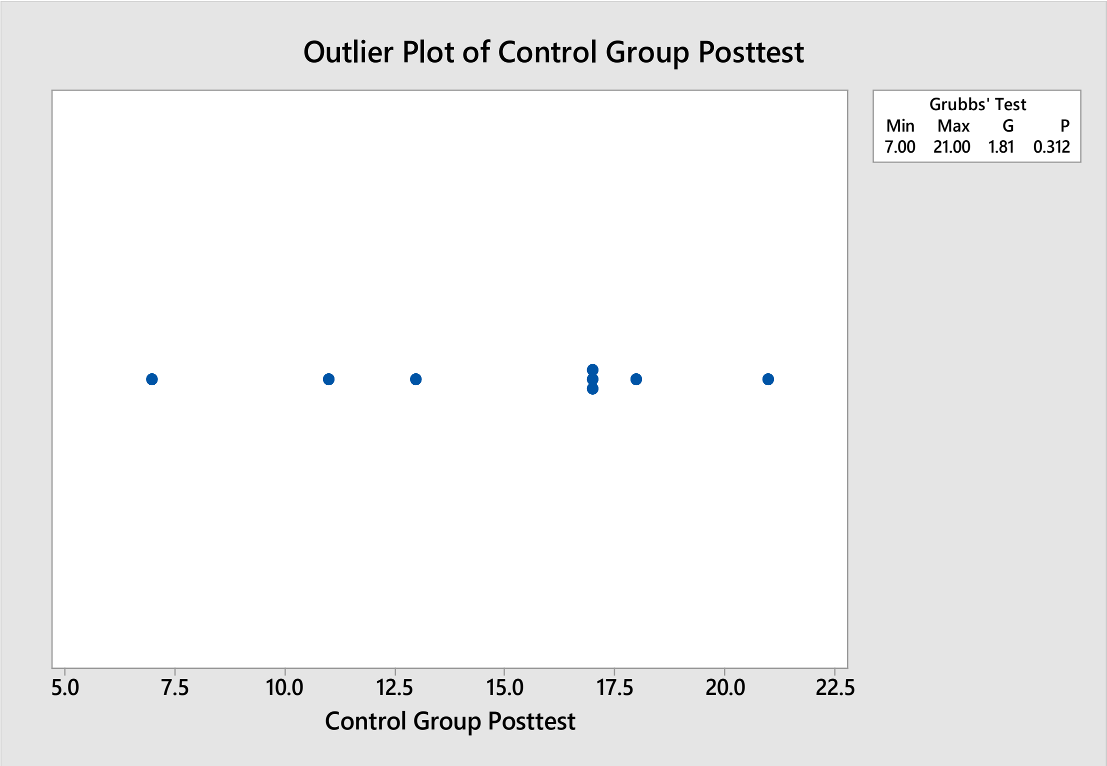
Variable	N	Mean	StDev	Min	Max	G	P
Control Group Pretest	8	17.125	2.642	13.000	21.000	1.56	0.749
Control Group Posttest	8	15.13	4.49	7.00	21.00	1.81	0.312
Online Group Pretest	7	18.714	2.563	15.000	22.000	1.45	0.857
Online Group Posttest	7	17.857	1.464	15.000	19.000	1.95	0.090
Workshop Group Pretest	8	17.50	3.30	13.00	23.00	1.67	0.533
Workshop Group Posttest	8	17.00	4.24	9.00	21.00	1.89	0.224

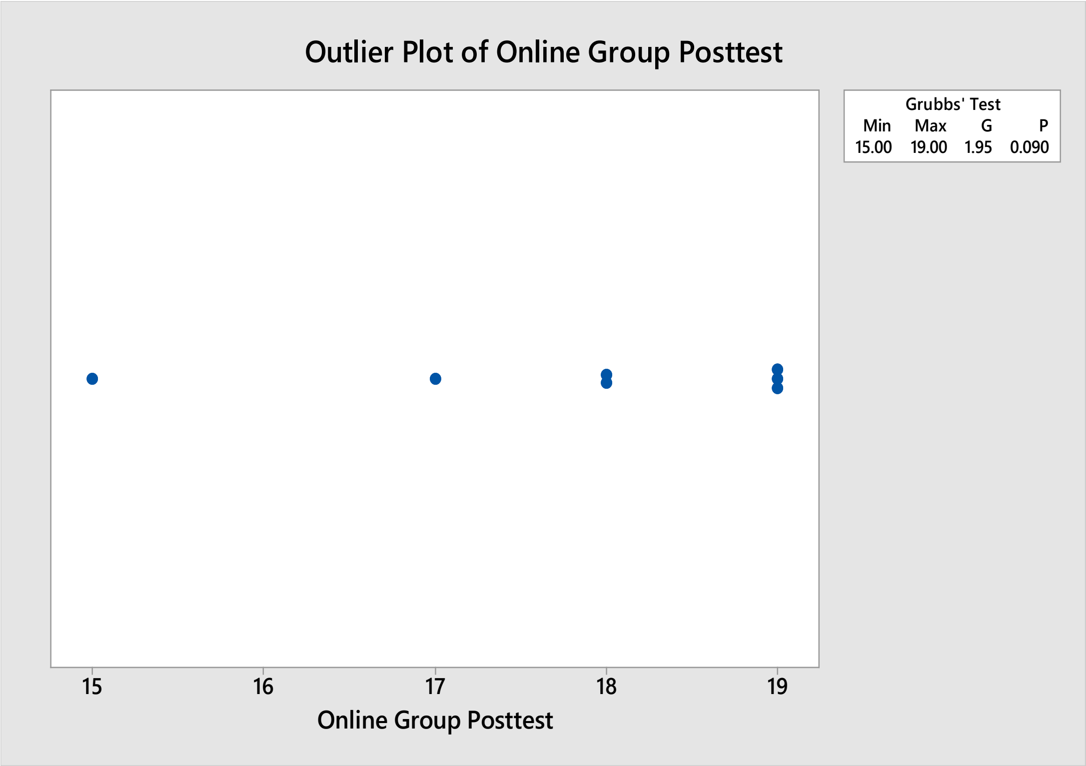
* NOTE * No outlier at the 5% level of significance

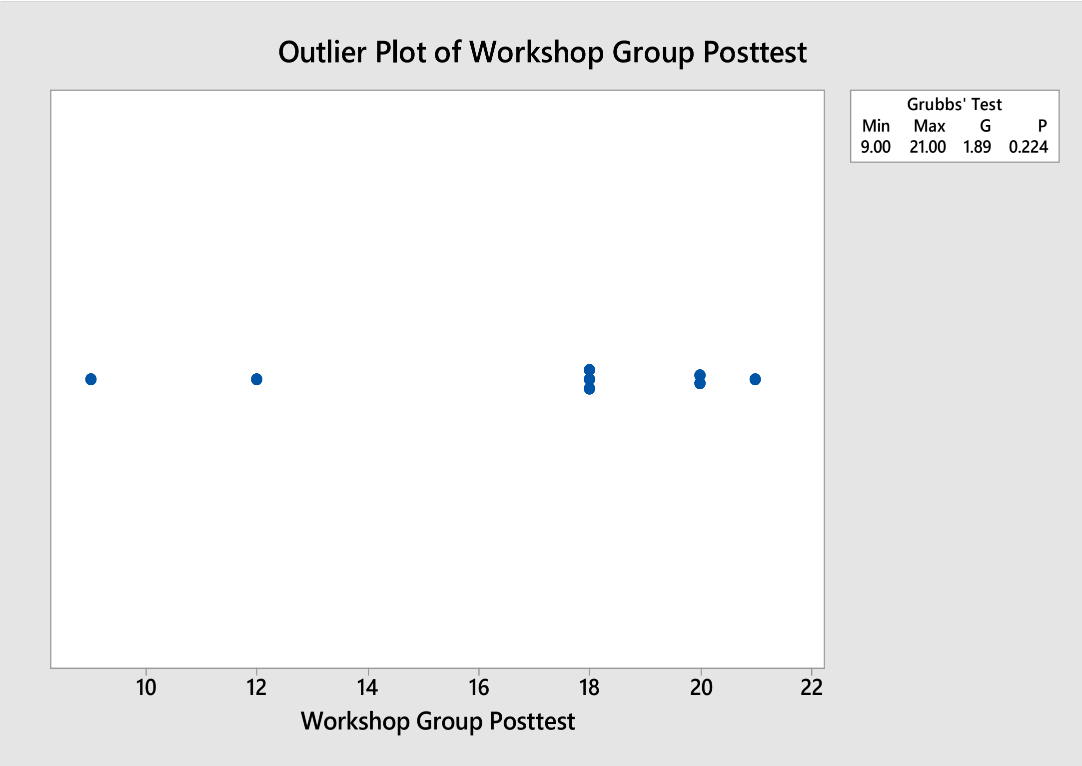

Outlier Plot of Control Group Pretest
Grubbs' Test
Min Max G P
13.00 21.00 1.56 0.749
12 13 14 15 16 17 18 19 20 21
Control Group Pretest


Outlier Plot of Online Group Pretest
Grubbs' Test
Min Max G P
15.00 22.00 1.45 0.857
15 16 17 18 19 20 21 22
Online Group Pretest


Outlier Plot of Workshop Group Pretest
Grubbs' Test
Min Max G P
13.00 23.00 1.67 0.533
12 14 16 18 20 22 24
Workshop Group Pretest


Outlier Plot of Control Group Posttest
Grubbs' Test
Min Max G P
7.00 21.00 1.81 0.312
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
Control Group Posttest


Outlier Plot of Online Group Posttest
Grubbs' Test
Min Max G P
15.00 19.00 1.95 0.090
15
16
17
18
19
Online Group Posttest


Outlier Plot of Workshop Group Posttest
Grubbs' Test
Min Max G P
9.00 21.00 1.89 0.224
10
12
14
16
18
20
22
Workshop Group Posttest

Appendix V: Test for Equal Variance Pretest and Posttest-Purdue Participants

Test for Equal Variances: Control Group Pretest, Online Group Pretest, Workshop Group Pretest

Method

Null hypothesis	All variances are equal
Alternative hypothesis	At least one variance is different
Significance level	α = 0.05

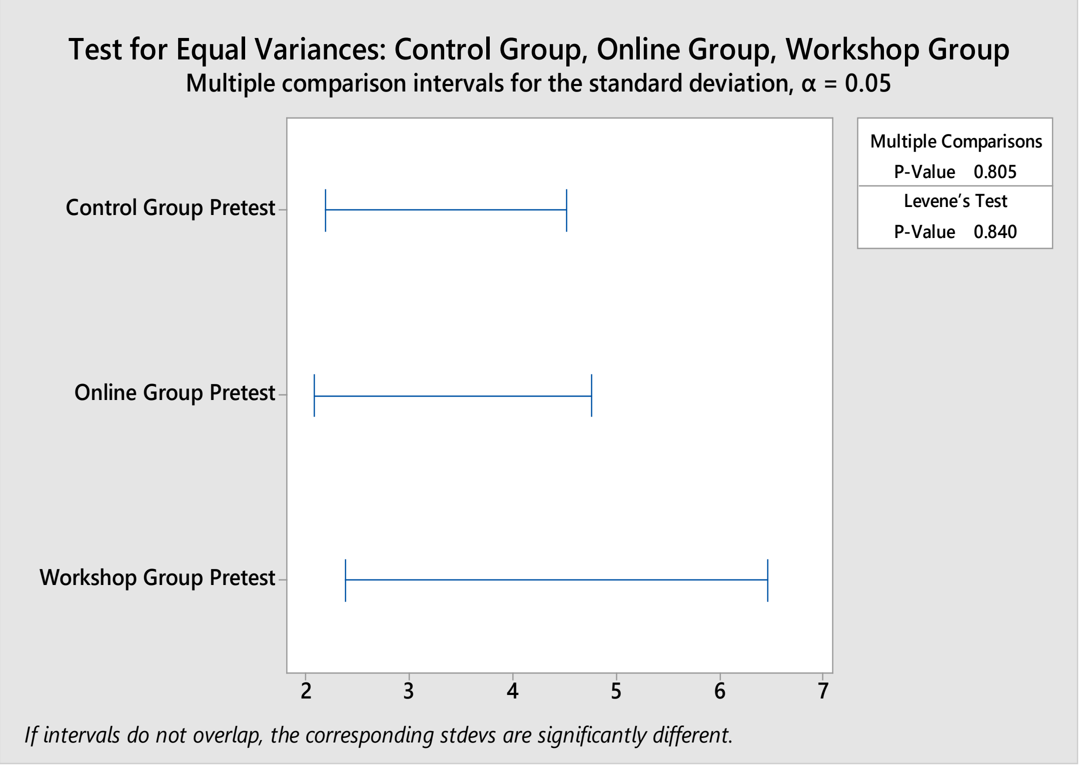
95% Bonferroni Confidence Intervals for Standard Deviations

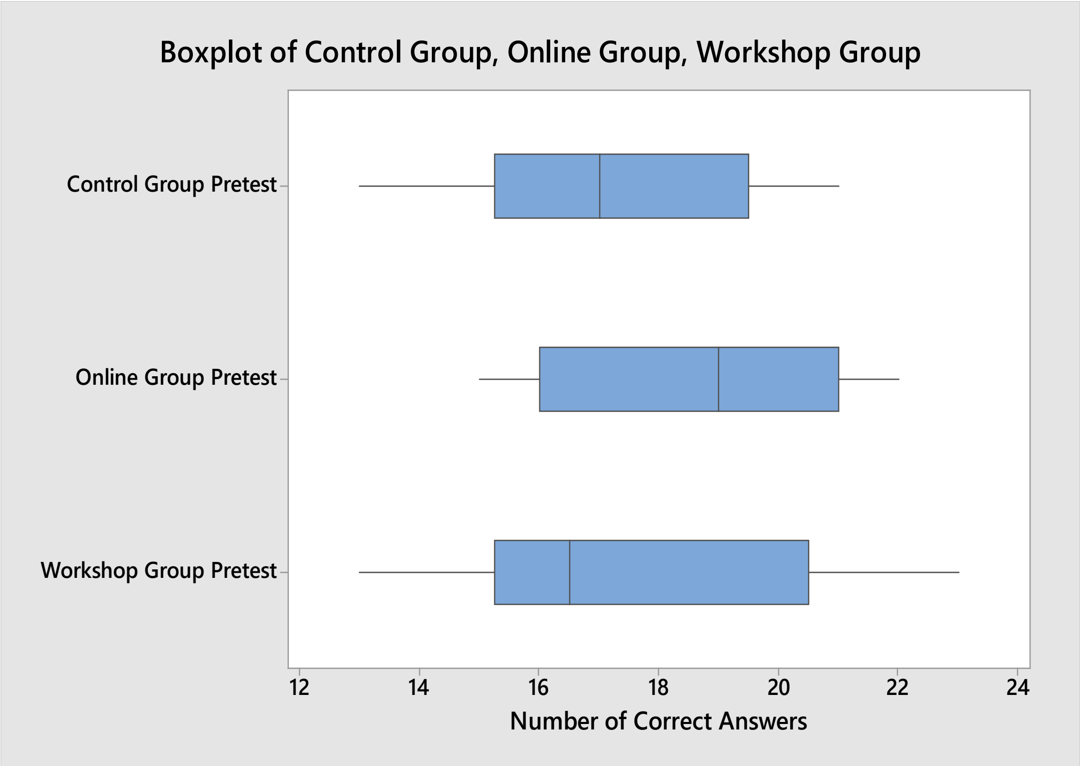
Sample	N	StDev	CI
Control Group Pretest	8	2.64237	(1.45934, 6.82759)
Online Group Pretest	7	2.56348	(1.31588, 7.58954)
Workshop Group Pretest	8	3.29502	(1.60667, 9.64329)

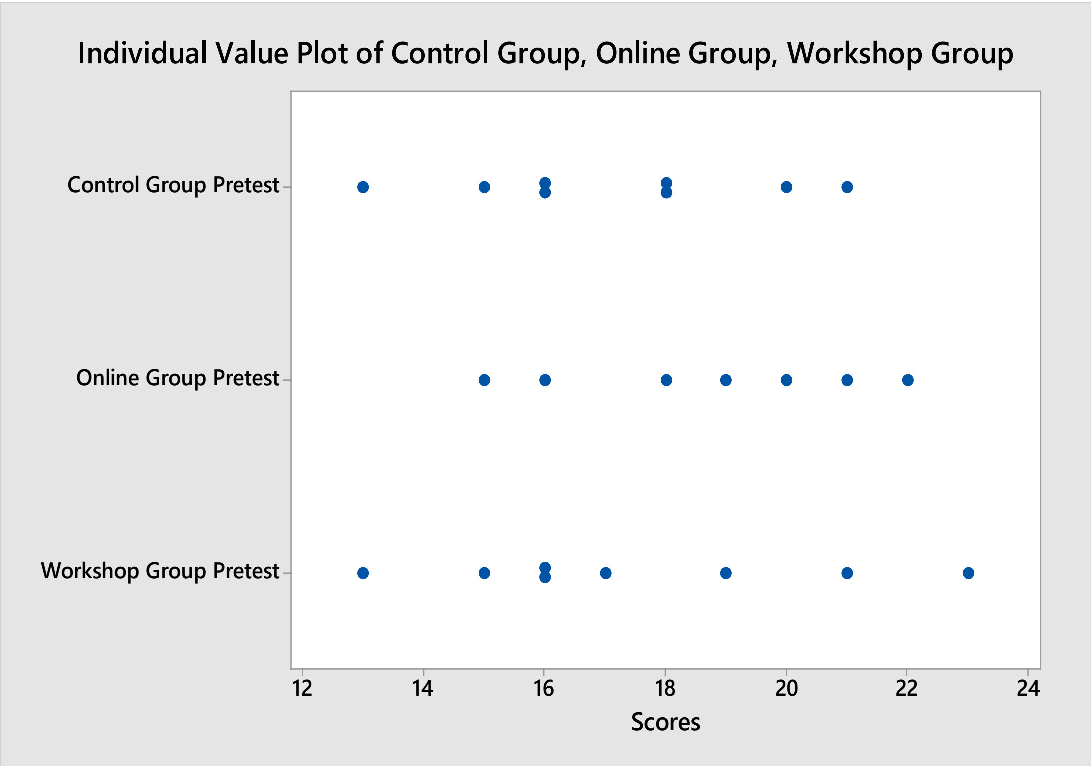
Individual confidence level = 98.3333%

Tests

Method	Test Statistic	P-Value
Multiple comparisons	—	0.805
Levene	0.18	0.840

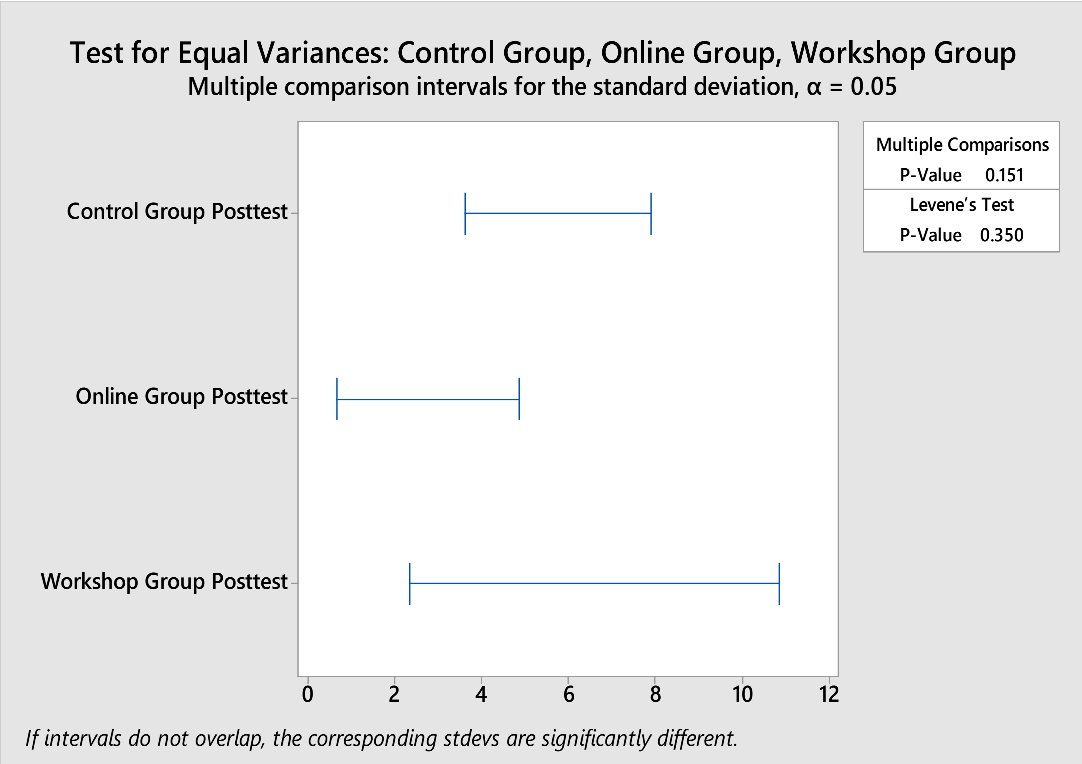


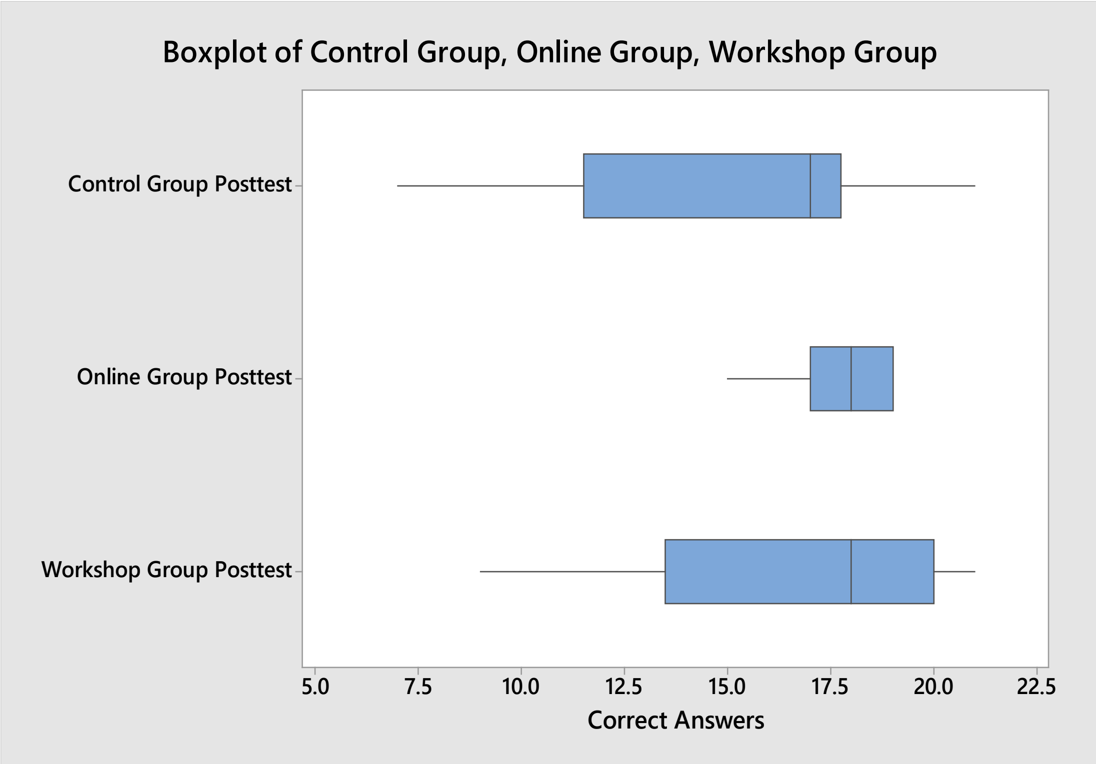

Boxplot of Control Group, Online Group, Workshop Group
Control Group Pretest
Online Group Pretest
Workshop Group Pretest
12
14
16
18
20
22
24
Number of Correct Answers

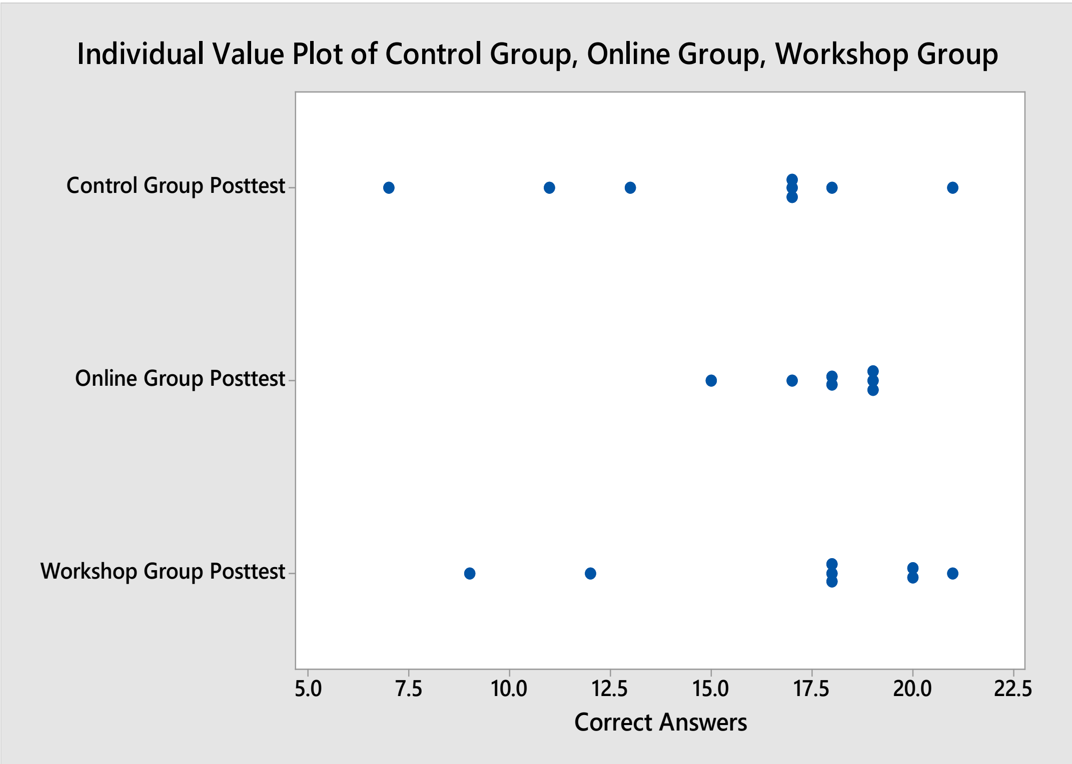

Individual Value Plot of Control Group, Online Group, Workshop Group
Control Group Pretest
Online Group Pretest
Workshop Group Pretest
12
14
16
18
20
22
24
Scores

Test for Equal Variances: Control Group Posttest, Online Group Posttest, Workshop Group Posttest

```
Method

Null hypothesis         All variances are equal
Alternative hypothesis  At least one variance is different
Significance level      α = 0.05

95% Bonferroni Confidence Intervals for Standard Deviations

                 Sample  N    StDev          CI
 Control Group Posttest  8  4.48609  (1.90596, 15.0681)
  Online Group Posttest  7  1.46385  (0.35454,  9.1854)
Workshop Group Posttest  8  4.24264  (1.30754, 19.6450)

Individual confidence level = 98.3333%

Tests
                            Test
Method                 Statistic  P-Value
Multiple comparisons           —    0.151
Levene                      1.11    0.350
```




Boxplot of Control Group, Online Group, Workshop Group
Control Group Posttest
Online Group Posttest
Workshop Group Posttest
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
Correct Answers


Individual Value Plot of Control Group, Online Group, Workshop Group
Control Group Posttest
Online Group Posttest
Workshop Group Posttest
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
Correct Answers

Appendix W: One-Way ANOVA Pretest and Posttests-Purdue Participants

One-way ANOVA: Control Group Pretest, Online Group Pretest, Workshop Group Pretest

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Control Group Pretest, Online Group Pretest, Workshop Group Pretest

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	10.13	5.066	0.62	0.550
Error	20	164.30	8.215		
Total	22	174.43			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
2.86621	5.81%	0.00%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Control Group Pretest	8	17.125	2.642	(15.011, 19.239)
Online Group Pretest	7	18.714	2.563	(16.455, 20.974)
Workshop Group Pretest	8	17.50	3.30	(15.39, 19.61)

Pooled StDev = 2.86621

Dunnett Multiple Comparisons with a Control

Grouping Information Using the Dunnett Method and 95% Confidence

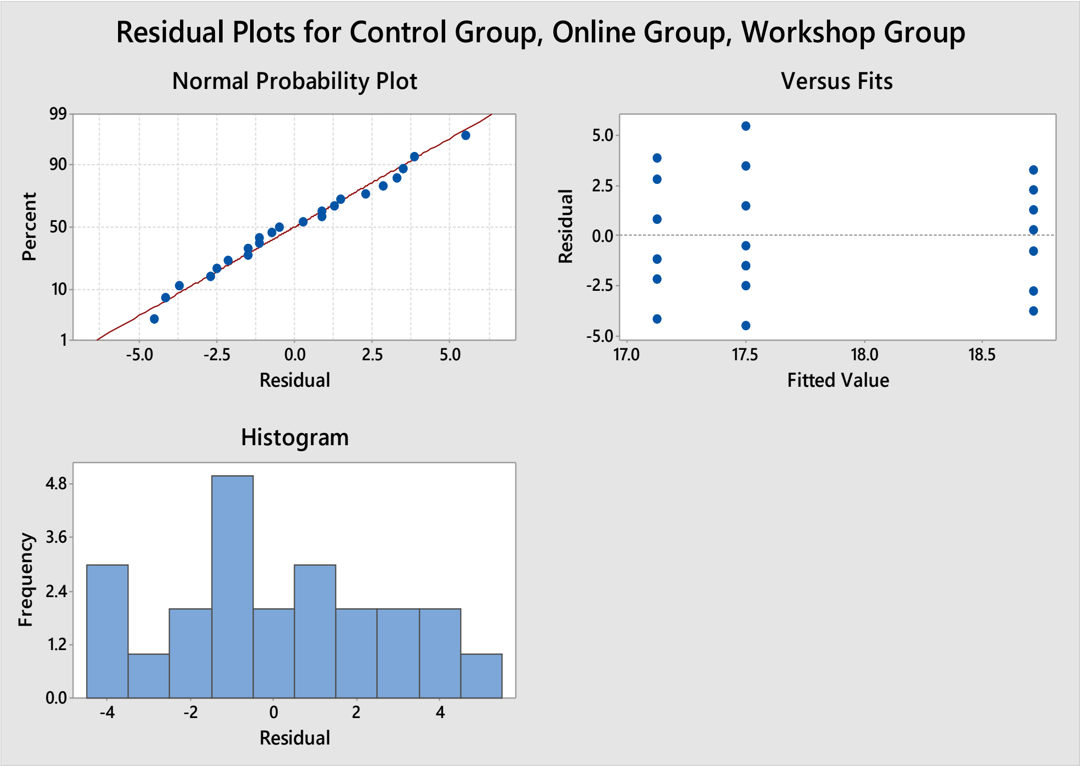
Factor	N	Mean	Grouping
Control Group Pretest (control)	8	17.125	A
Online Group Pretest	7	18.714	A
Workshop Group Pretest	8	17.50	A

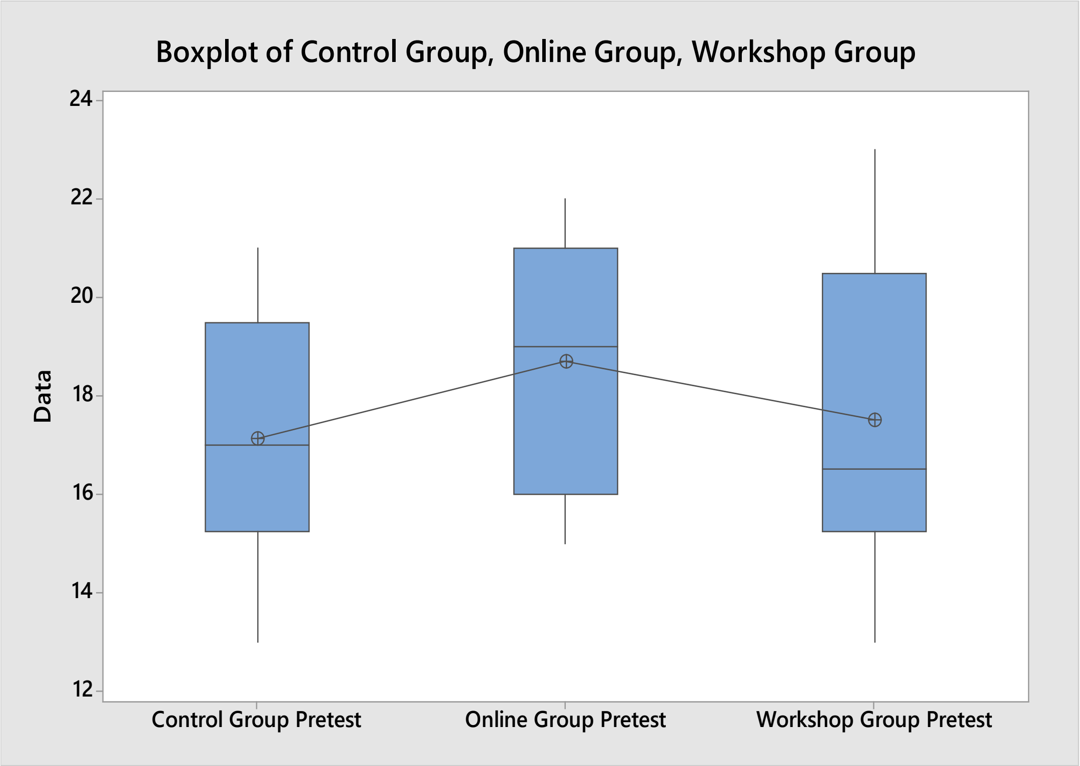
Means not labeled with the letter A are significantly different from the control level mean.

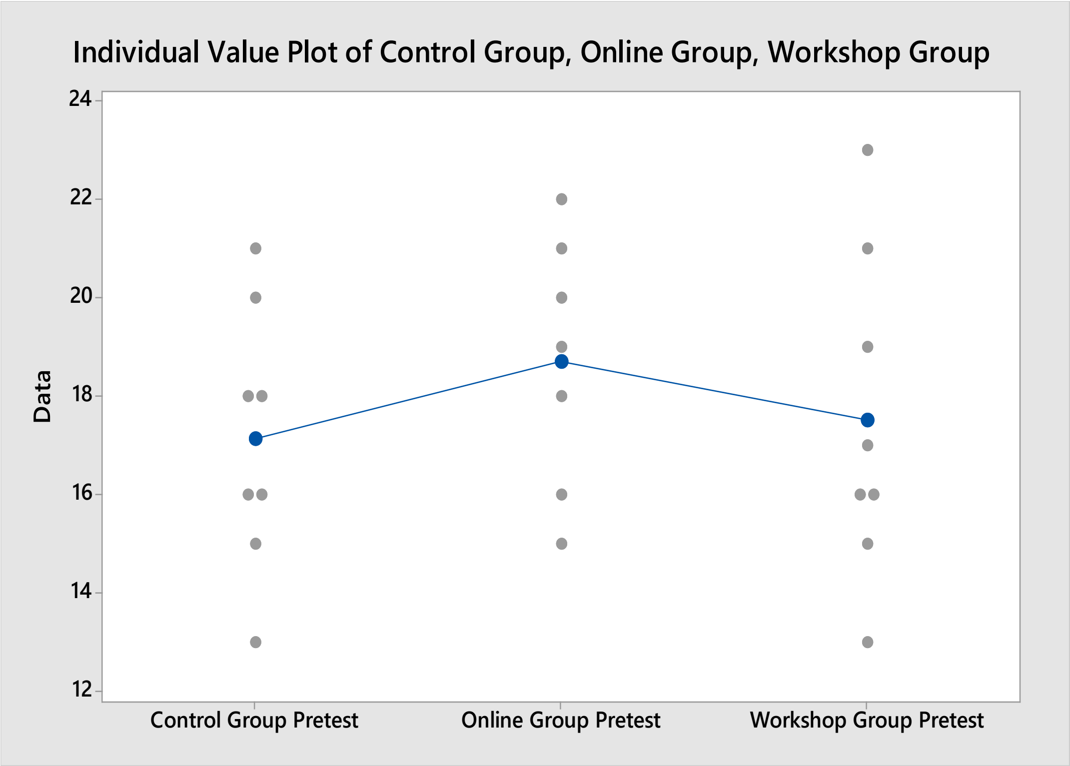
Dunnett Simultaneous Tests for Level Mean - Control Mean

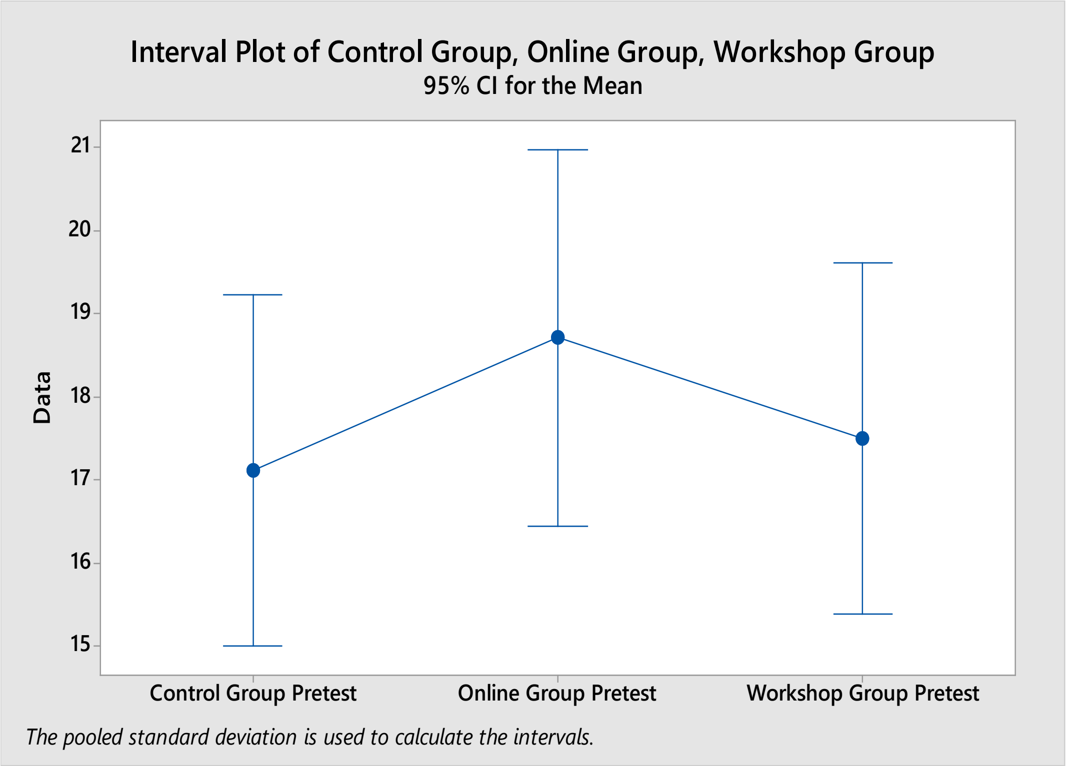
Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Online Group - Control Grou	1.59	1.48	(-1.94, 5.12)	1.07	0.472
Workshop Gro - Control Grou	0.38	1.43	(-3.04, 3.79)	0.26	0.952

Individual confidence level = 97.27%


Residual Plots for Control Group, Online Group, Workshop Group
Normal Probability Plot
Percent
99
90
50
10
1
-5.0
-2.5
0.0
2.5
5.0
Residual
Versus Fits
Residual
5.0
2.5
0.0
-2.5
-5.0
17.0
17.5
18.0
18.5
Fitted Value
Histogram
Frequency
4.8
3.6
2.4
1.2
0.0
-4
-2
0
2
4
Residual


Boxplot of Control Group, Online Group, Workshop Group
Data
24
22
20
18
16
14
12
Control Group Pretest
Online Group Pretest
Workshop Group Pretest


Individual Value Plot of Control Group, Online Group, Workshop Group
Data
24
22
20
18
16
14
12
Control Group Pretest
Online Group Pretest
Workshop Group Pretest


Interval Plot of Control Group, Online Group, Workshop Group
95% CI for the Mean
Data
21
20
19
18
17
16
15
Control Group Pretest
Online Group Pretest
Workshop Group Pretest
The pooled standard deviation is used to calculate the intervals.

One-way ANOVA: Control Group Posttest, Online Group Posttest, Workshop Group Posttest

Method

Null hypothesis	All means are equal
Alternative hypothesis	At least one mean is different
Significance level	α = 0.05

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Factor	3	Control Group Posttest, Online Group Posttest, Workshop Group Posttest

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Factor	2	29.75	14.87	1.06	0.364
Error	20	279.73	13.99		
Total	22	309.48			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
3.73987	9.61%	0.57%	0.00%

Means

Factor	N	Mean	StDev	95% CI
Control Group Posttest	8	15.13	4.49	(12.37, 17.88)
Online Group Posttest	7	17.857	1.464	(14.909, 20.806)
Workshop Group Posttest	8	17.00	4.24	(14.24, 19.76)

Pooled StDev = 3.73987

Dunnett Multiple Comparisons with a Control

Grouping Information Using the Dunnett Method and 95% Confidence

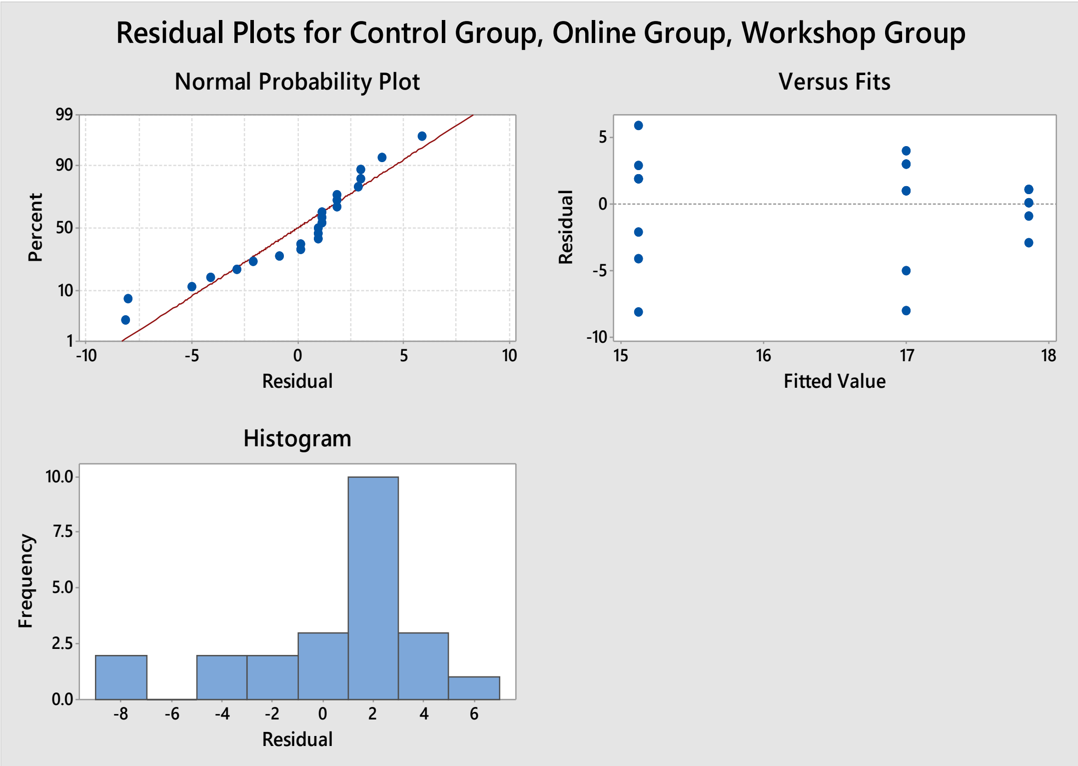
Factor	N	Mean	Grouping
Control Group Posttest (control)	8	15.13	A
Online Group Posttest	7	17.857	A
Workshop Group Posttest	8	17.00	A

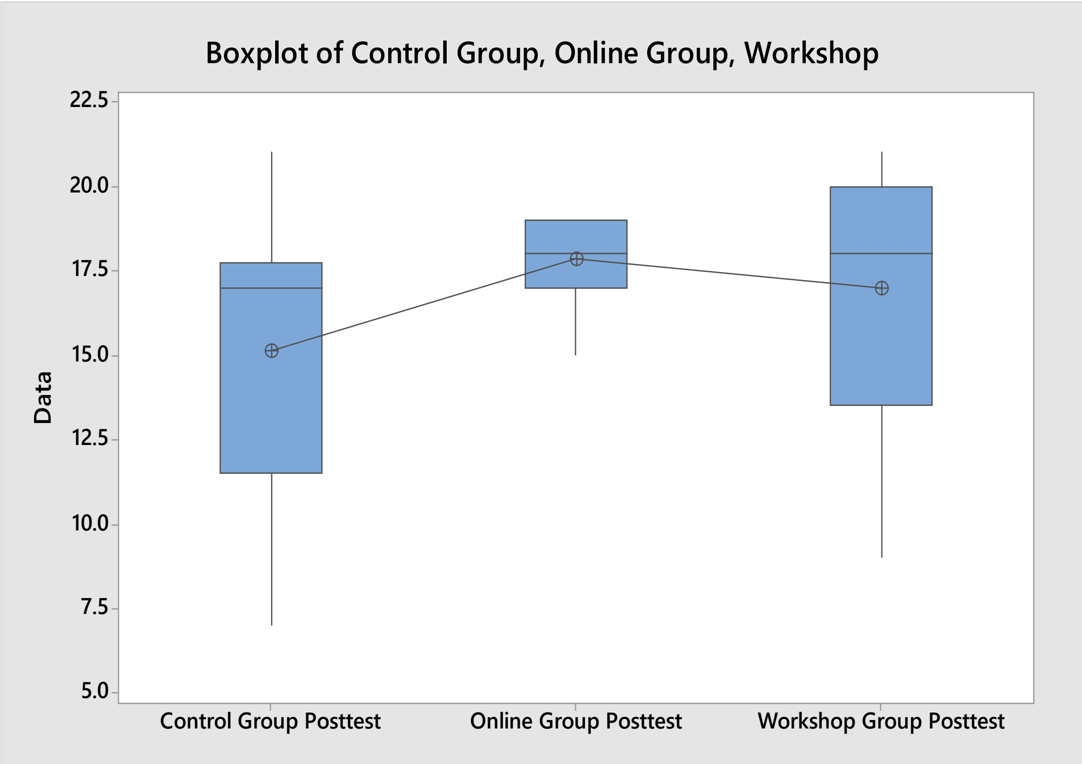
Means not labeled with the letter A are significantly different from the control level mean.

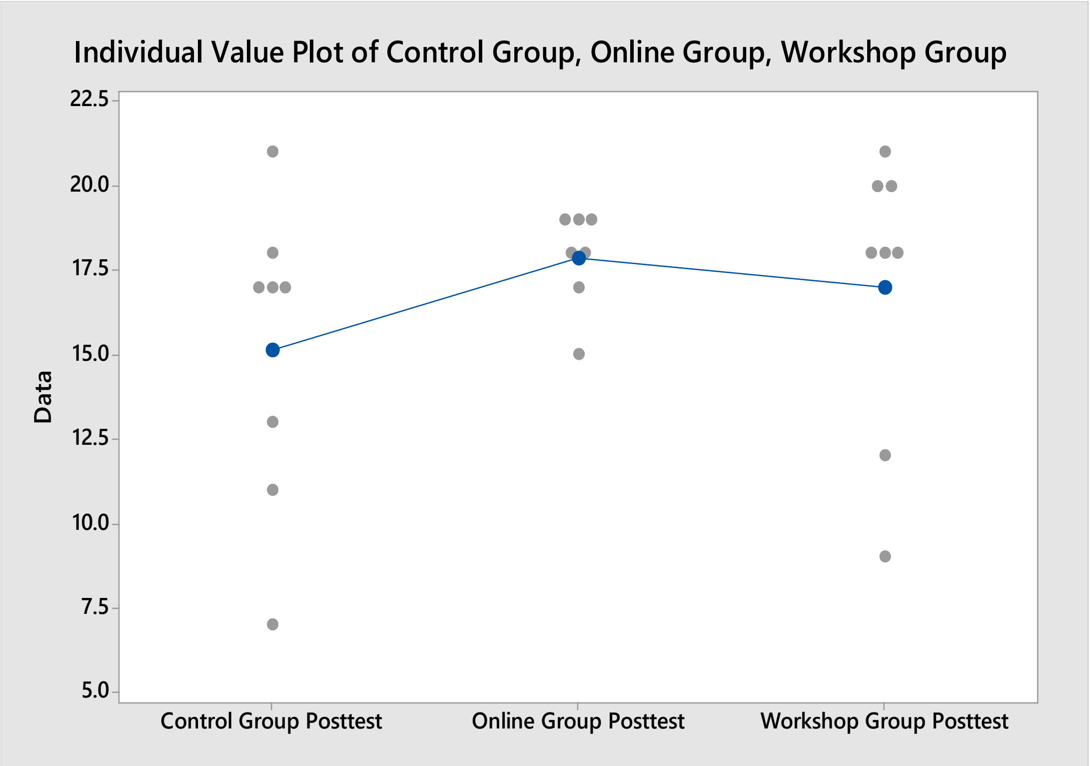
Dunnett Simultaneous Tests for Level Mean - Control Mean

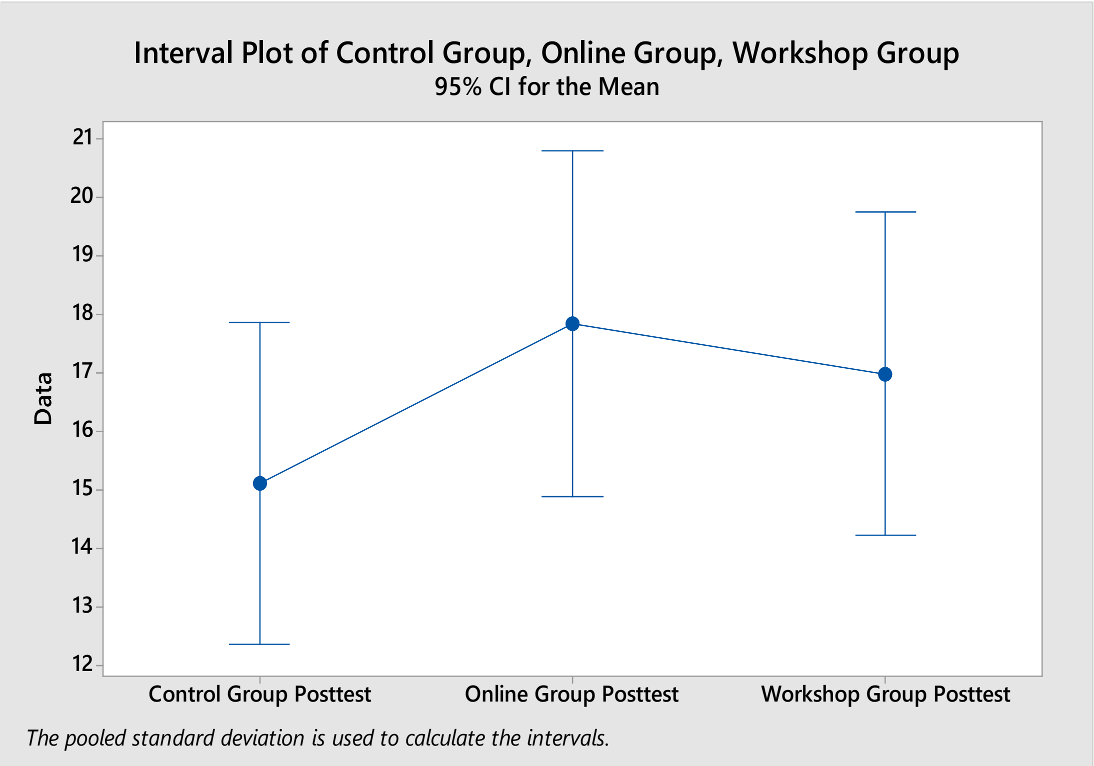
Difference of Levels	Difference of Means	SE of Difference	95% CI	T-Value	Adjusted P-Value
Online Group - Control Grou	2.73	1.94	(-1.88, 7.34)	1.41	0.291
Workshop Gro - Control Grou	1.88	1.87	(-2.58, 6.33)	1.00	0.514

Individual confidence level = 97.27%


Residual Plots for Control Group, Online Group, Workshop Group
Normal Probability Plot
Percent
99
90
50
10
1
-10
-5
0
5
10
Residual
Versus Fits
Residual
5
0
-5
-10
15
16
17
18
Fitted Value
Histogram
Frequency
10.0
7.5
5.0
2.5
0.0
-8
-6
-4
-2
0
2
4
6
Residual


Boxplot of Control Group, Online Group, Workshop
Data
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Control Group Posttest
Online Group Posttest
Workshop Group Posttest


Individual Value Plot of Control Group, Online Group, Workshop Group
Data
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Control Group Posttest
Online Group Posttest
Workshop Group Posttest


Interval Plot of Control Group, Online Group, Workshop Group
95% CI for the Mean
Data
21
20
19
18
17
16
15
14
13
12
Control Group Posttest
Online Group Posttest
Workshop Group Posttest
The pooled standard deviation is used to calculate the intervals.

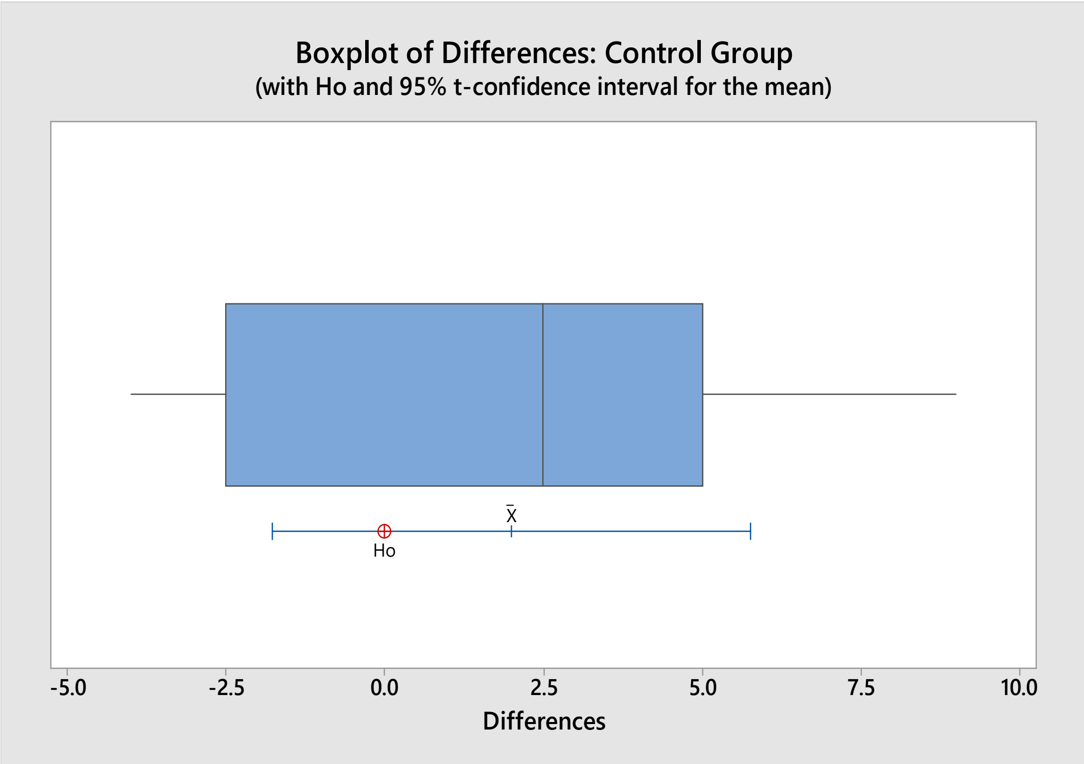
Appendix X: Paired t-test for All Groups-Purdue Participants

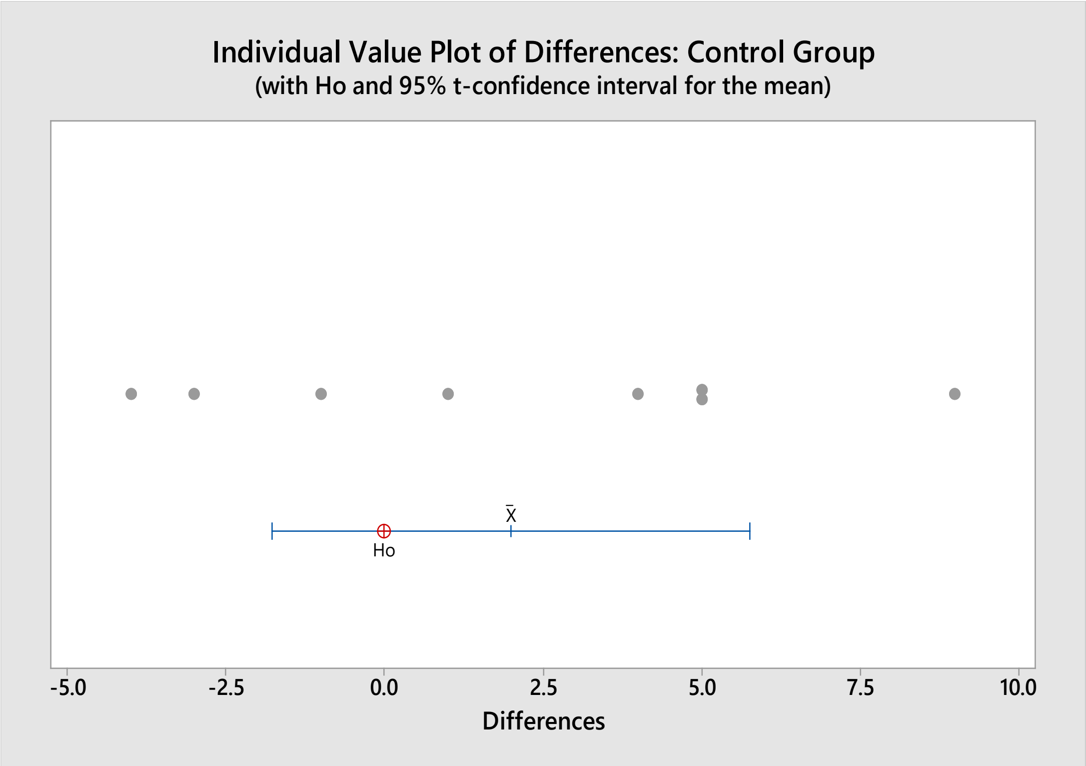
Paired T-Test and CI: Control Group Pretest, Control Group Posttest

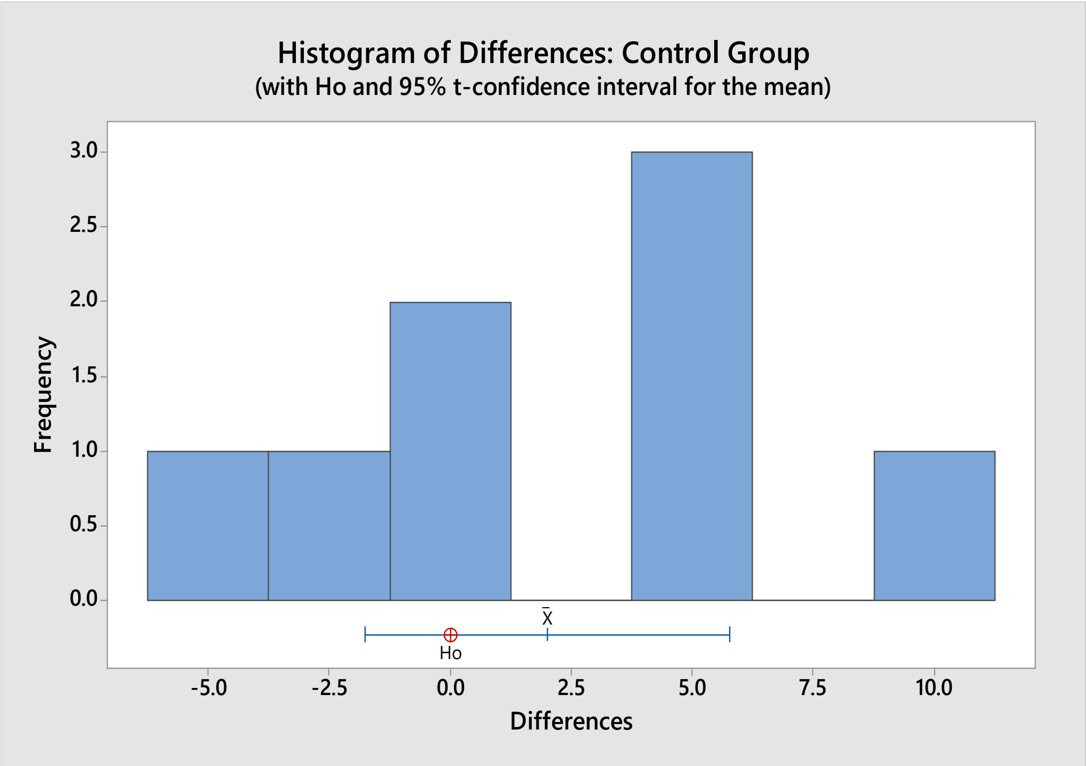
Paired T for Control Group Pretest - Control Group Posttest

	N	Mean	StDev	SE Mean
Control Group Pretest	8	17.13	2.64	0.93
Control Group Posttest	8	15.13	4.49	1.59
Difference	8	2.00	4.50	1.59

95% CI for mean difference: (-1.77, 5.77)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 1.26 P-Value = 0.249




Individual Value Plot of Differences: Control Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
Differences

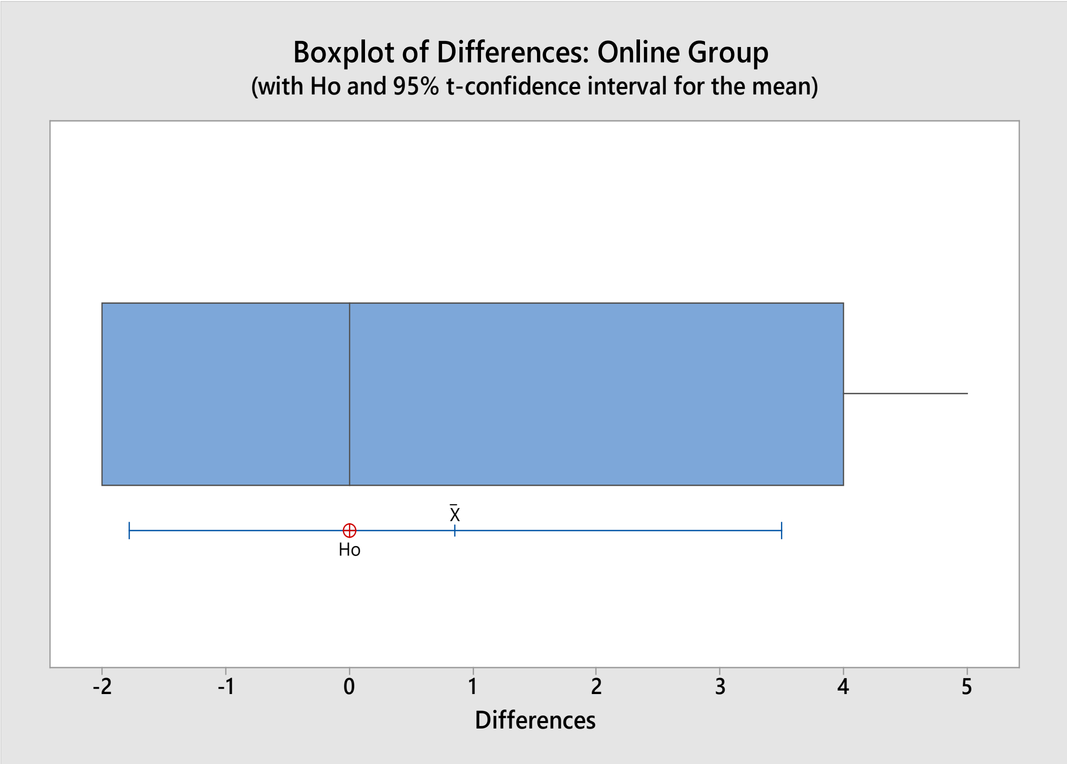

Histogram of Differences: Control Group
(with Ho and 95% t-confidence interval for the mean)
Frequency
3.0
2.5
2.0
1.5
1.0
0.5
0.0
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
10.0
Differences

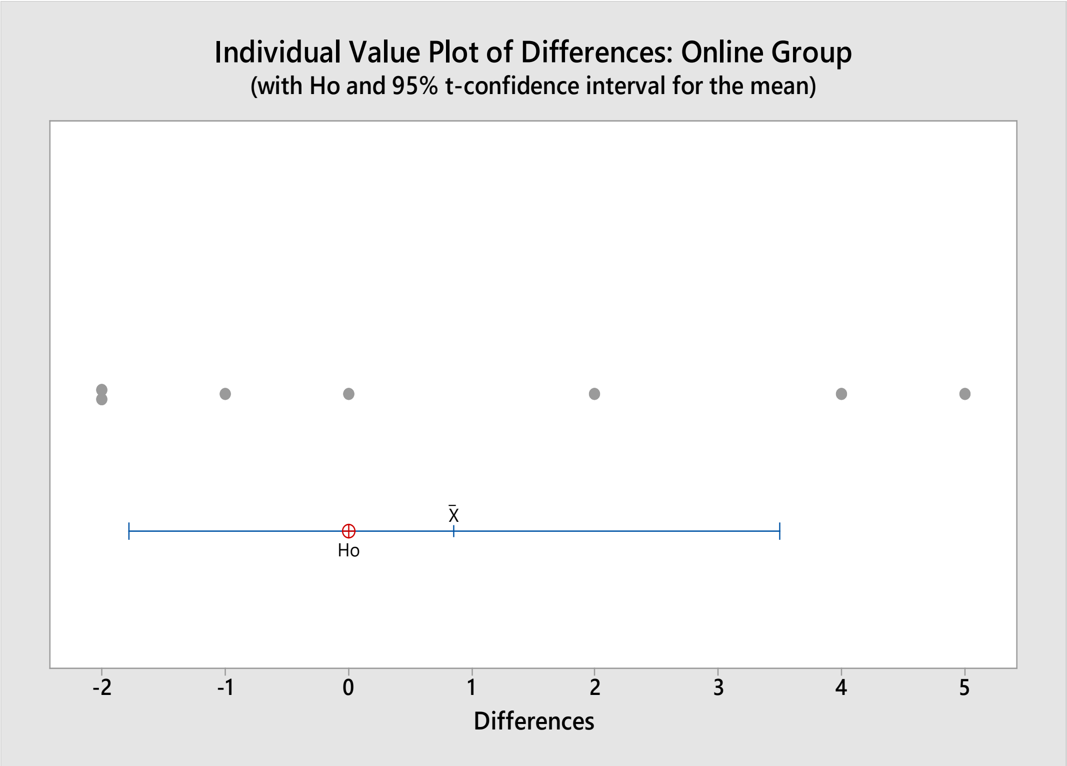
Paired T-Test and CI: Online Group Pretest, Online Group Posttest

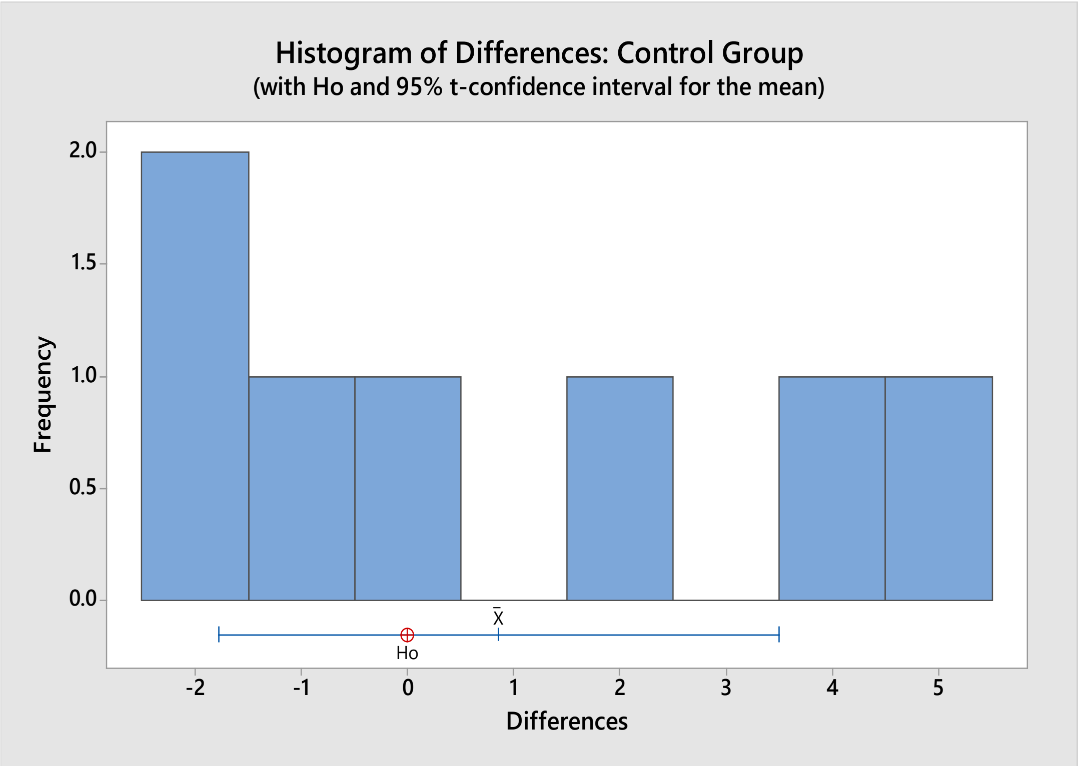
Paired T for Online Group Pretest - Online Group Posttest

	N	Mean	StDev	SE Mean
Online Group Pretest	7	18.714	2.563	0.969
Online Group Posttest	7	17.857	1.464	0.553
Difference	7	0.86	2.85	1.08

95% CI for mean difference: (-1.78, 3.50)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 0.79 P-Value = 0.457

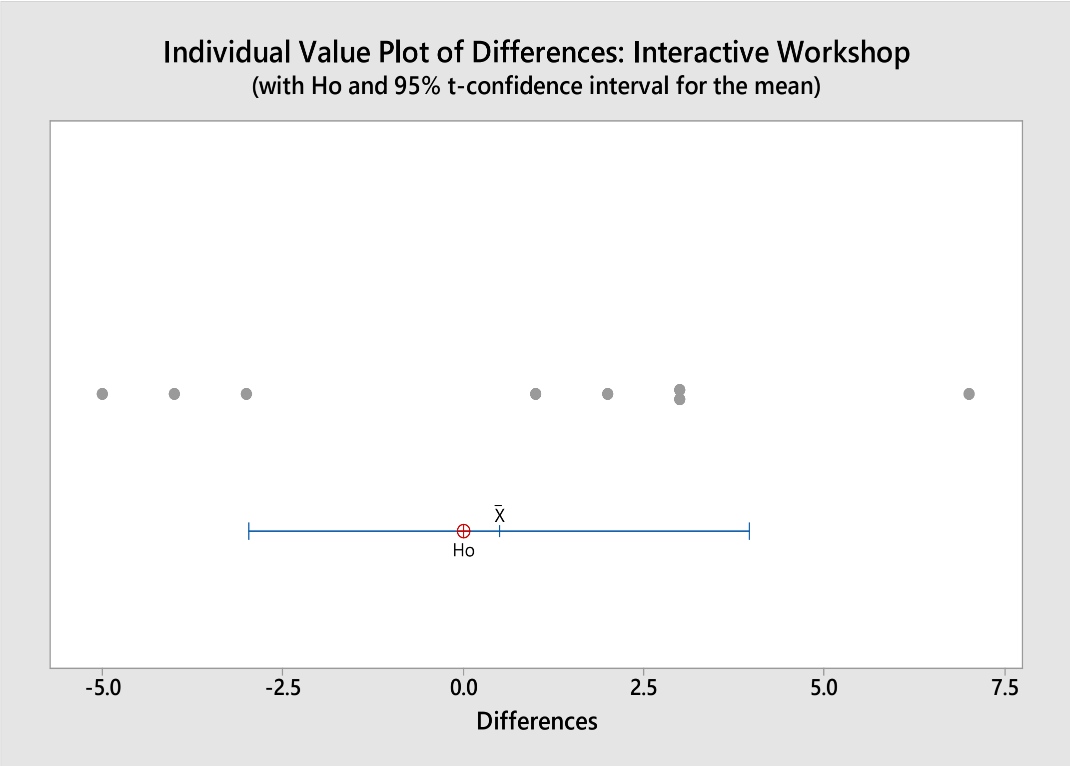


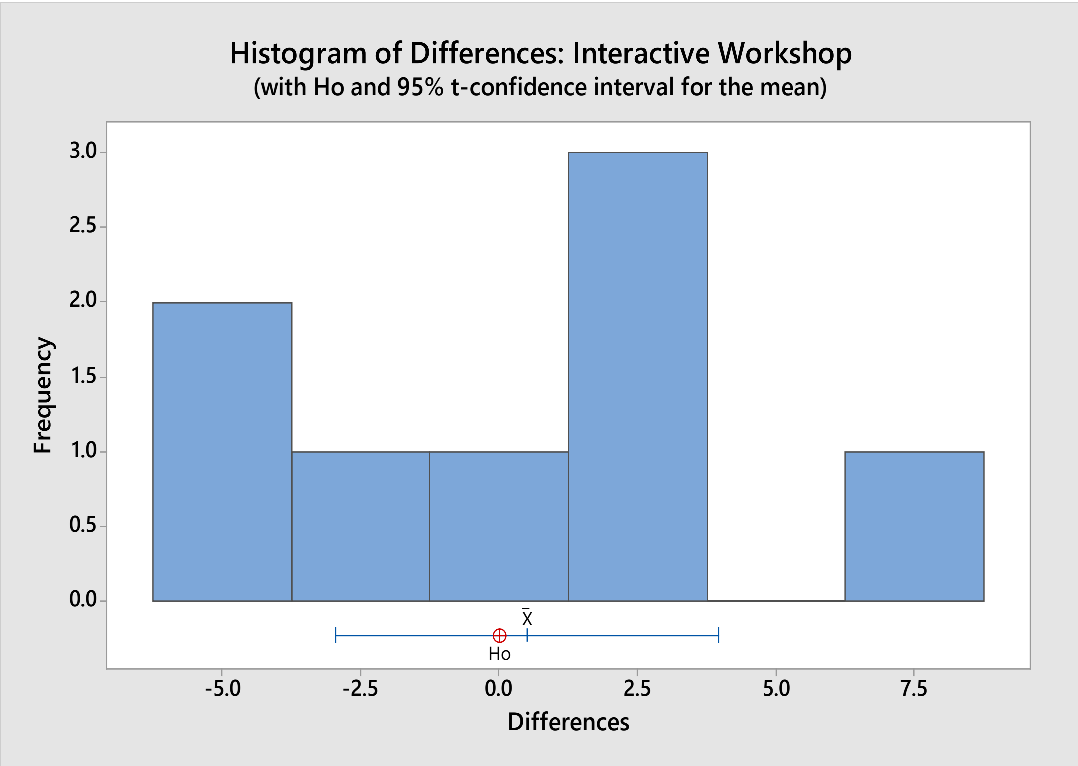

Individual Value Plot of Differences: Online Group
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-2
-1
0
1
2
3
4
5
Differences


Histogram of Differences: Control Group
(with Ho and 95% t-confidence interval for the mean)
Frequency
2.0
1.5
1.0
0.5
0.0
X̄
Ho
-2
-1
0
1
2
3
4
5
Differences

Paired T-Test and CI: Workshop Group Pretest, Workshop Group Posttest

```
Paired T for Workshop Group Pretest - Workshop Group Posttest

                           N   Mean  StDev  SE Mean
Workshop Group Pretest     8  17.50   3.30     1.16
Workshop Group Posttest    8  17.00   4.24     1.50
Difference                 8   0.50   4.14     1.46


95% CI for mean difference: (-2.96, 3.96)
T-Test of mean difference = 0 (vs ≠ 0): T-Value = 0.34  P-Value = 0.743
```


Individual Value Plot of Differences: Interactive Workshop
(with Ho and 95% t-confidence interval for the mean)
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
Differences


Histogram of Differences: Interactive Workshop
(with Ho and 95% t-confidence interval for the mean)
Frequency
3.0
2.5
2.0
1.5
1.0
0.5
0.0
X̄
Ho
-5.0
-2.5
0.0
2.5
5.0
7.5
Differences

Appendix Y: Responses to Post-flight Questions-FAA Technical Center Participants

Group	In the Alaska Simulation Scenario, did you divert, turn back or continue on?	Why did you make the decision that you made?	Would you make the same decision again, and why?	Using a percentage, how much of your attention do you estimate was dedicated
Control	180 turn to divert	Rapid deterioration of visibility into harsh terrain	Yes I would because I would feel more comfortable going to a closer airport with better visibility than risking flight into terrain any day.	30% controls, 30% traffic, 40% weather.
Control	Continue	I thought that I had to follow the route on the chart.	Definitely not. The visibility is very bad. I can rarely see anything. For safety, if it happens again, i will turn back to the orginal airport.	50% and 50%
Control	Divert to Haines	Visibility decreased way below what I was comfortable with while flying so close to mountains in a narrow	Of course. For the same reasons. Not comfortable with the visibility in mountains and unfamiliar location.	50-50
Control	I tried to turn back, but the space in the tinya inlet is limited. So I decided to continue on and turn back later when near the airport.	Since the space between the mountain is not sufficient for a turn around, I decided to go to the airport where	Yes, since the visiability reduced when I was already inside the inlet, it would be safer to rely on the G1000 a go straight. If the	60 percent. I have to pay attention on my altitude. Once I was distracted by other tasks, like looking for traffic or looking for checkpoint, I start
Control	Turn back	I started flying in IMC conditions.	No, I would spend more time reading the TAF's and would have determined that I should intially just land at the alternate until the weather cleared up.	A lot of it since I have never flown in a simulator, and never flown with a G1000, I didn't know where to look to even get information. I was
Control	continue on	I have a gps and already know the altimeter setting.	No, I should make a 180 U turn and fly out of IFR condition.	40%
Control	Diverted	Weather already reported below my miniumn	Yes, no need to risk it. Can always drive or wait till a better day	90%
Control	Turn back	Could not see terrain around me, went back to what I was trained and turned right back around while using the limited IFR	Yes but I would first think which side had more clearence from the valley walls and turn to the one with more clearence before I made the turn.	About 40%
Interactive Group	turn back and divert to Haines	Decreased visibility ahead, mountains to either side ahead	I would have made the same decision but may have turned earlier so as to complete the turn with less risk of terrain.	50/50
Interactive Group	i diverted	because the weather is getting worst and worst, becoming IMC, and i don't want to get lost in the clouds around	yes, because i want to be safe	about 50% each
Interactive Group	diverted back to haines	The visibility was decreasing rapidly and with the combination of terrain and VFR mins, it would have been unsafe	Yes, There was another airport within a few minutes and it wasn't worth risking it.	probably about 30% of my attention was given to flight controls. The rest was divided between the visual weather I was seeing out of the window and
Interactive Group	I continued on until a few miles of the airport where I was about to turn around at the end of the scenario	I couldn't turn around before because I was afraid I didn't have enough room to turn around without hitting	In the first place, I would never have taken off in the conditions that were present and forecast at the time of take off. Supposing that I did take off again for	Maybe 30% on flight controls and 70% situational awareness. For me the hardest is to process information I obtain verbally regarding location,
Interactive Group	I continued onto the path	With the G1000 that I have. I was able to use the instruments and the MFD to keep myself situationally aware	I proabably would not because there were mountains in the area and you could easily crash into them.	75 Percent was making sure that I was in control of the airplane and making sure that I was not in any unsual attitudes or if my scan was not being
Interactive Group	I continued on and turned back at the last minute when visuals became zero.	I believed that I would be able to make the airport before the haze got too bad.	No, I would not because it was almost too late to turn back and would have been too dangerous if I had done so any later. I'd divert much sooner and	Flight controls - 60% Situational awareness - 40%
Interactive Group	Diverted	Weather was deteriorating - low ceilings kept me close to the ground, and the terrain (canals and mountains) was	Probably. In real life, I would probably have turned back altogether, but it's easy to be brave/foolhardy in a simulator.	Flight controls: 15% Weather: 50% Traffic: 15% Remembering how to talk to ATC: 20%
Workshop	Continued on	Visibility still acceptable, didn't lose ground reference at any time	Yes. Altitude is high enough to ensure safety and we can still see the ground	40% and 60%
Workshop	continue	I thought that I had 3 miles visibility and all of the sudden I got black out conditions. After I got into the soup I was afraid	No, would turn around at the first sign of poor visibility	80
Workshop	divert	The visibility was low and appeared to be worsening. There were few locations to land because of the water and	Yes, because flying into IMC as a VFR pilot would be hazardous, especialy in the vicinity of mountains.	20% flight controls, 80% situational awareness
Workshop	turn back with intention to divert to the 1st airport passed	Mountain pass with visibility dropping. Unfamiliar with area, not IFR current, really nice lights on the	Given the terrain, yes. If it was Indiana (flat, few obstructions) I might have gone a little further.	Flight controls, 30%. Situational awareness, 70%
Workshop	I was getting ready to do a 180 when the scenario ended.	I was going down in altitude. I was over the channel, so I was going to go to 1300 feet. If I could see, I was going to continue.	I would turn 180 degrees sooner.	In the second scenario, 40 to 50% was maintaining flight control. 25% situational awareness and 25% weather. In the first scenario, 25%
Workshop	Turn back	Poor visibility, lack of any traffic advisory.	Yes, because the visibility was very poor and dropping, so it made sense to go back to VFR weather	65-flight control/35-situational awareness
Workshop	turn back	Aftering turing from Hanes, the visibility is too low so that I have to abort the flight.	Yes. As the route is along the river and there are narrow flight channel, it is extremely hard to diverge in such terrian.	60% for flight control, 40% for situational awareness.
Workshop	divert	that air port was close and i was over half way to my destination	yes it was close and i think i could make it if not i would return home	50 flying 40 weather and 10 on the radio

In the New Mexico simulation scenario, did you divert, turn back or continue on?	Why did you make the decision that you made?	Would you make the same decision again, and why?	Using a percentage, how much of your attention do you estimate was dedicated to maintaining the flight controls? And to maintaining situational	Is there anything you would like the researchers to know about your simulation experience today?
Diverted	Loss of radar contact mixed with rapid visibility loss, with a closer airport available.	Yes, because even though I was about to make contact with an approach control, I felt more comfortable getting to an airport faster, in case of further deterioration of visibility.	30% controls, 20% traffic, 50% weather.	The experience was very informative, and allowed me to realize how I would act in situations that I do not normally face.
Turn back	Cant see clearly.	Yes. I think safety is my toppest priority	50% and 50%	I have not flown airplanes for a while. Many things about flight that I have forgotten, such as call signs. Also, I have never used flight simulators before and am not familar with the navigation equipment at all. So when I was flying the sim, I was not that comfident to use
Divert to Sandia East	Reduced visibility near mountains.	Yes, because of the poor visibility and proximity to the mountains	50-50	I perfomed this to the best of my abilities as a VFR pilot.
No. I never think about turning back since I think I was still on the right track. Also, the surface conditions is not mountainous, which makes me more comfortable about my current condition	As mentioned above, I'm comfortable with the surface condition, so I did not turn around.	Yes. Since the situation haven't gone so bad that I have to give up my destination.	50 percent. The surface condition makes me less worried about hitting the mountains, so I paid less attention on the altitude, and spend more time looking outside.	For the New Mexico scenario, there is no visual reference for the cement plant checkpoint. So maybe add something there.
I continued on.	Although there was turbulence, there was little indication that visibility would be as low as it was, and I was in contact with ABQ approach (flight folowing).	Yes, I would have listened to ATIS sooner.	Almost all of it, again because I wasn't familiar with the G1000 or the airplane. I wouldn't have made this flight in real life.	I wish I knew what I was doing or where to find things on the G1000. I enjoyed it because it made me realize I need to have a better understanding of the weather since it plays such a large role in general aviaiton. This will serve as a motivator for me to gain better
continue on	I forgot to turn back.	NO. It's danger.	60% control 40%situational awareness	Nice test, I'll remember turing back when going in to IFR.
Divert	Pushed on for a bit as reports were VFR flights making it in. But just because they can do it, doesn't mean I can.	Yes, not worth the risk	90%	Good expereince, thanks for the opportunity to fly
Did not finish scenario	Did not finish scenario	Did not finish scenario	Did not finish scenario	Possibly provide paper copy of flight plan to reference frequencies, airport identifiers etc. There was confusion with lack of familiarization with the G1000 and the different areas flown and quickly frustrated me, particularly in the second scenario.
Turned back and diverted to Sandia	Mountain obscuration which appeared worse once I was in the pass.	Would have been better to turn back sooner. New to a simulator, a cessna, and a glass panel and no physical input and in that scenario I approached a stall while turning back.	50/50	Challenging due to my experience limitations with sim, type, and glass panel but great practice anyway!
i diverted	brcause i don't want to crash	yes, because i want to survive	50% each	it was great
Diverted to 1N1	I wasn't sure of my visiblity and at the position I was at I was getting funnelled into a higher traffic area and did not want to be going there in low vis.	Maybe, I may have been a little over-cautious in terms of my visual sight of weather. If I was more familiar with the area and the aircraft I may have continued on with the assisitance of vectoring from KABQ approach	In this flight about %20 percent of my attention was on the controls as the turbulence did not concern me much. About %30 was to comms, and the rest %50 was to navigation	negative..
I divert to 1N1 after reaching highway 40 that I couldn't see	I lost visibility once past the mountains when reaching highway 40. I contacted Albuquerque approach who said 1N1 was VFR. When pushing on nearest I also realized that Albuquerque was IFR and 1N1 VFR, which confirmed what ATC said and I	I hope I would see that Albuquerque is IFR when clicking on nearest before and divert to 1N1 before I reached the mountainous terrain.	At the time I was trying to find an alternative airport, maybe 50/50 as I tried to find other options but in the meantime I had to maintain my visual on the close terrain. I didn't know where the 2 nearby airports where in relation to my location so at first I wasn't sure which	I would not have taken off in the first place. I'm a low experience pilot and I know my limitations are pretty low. In the Alaska scenario, there was forecast for overcast at 1000, I would not fly in such a weather in flat Indiana, so no way I fly that in mountain and canal
I continued on because the visibility was not too extreme and I would rely on ATC to vector me to the airport or divert in case I was not able to make it to ABQ	I made the decision that I made because I felt that I was capable of following the flight plan and making sure that I maintained safe flight conditions.	If I were to do this next time I would have diverted to another airport that was reproting VFR conditions. Flying in low visibility is not safe and it can be stressful as well.	For this scenario it would have to be 50-50 for both. The visibility was not that extreme in this scenario and spent a lot of time making sure I was listening to ATC and maintaining stable flight.	I thought it was awesome and it makes me want to get checked out in a Cessna 172 and fly it!
I turned back and would possibly have diverted had the simulation gone longer.	The weather was starting to get worse, and I did not want to take chances like I did with the Alaska simulation.	Yes, I would make the same decision because the costs of turning back or diverting outweighed the risks that would have been taken had I gone on. I might even divert earlier given if I had to make the decision again, simply because of safety.	Flight Controls - 60% Situational Awareness - 40%	It was a really great experience to fly in the simulator. This was my first time in one, and obviously it felt very different from flying an ordinary aircraft. Since I have only flown in a Cessna aircraft twice before, some of the controls still felt alien to me, but that could only
Turn back.	Weather was deteriorating rapidly and I was flying into rising terrain.	I would probably turn back sooner. It was stupid to imagine that the weather would improve when it was clearly deteriorating.	Flight Controls: 15% Traffic: 0% (since ATC informed me there was none) Weather: 60% Talking to ATC: 25%	I feel like I was handicapped a bit by being in a very unfamiliar environment (glass panels), and definitely out of my comfort zone in terms of the weather scenarios. I am a leisure/recreational pilot and as such I try to avoid flying when the weather is inclement.
Continued on	Called flight following, altitude enough to ensure safety and I could still see the ground.	Yes. Visibility is fair, but I don't lose ground reference and maintain sufficient altitude to ensure safety. I'll only divert or turn back if the visibility condition deteriorates.	35%, 65%	Flying a simulator is a little bit harder than flying a real plane because we can't feel the movement and all our organ feelings are limited to visual inputs. Also the simulator seems to be more sensitive than a real aircraft so we need to make subtle movements
turn back	After my first flight I knew that things could turn bad quickly, therefore decided to turn back	Yes, learned that bad visibility gives you very little good options and of course breaking VFR flgiht rules	80	It was great and I learned I need to continue to learn more about weather.
divert	The visibility was low and worsening. There was some turbulence and reports of mountain turbulence near ABQ.	Yes, because flying into IMC as a VFR pilot is very hazardous.	20% flight controls, 80% situational awareness	negative
turn back, didn't have a divert airport in mind except for departure airport	Terrain warning and low visibility.	Yes. The visibility dropped rapidly and didn't know if it was just temporary. Also unfamiliar with the airport and area for weather that marginal	Initially 20% flight controls, 80% weather/traffic/terrain. After deciding to divert, then 80% flight controls.	Should have spent more time reviewing scenario/navigation plan/frequencies. If I had done the planning for my own trip I would have spent more time and would have been more familiar with the route/frequencies... Did like flying the sim though,
I was continuing on and decending to 7,500 feet	The airport is at 5,500. If at 7,500 feet I had visibility, I would continue.	Again, I think I would turn back sooner. I did not realize the visibility was dropping that fast.	In the New Mexico scenario, 40 to 50% flight control. 25% situational wareness and 25% weather.	They seemed to be very good sims. Very realistic.
Turn Back	Contacted the tower and they suggested that SAF had VFR weather	Yes. The tower has more info than me, and can give me better advice, and like in the other scenario, the probabality of getting VFR weather on the way back is greater.	65-35	The elevator was unusually sensetive and hence some of the weird clib/decents that happened.
No.	Immediately entering the airspace, I want to evaluate the situation further.	Probably not. As the situation turns bad, I will clear away from the Class-C airspace and maintain VFR.	The weather condition changes too fast. I use 40% for flight controls, 30% for contacting Approach, 30% for situational awareness.	If there is more weather information provided during flight, it can make the pilot evaluation the situation better.
divert	the other airport was away from the weather and it was close	yes i still need to get to my destination	50 flying, 40 weather 10 on radio	it was fun and i enjoied the training. i would also like to partisipate in more experiences

Appendix Z: Responses to Post-flight Questions-Purdue University Participants

Group	In the Alaska Simulation Scenario, did you divert, turn back or continue on?	Why did you make the decision that you made?	Would you make the same decision again, and why?	Using a percentage, how much of your attention do you estimate was dedicated
Control	180 turn to divert	Rapid deterioration of visibility into harsh terrain	Yes I would because I would feel more comfortable going to a closer airport with better visibility than risking flight into terrain any day.	30% controls, 30% traffic, 40% weather.
Control	Continue	I thought that I had to follow the route on the chart.	Definitely not. The visibility is very bad. I can rarely see anything. For safety, if it happens again, i will turn back to the orginal airport.	50% and 50%
Control	Divert to Haines	Visibility decreased way below what I was comfortable with while flying so close to mountains in a narrow	Of course. For the same reasons. Not comfortable with the visibility in mountains and unfamiliar location.	50-50
Control	I tried to turn back, but the space in the tinya inlet is limited. So I decided to continue on and turn back later when near the airport.	Since the space between the mountain is not sufficient for a turn around, I decided to go to the airport where	Yes, since the visiability reduced when I was already inside the inlet, it would be safer to rely on the G1000 a go straight. If the	60 percent. I have to pay attention on my altitude. Once I was distracted by other tasks, like looking for traffic or looking for checkpoint, I start
Control	Turn back	I started flying in IMC conditions.	No, I would spend more time reading the TAF's and would have determined that I should intially just land at the alternate until the weather cleared up.	A lot of it since I have never flown in a simulator, and never flown with a G1000, I didn't know where to look to even get information. I was
Control	continue on	I have a gps and already know the altimeter setting.	No, I should make a 180 U turn and fly out of IFR condition.	40%
Control	Diverted	Weather already reported below my miniumn	Yes, no need to risk it. Can always drive or wait till a better day	90%
Control	Turn back	Could not see terrain around me, went back to what I was trained and turned right back around while using the limited IFR	Yes but I would first think which side had more clearence from the valley walls and turn to the one with more clearence before I made the turn.	About 40%
Interactive Group	turn back and divert to Haines	Decreased visibility ahead, mountains to either side ahead	I would have made the same decision but may have turned earlier so as to complete the turn with less risk of terrain.	50/50
Interactive Group	i diverted	because the weather is getting worst and worst, becoming IMC, and i don't want to get lost in the clouds around	yes, because i want to be safe	about 50% each
Interactive Group	diverted back to haines	The visibility was decreasing rapidly and with the combination of terrain and VFR mins, it would have been unsafe	Yes, There was another airport within a few minutes and it wasn't worth risking it.	probably about 30% of my attention was given to flight controls. The rest was divided between the visual weather I was seeing out of the window and
Interactive Group	I continued on until a few miles of the airport where I was about to turn around at the end of the scenario	I couldn't turn around before because I was afraid I didn't have enough room to turn around without hitting	In the first place, I would never have taken off in the conditions that were present and forecast at the time of take off. Supposing that I did take off again for	Maybe 30% on flight controls and 70% situational awareness. For me the hardest is to process information I obtain verbally regarding location,
Interactive Group	I continued onto the path	With the G1000 that I have. I was able to use the instruments and the MFD to keep myself situationally aware	I proabably would not because there were mountains in the area and you could easily crash into them.	75 Percent was making sure that I was in control of the airplane and making sure that I was not in any unsual attitudes or if my scan was not being
Interactive Group	I continued on and turned back at the last minute when visuals became zero.	I believed that I would be able to make the airport before the haze got too bad.	No, I would not because it was almost too late to turn back and would have been too dangerous if I had done so any later. I'd divert much sooner and	Flight controls - 60% Situational awareness - 40%
Interactive Group	Diverted	Weather was deteriorating - low ceilings kept me close to the ground, and the terrain (canals and mountains) was	Probably. In real life, I would probably have turned back altogether, but it's easy to be brave/foolhardy in a simulator.	Flight controls: 15% Weather: 50% Traffic: 15% Remembering how to talk to ATC: 20%
Workshop	Continued on	Visibility still acceptable, didn't lose ground reference at any time	Yes. Altitude is high enough to ensure safety and we can still see the ground	40% and 60%
Workshop	continue	I thought that I had 3 miles visibility and all of the sudden I got black out conditions. After I got into the soup I was afraid	No, would turn around at the first sign of poor visibility	80
Workshop	divert	The visibility was low and appeared to be worsening. There were few locations to land because of the water and	Yes, because flying into IMC as a VFR pilot would be hazardous, especialy in the vicinity of mountains.	20% flight controls, 80% situational awareness
Workshop	turn back with intention to divert to the 1st airport passed	Mountain pass with visibility dropping. Unfamiliar with area, not IFR current, really nice lights on the	Given the terrain, yes. If it was Indiana (flat, few obstructions) I might have gone a little further.	Flight controls, 30%. Situational awareness, 70%
Workshop	I was getting ready to do a 180 when the scenario ended.	I was going down in altitude. I was over the channel, so I was going to go to 1300 feet. If I could see, I was going to continue.	I would turn 180 degrees sooner.	In the second scenario, 40 to 50% was maintaining flight control. 25% situational awareness and 25% weather. In the first scenario, 25%
Workshop	Turn back	Poor visibility, lack of any traffic advisory.	Yes, because the visibility was very poor and dropping, so it made sense to go back to VFR weather	65-flight control/35-situational awareness
Workshop	turn back	Aftering turing from Hanes, the visibility is too low so that I have to abort the flight.	Yes. As the route is along the river and there are narrow flight channel, it is extremely hard to diverge in such terrian.	60% for flight control, 40% for situational awareness.
Workshop	divert	that air port was close and i was over half way to my destination	yes it was close and i think i could make it if not i would return home	50 flying 40 weather and 10 on the radio

In the New Mexico simulation scenario, did you divert, turn back or continue on?	Why did you make the decision that you made?	Would you make the same decision again, and why?	Using a percentage, how much of your attention do you estimate was dedicated to maintaining the flight controls? And to maintaining situational	Is there anything you would like the researchers to know about your simulation experience today?
Diverted	Loss of radar contact mixed with rapid visibility loss, with a closer airport available.	Yes, because even though I was about to make contact with an approach control, I felt more comfortable getting to an airport faster, in case of further deterioration of visibility.	30% controls, 20% traffic, 50% weather.	The experience was very informative, and allowed me to realize how I would act in situations that I do not normally face.
Turn back	Cant see clearly.	Yes. I think safety is my toppest priority	50% and 50%	I have not flown airplanes for a while. Many things about flight that I have forgotten, such as call signs. Also, I have never used flight simulators before and am not familar with the navigation equipment at all. So when I was flying the sim, I was not that comfident to use
Divert to Sandia East	Reduced visibility near mountains.	Yes, because of the poor visibility and proximity to the mountains	50-50	I perfomed this to the best of my abilities as a VFR pilot.
No. I never think about turning back since I think I was still on the right track. Also, the surface conditions is not mountainous, which makes me more comfortable about my current condition	As mentioned above, I'm comfortable with the surface condition, so I did not turn around.	Yes. Since the situation haven't gone so bad that I have to give up my destination.	50 percent. The surface condition makes me less worried about hitting the mountains, so I paid less attention on the altitude, and spend more time looking outside.	For the New Mexico scenario, there is no visual reference for the cement plant checkpoint. So maybe add something there.
I continued on.	Although there was turbulence, there was little indication that visibility would be as low as it was, and I was in contact with ABQ approach (flight folowing).	Yes, I would have listened to ATIS sooner.	Almost all of it, again because I wasn't familiar with the G1000 or the airplane. I wouldn't have made this flight in real life.	I wish I knew what I was doing or where to find things on the G1000. I enjoyed it because it made me realize I need to have a better understanding of the weather since it plays such a large role in general aviaiton. This will serve as a motivator for me to gain better
continue on	I forgot to turn back.	NO. It's danger.	60% control 40%situational awareness	Nice test, I'll remember turing back when going in to IFR.
Divert	Pushed on for a bit as reports were VFR flights making it in. But just because they can do it, doesn't mean I can.	Yes, not worth the risk	90%	Good expereince, thanks for the opportunity to fly
Did not finish scenario	Did not finish scenario	Did not finish scenario	Did not finish scenario	Possibly provide paper copy of flight plan to reference frequencies, airport identifiers etc. There was confusion with lack of familiarization with the G1000 and the different areas flown and quickly frustrated me, particuarly in the second scenario.
Turned back and diverted to Sandia	Mountain obscuration which appeared worse once I was in the pass.	Would have been better to turn back sooner. New to a simulator, a cessna, and a glass panel and no physical input and in that scenario I approached a stall while turning back.	50/50	Challenging due to my experience limitations with sim, type, and glass panel but great practice anyway!
i diverted	brcause i don't want to crash	yes, because i want to survive	50% each	it was great
Diverted to 1N1	I wasn't sure of my visiblity and at the position I was at I was getting funnelled into a higher traffic area and did not want to be going there in low vis.	Maybe, I may have been a little over-cautious in terms of my visual sight of weather. If I was more familiar with the area and the aircraft I may have continued on with the assisitance of vectoring from KABQ approach	In this flight about %20 percent of my attention was on the controls as the turbulence did not concern me much. About %30 was to comms, and the rest %50 was to navigation	negative..
I divert to 1N1 after reaching highway 40 that I couldn't see	I lost visibility once past the mountains when reaching highway 40. I contacted Albuquerque approach who said 1N1 was VFR. When pushing on nearest I also realized that Albuquerque was IFR and 1N1 VFR, which confirmed what ATC said and I	I hope I would see that Albuquerque is IFR when clicking on nearest before and divert to 1N1 before I reached the mountainous terrain.	At the time I was trying to find an alternative airport, maybe 50/50 as I tried to find other options but in the meantime I had to maintain my visual on the close terrain. I didn't know where the 2 nearby airports where in relation to my location so at first I wasn't sure which	I would not have taken off in the first place. I'm a low experience pilot and I know my limitations are pretty low. In the Alaska scenario, there was forecast for overcast at 1000, I would not fly in such a weather in flat Indiana, so no way I fly that in mountain and canal
I continued on because the visibility was not too extreme and I would rely on ATC to vector me to the airport or divert in case I was not able to make it to ABQ	I made the decision that I made because I felt that I was capable of following the flight plan and making sure that I maintained safe flight conditions.	If I were to do this next time I would have diverted to another airport that was reproting VFR conditions. Flying in low visibility is not safe and it can be stressful as well.	For this scenario it would have to be 50-50 for both. The visibility was not that extreme in this scenario and spent a lot of time making sure I was listening to ATC and maintaining stable flight.	I thought it was awesome and it makes me want to get checked out in a Cessna 172 and fly it!
I turned back and would possibly have diverted had the simulation gone longer.	The weather was starting to get worse, and I did not want to take chances like I did with the Alaska simulation.	Yes, I would make the same decision because the costs of turning back or diverting outweighed the risks that would have been taken had I gone on. I might even divert earlier given if I had to make the decision again, simply because of safety.	Flight Controls - 60% Situational Awareness - 40%	It was a really great experience to fly in the simulator. This was my first time in one, and obviously it felt very different from flying an ordinary aircraft. Since I have only flown in a Cessna aircraft twice before, some of the controls still felt alien to me, but that could only
Turn back.	Weather was deteriorating rapidly and I was flying into rising terrain.	I would probably turn back sooner. It was stupid to imagine that the weather would improve when it was clearly deteriorating.	Flight Controls: 15% Traffic: 0% (since ATC informed me there was none) Weather: 60% Talking to ATC: 25%	I feel like I was handicapped a bit by being in a very unfamiliar environment (glass panels), and definitely out of my comfort zone in terms of the weather scenarios. I am a leisure/recreational pilot and as such I try to avoid flying when the weather is inclement.
Continued on	Called flight following, altitude enough to ensure safety and I could still see the ground.	Yes. Visibility is fair, but I don't lose ground reference and maintain sufficient altitude to ensure safety. I'll only divert or turn back if the visibility condition deteriorates.	35%, 65%	Flying a simulator is a little bit harder than flying a real plane because we can't feel the movement and all our organ feelings are limited to visual inputs. Also the simulator seems to be more sensitive than a real aircraft so we need to make subtle movements
turn back	After my first flight I knew that things could turn bad quickly, therefore decided to turn back	Yes, learned that bad visibility gives you very little good options and of course breaking VFR flgiht rules	80	It was great and I learned I need to continue to learn more about weather.
divert	The visibility was low and worsening. There was some turbulence and reports of mountain turbulence near ABQ.	Yes, because flying into IMC as a VFR pilot is very hazardous.	20% flight controls, 80% situational awareness	negative
turn back, didn't have a divert airport in mind except for departure airport	Terrain warning and low visibility.	Yes. The visibility dropped rapidly and didn't know if it was just temporary. Also unfamiliar with the airport and area for weather that marginal	Initially 20% flight controls, 80% weather/traffic/terrain. After deciding to divert, then 80% flight controls.	Should have spent more time reviewing scenario/navigation plan/frequencies. If I had done the planning for my own trip I would have spent more time and would have been more familiar with the route/frequencies... Did like flying the sim though,
I was continuing on and decending to 7,500 feet	The airport is at 5,500. If at 7,500 feet I had visibility, I would continue.	Again, I think I would turn back sooner. I did not realize the visibility was dropping that fast.	In the New Mexico scenario, 40 to 50% flight control. 25% situational wareness and 25% weather.	They seemed to be very good sims. Very realistic.
Turn Back	Contacted the tower and they suggested that SAF had VFR weather	Yes. The tower has more info than me, and can give me better advice, and like in the other scenario, the probabality of getting VFR weather on the way back is greater.	65-35	The elevator was unusually sensetive and hence some of the weird clib/decents that happened.
No.	Immediately entering the airspace, I want to evaluate the situation further.	Probably not. As the situation turns bad, I will clear away from the Class-C airspace and maintain VFR.	The weather condition changes too fast. I use 40% for flight controls, 30% for contacting Approach, 30% for situational awareness.	If there is more weather information provided during flight, it can make the pilot evaluation the situation better.
divert	the other airport was away from the weather and it was close	yes i still need to get to my destination	50 flying, 40 weather 10 on radio	it was fun and i enjoied the training. i would also like to partisipate in more experiences

VITA

VITA

Julius C. Keller
Purdue University
Polytechnic Institute
School of Aviation and Transportation Technology
West Lafayette, Indiana 47906

EDUCATION

- **Doctor of Philosophy Degree in Technology**
  Purdue University, West Lafayette, Indiana, December, 2015
- **Master of Science Degree in Aviation and Transportation**
  Lewis University, Romeoville, Illinois, December 2011
- **Bachelor of Arts Degree in Aviation Aircraft Systems**
  The Ohio State University, Columbus, Ohio, August 2006

PROFESSIONAL EXPERIENCE

Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS)
Purdue University, Aviation Technology Department
Spring 2013-Present

- Team member on government funded collaborative research project pertaining to general aviation safety (VFR into IMC).
- Team member on government funded collaborative research project pertaining to general aviation safety (Midpoint Runway Markings to Prevent Runway Runoffs).
- Assists with project management, research design, data collection and analysis for purpose of reporting to the Federal Aviation Administration and publishing efforts.

Certified Flight Instructor, CFII, MEI
Purdue University, Department of Aviation Technology, West Lafayette, Indiana
January 2013-Present

- Conducts safe commercial flight operations according to Part 141 and SOP’s
- Operate Cirrus FTD’s according to SOP’s and Part 141regulations.
- Creates detailed records of training
- Teaches private, commercial and instrument discussion lessons
- Over 900 total hours with 375 hours dual instruction given
- 100% pass rate (7 signoffs)

Graduate Assistant
Purdue University, Department of Aviation Technology, West Lafayette, Indiana
August 2012 – Present

- Teach and co-teach undergraduate courses
- Create and execute syllabi according to accreditation standards
- Distribute grades while following FERPA regulations
- Assist with department functions
- Conceive, conduct and write detailed research analyses for publication
- Submit proposals to the Institutional Review Board (for human subjects research)
- Follow guidelines for conducting experimental research using human subjects

Graduate Research Assistant
Lewis University, Romeoville, Illinois
April 2011 to November 2011

- Analyzed data from research project
- Wrote findings in technical format
- Assisted in new findings and future research
- Submission for publication

Market Manager
Knight Transportation (Fortune 500), Joliet, Illinois
October 2010-September 2011

- Generated over $1 million in revenue while developing operation and marketing strategies
- Inside/Outside Sales
- Operations, planning and dispatching
- Account management and market pricing

Executive Assistant
LinMar, HR Solutions Plus, Matteson, Illinois
October 2009-October 2010

- Assisted in securing 20 clients and generating over $500,000 in revenue
- Wrote reports based on client needs and human resource practices
- Assisted Human Resource Consultants in day-to-day tasks by making travel arrangements, creating appointments, and organization of daily work

Certified Flight Instructor
International Airline Training Academy, Tucson, Arizona
May 2008-September 2008

- Provided international students with flight training in accordance to FAA Part 141 requirements
- Ensured safety of all flight operations
- Supervised student training in flight training devices

Certified Flight Instructor
Mesa Airlines, Inc, Mesa, Arizona
January 2008-April 2008

- Instructed flight training, simulator and ground training
- Supervised student testing
- Ensured safety in all student flight operations

Certified Flight Instructor
The Ohio State University, Columbus, Ohio
September 2007-January 2008

- Instructed degree seeking students in flight instruction
- Kept detailed training records in accordance to Federal Regulations
- Ensured safety compliance with all flight operations

First Officer
Caribbean Wings, Inc., Tortola, British Virgin Islands
March 2007-September 2007

- Assisted Captain with all flight duties
- Assisted passengers with international paperwork
- Operated Piper Navajo 310 under Part 135 regulations

Senior Collection Specialist
Discover Financial Services (Fortune 500), New Albany, Ohio
January 2001-March 2007

- Collected over $5 million dollars in potential loss revenue
- Trained new employees in accordance to policy
- Resolved account issues by negotiating payment arrangements
- Maintained calling queues and monitored efficiency

ADDITIONAL EXPERIENCE

Recruitment Camp Advisor
Purdue University, Office of Diversity and Recruitment
Summer June 2012-August 2014

- Led camp participants in College of Technology events
- Advised students on aviation, STEM and higher education
- Presented university statistics and financial resource information

Biometric Test Administrator
Purdue University, West Lafayette, Indiana
June 2012-August 2012

- Operated experimental equipment valued over $1 Million
- Assisted with gathering data from human test subjects
- Assisted in experiment project management
- Managed biometric equipment and software

LEADERSHIP, HONORS AND MEMBERSHIP

- D and M Lewis GEM Scholarship (2015)
- Purdue Graduate Teaching Award (2015)
- Purdue Graduate Student Government Proxy Senator (2014-2015)
- Co-founder of Global Aviation Leadership Association (2014-2015)
- Swengel Minority and Women Scholarship (2014)
- College of Technology Summer Research Award (2014)
- Organization of Black Aerospace Professionals (2013-Present)
- University Aviation Association Member (2013-Present)
- Graduate Research Symposium Committee Member (2013)
- University Aviation Association Second Place Virtual Poster Winner (2013)
- University Aviation Association Second Place Virtual Poster Winner (2012)
- President-Aviation Graduate Council (Purdue University, 2012-2013)
- The Ohio State University Aviation Scholarship (2006)

PUBLICATIONS & PRESENTATIONS

Refereed Journal Publications

Yu, W., Keller, J. C., Huang, C., Fanjoy, R.O. (In Submission). An Exploratory Study: the relationship between occupational stressors, coping mechanisms and job performance among Chinese aviation maintenance technicians. *Journal of Aviation Technology and Engineering*.

Adjekum, K. D., Keller, J.C., Walala, M. S., Christensen, C., Young, J.P. DeMik, R. J.& Northam, G. (2015). Cross-Sectional Assessment of Safety Culture Perceptions and Safety Behavior in Collegiate Aviation Programs in the United States. *International Journal of Applied Aerospace and Aviation, 2*(4), 1-36.

Keller, J.C., Wang, Y., Cooney, J., Erstad, A.E., & Lu, C. T. (2015). Cultural dimensions: A comparative analysis of aviation students in China and the U.S. *International Journal of Applied Aerospace and Aviation, 2*(3), 1-17.

Keller, J. C., Walala, M., & Fanjoy, R.O. (2014). Interaction of weather and other contributing factors in general aviation instrument approach accidents. *Collegiate Aviation Review, 32*(2).

Keller, J. C., Shila, J. J., & Lu, C. T. (2014). What does flight school security mean? A case study of university affiliated flight schools in the United States. *Journal of Transportation Security*, 1-12.

Fanjoy, R. O. & Keller, J. (2013). Flight skills proficiency issues in instrument approach accidents. *Journal of Aviation Technology and Engineering, 3*(1).

Refereed Journal Publications (continued)

Demik, R., Keleher, J., Kasak, N., Keller, J., Mazza, A & Raess, J. (2011). Lead memory in general aviation aircraft engine emissions. *Journal of Aviation Technology and Engineering, 1*(2), 74-79.

Peer Reviewed Presentations

Wang, Y., Keller. J. & Fanjoy, R.O. (2015). Chinese Aviation Maintenance Professionals: The relationship between occupational stresses, coping mechanisms and work performance. A Presentation at A3irCon. Phoenix, Arizona.

Keller, J.C., Walala, M. & Fanjoy, R.O. (2014). Interaction of weather and other contributing factors in general aviation instrument approach accidents. A presentation at the University Aviation Association. Daytona Beach, Florida.

Keller, J.C., Walala, M. & Fanjoy, R.O. (2014). Relationships between weather and other contributing factors in general aviation instrument approach accidents. A presentation at the 5th annual graduate research symposium. Lewis University, Romeoville, Illinois.

Fanjoy, R & Keller, J. (2013). Flight skills proficiency issues in instrument approach accidents. A presentation at the 4th annual graduate research symposium. Purdue University, West Lafayette, Indiana.

Demik, R., Keleher, J., Kasak, N., Keller, J., Mazza, A & Raess, J. (2011). *Lead memory in general aviation aircraft engine emissions.* A presentation at the 1st annual symposium, Lewis University. Romeoville, Illinois.

Workshops and Seminars

University Aviation Association Conference (2015). Cleared to Climb: Collaboration research between collegiate aviation and the Federal Aviation Administration. Salt Lake City, Utah.

University Aviation Association Conference. (2014). Exploration of Collegiate Aviation Recruitment and Retention Research. Daytona Beach, Florida.

University Aviation Association Conference. (2013). Globalization of Collegiate Aviation. San
Juan, Puerto Rico.

ACADEMIC TEACHING EXPERIENCE

Teaching

Purdue University

Aviation Technology	101 Introduction to Aviation (3 credit hours)

Co-Teaching/Teaching Assistant

Purdue University

Aviation Technology	102 Aviation Business (3 credit hours)
Aviation Technology	327 Advanced Operations (3 credit hours)
Environmental Atmospheric Sciences	325 Aviation Meteorology (3 credit hours)
Aviation Technology	254 Commercial Pilot Fundamentals (3 credit hours)

SERVICE WORK

- Carroll County Elementary Career Day, Flora, Indiana May 2015
- Purdue University Airport Fly-in Planning Committee April 2015
- Women in Technology Program Facilitator, Purdue University October 2014
- Youth Aviation Adventure, The Ohio State University Sept 2014
- Mentored at Risk Youth, Canyon State Academy, Queen Creek, Arizona Dec 2013
- Ace Camp, The Ohio State University, Columbus, Ohio July 2013
- College of Technology Team Camp, Purdue University June 2013
- College of Technology Total Camp, Purdue University June 2013
- Girl Scouts Simulator Event, Purdue University April 2013
- Flight One, Purdue University, West Lafayette, Indiana April 2013
- Mentored at Risk Youth, Canyon State Academy, Queen Creek, Arizona Dec 2012
- Reading Sessions J.C. Sommer Elementary School, Grove City, Ohio June 2012
- Aviation Conference, Lewis University, Romeoville, Illinois April 2011
- Ace Academy, Lewis University, Romeoville, Illinois July 2010
- Relay Race for Cancer, Homewood, Illinois July 2010
- Aviation Summer Camp, Lewis University, Romeoville, Illinois June 2010
- Mentored At Risk Youth, Canyon State Academy, Queen Creek, Arizona June 2008

RESEARCH INTERESTS

- General Aviation Human Factors, Collegiate Aviation Recruitment and Retention, General Aviation/Collegiate Aviation Training and Education and Part 141 SMS Policy.