PILOT KNOWLEDGE OF AUTOMATED FLIGHT CONTROLS:

IMPLICATIONS FOR DESIGNING TRAINING BASED

ON ADULT LEARNING PRINCIPLES

By

Matthew A. Wise

Bachelors of General Studies
Ball State University
Muncie, Indiana
1990

Masters of Science
Oklahoma State University
Stillwater, Oklahoma
1994

Submitted to the Faculty of the
Graduate College of
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
May, 2011

PILOT KNOWLEDGE OF AUTOMATED FLIGHT CONTROLS:

IMPLICATIONS FOR DESIGNING TRAINING BASED

ON ADULT LEARNING PRINCIPLES

Thesis Approved:

Gary J. Conti
Thesis Advisor

Lynna J. Ausburn
Committee Chair

Mary N. Kutz

Steven K. Marks

Mark Payton
Interim Dean of the Graduate College

Table of Contents

Table of Tables

Table of Figures

CHAPTER 1

INTRODUCTION

Airline Industry

The year was 1903; on December 17th the first powered flight was completed in Kitty Hawk, North Carolina, on a wind swept sandy beach.

> At 10:35 a.m., Orville moved his right hand; the line released and the Flyer moved forward, Wilbur running along the right side, able to keep up in the twenty-seven-mile-per-hour wind that slowed the Flyer down but also helped it get airborne. Orville had not gone down the track more than forty feet when the Flyer lifted off and John Daniels snapped the shutter. Wilbur had halted as the Flyer swept by. (Boyne, 2003, pp. 2512-2519)

The 12-second 120-foot flight forever changed the course of aviation history. In just over a 100-year time span, powered flight has developed from a dream of two brothers skilled in bicycle repair to the development of transcontinental aircraft spanning twice the length in aircraft size of the very first flight distance.

Aviation has evolved through improvements in technology, workforce production, and manufacturing. Historically, the greatest advancements in aviation have been produced through the processes of world wars. During wartime, a nation's economic resources are diverted to assist the country's cause. "Warfare always acts as an accelerator for development, and the largest conflict in the history of mankind prompted unprecedented leaps forward" (Woolford & Warner, 2009, p. 40). The post war era of WWII created mass production capability for aircraft and a workforce enabled to produce and fly aircraft. The military produced, trained, and created qualified pilots that were capable of easily transitioning into commercial airline aircraft.

Through the decades, the flying passenger has benefitted from the government's deregulation of airlines and the opening of different route structures (Woolford & Warner, 2009, p. 51). This created the opportunity for new start-up airlines thus providing competition among the existing air carriers to reduce the costs of ticket prices and allowing greater frequency of flights from additional airports. Air travel that was once reserved for the rich became available for all to benefit.

Today's commercial airlines have created an industry that supports the U.S. commerce by transporting economic goods as well as providing an infrastructure for air travel and freight shipping. The airline industry is a highly structured and complex business model where the fate and survival of an air carrier depends upon the economics of world markets and the uniqueness of a company's culture to support the airline.

Pilot Training

Due to the potential risks involved with air travel, the airline industry has developed training procedures that are governed and sanctioned by the Federal Aviation Administration (FAA). The FAA creates regulatory procedures, sets flight training standards, and establishes a framework of safety guidelines. Pilots are in a highly regulated and structured environment because of inherent safety concerns involved with flying. As a result, a structured and regulated system has been put in place to administer pilot training. Major airlines have training departments that typically utilize three phases of training: ground training classrooms, flight training simulators, and in-flight observations. The ground training segment usually contains teacher-centered lecture material that covers various aspects of the particular type-specific aircraft and company operational procedures. The flight training simulators are needed to complete flight scenarios that emulate normal and non-normal procedures that are created to allow the training pilots to practice each procedural task to a set standard. The level of simulated flight motion and simulated visual displays allows for a realistic emersion of pilot training to occur. The final phase of training pilots consists of observed flight procedures from actual flights with passengers onboard from company-approved training personal (typically called a check-airman).

All flight and ground training that includes simulator training that is administered by an airline requires approval by the FAA. The training consists of documented procedural tasks that are administered by the airline's training personal. This training is structured in a manner that allows for the completion of each task in a manner that complies with an FAA regulation and/or company procedure.

Airlines provide training for their employees on a reoccurring basis, for any new-hire employee, and for employee transition from one aircraft to another. During times of peak hiring, an airline may experience an average of 15 new-hire pilots per month at their training center. Typical new-hire training events are scheduled from 5 to 6 weeks in duration. A recurrent training event will generally be a 2 or 3 day event. Because financial concerns are extremely critical to an airline, airlines have limited resources to dedicate towards training pilots. While an airline cannot operate without well-trained and qualified pilots, there is a point at which a cost-benefit analysis is completed internally at an airline's training department to justify the time and cost of ground, simulator, and flight training that is involved to produce a set level of standard in pilot training.

The typical airline training model of ground-based lecture, flight simulation, and flight instruction during actual flights is the traditional method of training pilots and has not changed in decades of airline training operations. This training model has its roots based in military training.

The typical pilot training by the airlines has been influenced not only by the military but also by a system implemented by the FAA to standardize all pilot training. As a result, decades of airline training have been taught from a behaviorist perspective of a highly structured teacher-centered approach with minimal learner-centered involvement. In a behaviorist approach:

> The roles of teacher and learner are quite defined in the behaviorist framework. The ultimate goal of education is to bring about behavior that will ensure survival of the human species, societies, and individuals. The role of the teacher is to design an environment that elicits desired behavior toward meeting these goals and to extinguish behavior that is not is not desirable. (Elias & Merriam, 2005, p. 93)

While this behaviorist approach to training may be conducive to the rote knowledge needed by pilots, pilots are asked to perform multiple tasks and to apply decision-making skills to various dynamic flight environments. While this teacher-centered method of delivering highly technical content may function to disseminate information to pilot groups in training, the National Transportation and Safety Board sites numerous airline incidents and accidents resulting from pilot error. This suggests that the current training may not be fully accomplishing its objectives and that additional perspectives need to be considered for pilot training. One such perspective is adult learning theory with its learner-centered approach that allows for reflective practice and metacognition in training among pilots. Such an approach could be the basis for a curriculum for developing problem-solving and application-based pilots.

Adult Learning

Adult learning and the way adults go about learning has been a topic of research for many decades. There has been no single theory or concept that has explained the processes by which adults learn. “What we do have is a mosaic of theories, models, sets of principles, and explanations that, combined, compose the knowledge base of adult learning. Two important pieces of that mosaic are andragogy and self-directed learning” (Merriam, 2001, p. 3).

Both foundational elements of adult learning support a learner-centered approach to the teaching-learning transaction. Andragogy refers to a set of assumptions proposed by Malcolm Knowles (1970) that deal with how adults learn. These assumptions describe an independent learner who is in constant development and who reflects on experiences for new learning to address immediate problems in real life. "Being self-directing means that adult students can participate in the diagnosis of their learning needs, the planning and implementation of the learning experiences, and the evaluation of those experiences" (Merriam & Caffarella, 1999, pp. 272-273).

In a learner-centered approach, the focus is on individual differences (McClellan & Conti, 2008, p. 14). There are several ways of identifying individual differences in learning. One approach is to identify a learner's learning strategy preference. Learning strategies refer to the various ways that an individual goes about learning a specific task (Fellenz & Conti, 1989, p. 7).

Experiences play a key role in adult learning. In his foundational work on adult education, Lindeman (1926/1989) pointed out that a central function of adult learning is identifying one's meaningful experience and making sense of them. This is a reflective process which has been referred to as metacognition, which is thinking about how one thinks.

Problem Statement

Problem

A major airline had collected institutional data related to the knowledge level of automated flight control (AFC) of its pilots. However, this data had only received a cursory analysis. In order to development meaningful training programs for the pilots related to automated flight control, this data needed to be thoroughly analyzed.

<u>Background of the Problem</u>

To get technical assistance with a research study to gather the knowledge they desired, they contacted Matt Wise, who was in a doctoral program at Oklahoma State University. Wise is also an experienced commercial airline pilot with extensive experience with automated flight control. In addition, Wise had indicated to the airline that he had additional support for a study from the members of his doctoral advisory committee. Through a series of electronic messages and direct conversations, Wise volunteered his assistance and that as needed from committee members.

As a result of this cooperation, data were collected to provide information about the knowledge level of automated flight control of the pilots at the airline following the initial stage of training. An instrument was developed and validated for this data gathering. Data were gathered to provide information for decision making related to training. It was made clear by the research team that this was not a study about the competency of the pilots. Rather, it was an assessment of the current knowledge level of the pilots related to their needs for training related to automated flight systems. The purpose of gathering this information was to inform the airline's training department and was not to be used to make judgments about the pilots.

An initial analysis of the data was conducted to provide a general overview of the knowledge level of the pilots related to automated flight control. This information was provided to the continuous quality control team.

In order to use this data as a basis for designing training for automated flight control, an extensive analysis of this data was needed involving not only descriptive statistics but also including univariate and multivariate analyses. This information is needed to develop a training program that is based on the needs of the pilots. Without this additional analysis, the training program will remain generic and not tailored to the pilots.

Purpose

The purpose of this study was to analyze the institutional data collected by a major airline on their pilots related to automated flight control. These analyses were used to provide the airline with a detailed profile of the knowledge level of their pilots related to automated flight control and to provide recommendations for training activities for training related to automated flight control. The concept of automated flight control was measured by a 30-item instrument developed for this study. The concept of learning strategy preference was measured by Assessing The Learning Strategies of AdultS (ATLAS).

Research Questions

The data analysis will be guided by the following research question.

1. What is the knowledge level of automated flight control of the airline pilots?

2. What factors make up the airline pilots' knowledge of automated flight control?

3. What is the relationship between the pilots' knowledge level of automated flight control and selected demographic and professional variables?

4. What is the learning strategy profile of the airline pilots?

5. What is the relationship between the pilots' learning strategy preferences and selected demographic and professional variables?

6. What naturally-occurring groups exist among the airline pilots related to their knowledge of automated flight control?

The institutional data were collected to answer these questions had been gathered via the Internet. The data were analyzed using the following procedures:

Question	Data Source	Procedure
1. Knowledge profile	Knowledge survey	Frequency distributions
2. Factors in automated flight control	Knowledge survey	Factor analysis
3. Knowledge level and demographic variables	Knowledge survey	Analysis of variance
4. Learning strategy preference profile	ATLAS	Frequency distributions and chi square
5. Learning strategies, preferences and demographic variables	ATLAS and demographic survey	Chi square
6. Naturally-occurring groups among pilots	Knowledge survey	Cluster analysis and discriminant analysis

Conceptual Framework

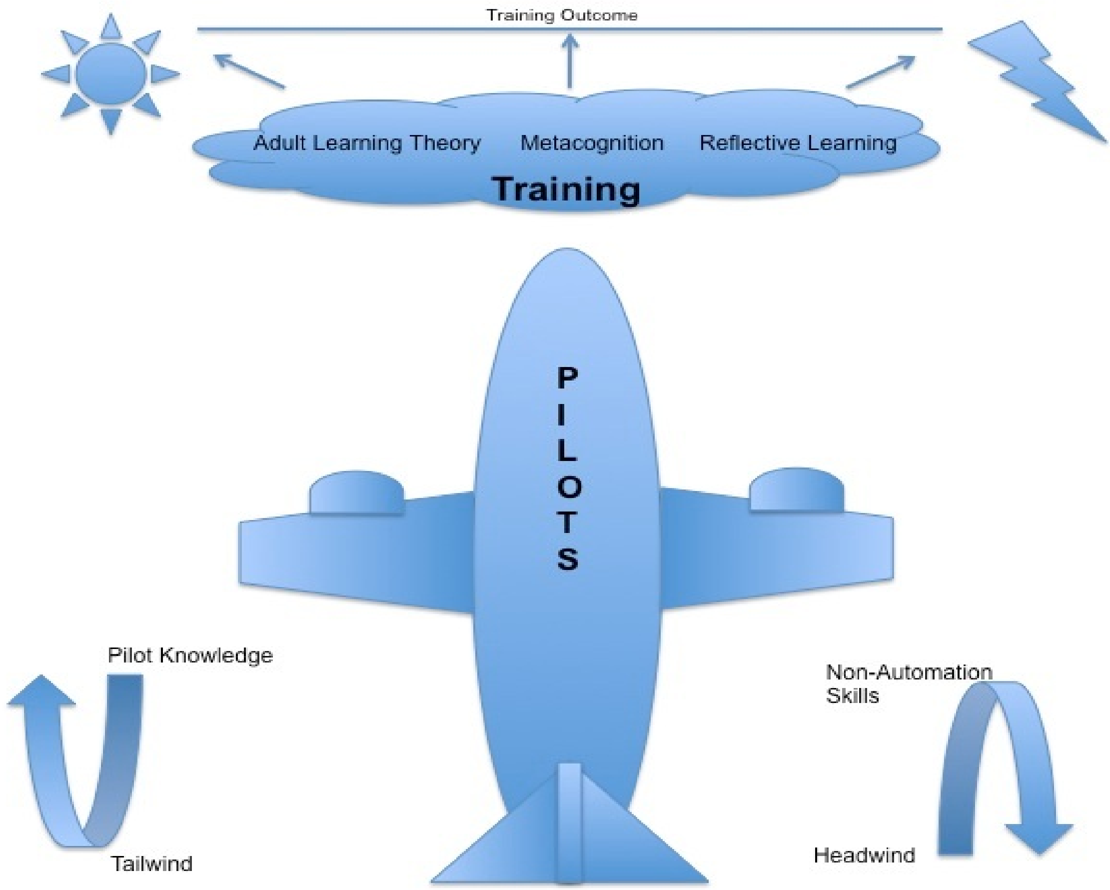
The theoretical/conceptual framework assists and guides a study through theory-based content to develop a strategic supporting outline for the study to be completed.

> One way to help you identify your conceptual or theoretical framework is to attend to the literature you are reading related to your research interest. Reflecting on the literature and developing a list of propositions about your research problem will help you identify the predominant theories and concepts that have emerged over a period of time. (Gay, Mills, & Airasian, 2009, p. 429)

This study deals with the aircraft automaton knowledge level of pilots at a major airline. The results of this study can assist the airline in assessing their pilots overall knowledge level of flying aircraft on automated flight systems after an initial stage of training. This airline has invested a large amount of money to equip their fleet of aircraft with automated flight control systems, establish training procedures, and prepare their internal training department and pilots for the next generation of flight in automated aircraft.

The concepts that are involved in this study are displayed graphically in the form of an aircraft (see Figure 1). The aircraft contains a flight crew of two pilots flying through the depicted cloud. The cloud represents the filter of training that the pilots receive at the airline training center. Pilots are required to receive initial and recurrent flight training via ground school and simulator training events on a regular basis. The cloud depicts the three concepts of the study that the pilots would receive in their training events at the airline. The concepts are Adult Learning Theory, Metacognition, and Reflective Learning. Above the cloud is a Likert-type scale of learning outcomes. The scale ranges from clear skies and sunshine to represent positive training outcomes to thunderstorms and lightning to represent negative learning outcomes. The lower left and right corners of the diagram show tailwinds and headwinds respectively. The tailwinds are advantages in training such as previous pilot knowledge in automated aircraft, the airline’s commitment to training in automation, and the pilot’s willingness to accept training. The headwinds are the obstacles to overcome in training such as the lack of previous automated flight system knowledge that the pilot may have experienced prior to working for the airline. The diagram was created as a result of comments from a pilot survey from a random sample of pilots that represent the airline.

Figure 1: Conceptual Framework for Study



Adult learning theory concepts may assist the airline in understanding their pilot group to create training programs. The self-directed adult learner that the airline has flying the aircraft may embrace the concepts that are offered within adult learning theory.

A model of how pilots learn and train may be created at the airline to develop a reflective practitioner within the pilot. Pilots may transition into becoming self-directed and problem-solving learners who apply their knowledge gained from training to their profession.

Pilots are in a highly regulated and structured environment because of obvious safety concerns. Aviation training will always be governed and regulated by the FAA, and the airlines will have mandated procedures and regulations with which to comply. The airline could benefit if training moves away from a strictly behaviorist approach and integrates a humanistic approach to training pilots. A result of restructuring airline training may produce a learner-centered training curriculum that utilizes adult learning theory practices, metacognitive concepts, and allows for reflective practice in training among pilots. This new shift in airline training methods may allow pilots to develop learning abilities beyond a knowledge level of rote understanding and create a problem-solving application based pilot. In addition to the findings from the data collected from the pilot survey at the airline, several pilots provided written comments. These comments provided insights that give meaning and understanding to the needs of the pilot group. These comments showed that the pilots were adult learners who vocalize a demand for the application of adult learning principles in their training.

Assumptions

The validity of any research study may be affected or threatened by the assumptions, limitations, and delimitations of the study. A research assumption is "an assertion presumed to be true but not actually verified" (Gay, Mills, & Airasian, 2009, p. 109). A research limitation is "an aspect of a study that the researcher knows may negatively affect the results or generalizability of the results but over which the researcher has no control" (p. 603). A definition of delimitation is "to establish the limits of" (Anderson, Forston IV, Kleinedler, & Schonthal, 2007, p. 230). The delimitations refer to situations where the researcher imposes limitations within the research design.

This study with the airline is based on four assumptions. They are as follows:

1. All pilots want to learn to fly with automation.

Rationale: The pilots at the airline are professionals and are involved in continuous training events to maintain mandated Federal Aviation Administration (FAA) currency requirements. The training is directly related to their job description and duties as a pilot for the airline.

2. Competency in automation can be learned.

Rationale: The pilots at the airline are adult learners who have a willingness to learn and gain knowledge within their career field. Other major U.S. air carriers possess aircraft that are flying with full levels of automation. This demonstrates that pilots are capable of being trained on automated equipment.

3. Competency in automation can be measured.

Rationale: Automation procedures may be applied to current tasks that are currently being measured by FAA required recurrent training. Valid testing instruments may be designed to measure pilot knowledge of automation.

4. Data related to the competency of automation can be accurately collected via the Internet.

Rationale: U.S. air carriers, which currently utilize automation, test and obtain pilot knowledge competency via on-line computer based training modules. The

Internet provides an environment to post testing modules and obtain accurate outcomes from instrument surveys.

CHAPTER 2

LITERATURE REVIEW

The Airline Industry

Development of Flight

The early drawings of Leonardo da Vinci created around the year 1500 depicted winged flying machines based upon observations of birds in flight (Millbrooke, 1999, pp. 1-4). However, the first air flight came with balloons. The fascination of flight and the development of lighter than air balloons furthered the advancement for inventing machines that are capable of traveling through the air. In France in the late 1700's, two brothers, Joseph and Etienne Montgolfier, experimented with small bags called "balons" (Crouch, n.d.). They discovered that the bag would expand and become airborne if held over hot air from a fire. The brothers created, built, and tested various models, which lead to their first public launch of an ascension of a balloon in 1783 (Millbrooke, 1999, pp. 1-7). "Etienne suggested this new machine might be used to transmit communications, to conduct scientific experiments, to carry people, drop bombs, or transport goods" (p. 7). "In the process, Etienne became the first person to fly, the first aerial pilot, the first airman" (p. 7).

As years pasted, ballooning was adopted within the

United States and in the mid-1800s a world distance record was set by aeronauts John Wise, O. Gager, and John La Mountain when they piloted a balloon from St. Louis to New York completing a 809 mile journey. This world record was held for over 60 years (Millbrooke, 1999, pp. 1-19). John Wise was a prominent balloonist in the United States who made balloons, barnstormed, and taught both men and women in becoming aeronauts in balloons. The crossing of the Atlantic Ocean in a balloon was the great challenge for balloonist in the mid 1800s. A reporter for the New York Sun falsified a report as a joke on the newspaper and the public that a manned balloon had made the crossing of the Atlantic Ocean. That reporter was Edgar Allan Poe. Although many attempts were made to cross the Atlantic, the journey was not completed until 1978 when the 5-day transatlantic flight was completed successfully.

For over a century, aviation was composed of lighter-than-air machines (Millbrooke, 1999, pp. 2-4). The early 1900s ushered in the creation and advancement of heavier-than-air machines. Leonardo da Vinci's drawings depicted theoretical heavier-than-air devices designed for flight. His designs and creations remained undiscovered for others to benefit from until they were published in the later part of the 19th century. Therefore, his later drawings of more practical fixed-wing gliders were not available to influence others in the early years of ballooning. Two devices that were predecessors to the various forms of lighter-than-air machines were the 1st Century Chinese kite and the ancient Roman windmill. The kite was to later emulate the flying wing, and the windmill was to be reinvented into a propeller. These devices were to become critical components of the fixed-wing flying machines that were to forever change the course of aviation.

Wilbur and Orville Wright were self-directed and externally motivated in their actions to discover, invent, and further the concept of heavier-than-air flight. They were sons of a respected minister form Dayton, Ohio (Bilstein, 2001, p. 10). They gained a local respectable reputation in their hometown of having an inquisitive and inventive spirit, and they were well known for their accomplished design and manufacturing of quality bicycles (p. 10). The brothers never attended a university; however, they pursued their interests in managing their Wright Cycle Co. in which they utilized the company's profits to fund their true love, aviation (Woolford & Warner, 2009, p. 6). They created and tested various forms of fixed-wing designs that they mounted on the front end of a bicycle (p. 6). Meticulous measurements where taken from their experiments and from their homebuilt wind tunnel to produce a glider wing with control surfaces which they tested and flew with great success (p. 6). Propellers were designed, and a lightweight motor was created that weighed only 180 pounds and produced 12 horsepower to complete the Wright Flyer (pp. 6-7). The Wright brothers chose the coastal region of Kitty Hawk, North Carolina, for their first flights because it is a geographic location that produces consistent high winds that would be desirable to assist their flying machine to become airborne (p. 6). On December 17, 1903, Orville Wright made history as he flew the world's first powered fixed-winged flight lasting 12 seconds and covering only 120 feet (p. 7). John Daniels joined the Wright brothers in their history-making event as he took the photograph of the Wright Flyer airborne, documenting the flight for the world to see. The historic event was practically ignored for almost 5 years (Bilstein, 2001, p. 12).

Airline Industry

The years that followed the Wright brother's flight created interest in aviation among those attempting to build and fly aircraft (Millbrooke, 1999, pp. 3-28). In 1913, Katherine Stinson flew a Wright Model B aircraft at the Montana State Fair in Helena to become the first female American to fly US airmail. However, progress was slow to develop within the aviation industry due to the restrictions placed upon aircraft designers from the Wright brother’s aircraft patents. The Wright brothers themselves were diverted from designing aircraft due to the extensive time involved in battling their patent litigations. These patents were enforced to a lessor degree within the European aviation community allowing for a greater development in aircraft technology within Europe. As concerns of a World War approached and demands increased for the government to assist Europe positioned, the military became a major driving force for aircraft development within the field of aviation.

During the First World War, the aeroplane developed into an effective an reliable machine used by the military for reconnaissance, artillery-spotting, air-fighting, ground-strafing, and tactical and strategic bombing (Woolford & Warner, 2009, p. 18). These roles would continue throughout subsequent conflicts. Aircraft and airships were also used at sea by naval air services. Airships, particularly non-ridged airships or blimps as they became known, together with flying boats were used for long-range reconnaissance and increasingly important anti-submarine work. In 1918, the British Royal Air Force had nearly 300,000 troops and was the first air force to be created and operated separate from a navy or army (p. 19).

The creation of the long-range bomber gave the air forces their main independent strategic mission. It was the arrival of these large aircraft that also lead to the development of commercial aviation as well as the destruction of European and Japanese cities from the air in the Second World War (Woolford & Warner, 2009, p. 19).

Following World War I, aircraft were geared to a more peaceful civil aviation need with passenger carrying aircraft designed from military airplanes (p. 22). Post-war civil aviation benefitted from the wartime production and aircraft development.

World War I was a huge stimulant to the aviation industry. It created a demand for aircraft that far exceeded the prewar capacity of the industry. Government contracts subsidized the expansion of the industry (Millbrooke, 1999, pp. 4-37)

Aviation efforts and interests turned to the development of long-distance air travel (Millbrooke, 1999, pp. 5-4). The Atlantic Ocean was crossed for the first time in 1919 in a U.S. Navy NC (Navy/Curtiss aircraft) via several stops on a journey from Rockaway, Long Island, New York to Plymouth, England (pp. 5-7). Two British aviators via a non-stop flight accomplished this journey later that same year (Woolford & Warner, 2009, p. 21). A solo flight was soon accomplished that lasted over 33 hours and covered more than 3,600 miles when Charles Lindberg flew his aircraft, called the Sprit of St Louis, across the Atlantic Ocean departing from an airfield near New York and landing in Paris (p. 24). This solo flight made Lindberg famous. "Showered with honours and idolized by millions, he was one of the twentieth century's first celebrities. In the late 1920s and 1930s he helped to promote the rapid development of US commercial aviation" (p. 24).

Beginning with the U.S. Air Mail Service, organized by the government in 1918, air mail became an important element of American business communications. When the government established contract mail routes with commercial carriers in 1925, the airline industry began to flourish, and eventually it acquired large aircraft suitable for passenger transport (Bilstein, 2001, p. 41).

Legislation passed by Congress in 1925 allowed for government mail contracts to be awarded to private air carriers through the United States Postal Service. Contracts were granted based upon completive bidding (AvStop.com, n.d. a). The postmaster general during President Coolidge's term desired for the airmail carriers to increase their route structure and purchase bigger aircraft. He granted the contracts to the largest carriers with large airplanes, which carried more mail by volume and allowed for the carriage of more passengers. This allowed for an expanding air carrier industry within the field of aviation. From the US Army Service creating the first scheduled airmail service to the restructuring of the transcontinental airmail route structure by the US Postal Service, various pieces of government legislation stimulated the development of this airmail infrastructure and network over commercial aviation operators (Woolford & Warner, 2009, p. 28).

In 1926 the Air Commerce Act created federal aviation regulations with oversight for the safety of aircraft, for airmen certificates, for establishing air traffic rules and regulations, and for creating a safer environment for the flying public (AvStop.com, n.d. b). The legislation allowed for the creation of new airfields and for the implementation of navigational facilities and airways. These new rules were defined as the Civil Air Regulations, which are known today as the Federal Aviation Regulations.

The Airmail Act in 1930 restructured how the US Postal Service granted mail contracts thus removing the opportunity for companies to make competitive bid for mail routes (AvStop.com, n.d. c). This legislation transformed the air carriers in the industry consolidating the mail routes.

Three air carriers transformed from the mail routes were Transcontinental and Western (TWA), northern airmail route (United Airlines), and American Airways (American Airlines).

By the late 1930s, the flying public had access to flight cabins with heat and soundproofing, in-flight meals served from stewardesses, and relative safety in flying due to the advancement in aircraft technology and a safer air transportation infrastructure (Woolford & Warner, 2009, p. 29). The development of private aircraft in the 1930s allowed for individuals to complete flights of great distances, furthering the public's fascination with aviation. Oklahoma native, Wiley Post flew his Lockheed Vega, Winnie Mae, around the world twice, Howard Hughes completed his journey around the world in 1938 (Millbrooke, 1999, pp. 6-15).

World War II redirected nations industries and resources to the development of their military needs (Woolford & Warner, 2009, p. 40). Warfare always acts as an accelerator for development, and the largest conflict in the history of mankind prompted unprecedented leaps forward. Aviation was greatly affected by the war and saw developments such as the appearance of the jet engine, radar, rockets, and nuclear weapons (p. 40).

The war created advancements in aircraft technology and an advanced communication and navigation network (Woolford & Warner, 2009, p. 42). The post-war era began with a workforce skilled in aircraft development and assembly ready to divert their efforts to producing commercial aircraft (p. 42). The war produced skilled pilots and ground support personnel as well as airfields around the world that were ready to be deployed within the commercial airline industry (p. 42).

The 1950s ushered in the era of the jet engine within the commercial airline industry with the development of the British de Havilland Comet as the first turbine powered aircraft (Spenser, 2009, p. 196). By the late 1950s, the Boeing 707 and Douglas DC-8 aircraft entered the commercial aviation market (p. 196). The Boeing 727, Boeing 737, and the Douglas DC-9 aircraft were introduced in the decade of the 1960s (p. 196). Passengers benefitted from reliable and efficient jet travel as the airline industry developed safer aircraft, which provided a new era of glamour for those who could afford to fly (Woolford & Warner, 2009, p. 50).

The airline industry was faced with financially difficult world economic circumstances making it hard to flourish in the 1970s (Woolford & Warner, 2009, p. 51). Competition was created within the traditional air carriers as the US government allowed for the opening of routes to smaller air carriers (p. 51). "With the advent of deregulation, airlines were free to fly to destinations that would be determined by market demand instead of government regulators" (Millbrooke, 1999, p. 100). Smaller start-up airlines like the airline were able to prosper as a result of re-organized route structures.

During the 1980s and 1990s, there were improvements to the development of aircraft and minor refinements within the airline industry (Woolford & Warner, 2009, p. 51). Flying became less of a luxury and more of a common means of transportation for the airline traveler (p. 51). Low cost air carriers such as the airline prospered amid the legacy air carriers that were stricken with high operating costs.

In the first decade of the 21st Century, aviation witnessed the horrific events of terrorism as commercial aircraft were utilized to attack the United States of America. The industry saw consolidation through mergers as airlines vied for competitive routes and customer market share. Thus, in just over a 100-year time span, aircraft have developed from a few seconds of flight to over half-a-day journeys around the globe shrinking the world in which we live.

Airline Training

The primary operational goal within the airline industry is safety. For example, despite the various elements of the airline Airline's unique culture, Colleen Barrett emphasis that "safety is first" (Blanchard & Barrett, 2011, p. 91). The industry experienced improvements in safety through the later half of the 20th Century by technological advances in aircraft design, equipment reliability, and training (Dismukes, Berman, & Loukopoulos, 2007, p. 1). For example, among the numerous advancements in aircraft design has been the development of composite aircraft components. These components were utilized in the construction of Boeing's new 787 aircraft creating structurally stronger, fuel-efficient, and lighter aircraft than those that were produced through the 1960s (AvStop.com, 2011b). The reliability of the aircraft equipment and the modernization of the aircraft systems have advanced through the years eliminating the traditional third flight crewmember, the flight engineer. The flight engineer was utilized to complete various operational tasks that now are completed automatically by advancements in reliable systems. However, with the enormous amount of technology that has been produced to provide a safer environment for the airline industry, there is nothing more critical than a well-trained, well-qualified flight crewmember. "According to National Transportation Board (NTSB) statistics, in the last 20 years, approximately 85 percent of aviation accidents have been caused by 'pilot error'" (Federal Aviation Administration, 2009, p. v). Therefore, airlines have developed training facilities that are designed to produce safe, well-trained pilots to fly for their respective airlines. These training facilities are comprised of a dedicated group of airline employees both current line-pilots (active flying pilots) as well as retired pilots from the company and within the airline industry. the airline's training department sets forth company procedures and policies that are mandated and required by the Federal Aviation Administration (FAA) in order to become certificated as a passenger flying airline. These procedures and policies are outlined in great detail within various forms of the airline's training manuals and the specific aircraft manufacture's operation manuals. One such company manual is the Flight Operations Manual (FOM). This manual contains a multitude of sequenced procedural tasks, company rules, and FAA regulations with which all pilots must comply. The overall goal of the airline's training department is to produce a well qualified, safe, and company-standardized pilot. Standardization is a critical component within the airline-training environment.

Cockpit tasks are highly proceduralized. The steps of each task are described in detail in the FOM, and pilots are expected to preform these tasks in a standard manner and sequence. This standardization accomplishes several things. It ensures that aircraft equipment systems are operated correctly, and it allows coordination of large numbers of aircraft moving through the airspace system. It facilitates learning how to operate an aircraft, minimizes the load on pilots' cognitive resources such as working memory and attention, and it allows pilots who have never flown together to coordinate their work effectively (Loukopoulos, Dismukes, &Barshi, 2009, p. 8).

When there has been an accident, investigators diagnose potential causes of error by comparing any deviations the crew may have completed away from the scripted FOM along with confirming the airline's FOM contained correct procedural tasks (Dismukes, Berman, & Loukopoulos, 2007, p. 2). "The NTSB (1994a) has cited crew procedure errors as the largest category of primary errors in airline accidents" (p. 2).

Due to the inherent nature of risk involved with operating aircraft, airline training personnel recognize the level of safety that must be maintained. They train their pilots to become aware of mitigating risk and assessing potential concerns of safety related to flight. "Managing these risks requires a conscious effort and established standards (or a maximum risk threshold). Pilots who practice effective risk management have predetermined personal standards and have formed habit patterns and checklists to incorporate them" (Federal Aviation Administration, 2009, p. v).

Aeronautical decision-making (ADM) is another key component to managing risk that is taught within airline training programs. ADM is "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" (Federal Aviation Administration, 2008, p. 17-1). Airline pilot training programs place great emphasis upon decision-making skills that are made individually and within a crew environment. "When a pilot follows good decision-making practices, the inherent risk in a flight is reduced or even eliminated" (p. 17-3).

Due to the potential inherent risks involved with air travel, the airline industry has developed training procedures that are governed and sanctioned by the Federal Aviation Administration (FAA). The FAA creates regulatory procedures, sets flight training standards, and establishes a framework of safety guidelines. Pilots are in a highly regulated and structured environment because of inherent safety concerns involved with flying. As a result, a structured and regulated system has been put in place to administer pilot training. Major airlines have training departments that typically utilize three phases of training: ground training classrooms, flight training simulators, and in-flight observations. The ground-training segment usually contains teacher-centered lecture material that covers various aspects of the particular type-specific aircraft and aspects of the company's operational procedures. The flight training simulators are needed to complete flight scenarios that emulate normal and non-normal procedures that are created to allow the training pilots to practice each procedural task to a set standard. The level of simulated flight motion and simulated visual displays allows for a realistic emersion of pilot training to occur. The final phase of training pilots, called Initial Operating Experience, consists of observed flight training during actual flights with passengers onboard from company-approved training personnel (typically called a check-airman).

All flight and ground training which includes simulator training that is administered by an airline requires approval by the FAA. The training consists of documented procedural tasks that are administered by the airline's training personnel. This training is structured in a manner that allows for the completion of each task to comply with an FAA regulation and/or company procedure. Airlines provide training for their employees on a re-occurring basis, for any new-hire employee and for employee transition from one aircraft to another. During times of peak hiring, an airline may experience an average of 15 new-hire pilots per class at its training center. Typical new-hire training events are scheduled from 5 to 6 weeks in duration. These include approximately 3 weeks of ground training, 1 week of simulator training (if the pilot is not requiring an initial type qualification in the aircraft), and a week of Initial Operating Experience. A recurrent training event will generally be a 2 or 3 day event.

Adult Learning

"The distinguishing characteristic of adult education is its focus on the individual learner" (McClellan & Conti, 2008, p. 13). While "we have no single answer, no one theory or model of adult learning that explains all that we know about adult learners, the various contexts where learning takes place and the process of learning itself" (Merriam, 2001, p. 3), there are two foundational elements that form the core of the adult learning theory base. Among a mosaic of theories, models, set of principles and knowledge base about adult learning, the two elements that have been foundational elements of adult learning theory are andragogy and self-directed learning (p. 3). These two form the twin pillars of adult learning theory (p. 3).

Andragogy

Andragogy, one of the foundational theories within adult learning, conceptualized by Malcolm Knowles. "Malcolm S. Knowles stands as a giant catalyst at the juncture-past, present, and future--of andragogy (the art and science of helping adults learn) within the field of Adult Education and Human Resource Development" (Henschke, 2008, p. 44). Knowles (1970) defined andragogy as "the art and science of helping adults learn" (p. 38). This concept was contrary to the term pedagogy, which defined the teacher-centered process of helping children learn. Andragogy was originally based on a set of four assumptions. In these, the adult learner is someone who:

> (1) has an independent self-concept and who can direct his or her own learning, (2) has accumulated a reservoir of life experiences that is a rich resource for learning, (3) has learning needs closely related to changing social roles, (4) is problem-centered and interested in immediate application of knowledge. (Merriam, 2001, p. 5)

Knowles (1984) later expanded these to include two additional assumptions. These are that the adult learner is motivated to learn by internal rather than external factors and that adults need to know why they should learn. "From these assumptions, Knowles proposed a program-planning model for designing, implementing, and evaluating educational experiences for adults" (Merriam, 2001, p. 5). "When the principles of andragogy are translated into a process for planning and operation educational programs, that process turns out to be quite different from the curriculum planning and teaching processes traditionally employed in youth education" (Knowles, 1970, p. 54). This process is centered on the learner, and these principles "are the most applicable and meaningful principles for adult learning in the work setting" (Stolovitch & Keeps, 2002, p. 47). Moreover, "the possibilities for developing and delivering learner-centered educational opportunities based on sound adult learning principles are endless" (p. 59).

Knowles (1970) presented andragogy as an alternative to the pedagogic model. The pedagogical model refers to the teacher-centered approach that is used to help children learn. However, instructors often use teacher-centered instruction with both child and adult learners (Knowles, 1980, p. 40). In the teacher-centered approach, students are treated as passive objects who exist for the purpose of receiving knowledge from the instructor and providing feedback is a designated format. In the teacher-centered approach to learning, the instructor controls the major aspects of the learning process.

The andragogical model is a contrast to the pedagogic model that has traditionally been used in education. The andragogical model assumes that adults are active learners who are involved in all parts of the learning process. In this process, the instructor serves as a facilitator to help students identify their needs and work toward achieving their learning outcomes.

The original four assumptions of andragogy offered a sharp distinction from the pedagogical model. The first assumption stressed that adult learners gain increased responsibility for their own learning as they progress through life while with the pedagogical model learners remain dependent on the instructor. The second assumption pointed out that experiences are a key factor in learning. Just as others before him such as Dewey and Lindeman (1961/1926) and others after him such as Meizrow (1990) and Schon (1983, 1987) have pointed out that experiences are the building blocks for new learning. The key is reflecting upon these experiences so that they can be related to the new learning. The third assumption points out that the teachable moment for adults is related to their awareness of how the learning relates to real-world tasks, and the fourth assumption then stresses that their learning is problem centered. When learning is based on these assumptions, adults are able to take control of their learning process and thereby expand their human possibilities (Knowles, 1980, pp. 67-68).

In addition to developing a theoretical model of how adults learn, Knowles (1980) proposed a seven-step program planning model for implementing these assumptions. This program planning model provides "procedures and resources for helping learners acquire information and skills" (Knowles, 1990, p. 120). The respected dean of adult education, Cyril Houle, felt that this program planning model "remains the most learner centered of all patterns of adult educational programming" (Henschke, 2008, p. 47).

The first step in Knowles' program-planning model focuses on establishing a climate that is conducive to learning. This climate is both physical and psychological. Creating a conducive climate for learning is critical because it is the foundation upon which the learning episode is based. "The physical environment requires provision for animal comforts (temperature, ventilation, easy access to refreshments and rest rooms, comfortable chairs, adequate light, good acoustics, etc.) to avoid blocks to learning" (Knowles, Holton, & the airlinenson, 2005, p. 118). For pilots in commercial aviation, this includes the training facilities with such things as training rooms, labs, and simulators. The psychological refers to how the learners are treated; a student-centered atmosphere with trust, mutual respect, and cooperation are essential to creating a conducive learning climate for adults (Knowles, 1980, p. 224). For pilots, this means treating them as professionals and respecting and involving their experiences.

The second step involves a mutual program planning process in which the learner is actively involved. In the pedagogical model, the "responsibility for planning is assigned almost exclusively to an authority figure (teacher, programmer, trainer)" (Knowles, Holton, & the airlinenson, 2005, p. 123). However, in the andragogical model, the learner is actively involved in the planning of the learning program because people are committed to a decision in direct proportion to their involvement in making that decision (p. 123).

The third step involves diagnosing learning needs. With the assistance of the facilitator, the learners diagnose their own learning needs. A learning need is the discrepancy or gap between the competency level desired by the learner and the present level (Knowles, Holton, & the airlinenson, 2005, p. 125). The assessment of the gap is the learner's perception of the "discrepancy between where they are now and where they want (and need) to be" (p. 125) Since this self-assessment makes the learning relevant, it increases the leaner’s motivation to learn (Knowles, 1980, p. 227).

The fourth step involves the adult learner in the formulation of the learning objectives. This also increases motivation because adults are more likely to participate in activities that have objectives that are relevant to their needs.

The fifth step implements the results of the previous two steps. In this step, the learners' needs and objectives are combined into a formal learning plan with sequential learning activities (Knowles, 1980, p. 234)

The final two steps in the program planning model deal with the implementation and evaluation of the learning objectives. The sixth step addresses the instructor as a facilitator. In this role, the instructor serves as a guide and resource person to assist the learners in the selection of appropriate materials, resources, and techniques for conducting their learning objectives (Knowles, 1980, p. 239). The seventh and final step involves the evaluation of the learning activity. This is often a weak and neglected area in education (Knowles, Holton, & the airlinenson, 2005, p. 132). However, in the andragogical program planning model, learners are involved in evaluating their own learning. By reviewing their learning process and by rediagnosing their learning needs, the learners can determine "whether they have learned what is useful to them" (Knowles, 1980, p. 171).

Self-Directed Learning

Another foundational theory within adult learning is that of self-directed learning. The self-directed learning model assisted further in defining the ways in which adults learn. Self-directed learning is:

> In its broadest meaning, "self-directed learning" describes a learning process in which individuals take initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (Knowles, 1975, p. 18)

Knowles embraced the model as he added to the research base from his writings supporting his views of andragogy stating "learners become increasingly self-directed as they mature" (Merriam, 2001, p. 8). Learner outcome goals as a result of self-directed learning position the learner as autonomous in learning in order to promote a transformation of learning and to further assist the individual learner for social and political action (p. 9).

Although the concept of self-directed learning is closely associated with Knowles, Alan Tough (1967, 1971,

1979) was the one "who provided the first comprehensive description of self-directed learning as a form of study" (Merriam, 2001, p. 8). However, he referred to it as self-planned learning. In his major study in which he interviewed adult learners, Tough (1977) examined various learning projects in which adults undertook. He defined a self-directed learning project as "a major deliberate learning effort which the learner himself or herself is responsible for most of the day-to-day planning of what and how to learn" (p. 2). Tough (1979) found that approximately 90% of adults involve themselves annually in a major learning project and that 70% of these projects were initiated by the learner (p. 1). Moreover, most adults undertake learning each year. Adults often spend 700 hours annually in learning projects. Many of these were designed to address real-life problems. Some of these projects dealt with short-term applications while others dealt with long-term objectives. Most of these were in informal settings although some were in formal work or educational settings.

One major misconception about self-directed learning is that it takes place in isolation. For many, "the term self-directed learning conjures up images of isolated individuals busily engaged in determining the form and content of their learning efforts and controlling the execution of these efforts in an autonomous manner" (Brookfield, 1986, p. 56). However, learning hardly ever takes place in isolation. Instead, "self-directed learning usually takes place in association with various kinds of helpers, such as teachers, tutors, mentors, resource people and peers" (Knowles, 1975, p. 18).

Thus, the adult learning principles differ from the standard practices currently used for most pilot training. "These foundational theories of andragogy and self-directed learning describe adult learning as a learner-centered activity. This focus mandates that individual differences be identified in the classroom in order for teachers to be effective" (McClellan & Conti, 2008, p. 14).

Learning Strategies

"Individual differences have always been identifiable and have long interested educators" (Smith, 1993, p. 24). One way of looking at individual differences is by examining a person's learning strategy preferences. "Learning strategies are the techniques or skills that an individual elects to use in order to accomplish a learning task" (Fellenz & Conti, 1989, p. 7). While learning strategies are related to leaning styles, they differ from learning styles in that "they are techniques rather than stable traits and they are selected for a specific task" (pp. 7-8). Consequently, they are things that an instructor can teach to a learner (Conti, 2009, p. 888). In the field of adult education, learning strategies have been linked with real-life learning and based upon the five constructs of metacognition, memory, metamotivation, resource management, and critical thinking (p. 888).

In the field of Adult Education, the study of learning strategy for adults has emphasized real-life learning. Unlike the research of McKeachie (1988) and Weinstein (1987) that associated learning strategies for adults with study skills for college students, learning strategies in Adult Education has dealt with "learning that is relevant to the living tasks of the individual in contrast to those tasks considered more appropriate to formal education" (Fellenz & Conti, 1989, p. 3). The line of inquiry used the conceptual framework of real-life learning of Sternberg (1990) which differentiated between limited classroom academic activities that focused on test-taking exercises and real-life learning that is concerned with problem-centered learning in daily life.

Sternberg (1990) listed nine differences between academic learning and real-life learning. These are:

1. Teachers in the classroom delineate what the problem is rather than recognizing it in a real-

life setting.

2. In the classroom, the teacher defines the problem. In the real-world in is sometimes difficult to define the problem without being confused by extraneous factors.
3. Structuring the problem can be complicated in the real world.
4. Problems in the real world are very contextualized while classroom problems have usually been decontextualized.
5. Academic problems usually have a definite answer contrary to real-life situations.
6. In the school setting, students are provided with relevant information while in a real-life environment one has to determine what is relevant and what is not.
7. Academic exercise often involve confirming a preconceived belief while real-world situations may involve many contrasting.
8. Detailed feedback is common in school while real-world feedback is rarely timely and frequently occurs after the event has happened.
9. Problem solving in academic settings is usually done individually while much problem solving in the real-world is a group process.

Although individuals vary in their learning strategies (Fellenz & Conti, 1989, p. 8), research indicates that "there are clear patterns in the learning strategies which people have a propensity to use when initiating a learning activity" (Conti, 2009, p. 889). These three distinct groups of learning strategy preferences have been named Navigators, Problem Solvers, and Engagers (p. 891). "Navigators are focused learners who chart a course for learning and follow it....Everything in the learning environment relates to achieving efficiency and effectiveness" (p. 893). "Problem Solvers rely on critical thinking skills....Because they are constantly seeking alternatives, most of their learning activities relate to generating alternatives" (p. 894). While both Navigators and Problem Solvers initiate a learning activity in the cognitive domain by identifying learning resources, "Engagers initiate a learning activity from the affective domain; that is, before they will begin a learning task, they involve themselves in the reflective process of determining internally that they will enjoy the learning task enough that it is worth doing" (p. 894). For Engagers, a central element of the learning process is concerned with building relationships with others (p. 894). By becoming aware of these learning strategy preference groups and of one's own learning strategy preference, both learners and teachers can improve the teaching-learning transaction by learning how they learn and by better understanding how others around them learn.

The research of learning strategies in the field of Adult Education has involved a line of inquiry that initiated at Montana State University and has continued at Oklahoma State University (Conti, 2009, p. 888).

> This dissertation research falls into four categories: (a) research that focussed on the instrument to better describe the groups in ATLAS (e.g., James, 2000; Ghostbear, 2001; Willyard, 2000), (b) research that tested the instrument with groups (e.g., Hulderman, 2003; Nichols-Sharpe, 2004; Shaw, 2004; Taylor, 2004), (c) research that used ATLAS as an auxiliary tool

> (e.g., Libertus, 2003; Lively, 2001; Massey, 2003; Varmecky, in press; Varmecky, 2003), and (d) research with an experimental format (Munday, D., 2002; Munday, W., 2002). Collectively, these 36 dissertations have provided an enhanced description of the three ATLAS groups that were uncovered with multivariate procedures, and they have discovered the relationship of learning strategies with some key demographic variables. (p. 893)

Research related to learning strategy preferences has found that learning strategy preference is not associated with the demographic variables of gender or race, that the distribution of the learning strategy preference groups are the same for international students as they are for students from North America, that learning strategy preferences are developed by the time a learner reaches adolescence, and that a knowledge of one's learning strategy preference by the learner and the teacher can lead to improved academic gain in the classroom (p. 893).

Experience

The concept of experiences is central to a learner-centered approach. "Numerous adult educators have underscored the fundamental role that experience plays in learning in adulthood" (Merriam, Caffarella, & Baumgartner, 2007, p. 161). One of Knowles' original four assumptions of andragogy related to experience. Prior to the conceptualization of andragogy, Lindeman (1926/1989), who is generally considered the father of the modern adult education movement, argued that "the resource of highest value in adult education is the learner's experience.... Experience is the adult learner's living textbook" (pp. 6-7).

Lindeman defined experience and related it to learning: "Experience is, first of all, doing something; second, doing something that makes a difference; third, knowing what difference it makes" (p. 87). Adults learn by becoming aware of these differences and reflecting upon them. This process of making sense out of one's experiences allows adults to transform their perspectives by broadening frames of reference that they have taken for granted and making "them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action" (Mezirow, 2000, p. 8). Thus, for adult educators, learning is really a process of giving meaning to new experiences by reflecting upon how new experiences relate to prior experiences.

This reflective practice function of learning "allows one to make judgments in complex and murky situations--judgments based on experience and prior knowledge" (Merriam, Caffarella, & Baumgartner, 2007, p. 172). The process of reflective practice involves using both past and current experiences and the tacit knowledge one uses everyday to think critically about meaningful new experiences. This process requires the learner (a) to deliberately slow down to consider multiple perspectives on things, (b) to maintain an open perspective, (c) to actively and consciously process thoughts in order to get a broader understanding of their experiences, and (d) to examine existing beliefs and practices (pp. 172-173). The purpose of all of this "is to gain deeper insights that lead to action" (p. 173).

Reflective Practice

Donald Schon (1983) contributed the seminal thought related to the concept of reflective practice and adult learning. He discussed two processes that "have been identified as central to reflective practice: reflection-on-action and reflection-in-action" (Merriam, Caffarella, & Baumgartner, 2007, p. 174). Reflection-on-action involves the analytical exercise of thinking through a situation after it has happened in order to form new perspectives on the experience or to change one's behavior. It is the conscious process of examining experiences to decide what could have been done differently and then taking action on the new decision. "In the process of improving their practice, people think about their espoused beliefs, examine what they actually do and the results of their actions, and contrast their espoused beliefs with their practice to unearth their theories-in-use” (p. 175).

The process of reflection-on-action is very similar to the process followed by the FAA for investigating crashes in aviation. It is a method for critical reflection that is guided by a four-step process (York-Barr et al., 2001). First, an event is identified, and the question is asked of what happened. Second, the event is analyzed and interpreted by asking why did it happen the way it did. Third, sense is made of the event by asking what one learned from it. Fourth, implications for action are determined by asking what should be remembered from this situation for the next time it occurs.

Reflection-in-action is a far different process. It reshapes “what we are doing while we are doing it” (Schon, 1987, p. 26). This is often referred to as thinking on your feet in response to unexpected or surprise situation. Although much of a field’s knowledge has been created through systematic, hypothesis-testing research,

> Real-world problems do not present themselves in a clear, well-defined structure suitable for laboratory research. Unexpected situations force practitioners to think in novel ways. They have to reframe the problems they face daily and construct a new reality for dealing with them. By using their prior knowledge and experiences, they are able to deal with new situations as they arise. As they reflect upon their responses to these situations, they acquire new knowledge for future

action (Schon, 1987).

> This reflection-in-action approach to professional practice is a problem-solving process. It starts with people and their needs. Importantly, it keeps people at the center of the entire process. (Conti, 2004, p. 76)

As a result of reflection-in-action, professionals are able to practice with "artistry where they create new ways of thinking and acting about problems of practice" (Merriam, Caffarella, & Baumgartner, 2007, p. 177).

Metacognition

The conscious processing of thoughts in reflective practice involve the learner in "metacognition (thinking about thinking) in order to achieve a 'broader context for understanding'" (Merriam, Caffarella, & Baumgartner, 2007, p. 173). Metacognition has been defined in various terms. It was developed in the area of cognitive psychology in the 1970s by John Flavell and Ann Brown (Paul & Fellenz, 1993, p. 7). Brown defined metacognition as "the knowledge and control one has over one's thinking and learning" (p. 7). Thus, the term may be thought of as thinking about how we think and learn.

Metacognition involves the three subprocesses of planning, monitoring, and adjusting (p. 8). Metacognitive planning is concentrated on the process of creating the most optimal method to plan a learning task (p. 9). Metacognitive monitoring is simply a way of assessing how well one is moving through the learning process (p. 10). Metacognitive adjusting is changing the learning plans as a result of self-assessment. For example, the learner might restructure or revise learning activities to meet the knowledge level needs of the learner (p. 9). These metacognitive learning concepts may be applied in pilot training development to assist the pilot’s training needs in creating individualized learner training modules.

CHAPTER 3

METHODOLOGY

Design

This was a descriptive study. Descriptive research is "research that determines and describes the way things are; involves collecting numerical data to test hypotheses or answer questions about the current subject of the study" (Gay, Mills, & Airasian, 2009, p. 601). This study described the knowledge level of pilots at a major airline related to automated flight control following the initial stage of training.

Sample

This study utilized a random sample. Based on a formula that has been developed for determining the required random sample size for a desired accuracy and level of confidence (Krejcie & Morgan, 1970). The sample of 321 was adequate for the population, which was the pilots of this major airline.

Knowledge Assessment Instrument

Instrument Development

The institutional data to evaluate the initial stage of training were collected with a 30-item survey that was developed by Matt Wise in cooperation with the continuous quality improvement team at the airline. The first step in developing the instrument was to determine its conceptual basis. The initial stage of training dealt with providing the pilots with a basic knowledge of automated flight systems (AFS). To test this knowledge, the following definition was used:

> Automated Flight System (AFS): controls both the navigation (Autopilot) and the thrust management (Autothrottles) of an aircraft together, or separately. At the heart of the AFS lies a Flight Management Computer (FMC in Boeing terminology) which accepts inputs from the pilots, manages it using information stored in regularly-updated databases (e.g ., location and other facility information for airports, runways, and navigational aids; route structure; approach procedures) and with information it also receives from the aircraft instruments, and calculates performance parameters necessary for various modes of flight. The desired flight mode is selected and data input by the pilot using buttons on a Mode Control Panel (MCP) and a Control Display Unit (CDU). The selected mode at each moment in time is indicated on the Flight Mode Annunciator, displayed on the pilots' instrument panels. (Loukopoulos, Dismukes, & Barshi, 2009, p. 166)

Using this definition of AFS, Wise met with members of the continuous quality improvement team to develop the format and items for the knowledge survey to evaluate the initial stage of training. The airline provided transportation for Wise to the training center, space for the meetings, and the time for the airline personnel to participate in these meetings. Wise provided the leadership for these meetings by supplying the definition for AFS and an explanation of why the conceptual framework was necessary and by facilitating discussion on the various elements of the definition. Wise also encouraged the airline personnel to provide real-life examples of the various elements of the definition. As a result of this process, the content for items were identified in the three construct areas of autothrottles (A/T) , flight management computer (FMC), and vertical navigation (VNAV). Following these meetings, Wise reviewed his notes from the discussions and used this information to draft the items for the knowledge assessment instrument. These draft items were then reviewed by continuous quality improvement team members until there was agreement between Wise and the team members on the content of the items.

The final form of the instrument that was developed through this process contained 30 items (see Table 1). It contained the following number of items for each construct: autothrottles (A/T)-6, flight management computer (FMC)-16, and vertical navigation (VNAV)-8. Seven of the items were designed as items that had a low difficulty level: Items 1, 9, 12, 16, 25, 26, and 28. Eleven of the items were designed as items that had a medium difficulty level: Items 2, 3, 5, 6, 8, 11, 13, 20, 27, 29, and 30. Twelve of the items were designed as items that had a high difficulty level: Items 4, 7, 10, 14, 15, 17, 18, 19, 21, 22, 23, 24.

Table 1: Items in Knowledge Assessment Instrument

No.	Construct	Item
1	FMC	What FMC page displays the FMC data base version and active dates?
2	VNAV	You are flying the company route from BWI to STL and have VNAV engaged. Your final cruise altitude is FL380 and that is set as the cruise altitude in the FMC. Washington Center has directed you to maintain FL300. What will the Pitch Mode of the FMA indicate after your aircraft levels at FL 300?
3	FMC	You are on a vector to intercept final for an ILS approach and want to extend the centerline. The approach has been programmed in the CDU. To extend the centerline, which page would you initially select?
4	VNAV	You are cruising at FL 370 with VNAV PTH annunciated on the FMA. Autothrottles are engaged. As you fly past the top of descent, the FMA annunciation ____________.
5	VNAV	In a VNAV capable NG aircraft, you have a method for recapturing the vertical path that is not available in the Classic aircraft. The method utilizes the _________ switch.
6	A/T	For the autothrottle system to operate, what two items must be input to the CDU?
7	A/T	With Vertical Speed selected, what will the Autothrottle Mode annunciate?
8	FMC	The GPS position information is displayed on which FMC page?
9	FMC	If a runway change needs to be made prior to departure, on which FMC page would the runway change be made?
10	FMC	How do you know if LNAV is engaged?
11	FMC	During IRS alignment you notice the IRS ALIGN lights flashing. What should you do to correct this condition?
12	FMC	While cruising at FL 340 from KISP to KFLL, Jacksonville Center tells you to cross CRANS at a time of 19:34:30. Which FMC function should you use to comply with that restriction?
13	FMC	The "UNABLE REQD NAV PERF - RNP" message will be displayed on the CDU scratchpad when:
14	A/T	Which autothrottle FMA indication will allow manual thrust changes without autothrottle interference?
15	A/T	With LVL CHG selected in the climb, what will the Autothrottle Mode annunciate?

16	FMC	During the departure briefing, the PF briefs the departure from the appropriate Jeppesen plate. The PM should verify the following:
17	A/T	Vertical Speed is recommended for altitude changes of _________ or less.
18	A/T	What indications are there on the flight deck if the autothrottles disengage?
19	VNAV	If you observe the FMC advisory message "STEEP DESCENT AFTER MAJEK", you can anticipate:
20	VNAV	The FMC alert message "RESET MCP ALT" is annunciated on the scratch pad. This indicates that:
21	FMC	Where is the corrective action found for a CDU alert message?
22	FMC	What does an illuminated FMC P/RST light indicate?
23	VNAV	In a VNAV capable NG aircraft, when the message "Unable 280 KIAS at SYMON" appears in the scratch pad, what is the corrective action?
24	FMC	All airspeed restrictions are considered by the FMC as ________ restrictions.
25	FMC	What are the indications of a Left FMC failure?
26	VNAV	During a VNAV descent, to meet an ATC issued crossing restriction on an arrival, the aircraft has become high on the desired descent path. In an effort to regain the original path, the PF has elected to use SPD INTV on the MCP. Will the AFDS automatically recapture and maintain the path with SPD INTV selected?
27	FMC	Which of the following is/are true in regards to selecting LVL CHG at 400' AGL?
28	FMC	What AFDS pitch mode will activate if the autopilot is engaged while TOGA is active?
29	VNAV	During climb, how do you pre-determine which speed the aircraft will fly when VNAV is selected?
30	FMC	The FMC advisory message "STEEP DESCENT AFTER MAJEK" displays on the scratch pad. This message indicates that:

Construct Validity

Once the instrument was developed, construct and content validity were established for it. This process also involved the members of the continuous quality improvement team and external consultants for the airline. Construct validity is the most important type of validity because it assesses what a test is really measuring (Gay, Mills, & Airasian, 2009, p. 157). It reflects the extent to which the test can be shown to measure hypothetical constructs which explain some aspect of human behavior (p. 157). The construct validity of the instrument was established by basing the instrument on the definition of Automated Flight Systems of Loukopoulos, Dismukes, and Barshi (2009). This definition breaks automated flight systems into the three components of the flight computer, the inputs that the pilot has for the computer, and the outputs from the computer that provide automated control of the airplane. The 30 items in the survey were distributed across these three areas, and each item was linked to one of these three areas.

In order to establish the construct validity of the 30-item instrument, the members of the continuous quality improvement team and two consultants served as jury members. Because "a construct is a postulated attribute or structure that explains some phenomenon, such as an individual's behavior" (Wiersma & Jurs, 2005, p. 328), establishing construct validity consisted of checking if the items represented the constructs of autothrottles, flight management computer, and vertical navigation. Because "researchers should determine the validity and reliability of the test for the specific situation" (p. 329) and because one way of determining construct validity is to use experts in the field (Gay, Mills, & Airasian, 2009, p. 157), the members of the continuous quality improvement team were asked to examine and testify to their agreement between the item and the construct to which it was associated.

In order to examine the constructs in the instrument, the eight members of the continuous quality improvement team divided into three groups. Each group examined the items for one of the concepts of automated flight systems of Loukopoulos, Dismukes, and Barshi (2009). The teams were as follows: FMC–2 members, VNAV–3 members, and A/T–3 members. Each team was provided with a list of the items in the concept. Next to the items was a column that had two subdivisions. In the column, the committee members were asked to place a check for each item to indicate if they felt the item represented a valid construct for the automated flight systems concept that they were evaluating. Overwhelmingly, the continuous quality improvement team members in the three groups agreed that the items represented valid constructs for the area being examined. Only 1 of the 30 items was questioned, and minor rewording was offered for a few items.

The testimony of two experts with both an aviation and an academic background were also used to determine the construct validity of the knowledge assessment instrument. Both were asked to review the items and testify to the validity of the items in terms of how they related to the constructs of autothrottles, flight management computer, and vertical navigation. Both provided verbal feedback to Wise related to the items, and this feedback was taken into consideration in designing the final format of the instrument.

Thus, the construct validity of the instrument to assess the knowledge level of the pilots following the initial stage of training was established by the testimony of content area specialists who were familiar with the exact situation of the training. One jury was made up of the members of the continuous quality improvement team. The other jury was made up of two research experts in the area of automated flight control.

Content Validity

Content validity deals with the degree to which a test measures the intended content area (Gay, Mills, & Airasian, 2009, p. 155). The content validity of the knowledge survey was established by the testimony of the same juries that were used to establish the construct validity. After reviewing the items, the groups for each area of the instrument were asked if they felt that the questions adequately represented their topic area. All three groups stated that they felt the questions in the instrument adequately represented the topic. It was therefore judged that the instrument had content validity.

Final Format

After the construct and content validity of the knowledge assessment instrument was established, the instrument was used in a form to collect data using the Internet. Upon the recommendation of the continuous quality improvement team, a pilot test was conducted to test the instrument with the airline pilots and to test the design of the study. The 43% response rate and the positive comments from several of the pilots indicated that the design was feasible. However, several respondents commented that responding to the survey items was more difficult than using the automated flight system in real-world circumstances because the questions were difficult to relate to the actual flying situation. Therefore, screen-shots were added to 13 of the questions to depict the actual situation; these were items 1, 3, 5, 8, 9, 12, 13, 16, 19, 20, 23, 29, and 30.

In addition to the 30 items in the survey, data were gathered on selected demographic variables, the frequency that the pilots used automated flight control, and their perception of how well prepared they are to fly the initial stage of operations following the computer-based training. In addition, they were provided space to comment on either the survey or on the initial stage of training. All responses were anonymous.

Reliability

The reliability of the knowledge assessment instrument was established with the 321 responses collected via the Internet. Reliability "is the degree to which a test consistently measures whatever it is measuring" (Gay, Mills, & Airasian, 2009, p. 158). Because the instrument was only given once, its internal consistency was measured. Internal consistency reliability "is the extent to which items in a single test are consistent among themselves and with the test as a whole" (p. 160).

Cronbach's alpha was used to measure the reliability of the knowledge assessment instrument. Cronbach's alpha is a statistical procedure to determine "how all items on a test relate to all other test items and to the total test" (Gay, Mills, & Airasian, 2009, p. 161). Cronbach's alpha is used for tests made up of items that are not dichotomous choices (i.e., the items have more than two choices) (p. 161). The reliability coefficient for the 30-items in the instrument with the 321 pilots was .62. Although the minimum level of acceptability for the reliability of various types of instruments differs (p. 162), this is slightly below the generally accepted minimum of .7, and the results from the instrument should be interpreted with this caveat.

ATLAS

The learning strategy preferences of the pilots at the airline were identified with ATLAS (Assessing The Learning Strategies of AdultS). ATLAS consists of five items with dichotomous choices. Each option is linked to the learning strategy preference groups of Navigators, Problem Solvers, or Engagers. Although its original form consists of a colored booklet with one question on each page and with each option directing the participant to the next appropriate question, "the items for ATLAS can be organized in a variety of formats for administering the instrument" (Conti, 2009, p. 889). The respondents are grouped as either a Navigator, Problem Solver, or Engager based upon their responses to these items. The original booklet form of ATLAS is designed to give the respondent immediate feedback on group placement. However, since this was a research project in which the participants did not receive feedback on their learning strategy preferences, the questions were arranged in a standard-text format and only the appropriate responses were used for placing individuals in their correct learning strategy preference group.

ATLAS has established validity and reliability (Conti, 2009). The items and structure for ATLAS was derived from a data set of 3,070 responses from the Self-Knowledge Inventory of Lifelong Learning Strategies (SKILLS). SKILLS consists of a series of 12 scenarios of real-life situations with 15 items for each scenario that represent the concept areas of metacognition, memory, metamotivation, resource management, and critical thinking (Conti & Fellenz, 1991). Participants complete 4 scenarios; thus, there are 60 responses for each participant. The construct validity of ATLAS was established by reviewing the literature of studies actually using SKILLS in field-based research and by consolidating the similar data from many of these studies (Conti, 2009). This North American data set of 3,070 adults was then subjected to multivariate statistical analyses using cluster analysis and discriminant analysis (pp. 890-891). "This resulted in the identification of three groups with similar patterns of learning strategy usage" (p. 891). These groups were named Navigators, Problem Solvers, and Engagers.

"For ATLAS, content validity is concerned with the degree to which the items are representative of learning strategy characteristics of the three groups identified in the SKILLS' research" (Conti, 2009, p. 891). To determine this, a series of discriminant analyses were conducted with the 60 items from SKILLS to determine the differences between the groups (p. 891). "Several separate discriminant analyses were conducted, and the findings from the structure matrix for each of these discriminant analyses were used to determine the wording of the items in ATLAS" (p. 891).

Several procedures were used to establish criterion-related validity for ATLAS because ATLAS was created by using multivariate procedures with "items that are scored in a univariate format on the original instrument" (Conti, 2009, p. 892). Three separate types of things were done to establish the criterion-related validity of ATLAS.

> First, the group placement on ATLAS was compared to the scores on SKILLS for the various SKILLS items from the structure matrices that were used to construct the items in ATLAS; this provided a comparison between the responses of the ATLAS preference groups and the specific items from SKILLS that were used to identify them. (p. 892)

For this, 40 professionals who work with adult learners in various settings completed the instruments. "For 80% of the participants, their scores on SKILLS in the six learning strategy areas that were most influential in the discriminant analyses for forming the ATLAS groups were consistent with their ATLAS preference group selection” (p. 892).

“Second, respondents completed four SKILLS scenarios that were modified to have two items with responses that reflected the learning strategies from the discriminant analysis results that were used for forming the preference groups for ATLAS” (Conti, 2009, p. 892). Each learning strategy preference group was expected to select the option that was created for it based on the discriminant analysis. The results indicated that “the 154 participants’ selections for the various items were 75.7% as expected for their learning strategy preference group” (p. 893).

“Third, the participants were asked to self-report on the accuracy of the ATLAS placement for them after they had read a description of the ATLAS groups; this provided a check between the response on ATLAS and the real-world of the respondent” (Conti, 2009, p. 892). Data were gathered from nine diverse research studies for this analysis. “Overall, 91.6% of the 2,321 participants in these studies agreed that the group in which ATLAS placed them was an accurate description of them” (p. 893).

The reliability of ATLAS was established by the test-retest method. ATLAS was administered to 121 adult education practitioners with a 2-week interval (Conti, 2009, p. 893). The reliability coefficient was .88 ($p < .001$); 90.9% of the participants responded the same on both testings (p. 893).

Threats to Validity of Design

Validity that applies to the research design is internal and external validity. Factors such as assumptions, limitations, and delimitations can threaten the internal and external validity of a study. Internal validity is "the degree to which observed differences on the dependent variable are a direct result of manipulation of the independent variable, not some other variable" (Gay, Mills, & Airasian, 2009, p. 602). External validity is "the degree to which results are generalizable or applicable to groups and environments outside the experimental setting" (p. 602).

The classic work of Donald Campbell and Julian Stanley identified eight major threats to internal validity in their book, Experimental and Quasi-Experimental Designs for Research (Gay, Mills, & Airasian, 2009, p. 243). These eight threats to internal validity may be grouped by the researcher in three separate areas: Time, Instruments, and Sampling.

The Time category includes History, Maturation, and

Mortality. Each of these are defined as follows:

> History: "Unexpected events occur between the pre-test and posttest, affecting the dependent variable" (Gay, Mills, & Airasian, 2009, p. 244).
> Maturation: "Changes occur in the participants, from growing older, wiser, more experienced, etc., during the study" (p. 244).
> Mortality: "Different participants drop out of the study in different numbers, altering the composition of the treatment groups" (p. 244).

The issue of Time was not a factor during the research study. History did not affect the study due to the fact that while the data was gathered, no major events occurred that affected the airline industry. Maturation was not a factor due to the nature that the participants were mature adult professionals, and the data were gathered over a short time frame. Mortality did not affect the study due to fact that there were no changes in the characteristics of the group from attrition or reduction in-group size because the study was over a short time period.

The Instruments category includes Testing, Instrumentation, and Statistical Regression. Each of these are defined as follows:

> Testing: "Taking a pretest alters the results of the posttest" (Gay, Mills, & Airasian, 2009, p. 244).
> Instrumentation: "The measuring instrument is changed between pre- and posttesting, or a single measuring instrument is unreliable" (p. 244).
> Statistical Regression: "Extremely high or extremely low scores tend to regress to the mean on retesting" (p. 244).

The nature of the study was designed to test with a single instrument. Therefore, Testing was not a threat due to the fact that a pretest was not administered. Instrumentation did not affect the study because the instrument was not changed because it had a single testing event. To guard against Instrumentation error, a Cronbach's alpha was run on the instrument to determine the reliability. The Statistical Regression was not a threat due to the design of the study did not allow for a retesting event.

The Sampling category includes Differential Selection of Participants and Selection-Maturation Interaction. Each of these are defined as follows:

> Differential Selection of Participants: "Participants in the experimental and control groups have different characteristics that affect the dependent variable differently" (Gay, Mills, & Airasian, 2009, p. 244).
>
> Selection-Maturation Interaction: "The participants selected into treatment groups have different maturation rates. Selection interactions also occur with history and instrumentation" (p. 244).

A single measure was taken on one sample population over short time period. The study was designed as a descriptive study and not an experimental study. Therefore, Differential Selection of Participants and Selection-Maturation Interaction were not threats to the study's internal validity.

Contributing on the work from Campbell and Stanley, Bracht and Glass identified seven major threats to external validity (Gay, Mills, & Airasian, 2009, p. 246). They created two categories of threats in "generalizing to whom" and "generalizing to what" (p. 246). The threats to external validity are as follows:

> Pretest-treatment Interaction: "The pretest sensitizes participants to aspects of the treatment and thus influences posttest scores" (Gay, Mills, & Airasian, 2009, p. 250).
>
> Selection-Treatment Interaction: "The nonrandom or volunteer selection of participants limits the generalizability of the study" (p. 250).
>
> Multiple-Treatment Interaction: "When participants receive more than one treatment, the effect of prior treatment can affect or interact with later treatment, limiting generalizability" (p. 250).
>
> Specificity of Variables: "Poorly organized variables make it difficult to identify the setting and procedures to which the variables can be generalized" (p. 250).
>
> Treatment Diffusion: "Treatment groups communicate and adopt pieces of each other's treatment, alerting the initial status of the treatment's comparison" (p. 250).
>
> Experimental Effects: "Conscious or unconscious actions of the researchers affect participants' performance and responses" (p. 250).
>
> Reactive Arrangements: "The fact of being in a study affects participants so that they act in ways different from their normal behavior. The Hawthorne and John Henry effects are reactive responses to being in a study" (p. 250).

Most of these threats deal with experimental studies and do not apply to this descriptive study with a random sample and single test. However, the specificity of variables does apply because of the very narrow definition of what automated flight control is based on from Immanuel Barshi and his colleague's definitions. In addition, the

90% mastery level of automation knowledge also applies. However, these two variables are listed as delimitations as to not threaten the external validity of the study.

Nevertheless, researchers still need to be aware that in a descriptive study there are issues related to sampling and instruments. The major threats of validity to a descriptive study are sample selection and instrumentation. The threats to the validity of this study from sampling were overcome by the random selection of the participants. A major concern with sampling is confirming that the study has a representative sample. "Random sampling is the best way to obtain a representative sample. Although no technique, not even random sampling, guarantees a representative sample, the probability of achieving one is higher for this procedure than any other" (Gay, Mills, & Airasian, 2009, p. 125).

The threats to the validity of the study from instrumentation were overcome by validating the knowledge test and by establishing the validity of this instrument.
A too-often-neglected procedure in a study like this one is that the validation of the questionnaire or data-collection instrument is not conducted in order to determine if it measures what it was developed to measure. Validation of the data-collection instrument may be because it is not easy

and because it requires much additional time and effort. However, anything worth doing is worth doing well. The appropriate validation procedure for a given questionnaire will depend upon the nature of the instrument (Gay, 1987, p. 198).

For the nature of the study with the airline, the construct and content validity of the instrument were established panels of practitioner and academic experts.

An important concern for the airline's training department was having the assurance that the instrument was established as a valid measurement for assessing their pilot's knowledge in automation. The procedures that were taken to establish a representative sample and to establish the validity on the instrument for this descriptive study assured the airline's management that the results supported their goals and outcomes for assessing their pilot's knowledge and ability on automated flight control systems.

Procedures

All data for this study were collected via the Internet. The knowledge assessment instrument, questions for ATLAS, demographic and professional items, and comment items were embedded on a form created in Microsoft Office FrontPage 2003. This form was posted on the personal website of the dissertation advisor for this study. Consequently, the data came directly to the researcher, and only the researcher and his academic advisors have had access to the data.

The sample for this study was randomly selected. The requests to participate in the study were sent to the pilots by the personnel office via the internal e-mail system for the airline. The request to participate contained a link to the form of the study that was located on the researcher's website.

The responses of the pilots were anonymous. When the pilots signed into the website, there was no link between their identity and the form on the researcher's website. When the pilots submitted their responses, this data was sent to the internal e-mail for the website. This message was received by the researcher's dissertation advisor. The contents of each e-mail was transferred to Microsoft Office Excel. The quantitative data were analyzed with SPSS.

After the data were analyzed, the findings were presented to the continuous quality improvement team. Using a model developed by Linkenbach (1995), Wise conducted a seminar with the airline stakeholders. First, he presented the findings from the data analysis in user-friendly language that was designed for practitioners. He then facilitated a discussion among the stakeholders to elicit their perceptions on the implications of these findings for the pilot training at the airline. These perceptions were incorporated in the conclusions and recommendations for the study.

CHAPTER 4

FINDINGS

Preparedness for Initial Training

Because the focus of this study was upon the knowledge level of the pilots following the initial stage of training, the pilots were asked how well prepared they felt they were to fly the initial stage of operations following the Computer-Based Training (see Table 2). Only 11 (4.7%) felt that they were Very Well Prepared. Most felt Well Prepared (39.6%) or Fair (46%). However, 20 (8.5%) felt Poorly Prepared, and 3 (1.3%) felt Very Poorly Prepared.

The pilots were also asked about the frequency that they use VNAV and/or autothrottle if they are available (see Table 2). Almost all (99.1%) are using the automated flight control extensively. There responses were as follows:

1. 146 (45.8%)--Yes, all the time. I understand the systems, and I am proficient.
2. 170 (53.3%)--Yes, most of the time, but the systems occasionally confuse me.

Only two pilot (.6%) responded “Rarely, I don’t understand the systems”, and only one (.3%) responded “ No, I prefer not to use them”.

Table 2: Distribution of Training-Result Variables

Variable	Frequency	Percent
Prepared		
Very Well Prepared	11	4.68
Well Prepared	93	39.57
Fair	108	45.96
Poorly Prepared	20	8.51
Very Poorly Prepared	3	1.28
Total	235	100.00
Use of Automation		
Use all the time	146	45.77
Use most of the time	170	53.29
Do not understand system	2	0.63
Prefer not to use	1	0.31
Total	319	100.00

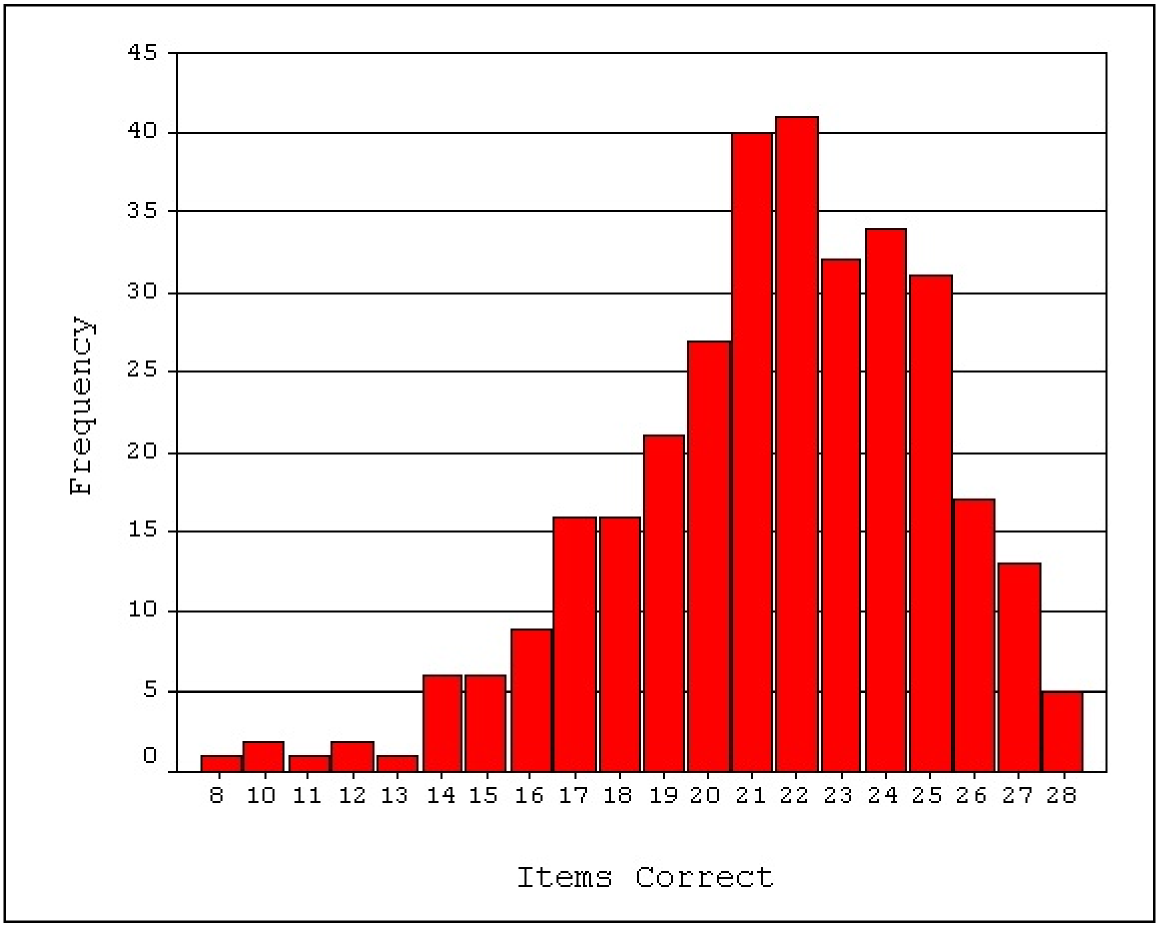
Knowledge Level of Automation

Overall Survey Scores

The first research question investigated the knowledge level of automated flight control of the airline pilots. Although the pilots indicated that they feel somewhat well prepared to use automated flight systems and although they are using automated flight systems nearly all the time, their knowledge scores do not reflect a mastery of the knowledge related to automated flight systems. For the 30 items in the survey, the median number of correct responses was 22. The mean for the group was 21.5 with a standard deviation of 3.5. The number correct ranged from 8 to 28 with the most commonly occurring score being 22. Thus, on the average, the pilots were able to correctly answer about slightly less than three-fourths (71.7%) of the knowledge items related to automated flight systems.

For the 30 item test, a score of 27 or above represents a 90% mastery level and a score of 24 or above represents an 80% mastery level. Eighteen (5.6%) of the pilots scored above the 90% mastery level, and 100 (31.2%) scored above the 80% mastery level. Thus, only a small percentage of the pilots were above the 90% mastery level, but nearly one-third of the pilots were above the 80% mastery level.

Figure 2: Distribution of Test Scores for the Pilots



Items Mastered

The pilots differed in their knowledge related to the various items related to automated flight systems (see Table 3). Almost all correctly knew which page to select in order to extend the centerline in the CDU. At least 90% of the pilots mastered (i.e., correctly answered) seven items and at least 85% mastered three additional items. Five of the seven that at least 90% mastered deal with FMC as do two of the three that at least 85% mastered; thus, seven of the ten items with a high degree of mastery focused on the FMC. Two of the other three items dealt with A/T, and one dealt with VNAV.

The difficulty index of a test refers to the proportion of examinees who answered the item correctly. Less than 80% of the pilots mastered 20 or two-thirds of the items (see Table 3). These items were distributed as follows: 5 items which 70-79% mastered, 5 items which 60-69% mastered, 8 items which 50-59% mastered, and 1 item which only 16.5% mastered.

Table 3: Difficulty Index of Knowledge Assessment Items

No.	Diff. Index	Concept	Item
3	98.8	FMC	You are on a vector to intercept final for an ILS approach and want to extend the centerline. The approach has been programmed in the CDU. To extend the centerline, which page would you initially select?
30	96.6	FMC	The FMC advisory message "STEEP DESCENT AFTER MAJEK" displays on the scratch pad. This message indicates that _________
16	95.3	FMC	During the departure briefing, the PF briefs the departure from the appropriate Jeppesen plate. The PM should verify the following:
29	93.1	VNAV	During climb, how do you pre-determine which speed the aircraft will fly when VNAV is selected?
17	92.2	A/T	Vertical Speed is recommended for altitude changes of _________ or less.
10	91.9	FMC	How do you know if LNAV is engaged?
13	90.7	FMC	The "UNABLE REQD NAV PERF – RNP" message will be displayed on the CDU scratchpad when:
18	89.1	A/T	What indications are there on the flight deck if the autothrottles disengage?
8	85.4	FMC	The GPS position information is displayed on which FMC page?
27	82.2	FMC	Which of the following is/are true in regards to selecting LVL CHG at 400' AGL?
14	79.4	A/T	Which autothrottle FMA indication will allow manual thrust changes without autothrottle interference?
1	76.6	FMC	What FMC page displays the FMC data base version and active dates?

9	73.5	FMC	If a runway change needs to be made prior to departure, on which FMC page would the runway change be made?
12	70.4	FMC	While cruising at FL 340 from KISP to KFLL, Jacksonville Center tells you to cross CRANS at a time of 19:34:30. Which FMC function should you use to comply with that restriction?
19	70.1	VNAV	If you observe the FMC advisory message "STEEP DESCENT AFTER MAJEK", you can anticipate:
11	69.8	FMC	During IRS alignment you notice the IRS ALIGN lights flashing. What should you do to correct this condition?
23	68.2	VNAV	In a VNAV capable NG aircraft, when the message "Unable 280 KIAS at SYMON" appears in the scratch pad, what is the corrective action?
21	66.4	FMC	Where is the corrective action found for a CDU alert message?
22	65.7	FMC	What does an illuminated FMC P/RST light indicate?
26	65.7	VNAV	During a VNAV descent, to meet an ATC issued crossing restriction on an arrival, the aircraft has become high on the desired descent path. In an effort to regain the original path, the PF has elected to use SPD INTV on the MCP. Will the AFDS automatically recapture and maintain the path with SPD INTV selected?
6	62.3	A/T	For the autothrottle system to operate, what two items must be input to the CDU?
15	58.3	A/T	With LVL CHG selected in the climb, what will the Autothrottle Mode annunciate?
5	57.9	VNAV	In a VNAV capable NG aircraft, you have a method for recapturing the vertical path that is not available in the Classic aircraft. The method utilizes the _________ switch.
2	57.6	VNAV	You are flying the company route from BWI to STL and have VNAV engaged. Your final cruise altitude is FL380 and that is set as the cruise altitude in the FMC. Washington Center has directed you to maintain FL300. What will the Pitch Mode of the FMA indicate after your aircraft levels at FL 300?
4	56.7	VNAV	You are cruising at FL 370 with VNAV PTH annunciated on the FMA. Autothrottles are engaged. As you fly past the top of descent, the FMA annunciation ____________.
20	55.1	VNAV	The FMC alert message "RESET MCP ALT" is annunciated on the scratch pad. This indicates that:
28	55.1	FMC	What AFDS pitch mode will activate if the autopilot is engaged while TOGA is active?
7	53.6	A/T	With Vertical Speed selected, what will the Autothrottle Mode annunciate?
25	53.6	FMC	What are the indications of a Left FMC failure?
24	16.5	FMC	All airspeed restrictions are considered by the FMC as ________ restrictions.

90% Mastery Level

The items in the 30-item survey for this study tests the knowledge level of pilots related to automated flight control after the initial stage of training. A minimum level of knowledge is necessary in order to competently progress to the next level of training. It is not the purpose of this study to determine what this minimum level is; it is the responsibility of content level and training experts at the airline to determine what they consider the minimum level to be for successful instruction and safe flying at the airline. However, one level that is often used in competency-based training programs is to have at least 90% mastery of the knowledge or skills related to the competency.

The items were analyzed to see if those who answered at least a 90% of the items on the test responded differently on the item that those who had less than 90% of the items correctly. The group with at least 90% of the items correct contained 18 pilots, and the group with less than 90% correct contained 303 pilots. The distribution of the correct and incorrect responses for each group was compared using chi square.

Chi square is used to test for differences in data when it is in the form of frequencies (Gay & Airasian, 2000, p.

502). Chi square "compares the proportions actually observed in a study to the proportions expected, to see if they are significantly different. Expected proportions are usually the frequencies that would be expected if the groups were equal" (pp. 502-503). The independent samples chi-square test is used to compare two or more groups on a response variable that is categorical in nature (Huck, 2000, p. 618). Contingency table are used in this approach to determine if the distribution of the groups is related. The data are arranged in a contingency table in columns and rows, and "the statistical test is made to determine whether classification on the row variable is independent of classification on the column variable" (p. 254). A criterion level of .05 was used to test the significance of any differences.

Significant differences were found between the two groups for 17 of the items: 1, 2, 4, 5, 6, 11, 12, 14, 15, 19, 20, 22, 23, 24, 25, 26, and 28 (see Table 4). For each of these items except for Item 24, most of the group that had at least a 90% mastery level on the test answered these items correctly while the other group had a variety of distributions between the correct and incorrect answers for the items. On Item 24, most (83.5%) of the pilots answered the questions incorrectly; however, 38.8% of the 90% mastery group answered it correctly while only 15.2% of the group with a mastery level below 90% answered it correctly. The 17 items that the high-scoring group outperformed the others on were distributed as follows: FMC–7 (41.2%), VNAV–7 (41.2%), and A/T–3 (17.6%). The 16 FMC items made up 53.3% of the test, and the 6 A/T items made up 20% of test; thus, these types of items were slightly under-represented in the type of items on which the high-scoring group outperformed the other group. However, the 8 VNAV items only represented 26.7% of the test, but VNAV items represented 41.2% of the type of items on which the high-scoring group outperformed the others.

No differences were found between the groups for 13 of the items: 3, 7, 8, 9, 10, 13, 16, 17, 18, 21, 27, 29, and 30 (see Table 4). Of these 13 items, 9 (69.2%) were FMC items, and 3 (23.1%) were A/T items. Only 1 (7.7%) of the items was a VNAV item. Thus, the one area that strongly influenced the differences in the performance levels was the VNAV area with those who performed well having more knowledge about VNAV.

Table 4: Distribution of Pilots with 90% or More Mastery by Item

No.	**Answer**	**In 90% Group**		**Total**	**Chi Square**		
		Yes	**No**		**Value**	***df***	***p***
1	Incorrect	0	75	75	5.81	1	0.016
	Correct	18	228	246			
2	Incorrect	2	134	136	7.63	1	0.006
	Correct	16	169	185			
3	Incorrect	1	3	4	2.88	1	0.090
	Correct	17	300	317			
4	Incorrect	2	137	139	8.05	1	0.005
	Correct	16	166	182			
5	Incorrect	3	132	135	5.04	1	0.025
	Correct	15	171	186			
6	Incorrect	1	120	121	8.39	1	0.004
	Correct	17	183	200			
7	Incorrect	5	144	149	2.66	1	0.103
	Correct	13	159	172			
8	Incorrect	1	46	47	1.26	1	0.262
	Correct	17	257	274			
9	Incorrect	2	83	85	2.31	1	0.128
	Correct	16	220	236			
10	Incorrect	0	26	26	1.68	1	0.195
	Correct	18	277	295			
11	Incorrect	1	96	97	5.50	1	0.019
	Correct	17	207	224			
12	Incorrect	1	94	95	5.29	1	0.021
	Correct	17	209	226			
13	Incorrect	0	30	30	1.97	1	0.161
	Correct	18	273	291			
14	Incorrect	0	66	66	4.94	1	0.026
	Correct	18	237	255			
15	Incorrect	3	131	134	4.93	1	0.026
	Correct	15	172	187			
16	Incorrect	0	15	15	0.93	1	0.334
	Correct	18	288	306			
17	Incorrect	0	25	25	1.61	1	0.204
	Correct	18	278	296			
18	Incorrect	1	34	35	0.56	1	0.454
	Correct	17	269	286			
19	Incorrect	0	96	96	8.14	1	0.004
	Correct	18	207	225			
20	Incorrect	3	141	144	6.13	1	0.013
	Correct	15	162	177			
21	Incorrect	4	104	108	1.11	1	0.291

	Correct	14	199	213				
22	Incorrect	1	109	110		6.98	1	0.008
	Correct	17	194	211				
23	Incorrect	1	101	102		6.05	1	0.014
	Correct	17	202	219				
24	Incorrect	11	257	268		6.93	1	0.008
	Correct	7	46	53				
25	Incorrect	2	147	149		9.56	1	0.002
	Correct	16	156	172				
26	Incorrect	1	109	110		6.98	1	0.008
	Correct	17	194	211				
27	Incorrect	1	56	57		1.94	1	0.163
	Correct	17	247	264				
28	Incorrect	1	143	144		11.91	1	0.001
	Correct	17	160	177				
29	Incorrect	1	21	22		0.05	1	0.822
	Correct	17	282	299				
30	Incorrect	0	11	11		0.68	1	0.411
	Correct	18	292	310				

80% Mastery Level

Instead of having at least 90% mastery of the knowledge or skills related to the competency, an 80% mastery level is sometimes used in competency-based training. While only 18 pilots achieved at least 90% mastery on the 30 items in the survey, 100 had at least 80% mastery on the survey. When the mastery level is set at the 80% level, the results are very different from when it is set at the 90% level (see Table 5). The group of 100 scoring at least at the 80% correct level on the survey significantly outperformed the group of 221 below that level on 26 of the 30 items. These 26 items were distributed among the automated flight control concepts as follows: FMC–13 (50%), VNAV–8 (30.8%), and A/T–5 (19.2%). The groups did not significantly differ in their distribution on four items: 3, 17, 24, and 30. Three of these four items are FMC items, and the other is an A/T item. As with the 90% mastery group, the lower-performing group does more poorly in the VNAV area than the higher-performing group. They also do more poorly on most of the A/T items and on slightly over four-fifths (81.3%) of the FMC items.

Table 5: Distribution of Pilots with 80% or More Mastery by Item

Item	**Answer**	**In 80% Group**		**Total**		**Chi Square**		
		Yes	**No**			**Value**	***df***	***p***
1	Incorrect	10	65	75		14.49	1	0.000
	Correct	90	156	246				
2	Incorrect	26	110	136		15.94	1	0.000
	Correct	74	111	185				
3	Incorrect	1	3	4		0.07	1	0.789
	Correct	99	218	317				
4	Incorrect	28	111	139		13.85	1	0.000
	Correct	72	110	182				
5	Incorrect	23	112	135		21.64	1	0.000
	Correct	77	109	186				
6	Incorrect	24	97	121		11.60	1	0.001
	Correct	76	124	200				
7	Incorrect	19	130	149		43.90	1	0.000
	Correct	81	91	172				
8	Incorrect	7	40	47		6.79	1	0.009
	Correct	93	181	274				
9	Incorrect	15	70	85		9.83	1	0.002
	Correct	85	151	236				
10	Incorrect	3	23	26		5.07	1	0.024
	Correct	97	198	295				
11	Incorrect	15	82	97		15.95	1	0.000
	Correct	85	139	224				
12	Incorrect	9	86	95		29.57	1	0.000
	Correct	91	135	226				
13	Incorrect	1	29	30		11.94	1	0.001
	Correct	99	192	291				
14	Incorrect	6	60	66		18.85	1	0.000
	Correct	94	161	255				
15	Incorrect	26	108	134		14.81	1	0.000

	Correct	74	113	187				
16	Incorrect	0	15	15		7.12	1	0.008
	Correct	100	206	306				
17	Incorrect	4	21	25		2.90	1	0.088
	Correct	96	200	296				
18	Incorrect	3	32	35		9.34	1	0.002
	Correct	97	189	286				
19	Incorrect	16	80	96		13.40	1	0.000
	Correct	84	141	225				
20	Incorrect	26	118	144		20.89	1	0.000
	Correct	74	103	177				
21	Incorrect	23	85	108		7.37	1	0.007
	Correct	77	136	213				
22	Incorrect	11	99	110		34.91	1	0.000
	Correct	89	122	211				
23	Incorrect	20	82	102		9.29	1	0.002
	Correct	80	139	219				
24	Incorrect	83	185	268		0.03	1	0.874
	Correct	17	36	53				
25	Incorrect	26	123	149		24.35	1	0.000
	Correct	74	98	172				
26	Incorrect	17	93	110		19.23	1	0.000
	Correct	83	128	211				
27	Incorrect	7	50	57		11.51	1	0.001
	Correct	93	171	264				
28	Incorrect	24	120	144		25.55	1	0.000
	Correct	76	101	177				
29	Incorrect	2	20	22		5.36	1	0.021
	Correct	98	201	299				
30	Incorrect	1	10	11		2.58	1	0.108
	Correct	99	211	310				

Factors in Survey

Factor Analysis

The second research question investigated the factors that make up the airline pilots' knowledge of automated flight control. The 30-item survey developed for this study conceptualized automated flight systems as being divided into three primary parts that were operationalized as FMC, VNAV, and A/T. The responses of the pilots were analyzed to determine if they confirmed this structure. Factor analysis was used for this confirmatory process.

Factor analysis is a data reduction technique . As such, it "is a way to take a large number of variables and group them into a smaller number of clusters called *factors*" (Gay, Mills, & Airasian, 2006, pp. 203-204). Factor analysis removes the redundancy from a set of correlated variables; as a result, the variables can be represented in a smaller set of factors (Kachigan, 1991, p. 237). With factor analysis, the correlations among all of the variables are calculated, and then factors are "derived by finding groups of variables that are correlated highly among each other, but lowly with other variables" (Gay, Mills, & Airasian, 2006, p. 204). The factor, which contains several of the variables, represents the abstract underlying dimension of the variables in it (Kachigan, 1991, p. 237).

Factor analysis is a complicated statistical procedure, but it also involves the judgement of the researcher in deciding how many factors best represent the data (Kachigan, 1991, p. 252). To get information for this decision-making process, the researcher will usually run several separate analyses. The process for doing this is to first run a principal components analysis (p. 246); the principal components factor analysis initially extracts as many factors as there are variables in the analysis (p. 245). Each variable correlates with each factor to varying degrees, and the factor loading tells how much each of the variables correlate with each of the factors (Sheskin, 2007, p. 1623). After the principal components factor analysis provides an overview of the data, the factors can be "rotated" to provide greater clarity to the analysis. The rotation process is simply mathematically redefining the factors so that the loadings can provide a sharper distinctions in the meaning of the factors (Kachigan, 1991, p. 248). The most commonly used method of rotation is the varimax method; this approach "attempts to minimize the number of variables that have high loadings on a factor" (Norusis, 1988, p. B-54).

With each rotated analysis, the investigator can extract a different number of factors from the data. The purpose of this process is to gather information from the various analyses to determine the number of factors to retain to best "explain" the variance in the data (Kachigan, 1991, p. 252). Once the best solution is selected for describing the data, then the researcher assigns a name to each factor (Sheskin, 2007, p. 1633). This is a subjective process that is done by carefully examining the variables that load high on the factor (p. 1633). The purpose of the naming is to give a descriptive name to the higher-order abstraction represented by the combination of variables in the factor (Kachigan, 1991, p. 252).

The 30-item knowledge survey is based upon three concepts: FMC, VNAV, and A/T. Therefore, it was anticipated that a factor analysis would yield three factors with the items for each of these concepts loading into a separate and independent factor. To check this, a principal components factor analysis was calculated with a varimax rotation. Instead of producing three distinct factors, this analysis yielded 13 factors with an eigenvalue of over 1. An eigenvalue is a quantity "which corresponds to the equivalent number of variables which the factor represents" (Kachigan, 1991, p. 246). A general rule of exploring factor solutions is to retain only factors with a eigenvalue of 1 or greater (Sheskin, 2007, p. 1625). In addition to having many more factors than the three upon which the survey was conceptualized, the three conceptual areas were widely distributed among the factors rather than being concentrated in a factor of their own.

Because the first general analysis failed to confirm the conceptualized structure of the survey, a second analysis was run. This analysis used a principal components factor analysis with a varimax rotation and with limiting the number of extracted factors to three. This 3-factor solution had the following number of items in each factor: Factor 1–13, Factor 2–9, and Factor 3–8. A criterion of having a correlation of .3 or greater for being retained in the factor is generally considered as a guideline for a study with a large sample (Sheskin, 2007, p. 1627) such as in this study. However, each of the factors had items below this minimally accepted level. Factor 1 and 2 each had two items below this level, and Factor 3 had four items. Moreover, there was no clear concentration of the concepts in each factor. For example, Factor 1 contained the following distribution of items: FMC–6, VNAV–5, and A/T–2. These combinations indicated that the responses of the pilots to the items did not cause them to fall into the distinct categories that were used in forming the items. Instead, the responses of the pilots indicated that the pilots viewed various elements of these concepts as related. Therefore, additional analyses were conducted to explore for the best description of this combination of the concepts.

Three additional principal components factor analysis with a varimax rotation were run. In these, the number of extracted factors was limited to 4, 5, and 6. The results of these analyses were compared to determine the best solution for explaining the variance in the data. The 5-factor solution was selected as best solution. The 4-factor solution had similar limitations to those of the 3-factor solution and had seven items that failed to meet the .3 criterion for loading on any factor. The 6-factor solution reduced the number of items that did not load above the .3 level on any factor to two, but it contained two factors with only three items. In addition, if the two items below the .3 level are not included in the factor, Factor 1 of this solution contains only four items, and the first factor is the one that accounts for the most variance in the analysis. The 5-factor solution contains only one item (Item 21) below the .3 criterion and is made up of factors of relatively-equal size: Factor 1–8, Factor 2–5, Factor 3–7, Factor 4–5, and Factor 5–5 (see Table 6).

Table 6: 5-Factor Solution for 30-Item Knowledge Survey

Item	Factor				
	1	2	3	4	5
14	0.61				
7	0.58				
22	0.40				
5	0.39				
26	0.38				
30	0.38				
10	0.34				
20	0.30				
24		-0.55			
17		0.55			
4		0.50			
29		0.46			
28		0.33			
9			0.53		
15			0.42		
11			0.41		
18			0.38		
23			0.37		
19			0.35		
21			0.22		
8				0.63	
3				0.46	
6				0.46	
16				0.43	
1				0.32	
13					0.63
25					0.47
2					0.46
12					0.38
27					0.32

Factor 1 contained eight items: 5, 7, 10, 14, 20, 22, 26, and 30 (see Table 7). These items were divided among the three concepts of the survey as follows: FMC-3, VNAV-3, and A/T-2. Collectively, these items address Interpreting

Information from the Automated Flight System.

Table 7: Items in Factor 1 of Knowledge Survey

No.	Corr.	Concept	Item
14	0.61	A/T	Which autothrottle FMA indication will allow manual thrust changes without autothrottle interference?
7	0.58	A/T	With Vertical Speed selected, what will the Autothrottle Mode annunciate?
22	0.40	FMC	What does an illuminated FMC P/RST light indicate?
5	0.39	VNAV	In a VNAV capable NG aircraft, you have a method for recapturing the vertical path that is not available in the Classic aircraft. The method utilizes the _________ switch.
26	0.38	VNAV	During a VNAV descent, to meet an ATC issued crossing restriction on an arrival, the aircraft has become high on the desired descent path. In an effort to regain the original path, the PF has elected to use SPD INTV on the MCP. Will the AFDS automatically recapture and maintain the path with SPD INTV selected?
30	0.38	FMC	The FMC advisory message “STEEP DESCENT AFTER MAJEK” displays on the scratch pad. This message indicates that:
10	0.34	FMC	How do you know if LNAV is engaged?
20	0.30	VNAV	The FMC alert message “RESET MCP ALT” is annunciated on the scratch pad. This indicates that:

Factor 2 contained five items: 4, 17, 24, 28, and 29 (see Table 8). These items were divided among the three concepts of the survey as follows: FMC-2, VNAV-2, and A/T-1. Collectively, these items address Managing the Automated Flight System.

Table 8: Items in Factor 2 of Knowledge Survey

No.	Corr.	Concept	Item
24	-0.55	FMC	All airspeed restrictions are considered by the FMC as ________ restrictions.
17	0.55	A/T	Vertical Speed is recommended for altitude changes of _________ or less.
4	0.50	VNAV	You are cruising at FL 370 with VNAV PTH annunciated on the FMA. Autothrottles are engaged. As you fly past the top of descent, the FMA annunciation ____________.
29	0.46	VNAV	During climb, how do you pre-determine which speed the aircraft will fly when VNAV is selected?
28	0.33	FMC	What AFDS pitch mode will activate if the autopilot is engaged while TOGA is active?

Factor 3 contained seven items: 9, 11, 15, 18, 19, 21, and 23 (see Table 9). These items were divided among the three concepts of the survey as follows: FMC–3, VNAV–2, and A/T–2. Collectively, these items address If-Then Situations.

Table 9: Items in Factor 3 of Knowledge Survey

No.	Corr.	Concept	Item
9	0.53	FMC	If a runway change needs to be made prior to departure, on which FMC page would the runway change be made?
15	0.42	A/T	With LVL CHG selected in the climb, what will the Autothrottle Mode annunciate?
11	0.41	FMC	During IRS alignment you notice the IRS ALIGN lights flashing. What should you do to correct this condition?
18	0.38	A/T	What indications are there on the flight deck if the autothrottles disengage?
23	0.37	VNAV	In a VNAV capable NG aircraft, when the message “Unable 280 KIAS at SYMON” appears in the scratch pad, what is the corrective action?
19	0.35	VNAV	If you observe the FMC advisory message “STEEP DESCENT AFTER MAJEK”, you can anticipate:
21	0.22	FMC	Where is the corrective action found for a CDU alert message?

Factor 4 contained five items: 1, 3, 6, 8, and 16 (see Table 10). These items were divided among the three concepts of the survey as follows: FMC-4, VNAV-0, and A/T-1. Collectively, these items address Declarative Knowledge.

Table 10: Items in Factor 4 of Knowledge Survey

No.	Corr.	Concept	Item
8	0.63	FMC	The GPS position information is displayed on which FMC page?
3	0.46	FMC	You are on a vector to intercept final for an ILS approach and want to extend the centerline. The approach has been programmed in the CDU. To extend the centerline, which page would you initially select?
6	0.46	A/T	For the autothrottle system to operate, what two items must be input to the CDU?
16	0.43	FMC	During the departure briefing, the PF briefs the departure from the appropriate Jeppesen plate. The PM should verify the following:
1	0.32	FMC	What FMC page displays the FMC data base version and active dates?

Factor 5 contained five items: 2, 12, 13, 25, and 27 (see Table 11). These items were divided among the three concepts of the survey as follows: FMC-4, VNAV-1, and A/T-0. Collectively, these items address Display Indicators.

Table 11: Items in Factor 5 of Knowledge Survey

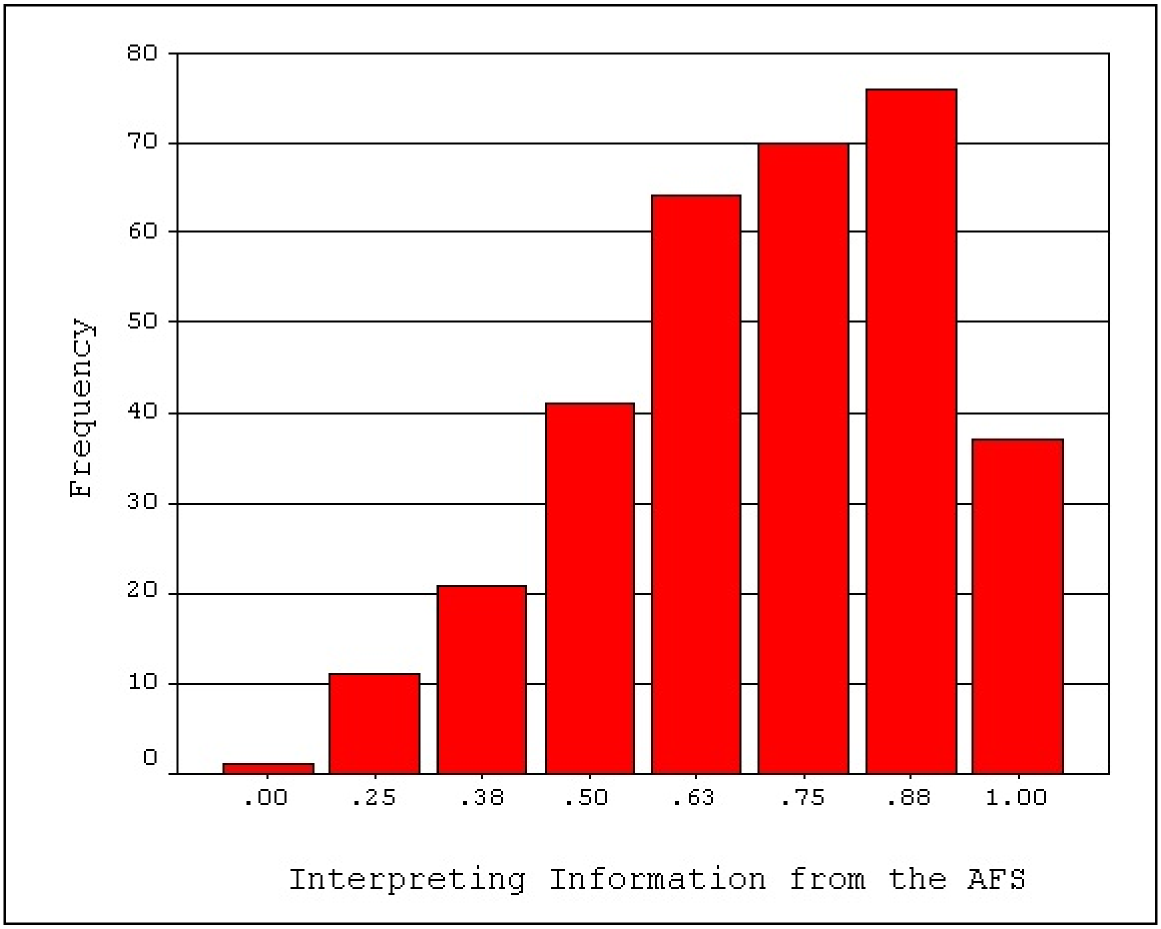
No.	Corr.	Concept	Item
13	0.63	FMC	The "UNABLE REQD NAV PERF – RNP" message will be displayed on the CDU scratchpad when:
25	0.47	FMC	What are the indications of a Left FMC failure?
2	0.46	VNAV	You are flying the company route from BWI to STL and have VNAV engaged. Your final cruise altitude is FL380 and that is set as the cruise altitude in the FMC. Washington Center has directed you to maintain FL300. What will the Pitch Mode of the FMA indicate after your aircraft levels at FL 300?
12	0.38	FMC	While cruising at FL 340 from KISP to KFLL, Jacksonville Center tells you to cross CRANS at a time of 19:34:30. Which FMC function should you use to comply with that restriction?
27	0.32	FMC	Which of the following is/are true in regards to selecting LVL CHG at 400' AGL?

Factor Scores

Scores were computed for each of the factors. This was accomplished by summing the items in each factor and then dividing by the number of items in the factor. The resulting score has a range of zero to one and represents the percentage of items the pilot got right in each factor. Because they are percentages, the scores are standardized so that they can be compared to each other.

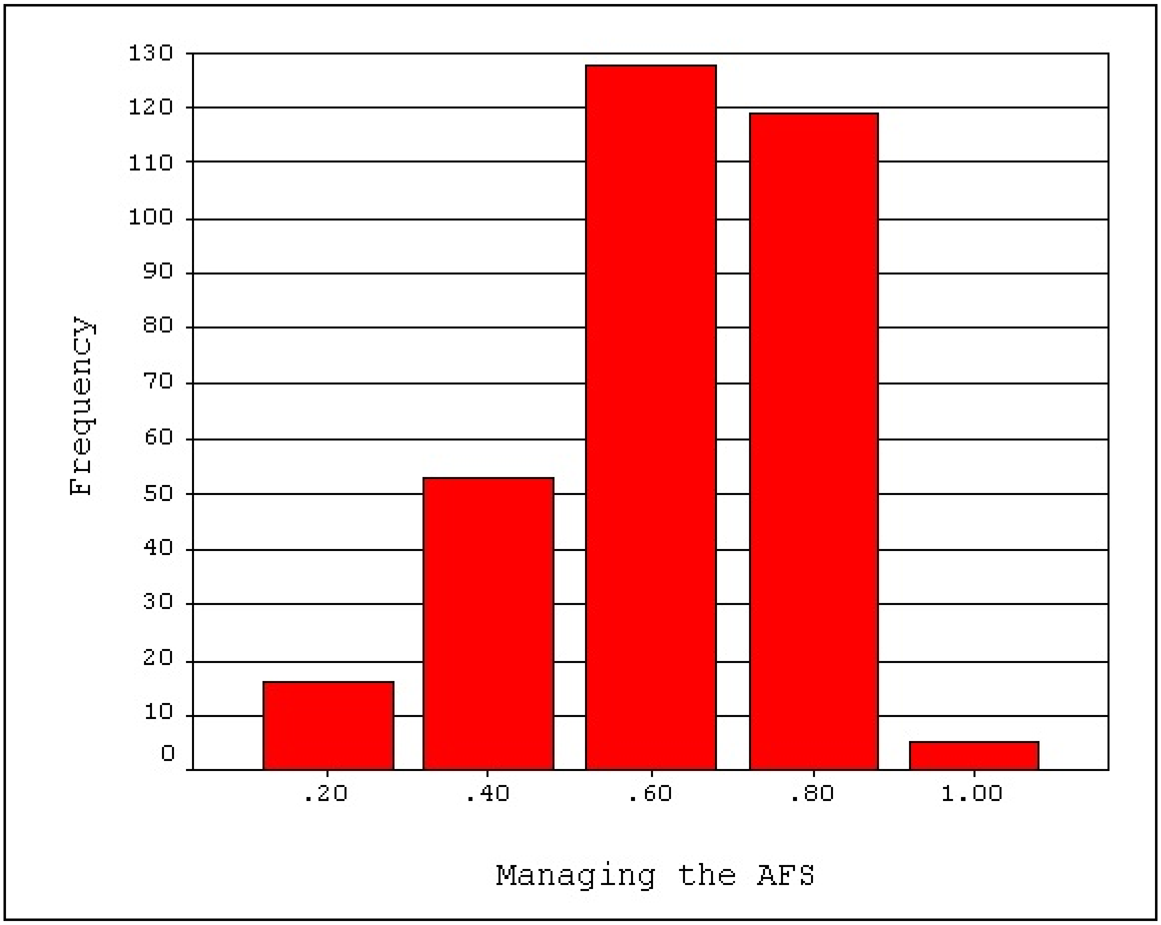
Factor 1 deals with Interpreting Information from the AFS. The mean score for the pilots on this factor was .71 with a standard deviation of .2; that is, the pilots averaged getting 71% of the 8 items in this factor correct. The scores ranged from 0 to 1. The distribution is skewed toward the high end of the scale; however, only 11.5% of the scores were above the at least 90% correct level (see Figure 3).

Figure 3: Distribution of Pilot Scores on Interpreting Information from the AFS



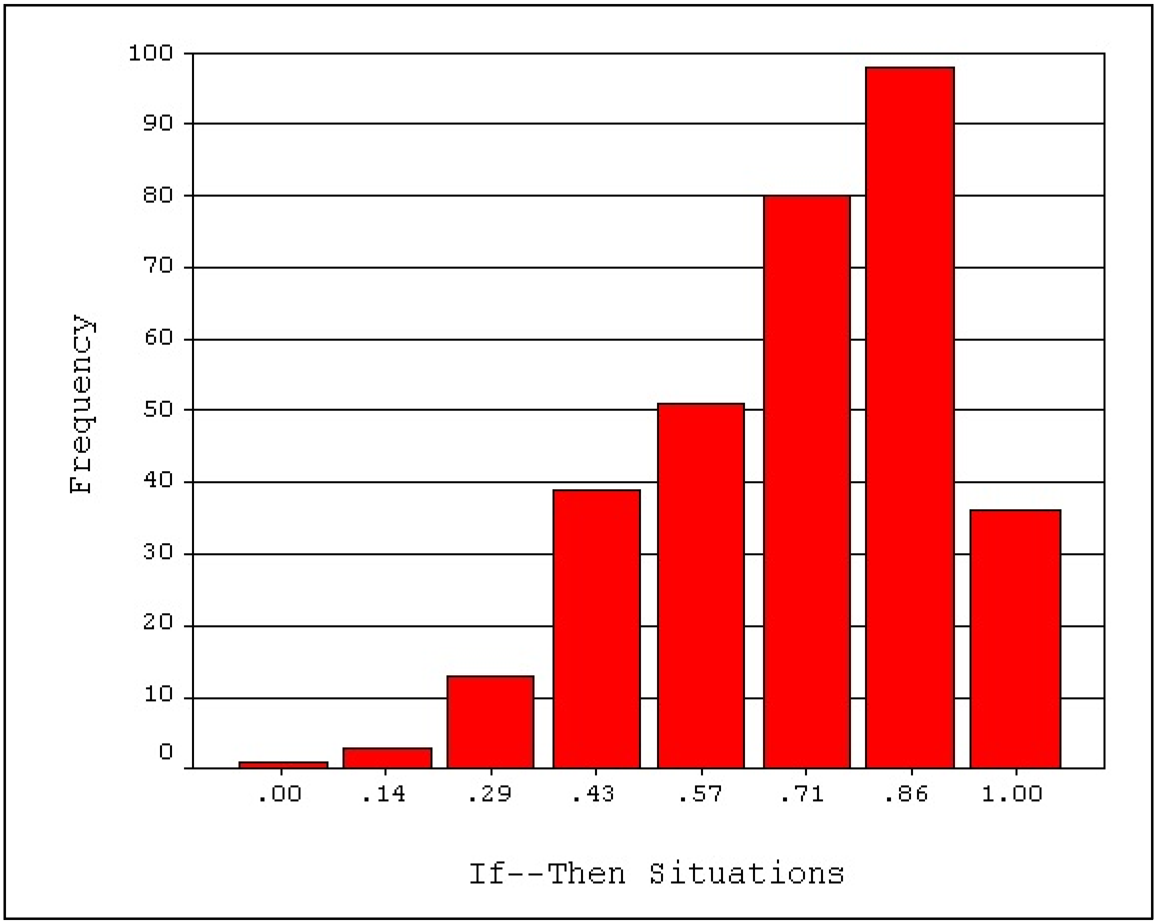
Factor 2 deals with Managing the AFS. The mean score for the pilots on this factor was .63 with a standard deviation of .18; that is, the pilots averaged getting 63% of the 5 items in this factor correct. The scores ranged from .2 to 1. The distribution is approximately bell shaped; however, only 1.6% of the scores were above the at least 90% correct level (see Figure 4).

Figure 4: Distribution of Pilot Scores on Managing the AFS



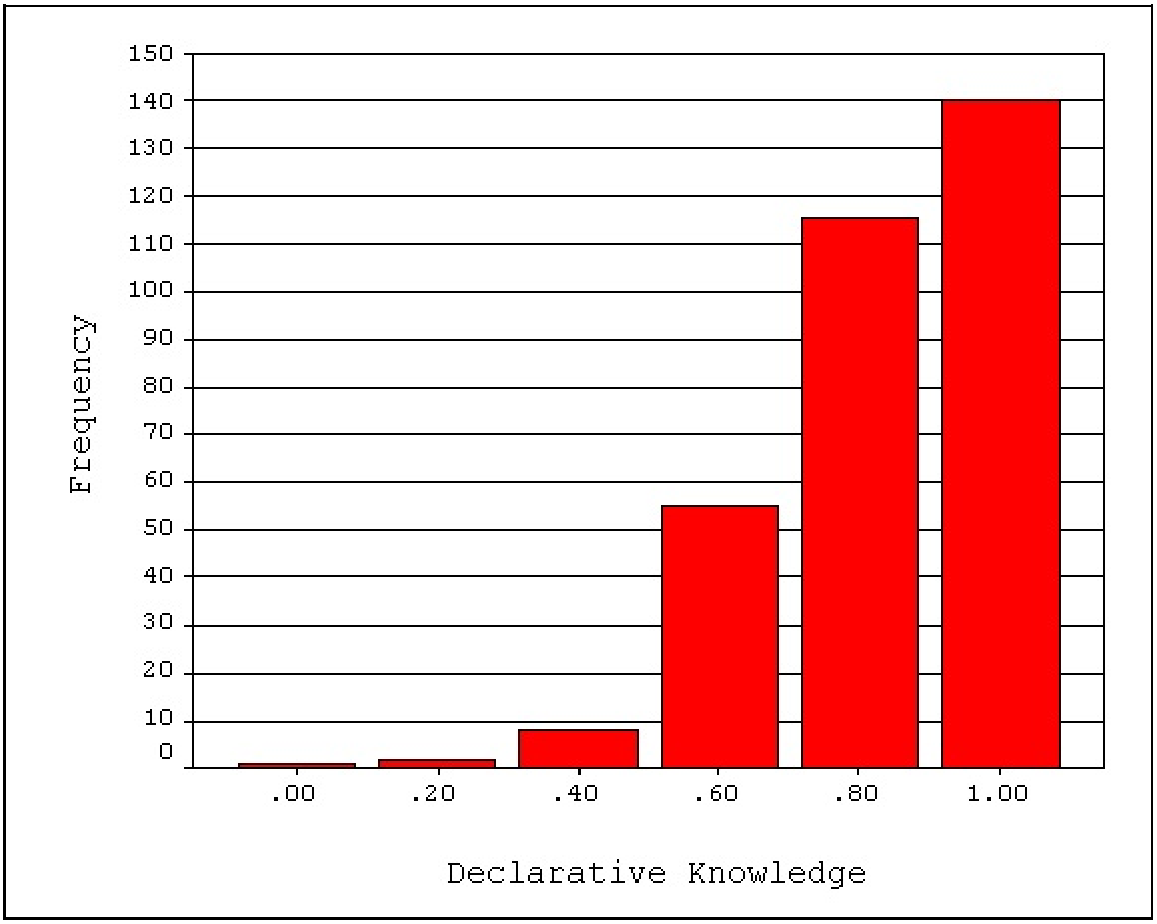
Factor 3 deals with If-Then Situations. The mean score for the pilots on this factor was .71 with a standard deviation of .2; that is, the pilots averaged getting 71% of the 7 items in this factor correct. The scores ranged from 0 to 1. The distribution is skewed toward the high end of the scale; however, only 11.2% of the scores were above the at least 90% correct level (see Figure 5).

Figure 5: Distribution of Pilot Scores on If-Then Situations



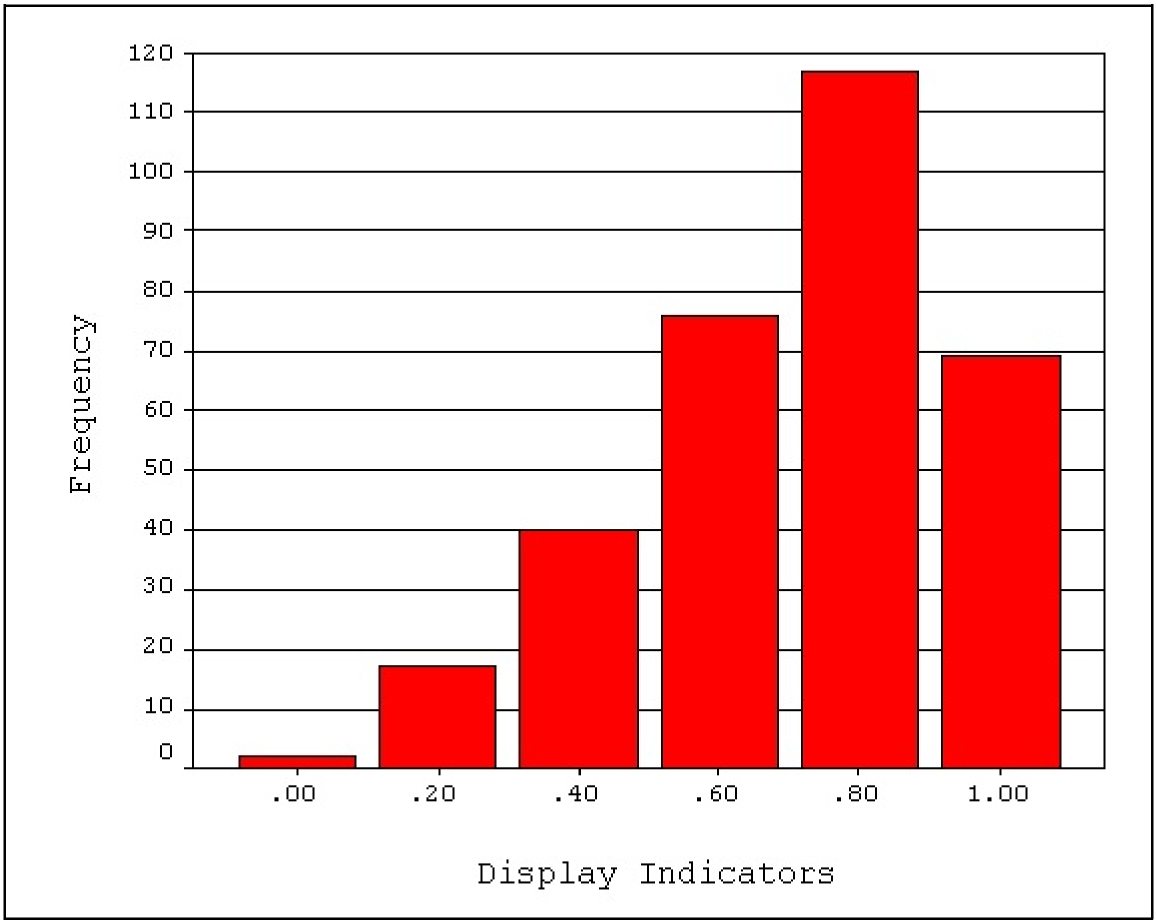
Factor 4 deals with Declarative Knowledge. The mean score for the pilots on this factor was .84 with a standard deviation of .18; that is, the pilots averaged getting 84% of the 5 items in this factor correct. The scores ranged from 0 to 1. The distribution is skewed toward the high end of the scale with 43.6% of the scores were above the at least 90% correct level (see Figure 6).

Figure 6: Distribution of Pilot Scores on Declarative Knowledge



Factor 5 deals with Display Indicators. The mean score for the pilots on this factor was .71 with a standard deviation of .23; that is, the pilots averaged getting 71% of the 5 items in this factor correct. The scores ranged from 0 to 1. The distribution is skewed toward the high end of the scale with 21.5% of the scores were above the at least 90% correct level (see Figure 7).

Figure 7: Distribution of Pilot Scores on Display Indicators



<u>Knowledge Level and Group Differences</u>

The third research question investigated the relationship between the airline pilot's knowledge of automated flight control and selected demographic and professional variables. Personal and demographic information was collected for the purpose of exploring for group differences based upon their scores on the knowledge survey. The personal variables were age, gender, and race. The professional variables were rank and experience flying commercial aircraft, experience with the airline, and experience with automated flight controls. In addition, the pilots were asked how well prepared they felt to fly the initial stage of operations following the computer-based training that they had received, and they were asked the frequency that they use VNAV and/or autothrottle if they are available.

Analysis of variance (ANOVA) was used to investigate the relationship of the pilot's knowledge scores to the various personal and professional variables. ANOVA is used to test the differences of two or more means at a selected probably level (Gay & Airasian, 2000, p. 491).

> The concept underlying ANOVA is that the total variation, or variance, of scores can be divided into two sources—treatment variance (variance between groups, caused by the treatment groups) and error variance (variance within groups). A ratio is formed (the F ratio) with treatment variance as the numerator (variance between groups) and error variance in the denominator (variance within groups). (p. 491)

With ANOVA the pilots were divided into groups, and the means of the groups were tested to determine whether the differences among the means were true, significant differences or whether they were due to chance (p. 491).

Age and the three measures of different types of experiences were continuous numbers. Therefore, they had to be recoded into groups. In order to maintain fairly equal-sized groups for the analysis, groups were formed for each of these variables by dividing the sample into quartiles for each variable. As a result, the groups used in the analysis for each variable were as follows:

3. Age: 28-39, 40-45, 46-50, and 51-63
4. Experience Flying: 0-10, 11-14, 15-21, and 22-41
5. Experience with the airline: 1-4, 5-9, 10-13, and 14-33
6. Experience with Automated Flight Systems: 0-2, 3-9, 10-14, and 15-40.

For the personal variables, no analyses were conducted for gender and race because there was so little variance in the groupings. No significant differences in the knowledge scores were found for the age groups with ANOVA (see Table 12).

Table 12: ANOVA of Personal and Professional Variables with Pilot's Knowledge Score

Groups	***SS***	***df***	***MS***	***F***	***p***
Prepared for AFS					
Between	315.9	4	78.97	6.75	0.000
Within	2691.4	230	11.70		
Frequency Use AFS					
Between	73.4	1	73.38	6.15	0.014
Within	3745.2	314	11.93		
Experience at the airline					
Between	67.3	3	22.44	1.80	0.148
Within	3950.6	316	12.50		
Experience with AFS					
Between	52.5	3	17.49	1.39	0.246
Within	3956.9	314	12.60		
Age					
Between	48.3	3	16.11	1.27	0.284
Within	3850.7	304	12.67		
Rank					
Between	3.9	1	3.91	0.31	0.579
Within	4013.7	317	12.66		
Experience Flying					
Between	6.6	3	2.20	0.17	0.914
Within	4011.5	317	12.65		

The professional variables consisted of rank and of various types of experience. For rank, the pilots were grouped as either Captain or First Officer. No significant differences in knowledge scores were found due to rank (see Table 12). Separate one-way ANOVAs were conducted for each of the experience variables. No significant differences in the knowledge scores were found for any of the experience groupings with ANOVA (see Table 12).

In addition to these personal and professional variables, separate one-way analysis of variances were conducted for the questions dealing with how prepared the pilots felt for flying the initial stage of operations after their training and for how frequently they used automated systems if available. For each of these questions, the pilots selected a choice from a list of options; therefore, their responses were already grouped into categories. Significant differences in the means of the knowledge score for the groups were found on both of these questions (see Table 12). For frequency of using automated flight systems, two options had to be eliminated from the analysis because they only contained three responses. While the overall ANOVA reported a significant difference between the group that used the automated flight controls all of the time ($\underline{M}$ = 22.05) and the group that used the automated flight controls most of the time ($\underline{M}$ = 21.09), the difference was very small. This difference of .96 point was spread over 30 items and represents a difference of .03 per items. This difference is so small that it has no practical significance.

For the question related to how well prepared they felt to fly the initial stage of operations following their computer-based training, the pilots had five response options: Very Well Prepared, Well Prepared, Fair, Poorly Prepared, and Very Poorly Prepared. When significant differences are found in ANOVA analyses with more than two groups, a follow-up procedure is needed to locate these differences. This procedure is referred to as post hoc analysis, and one of the most conservative and often used procedures is the Scheffe test (Sheskin, 2007, p. 895). The Scheffe test revealed that the difference in the groups was due to the group that felt Very Well Prepared ($\underline{M}$ = 23.4) scoring higher than the group that felt Poorly Prepared ($\underline{M}$ = 18.4). While this difference of 5 points was found to be significant, caution must be used in applying these findings because both of these groups were small: Very Well Prepared–11 and Poorly Prepared–20.

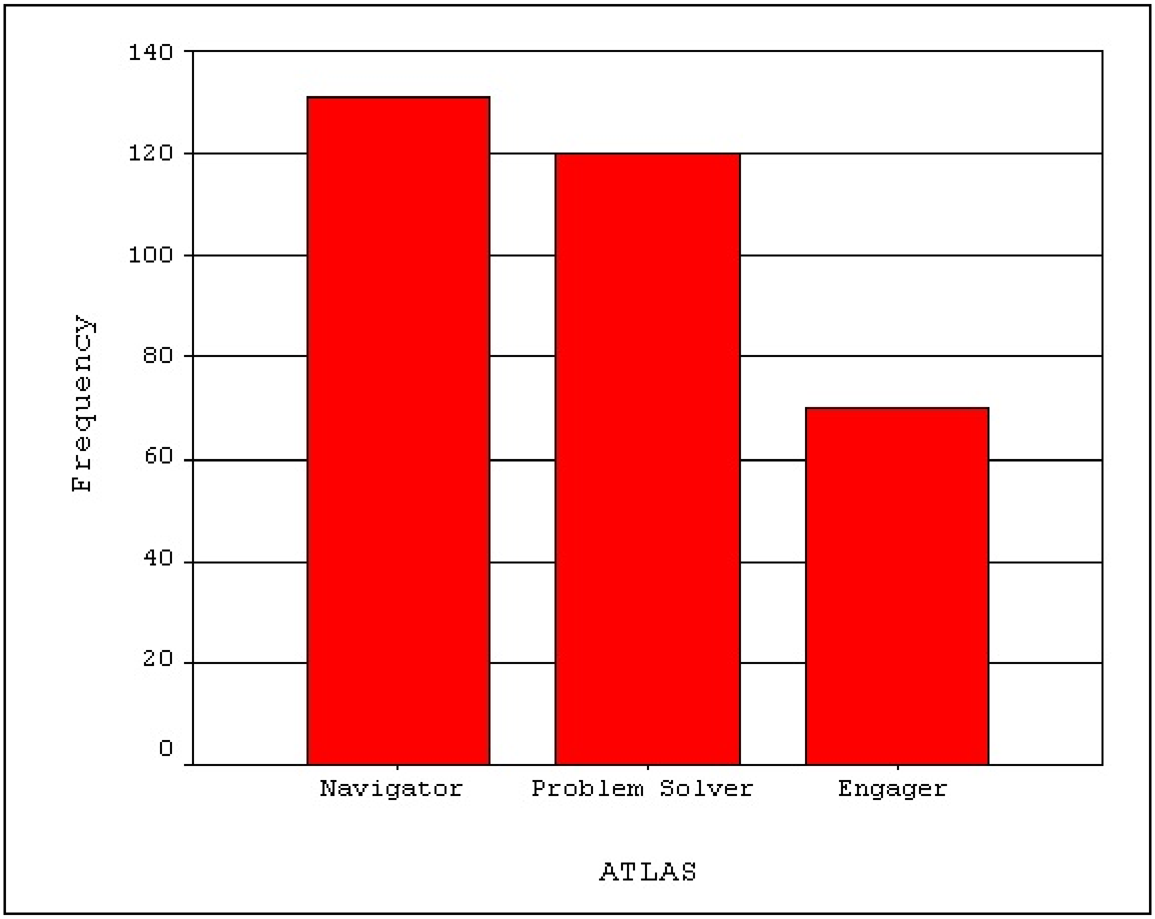
In summary, seven separate one-way analysis of variances were conducted to explore for differences in the knowledge scores for various groupings of the pilots according to personal and professional characteristics. No significant differences were found in five of these analyses. The differences that were found in the other analyses were mitigated by the difference being very small in one analysis and by the groups being very small in the other analysis. When these caveats are taken into consideration, it can be assumed that the pilots did not differ in their knowledge level due to the way they were grouped on any of the variables for which data were collected.

Learning Strategy Profile

The fourth research question investigated the learning strategy profile of the airline pilots. Assessing The Learning Strategies of AdultS (ATLAS) was used to identify the learning strategy preferences of the airline pilots. ATLAS identifies a person's learning strategy preference. Learning strategies are the techniques that people select to use to complete specific learning task (Fellenz & Conti, 1989, pp. 7-8).

Three distinct groups of learning strategy preferences exist among adult learners, and these groups have been named Navigators, Problem Solvers, and Engagers (Conti, 2009, p. 891). Individual differences in learning strategy preferences are related to the process used to initiate the learning task with Navigators and Problem Solvers initiating "a learning task by looking externally from themselves at the utilization of resources that will help them accomplish the learning" (p. 891) while Engagers "involve themselves in the reflective process of determining internally that they will enjoy the learning task enough to finish it" (p. 891). Navigators are "focused learners who chart a course for learning and follow it" (p. 893); the rely heavily on planning to achieve efficiency and effectiveness in the learning (p. 893). While Navigators seek to narrow the options available, Problem Solvers immediately begin to generate learning alternatives based upon the available resources (p. 894). While Navigators and Problem Solvers initiate a learning activity from the cognitive domain, Engagers initiate learning activities from the affective domain (p. 894). Engagers are "passionate learners who love to learn, learn with feeling, and learn best when they are actively engaged in a meaningful manner with the learning task (p. 894). For them, enjoying the learning and building relationships with others while learning are important (p. 894). The learning strategy preference distribution for the 321 pilots was as follows: Navigators--131 (40.8%), Problem Solvers–120 (37.4%), and Engagers–70 (21.8%) (see Figure 8).

Figure 8: Distribution of ATLAS Groups



ATLAS was developed from a data set of 3,070 responses with multivariate statistics that provide an expected distribution of the three learning strategy preference groups (Conti, 2008, p. 891). Chi square is a nonparametric test of significance that is appropriate to use when nominal data are in the form of frequencies (Gay, Mills, & Airasian, 2090, p. 348). "Chi square analysis helps determine if any observed differences between the variables are meaningful and is computed by comparing the frequencies of each variable observed in a study to the expected frequencies" (p. 348). A chi-square test "can be used to test hypotheses about how well a sample distribution fits some theoretical or hypothesized distribution. Such a test is also called a goodness-of-fit test; that is, it test how well the sample distribution fits the hypothesized distribution" (Wiersma & Jurs, 2005, p. 391).

The airline pilots' responses on ATLAS were a sample distribution of ATLAS responses. The one-sample chi-square test, which is also referred to goodness-of-fit test, was used to determine how well this sample fit the hypothesized sample from the creation of ATLAS. For ATLAS, the expected proportions are the percentages of the distributions from the cluster analysis that was used to create ATLAS. The expected percentages are as follows: Navigator–36.5%, Problem Solvers–31.7%, and Engagers–31.8% (Conti, 2009, p. 891). If the differences between the airline sample and the original sample used to create ATLAS could be attributed to sampling error, then there would be a "good fit" between the observed the airline data and the original data; however, if the sampling error could not adequately explain the discrepancies between the observed and the expected samples, then there would be a "bad fit" (Huck, 2000, p. 618). An alpha level of .05 was used to determine the significance level for this chi-square analysis; this is the most frequently used preset significant level of probability testing (p. 187).

The distribution of the airline pilots was significantly different from the original group used to create ATLAS (χ^2 = 14.98, df = 2, p = .001) (see Table 13). The airline pilot sample was different from the sample used to create ATLAS because there were nearly one-third (32.1/102.1 = 31.4%) less Engagers than expected. The distribution of the airline pilots also differed from the sample used to create ATLAS with slightly more Navigators (13.8/117.2 = 11.8%) and Problem Solvers (18.2/101.8 = 17.9%) than expected. Thus, the airline pilot sample had significantly more with a learning strategy preference for initiating learning in the cognitive domain than for initiating learning in the affective domain.

Table 13: Observed and Expected Distribution of Learning Strategy Groups

Learning Strategy	Observed	Expected	Difference
Navigators	131	117.2	+13.8
Problem Solvers	120	101.8	+18.2
Engagers	70	102.0	-32.1

Learning Strategies and Group Differences

The fifth research question investigated the relationship between the airline pilots' learning strategy preferences as identified by ATLAS and selected demographic and professional variables. Chi square was used for this research question because ATLAS places respondents into the three categories of Navigators, Problem Solvers, and Engagers. A chi-square test of independence is used to compare two or more samples when the responses are categorical in nature (Huck, 2000, p. 618); that is, it is used “when a single sample is categorized on two dimensions/variables” (Sheskin, 2007, p. 620). The chi-square test of independence

> Evaluates the general hypothesis that the two variables are independent of one another. Another way of stating that two variables are independent of one another is to say that there is a zero correlation between them. A zero correlation indicates there is no way to predict at above chance in which category an observation will fall on one of the variables, if it is known which category the observation falls on the second variable. (p. 620)

Consequently, this chi square test is used to determine if the variables in the analysis are independent of each other (Gay, Mills, & Airasian, 2009, p. 349).

The data for a chi-square test of independence is often displayed in a contingency table. Contingency tables

> Are two-dimensional tables with one variable on each dimension. Each of the variables has two or more categories, and the data are the sample frequencies in the categories. The null hypothesis of independence–that is, no relationship–between the variables is tested. (Wiersma & Jurs, 2005, p. 392)

In the test of relationships, the value for determining independence is determined by the data and not the researcher (Huck, 2000, p. 622). When significant differences are found on the chi square, the standardized residuals for each cell in the contingency table can be used "to determine which cells are the major contributors to a significant chi-square value" (Sheskin, 2007, p. 653) with residuals with an absolute value at or greater than 1.96 being significant at the .05 level and residuals with an absolute value at or greater than 2.58 being significant at the .01 level (p. 654).

Three sets of contingency tables were constructed to analyze the relationship between learning strategy preference as measured by ATLAS and the (a) personal variables, (b) professional variables, and (c) training-related variables. The personal variables that were in the analyses were (a) gender, (b) age, and (c) race (see Table 14). Because age was measured as a continuous variable, the pilots were placed in the following age groupings for this analysis: 28 to 39, 40 to 45, 46 to 50, and 51 to 63. There were no significant differences for the age groupings (χ^2 = 11.25, $\underline{df}$ = 6, $\underline{p}$ = .081) and race (χ^2 = 11.01, $\underline{df}$ = 10, $\underline{p}$ = .353); that is, learning strategy preference and the variables of age and race are independent of each other. However, a significant difference was found for gender (χ^2 =

9.64, df = 2, p = .008). An examination of the standardized residuals revealed that this difference was due to there being more female Engagers (Standardized Residual = 2.6) than expected. While this finding needs to be interpreted with caution because there were only 10 female pilots in the study, 6 of them were Engagers.

Table 14: Distribution of Personal Variables by ATLAS Groups

Variable	**Navigator**	**Pro Sol**	**Engager**	**Total**
Gender				
Male	130	117	63	310
Female	1	3	6	10
Total	131	120	69	320
Age Groups				
28 to 39	24	39	14	77
40 to 45	39	29	13	81
46 to 50	33	22	20	75
51 to 63	31	25	19	75
Total	127	115	66	308
Race				
African American		1	2	3
Asian	2			2
Hispanic	4	2	2	8
Native American	2	1		3
White	117	115	66	298
Other	3	1		4
Total	128	120	70	318

The professional variables that were in the analyses were (a) rank, (b) years experience flying, (c) years experience with the airline, and (d) years experience flying with automation (see Table 15). The years of experience were grouped as follows: Experience Flying--0 to 10, 11 to 14, 15 to 21, and 22 to 41; Experience with the airline--0 to 10, 11 to 14, 15 to 21, and 22 to 41; and Experience Flying with Automation--0 to 2, 3 to 9, 10 to 14, and 15 to 40. There were no significant differences for the groups for experience flying ($\chi^2 = 5.89$, df = 6, p = .436), experience flying with the airline ($\chi^2 = 11.76$, df = 6, p = .068), and experience flying with automation ($\chi^2 = 6.34$, df = 6, p = .386); this indicates that the various types of experience are independent of learning strategy preference. However, rank was significantly different ($\chi^2 = 6.61$, df = 2, p = .037). Although the overall chi-square test indicated a significant difference, none of the values of the standardized residuals were large enough to meet the 1.96 criterion to be significant at the .05 level. The greatest differences in the distribution was for Problem Solvers with there being less Captains (Standardized Residual = -1.3) and more First Officers (Standardized Residual = 1.4) in the group than expected; however, these differences were not great enough to be statistically significant.

Table 15: Distribution of Professional Variables by ATLAS Groups

Variable	Navigator	Pro Sol	Engager	Total
Rank				
Captain	72	51	42	165
First Officer	59	68	27	154
Total	131	119	69	319
Experience Flying				
0 to 10	43	44	16	103
11 to 14	32	24	16	72
15 to 21	31	27	17	75
22 to 41	25	25	21	71
Total	131	120	70	321
Experience with the airline				
0 to 10	33	45	15	93
11 to 14	39	36	17	92
15 to 21	30	15	17	62
22 to 41	29	24	20	73
Total	131	120	69	320
Experience Flying With Automation				
0 to 2	36	38	25	99
3 to 9	30	37	15	82
10 to 14	26	21	13	60
15 to 40	38	22	17	77
Total	130	118	70	318

The training-related variables that were in the analyses were (a) how well prepared to fly with automation following the initial stage of training, (b) frequency automation used in flight following the initial stage of training, (c) scoring 90% or above on the knowledge assessment, and (d) scoring 80% or above on the knowledge assessment (see Table 16). There were no significant differences for preparedness ($\chi^2 = 7.09$, $\underline{df} = 8$, $\underline{p} = .527$)

and being in the 90% correct group(χ^2 = .304, df = 2, p = .859); this indicates that the assessment of preparedness and achieving a score of 90% or above on the knowledge survey were independent of learning strategy preference. However, there were significant differences for frequency of use of automation following the initial stage of training (χ^2 = 8.86, df = 2, p = .012) and for being in the 80% correct group (χ^2 = 6.80, df = 2, p = .033). The difference in frequency of use of automation following the initial stage of training was due to less Engagers (Standardized Residual = -2.0) than expected using the automation all of the time. This differences was only slightly less for Engagers (Standardized Residual = -1.9) when the two extremely small groups for level of use were removed from the analysis. The difference for those being in the group with at least 80% of the knowledge items correct was due to less Engagers (Standardized Residual = -1.9) being in this group.

Table 16: Distribution of Training-Result Variables by ATLAS Groups

Variable	Navigator	Pro Sol	Engager	Total
Prepared				
Very Well Prepared	5	4	2	11
Well Prepared	44	33	16	93
Fair	41	38	29	108
Poorly Prepared	5	7	8	20
Very Poorly Prepared	1	1	1	3
Total	96	83	56	235
Use Automation				
Use all the time	66	59	21	146
Use most of the time	63	59	48	170
Total	129	118	69	316
90% Group				
In Group	8	7	3	18
Not In Group	123	113	67	303
Total	131	120	70	321
80% Group				
In Group	47	40	13	100
Not In Group	84	80	57	221
Total	131	120	70	321

Naturally-Occurring Groups

The sixth research question investigated for the existence of naturally-occurring groups among the airline pilots based upon their knowledge of automated flight control. Cluster analysis was used to identify these groups, and discriminant analysis was used to identify the process that separated these groups.

Cluster Analysis

Cluster analysis was used to explore for naturally-occurring groups among the pilots based on their knowledge of automated flight control. “Cluster analysis is a set of techniques for accomplishing the task of partitioning a set of objects into relatively homogeneous subsets based on the inter-object similarities” (Kachigan, 1991, p. 261). That is, it is a procedure in which “we ask whether a given group can be partitioned into subgroups which differ” (p. 262). Cluster analysis reveals naturally-occurring groups in the data because it groups “objects or individuals into homogenous clusters such that objects or subjects in a given cluster are more similar to one another than objects or subjects of a different cluster” (Sheskin, 2007, p. 1635). Thus, for the social sciences,

> Cluster analysis is a powerful multivariate tool for inductively making sense of quantitative data. Its power lies in its ability to examine the person in a holistic manner rather than as a set of unrelated variables. Cluster analysis can be used to identify groups which inherently exist in the data. (Conti, 1996, p. 71)

Three important concepts in understanding the process of cluster analysis are the concept of clustering, the concept of similarities, and the concept of how distances are measured (Aldenderfer & Blashfield, 1984). By combining these, “the ultimate goal is to arrive at clusters of objects which display small within-cluster variation, but large between-cluster variation” (Kachigan, 1991, p. 262).

Clustering is the process of placing either individuals or groups of individuals who have been previously clustered together into clusters. Clusters are formed sequentially in a hierarchical order starting with the total number of people in the dataset (Kachigan, 1991, p. 269), and “this procedure of sequential clustering continues until all the objects merge into a single undifferentiated group” (p. 270); that is, the process starts with each person in the dataset identified as an individual and processes to where everyone is in one single group. At each step, either one individual or one existing cluster is combined with another individual or existing cluster. This sequential process is repeated for as many times as there are individuals in the dataset.

The way that the clusters are formed in the hierarchical clustering process is influenced by the similarity of the individuals in the cluster and by the distance between the clusters; similarities and distances are complements of one another (Kachigan, 1991, p. 264). The concept of similarity is synonymous with resemblance, proximity, and association of items within a cluster (Aldenderfer & Blashfield, 1984, p. 17). Various metrics have been developed to measure these similarities. A commonly used measure for measuring the similarity between two cases is the Euclidean distance (Kachigan, 1991, p.

265). The squared Euclidean distance is the sum of the square of the differences over all of the variables (Conti, 1996, p. 69).

There are several methods for determining how cases will be combined into clusters in a cluster analysis (Aldenderfer & Blashfield, 1984, p. 35). Hierarchical agglomerative methods have been dominant in terms of the most frequently used method (p. 35). Within the hierarchical agglomerative methods, Ward's method has been the most widely used procedure in the social sciences for linking the clusters in the analysis (p. 43). The strength of this method is that "it tends to find (or create) clusters of relatively equal sizes and shapes" (p. 43).

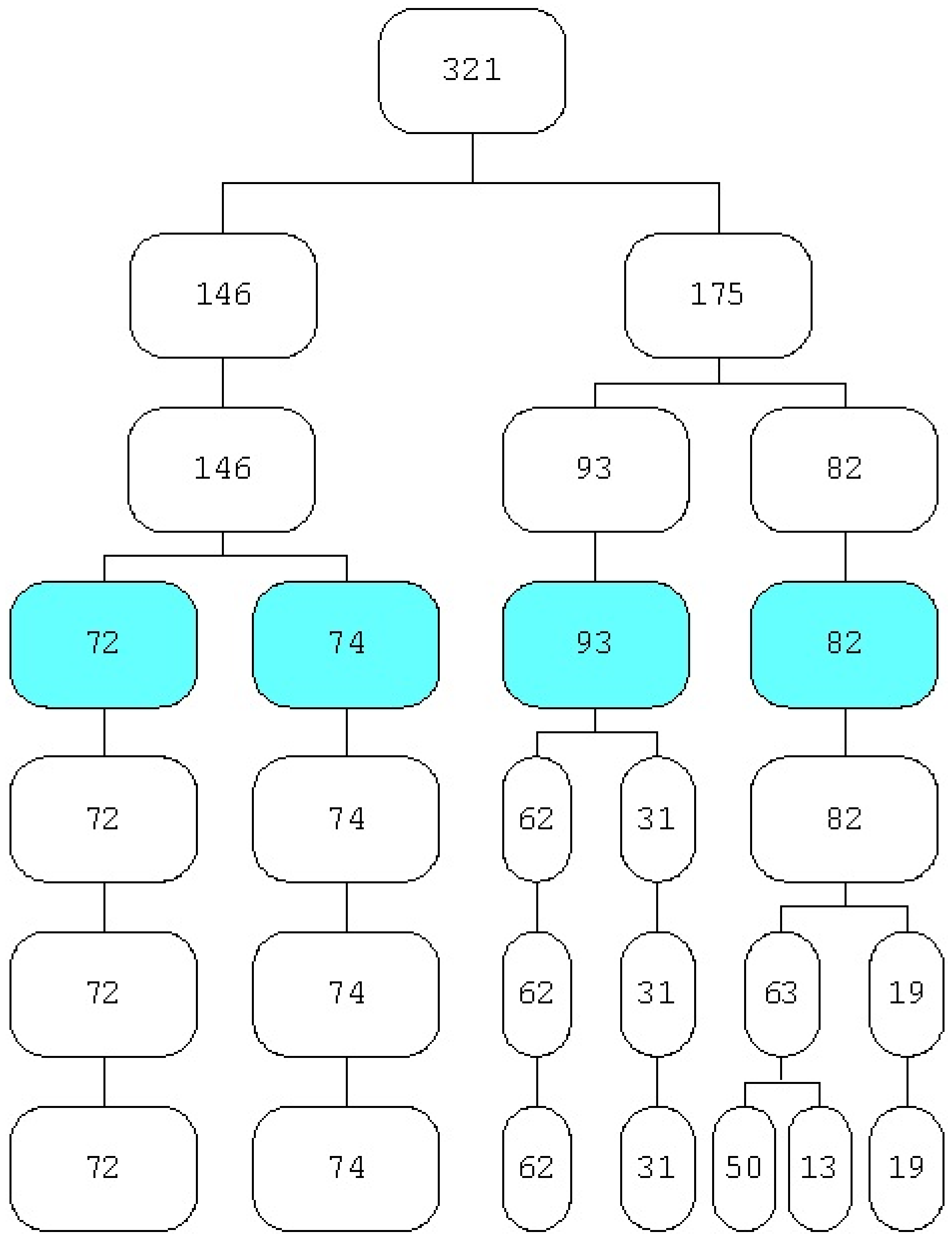
After the cluster analysis procedure is run, the task of the researcher is to determine the "optimal number of groups" (Aldenderfer & Blashfield, 1984, p. 53) for the analysis. Two basic approaches have evolved for doing this; they are heuristic procedures and formal tests (p. 54). While several techniques have been developed for each, the "heuristic procedures are by far the most commonly used methods" (p. 54).

Clusters of Pilots

Cluster analysis was used to answer the sixth research question that explored for naturally-occurring groups among the airline pilots based on their knowledge of automated flight control. The 30 items of the knowledge assessment instrument were used as the variables for this analysis. The clusters were formed using hierarchical cluster analysis. The squared Euclidean distance was used to measure the distance between the cases. The Ward's method was used for linking cases into clusters.

Using these options for the statistical analysis, a 4-cluster solution was judged the best explanation of the data (see Figure 9). At the 4-cluster level, the size of the groups are distributed more equitably than at the other levels: 93 (29.0%), 82 (25.5%), 74 (23.1%), and 72 (25.5%). At the 3-cluster level, the two nearly-equal sized groups of 74 and 72 combine to form a group of 146, and this group is 1.5 times larger than the group of 93 and twice as large as the group of 72. At the 2-cluster level the groups are somewhat equal, but the groups at the 4-cluster level provide a much more insightful description of the naturally-occurring groups among the pilots. When the number of clusters is expanded beyond 4, then very small groups emerge: 5-cluster level–9.7%, 6-cluster level–5.9%, and 7-cluster level–4.0%. Since the purpose of using Ward's method of linking the clusters was to uncover somewhat equal-sized groups, the 4-cluster solution both heuristically and logically is the best solution for describing the naturallyoccurring groups among the pilots based on their knowledge level of automated flight control.

Figure 9: Cluster Formation for Pilot Knowledge



Naming the Clusters

While knowing the number of clusters or of naturally-occurring groups that exist in a dataset is useful, the practical significance is in being able to describe these groups. "Once the object clusters have been formed, they must be compared in order to get some idea of how they differ. The most straightforward approach is to compare the clusters with respect to their means and variance" (Kachigan, 1991, p. 269). While this can be done with univariate analysis comparing the groups on one variable at a time, an interactive way of comparing the groups on the variables is to use discriminant analysis (Conti, 1996, p. 71; Kachigan, 1991, p. 269).

Discriminant Analysis Procedure

Discriminant analysis is a statistical procedure "for examining the difference between two or more groups of objects with respect to several variables simultaneously" (Klecka, 1980, p. 5). It identifies the relationship between qualitative criterion variables (i.e., the groups) and quantitative predictor variables (Kachigan, 1991, p. 216). As a multivariate statistical procedure, it examines the interaction of the predictor variables on discriminating between the groups. As a result, discriminant analysis has the ability to "simultaneously analyze multiple variables that have the potential of explaining group placement" (Conti, 1993, p. 90).

Discriminant analysis is used to help the researcher to be able to "discriminate" between the groups on the basis of some set of characteristics, be able to tell how well these characteristics discriminate, and determine which characteristics are the most powerful discriminators (Klecka, 1980, p. 9). To conduct a discriminant analysis in the social sciences, people are grouped according to some meaningful criterion (Kachigan, 1991, p. 218), and then predictor variables are used to determine their accuracy in correctly classifying the people in their proper group (Conti, 1993, pp. 91-92; Kachigan, 1991, pp. 218-219; Klecka, 1980, pp. 8-14).

The discriminant analysis procedure produces many statistics to help the researcher interpret the results of the analysis. When discriminant analysis is used in conjunction with cluster analysis in order to name the process that separates the clusters, the discriminant analysis uses the same variables that were used in the cluster analysis as the predictor variables and the groups from the cluster analysis as the grouping criterion; consequently, only the classification table and the structure matrix are used from the discriminant analysis

(Conti, 1996, p. 71). The discriminant analysis produces a discriminant function which is a formula that the procedure uses for placing people in the groups (Conti, 1993, p. 91). The accuracy of the discriminant function in placing people in their groups is displayed in the classification table (Conti, 1991, p. 91). Since the groups were created statistically by cluster analysis, the accuracy of the classification rate should be very high. If the classification accuracy is not high, then the discriminant analysis will not be helpful in providing information on how the predictor variables discriminate between the groups.

The discriminant analysis also produces a structure matrix. The structure matrix is a table of the correlation coefficients that show the relationship between the individual predictor variables and the discriminant function (Conti, 1993, pp. 93-94). The structure matrix is used to "name" the discriminant function (Klecka, 1980, p. 31). This naming identifies the process that separates the groups and can be used for describing the groups (Conti, 1996, p. 71). Thus, the structure matrix "is used to name the discriminant function so that qualitative terms exist to explain the interaction that exists among the variable in distinguishing among the groups" (p. 91).

Discriminant analysis was used to identify the process that separated or discriminated the groups of pilots based on their knowledge level of automated flight control. Because the two-group discriminant analysis is the easiest to analyze and provides very clear results (Klecka, 1980, p. 27; Norusis, 1988, Chapter 1), three discriminant analyses were conducted for naming the process that separated the groups. For each of these analyses, the groups from the cluster analysis were used, and the 30 items of the knowledge assessment instrument were used as predictor or discriminating variables.

<u>Groups of 175 and 146</u>

Figure 9 reveals that the four groups collapse into two sets of two groups at the 2-cluster level. The groups of 93 and 82 form a group of 175, and the groups of 74 and 72 form a group of 146. In order to determine what discriminates between these two sets of groups, the first discriminate analysis was performed using the clusters of 175 and 146 at the 2-cluster level for the groups. The discriminant function produced by this analysis was 89.1% accurate in placing the participants in their correct group. The structure matrix contained three variables with a correlation with the discriminant function of .3 or above. One of these items was from the VNAV concept, and the other two items were from the FMC concept (see Table 17).

Table 17: Items from Knowledge Assessment that Discriminate Groups of 175 and 146

Item	Corr	Concept	Item
5	0.43	VNAV	In a VNAV capable NG aircraft, you have a method for recapturing the vertical path that is not available in the Classic aircraft. The method utilizes the _________ switch.
22	0.38	FMC	What does an illuminated FMC P/RST light indicate?
12	0.30	FMC	While cruising at FL 340 from KISP to KFLL, Jacksonville Center tells you to cross CRANS at a time of 19:34:30. Which FMC function should you use to comply with that restriction?

The three items in the structure matrix with the highest correlations deal with Observing Change. In each of the items, a change has occurred in the operation of the automated flight system, and it is the task of the pilot to correctly identify how to deal with this observed change. Since the items were scored with one point for answering the item correctly and no points for answering it incorrectly, the means for the items can be read as the percentage of the group members who answered the item correctly. The average of the means for these three items for the group of 146 was 85.3 (or 85.3% correct) while that of the group of 175 was 47.7 (or 47.7% correct). Thus, while over four-fifths of the group of 146 answered these three items correctly, less than half of the group of 175 knew this information. Based on this, the group of 146 is good at dealing with Observed Change while the group is 175 is weak in dealing with Observed Change.

Groups of 93 and 82

At the 4-cluster level, the group of 175 that was weak in dealing with Observed Change divided into groups of 93 and 82. The second discriminate analysis that was performed was with these two groups to determine what discriminated them from each other in addition to being weak in dealing with Observed Change. The discriminant function produced by this analysis was 89.1% accurate in placing the participants in their correct group. The structure matrix contained only two variables with a correlation with the discriminant function of .3 or above. Therefore, the criterion value of a correlation of .2 was used to obtain variables to aid in the process of naming the function. There were seven variables at the .2 or above level. The item with the highest correlation and one other item were from the A/T concept; three items were from the FMC concept; and two items were from the VNAV (see Table 18).

Table 18: Items from Knowledge Assessment that Discriminate Groups of 93 and 82

Item	Corr	Concept	Item
15	0.59	A/T	With LVL CHG selected in the climb, what will the Autothrottle Mode annunciate?
8	0.31	FMC	The GPS position information is displayed on which FMC page?
23	0.26	VNAV	In a VNAV capable NG aircraft, when the message "Unable 280 KIAS at SYMON" appears in the scratch pad, what is the corrective action?
6	0.25	A/T	For the autothrottle system to operate, what two items must be input to the CDU?
5	-0.20	VNAV	In a VNAV capable NG aircraft, you have a method for recapturing the vertical path that is not available in the Classic aircraft. The method utilizes the _________ switch.
25	0.20	FMC	What are the indications of a Left FMC failure?
11	0.20	FMC	During IRS alignment you notice the IRS ALIGN lights flashing. What should you do to correct this condition?

The seven items in the structure matrix with the highest correlations deal with the Need to Take Action. The items indicate that information has been displayed or annunciated by the automated flight system, and the pilot has to take a corrective action to deal with a failure or problem. The average of the means for these seven items for the group of 93 was 68.6 (or 68.6% correct) while that of the group of 82 was 46 (or 46% correct). Thus, while about two-thirds of the group of 93 answered these seven items correctly, less than half of the group of 82 knew this information. Therefore, in addition to being weak in dealing with Observed Change, the group of 93 is somewhat weak at dealing with the Need to Take Action while the group of 82 is weak at dealing with the Need to Take Action.

Groups of 74 and 72

At the 4-cluster level, the group of 146 that was good in dealing with Observed Change divided into groups of 74 and 22. The third discriminate analysis that was performed was with these two groups to determine what discriminated them from each other in addition to being good in dealing with Observed Change. The discriminant function produced by this analysis was 91.1% accurate in placing the participants in their correct group. The structure matrix contained only one variable with a correlation with the discriminant function of .3 or above. Therefore, the criterion value of a correlation of .2 was used to obtain variables to aid in the process of naming the function. There were seven variables at the .2 or above level. Five of the seven items including the one with the highest correlation were from the FMC concept, and there was one item each from the VNAV and A/T concepts (see Table 19).

Table 19: Items from Knowledge Assessment that Discriminate Groups of 74 and 72

Item	**Corr**	**Concept**	**Item**
25	-0.44	FMC	What are the indications of a Left FMC failure?
4	0.29	VNAV	You are cruising at FL 370 with VNAV PTH annunciated on the FMA. Autothrottles are engaged. As you fly past the top of descent, the FMA annunciation ____________.
1	-0.28	FMC	What FMC page displays the FMC data base version and active dates?
8	-0.22	FMC	The GPS position information is displayed on which FMC page?
16	-0.20	FMC	During the departure briefing, the PF briefs the departure from the appropriate Jeppesen plate. The PM should verify the following:
7	-0.20	A/T	With Vertical Speed selected, what will the Autothrottle Mode annunciate?
27	0.20	FMC	Which of the following is/are true in regards to selecting LVL CHG at 400’ AGL?

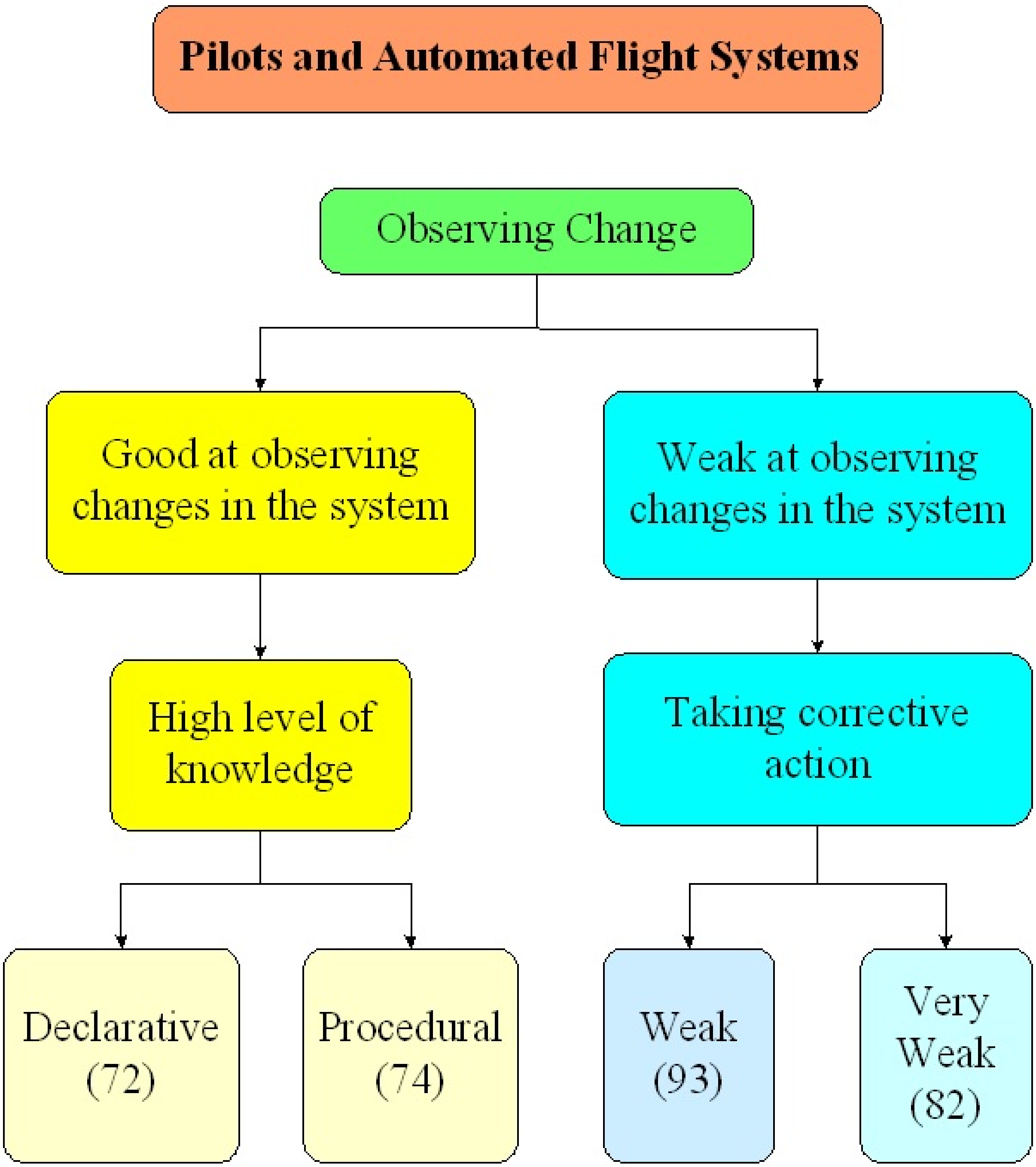
The seven items in the structure matrix with the highest correlations deal with Type of Knowledge. All seven items are at the knowledge or comprehension levels in

Bloom's Taxonomy of Learning in the Cognitive Domain. Five of the items address declarative knowledge, and two deal with procedural knowledge. Declarative knowledge is knowledge that allow a person to name, explain, and talk about things (Stolovitch & Keeps, 2002, p. 32) while procedural knowledge is the type of knowledge that enables one to act and do things in order to perform tasks (p. 33). The average of the means for the five declarative knowledge items for the group of 72 was 92 (or 92% correct). The average of the means for the two procedural knowledge items for the group of 74 was 92 (or 92% correct). Thus, in addition to being good in dealing with Observed Change, each of the groups was very high in either declarative or procedural knowledge.

Summary

Four distinct groups existed among the pilots based upon how they responded to the knowledge assessment items (see Figure 10). Approximately half of the group were good at observing changes taking place in the AFS while the other half was weak at observing change. Those in the group good at observing change differed almost equally in the type of knowledge they possessed. The group that was weak at observing change divided in fairly equal sized groups that were also weak or very weak in taking corrective actions.

Figure 10: Groups of Pilots Based on AFS Knowledge



CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Study

The training for a major airline utilized computer-based training to provide the initial training on automated flight control (AFC). Institutional data were collected related to this training, but it had not been extensively analyzed in order to provide information for future training of pilots. Therefore, the purpose of this study was to analyze the institutional data collected by the airline on their pilots related to automated flight control.

This was a descriptive study that described the knowledge level of the airline pilots related to automated flight control following the initial stage of training. Data were gathered using a 30-item knowledge assessment instrument that was designed for this training. The continuous quality improvement team for the airline and two experts with academic backgrounds were involved in the development and validation of the instrument. Data were also gathered on the learning strategy preferences of the pilots using ATLAS. Responses from 321 were secured through a random sampling of the airline’s pilots.

Summary of Findings

This study was an assessment of the current knowledge level of the pilots related to their needs for training related to automated flight systems; it was not a study about the competency of the pilots. Therefore, the first research question investigated the knowledge level of automated flight control of the airline pilots. For the 30 items in the knowledge assessment instrument, the median number of correct responses by the pilots was 22; this represents about 72% of the items. Only 18 of the pilots scored above the 90% mastery level, and 100 scored above the 80% mastery level. Those at the 90% mastery level outperformed the others by having more knowledge about vertical navigation (VNAV).

The second research question explored the factors that make up the airline pilots' knowledge of automated flight systems. The 30 items in the knowledge assessment instrument formed five factors. These were Interpreting Information from the AFS, Managing the AFS, If-Then Situations, Declarative Knowledge, and Display Indicators.

The third research question investigated the relationship between the airline pilot's knowledge of automated flight control and selected demographic and professional variables. For the seven analyses that were conducted to answer this question, no significant differences were found in five of the analyses, and the differences on the other two were too small to be meaningful.

The fourth research question investigated the learning strategy profile of the airline pilots. The distribution of learning strategy preferences of the airline pilots was significantly different from the norm group for ATLAS. There were less Engagers among the pilots than the group used to originally form ATLAS, and there were more Navigators and Problem Solvers. Thus, the groups that initiate learning activities in the cognitive domain were over-represented while the group that initiates learning activities from the affective domain were under-represented.

The fifth research question investigated the relationship between the airline pilots' learning strategy preferences as identified by ATLAS and selected demographic and professional variables. A significant difference was found with more females as Engagers, but the group was extremely small. While an overall significant difference was found with more First Officers than Captains as Problem Solvers, this difference in groupings was not large enough to be statistically significantly. For the training variables, there were less Engagers using the automation all the time, and there were less Engagers in the group with at least 80% of the items correct.

The sixth research question investigated for the existence of naturally-occurring groups among the airline pilots based upon their knowledge of automated flight control. Cluster analysis revealed that four distinct groups of pilots exist related to knowledge of automated flight control. Discriminant analysis indicated that two of the groups are good at dealing with Observed Change while the two other groups are weak in dealing with Observed Change. For the two groups that are weak in dealing with Observed Change, one group of 93 is somewhat weak at dealing with the Need to Take Action while the other group of 82 is weak at dealing with Need to Take Action. For the two groups that are good in dealing with Observed Change, one group of 72 was very high in declarative knowledge while the other group of 74 was very high in procedural knowledge.

Conclusions

The following conclusions can be drawn from the findings for this study.

1. Based upon the overall knowledge acquired by the pilot group, the training for automated flight systems was inadequate.
2. Learning about automated flight systems consists of five separate factors.
3. Learning about automated flight controls is not influenced by personal or the professional variables.
4. The field of airline pilots tends to attract people who initiate learning activates in the cognitive domain.
5. Pilots’ learning style preferences are not

influenced by selected personal and professional variables.

6. There are four distinct pilot groups related to learning about automated flight control.

Discussion

The airline designed a multi-stage process for training its pilots for implementing AFC throughout its fleet. The first step was suppose to provide the basic knowledge that the pilots would need for initiating AFC. This training consisted of the pilots individually using a computer-based system to learn the material. Later training was to then consist of sessions at the training center that would involve classroom instruction and training in the simulator. Because this training is very expensive, the results of the initial stage of training were critical because it provided the foundational knowledge for the later training.

The initial stage of training was inadequate in training the pilots to the knowledge level needed for conducting the later steps of training as planned. Only a small group of the pilots were able to demonstrate a proficiency above the 90% level on the knowledge level assessment following the training. Less than one-third were able to demonstrate a proficiency the above the 80% level on the knowledge level assessment. While the analysis of the assessment items indicated that many of the pilots mastered some areas of this knowledge, there was a great lack of knowledge in too many of the areas. Indeed, the overall proficiency level for all of the pilots was approximately at the 75% level. While the experts at the airline will have to decide what the desired proficiency level is for this type of training, this is an unacceptable level for the initial training for a process as important and complicated as AFC.

It is important to recognize that the inadequacy of the training does not rest with the pilots. As professionals, the pilots eagerly and dutifully engaged in the training. However, the computer-based training module was not based upon known adult learning principles. It contained much declarative knowledge and was filled with acronyms. The focus was just on presenting knowledge rather than on the application of that knowledge. The training did not take into consideration the pilot's experience and was not focused on problems and issues that the pilots might incur while implementing AFC. There was no interactive activities in the training, and it lacked scenarios that would allow the pilots to apply the knowledge to real-life situations such as pilots encounter on training in the simulators. Overall, the training was geared at the lower two levels of Knowledge and Comprehension on Bloom's Taxonomy rather than at higher levels that require the learner to be active in the learning process rather than passive. The results of this training, which ignored basic adult learning principles, was that the pilots did not learn the material at an adequate level to implement later training as originally planned.

Although many stereotypes exist about age, experience, and the use of technology, the personal and professional characteristics of the pilots did not influence the level of knowledge achievement of the pilots. Neither age, experience, nor rank influenced the level of learning during this step of the training. Thus, the training outcomes were a function of the design of the materials rather than factors related to those being trained.

The concept of AFC is different for training than it is conceived for its basic definition. The basic definition of AFC conceptualizes the system as three components. The heart of the system is the computer which receives inputs from the pilot and then produces outputs to the airplane. While this system is simple and clear, the training related to learning about AFC actually divided out into five separate factors. Each of these factors suggests topics and areas for training. The Declarative Knowledge factor suggests that basic information needs to be built into the training unit. However, the other factors strongly suggest that the learner needs to be actively engaged in the learning. Interpreting Information from the AFS, Managing the AFS, and Display Indicators require that the training move the learner beyond the passive learning of the Declarative Knowledge. To address the If-Then Situations, scenarios could be used to address real-life situations.

The planning of future training can be facilitated by the recognition that most of the pilots initiate learning from the cognitive domain. Nearly four-fifths of the pilots are either Navigators or Problem Solvers who initiate learning by immediately identifying the resources available and then either prioritizing them or generating alternatives based on them. Future program planning could take this into consideration for designing the materials with which pilots will be presented. The other one-fifth of the learners, the Engagers, need to see the value of the training before engaging in it. Since relationships with others are important for Engagers and since having a positive relationship with the instructor (Shaw, 2004) can stimulate this engagement, future training units could appeal to Engagers by focusing on building relationships as part of the learning experience and by emphasizing the safety benefits of the training for passengers and crew. As with the knowledge level training, the program planners should be aware that this learning strategy preference is not related to demographic or professional characteristics of the learners.

In addition to having learning strategy preferences that can influence the approach to training, the pilots form four distinct groups for training related to AFC. Two of the groups, which make up slightly over half of the pilots, are weak at picking up on changes that occur in the AFC system. Since the goal of the pilots is to not only know what is happening with the FMC but also to stay ahead of it in terms of what it is having the airplane do, this puts them in great danger of being “behind” the airplane. Worse yet, within this group that is slow to perceive the changes that are happening in the AFC, about half are somewhat weak in dealing with the need to take somekind of action, and the other half are even weaker in taking action. Training for these two groups cannot be based on passive, declarative knowledge. This group must be presented with training opportunities that prepare them to be sensitive to changes that are occurring in the AFC and to then immediately take the appropriate corrective action. This requires active, hands-on instruction with some form of immediate feedback.

Slightly less than half of the pilots are good at dealing with observed changes in the AFC. About half of these are able to learn the declarative knowledge very well while the other half is much better at the procedural knowledge. These differences suggest that diversity is needed in the training and that attention needs to be paid to individual differences. No "one size fits all" training package will do. Instead, training that incorporates options for these differences are needed.

Overall, the findings from this study are a clarion call for implementing adult learning principles in pilot training. Pilots clearly fit the pattern of the typical adult learner. They have a pressing need for problem-centered learning; safety is the uncompromising priority of all aspects of commercial aviation, and a well-trained pilot is a crucial element of this safety. Captains and First Officers bring a vast reservoir of experience to their training. These experiences provide the building blocks for learning which are enhanced with reflection and metacognition to produce better pilots who can provide safer air travel. Pilots are also eager to learn and embrace feedback from their peers as demonstrated in the self-regulatory nature of the industry with its regular recurrent check flights both in the air and in simulators. All of these factors suggest that adult learning principles can enhance training for pilots.

Recommendations for Training

Since this research project was conducted in cooperation with the airline using institutional data, a meeting was held with representatives of the airline's training and continuous quality improvement team to discuss the findings and implications of the research for future training. Such a process provides stakeholders an opportunity to have input and provide insights into the recommendations for the study (Linkenbach 1995). Recommendations for pilot training were made in collaboration with these representatives.

Due to the complexity of the modernized cockpit using automation to fly the aircraft, pilots have to possess the knowledge not only to comprehend the basics of the aircraft's automation but also to have a mastery level of understanding to apply the automation within all phases of flight. At the very basic level of describing the automation, the aircraft has two Flight Management Computers that are located within cockpit. These devices are capable of accepting pilot input commands in order to navigate the aircraft. Pilots have given these devices the nickname of the "Box". Pilots input commands into the "Box" as they engage or couple the commands to the aircraft's autopilot system through the Mode Control Panel while confirming the accuracy of the information as it is displayed on the “glass cockpit” screens within the cockpit. Thus, aircraft that was once flown by the experienced pilots “stick and rudder” skills and abilities, is now being flown by the usage of the aircraft’s automation. A fully automated flight might consist of “hand flying” the airplane at its rotation off the runway until 500 feet. Here the autopilot and various systems would become engaged and guide the flight to its destination for a fully automated landing. Then the automation would be disconnected upon the aircraft’s roll-out on the runway. The entire flight would consist of the pilots having a mastery level of application of the aircraft’s automation abilities while monitoring the displays, avionics, and systems to complete a safe flight. While basic flying skills will always be a fundamental requirement for flying aircraft, there is a developing paradigm-shift in pilot training from being ahead of the airplane from basic “stick and rudder” skills to being ahead of the “Box” from application based knowledge of the automation systems.

Based on the data and conclusions from it, the following recommendations for training:

1. Pilot training should be based on adult learning principles.
2. All airline training and program planning staff should be orientated in adult

learning principles.

3. A comprehensive instructional system design (ISD) program should be utilized to design the pilot training program.
4. The ISD program that is used should insure that adult learning principles are applied in the design and conducting of the training programs.

By implementing adult learning principles, the airline would be able to create active learners in the training program. Such a change would move the airline from a strictly teacher-centered approach to a learner-centered approach for training pilots. This can be done easily by integrating well-established adult learning principles into the program. Such an approach would introduce metacognitive concepts and allow for reflective practice in the training among pilots. This modification in airline training methods could allow the airline's pilots to move beyond a rote understanding of knowledge and to a level of problem-solving application in their training.

It is not the nature of the training content but rather how it is used that is important. For example, it was pointed out from the training and leadership team that some of the computer-based training was not itself bad, but its weakness was in how it was implemented and used. The instructional CD that was given to the pilots did not provide a situational awareness that was grounded within the cockpit nor did it demonstrate a standardized flow of procedural tasks. These deficiencies left the pilots without a physical memory tie to orientate them within a flight deck while completing required checklists. Therefore, "real life" flight training scenarios utilizing either high or low technology based flight training devices (FTD) should be implemented in order for the pilots to work as a crew within an actual sized cockpit to reinforce procedural tasks just as they are completed in real flight situations. The pilots just cannot be given a manual and then be expected to memorize the contents in order to transfer the knowledge to a practical application. Without meaningful reasoning for the pilots to understand the concepts, procedures, or tasks, the pilots only obtain rote knowledge level abilities without knowing how to apply the training content. The training development writers as well as the training staff should be orientated in these adult learning principles.

A structured training process is needed for developing and implementing instructional design principles in order to serve the future training needs of the airline. The training must contain realistic scenarios. This could be accomplished by designing structured exercises on a computer-based trainer that will flow the training procedures allowing the pilot to observe the process. These training exercises may be implemented prior to pilots commencing formalized training at the training center. In such a process, the training center staff could expect a given level of pilot knowledge prior to pilots arriving for simulator training. Moreover, a comprehensive ISD process to develop training events would include the evaluate training procedures as a process to restructure needed phases of training prior to proceeding to the next event.

The implementation of adult learning principles in the entire program planning and implementation process along with comprehensive instructor training in adult learning principles can assist in creating application based pilots. Instructional design principles can assist in the standardization of pilot training as the airline continues to train new-hire and recurrent pilots and also continues integrate pilots from an acquisition of another air carrier.

A major conclusion of this study that future pilot training needs to be based on adult learning principles. In the airline industry, this can be accomplished by also implementing a comprehensive instructional system design.

At first glance, it may appear that this combination of adult learning principles and an instructional design system (IDS) are contradictory. This is because ISD is based upon a behaviorist perspective and adult learning principles based on andragogy are grounded in a humanistic or constructionist perspective. However, when it comes to implementing ISD,

> Most model creators subscribe to one or more learning theories which shape their model. If the creator is a behaviourist, a cognitivist, or a constructivist the model will reflect that theoretical belief. As Gros et al describe it, "Instructional design models have the ambition to provide a link between learning theories and the practice of building instructional systems" (1997, p. 48). (The Herridge Group Inc., 2004, pp. 7-8)

The ISD model was created to solve problems related to learning or training (U.S. Department of Defense, 1975). It focuses on identifying the goals, selecting the strategy, and evaluating outcomes in order to create learning experiences that result in the transfer of training to the work situation (The Herridge Group Inc., 2004, p. 7).

The basic ISD model consists of the five steps found in the ADDIE model: analysis, design, development, implementation, and evaluation (Clark, 2004; Hodell, 1997; Rousseau, 2008). Competency-based curricula are developed according to the ISD process, which closely resembles the product development processes used in business (Rousseau, 2008, p. 84). Importantly, each step of the process has an outcome that feeds into the next step, and formative evaluation is involved at each step with an summative evaluation at the end of the overall process (Clark, 2004). Thus, evaluation and feedback are important throughout every part of the design process.

Thus, the ISD model is one that is very appealing to business and one that fits the history, traditions, and goals of the airline industry. With its priority of safety, training is vital to the airlines, and this training affects every aspect of the operation of the company. Therefore, it is important that many voices be heard in the instructional planning process and that there is constant evaluation at each stage of the training design and implementation and that feedback exists for all of those involved in the process.

Implementing adult learning principles in the instructional process and the ISD model can be complementary. The ISD model is one that the organization can use to organize and manage the planning of the instructional units. In the process, it can assure that training activities are included that are based on adult learning principles such as setting a proper climate for learning, linking the experiences of the pilots to the learning task, and being problem centered and based on real-life situation. Once the program has been designed with the constant evaluation and feedback inherent in the ISD model, then the instructors can use adult learning principles and methods in the classroom to make the learning experience a positive one for the pilots. Together, these two concepts offer the airline a means of applying established theory and current research to create a learner-centered training environment.

REFERENCES

Aldenderfer, M. S., & Blashfield, R. K. (1984). Cluster analysis. Beverly Hills, CA: Sage.

Anderson, B., Fortson IV, B. W., Kleinedler, S. R., & Schonthal, H. (2007). The American heritage dictionary (4th ed.). New York: Bantam Dell.

AvStop.com (n.d.)(a). The Air Mail Act of 1925 (Kelly Act). (Retrieved from http://avstop.com/history/ needregulations/ act1925.htm)

AvStop.com (n.d.)(b). The Air Commerce Act of 1926. (Retrieved from http://avstop.com/history/ needregulations/act1926.htm).

AvStop.com (n.d.)(c). The Airmail Act of 1930. (Retrieved from http://avstop.com/history/needregulations/ act1930.htm).

AvStop.com (January 19, 2011)(b). Boeing sets 787 first delivery for third quarter 2011. (Retrieved from http://avstop.com/ news_january_2011/boeing_sets_ 787_first_delivery_for_third_quarter_2011.htm).

Bilstein, R. E. (2001). Flight in America: From the Wrights to the astronauts. Baltimore, MD: Johns Hopkins University Press.

Boyne, Walter J. (2003). Dawn over Kitty Hawk: The novel of the Wright Brothers. New York: Tom Doherty Associates, LLC.

Brookfield, S. D. (1986). Understanding and facilitating adult learning. San Francisco, CA: Jossey-Bass.

Conti, G. J. (1993). Using discriminant analysis in adult education. Paper presented at the 34th annual Adult Education Research Conference. University Park, Pennsylvania.

Conti, G. J. (1996). Using cluster analysis in adult education. Paper presented at the 37th annual Adult Education Research Conference. Tampa, FL.

Conti, G. J. (2004). Identifying your teaching style. In M. W. Galbraith (Ed.), Adult learning methods: A guide for effective instruction (3rd ed.) (pp. 75-92). Malabar, FL: Krieger Publishing Company.

Conti, G. J. (2009). Development of a user-friendly instrument for identifying the learning strategy preferences of adults. Teaching and Teacher Education, 25, 887-896.

Conti, G. J., & Fellenz, R. A. (1991). Assessing adult learning strategies. Proceedings of the 32nd Adult Education Research Conference (pp. 64-73). Norman, Oklahoma.

Crouch, T. D. (n.d.). Lighter-than-air: An overview. (Retrieved from http://www.centennialofflight.gov/essay/Lighter-than-air/LTA-OV.htm).

Dismukes, R. K., Berman, B. A., & Loukopoulos, L. D. (2007). The limits of expertise: rethinking pilot error and the causes of airline accidents. Burlington, VT: Ashgate Publishing Co.

Elias, J. L., & Merriam, S. B. (2005). Philosophical foundations of adult education. Malabar: Krieger Publishing Company.

Fellenz, R. A., & Conti, G. J. (1989). Learning and reality: Reflections on trends in adult learning. Columbus, OH. The Ohio State University. (ERIC Clearinghouse on Adult, Career, and Vocational Training, Information Series No. 336).

Federal Aviation Administration. (2008). Pilot's handbook of aeronautical knowledge. Newcastle, WA: Aviation Supplies & Academics, Inc.

Federal Aviation Administration. (2009). Risk management handbook. Washington, DC: United States Government Printing Office.

Gay, L. R. (1987). Educational research: Competencies for analysis and application (3rd ed.). Columbus, OH: Merrill.

Gay, L. R., & Airasian, P. (2000). Educational research: Competencies for analysis and application (6th ed.). Columbus, OH: Merrill.

Gay, L. R., Mills, G., & Airasian, P. (2006). Educational research: Competencies for analysis and application (7th ed.). Columbus, OH: Merrill.

Gay, L. R., Mills, G., & Airasian, P. (2009). Educational research: Competencies for analysis and application (9th ed.). Columbus, OH: Merrill.

Henschke, J. A. (2008). Reflections on the experiences of learning with Dr. Malcolm Shepherd Knowles. New Horizons in Adult Education and Human Resource Development, 22(3/4), 44-52.

Herridge Group Inc. (2004). The use of traditional instructional systems design models for eLearning. Uxbridge, ON, Canada: Author.

Hodell, C. (1997). Basics of instructional systems development. Alexandria: ASTD.

Huck, S. W. (2000). Reading statistics and research (3rd Ed.). New York: Longman.

Hulderman, M. A. (2003). Decision-making styles and learning strategies of police officers: Implications for community policing. Unpublished doctoral dissertation, Oklahoma State University, Stillwater.

Kachigan, S. K. (1991). Multivariate statistical analysis: A conceptual introduction (2nd ed.). New York: Radius Press.

Klecka, W. R. (1980). Discriminant analysis. Beverly Hills, CA: Sage Publications.

Knowles, M. S. (1970). The modern practice of adult education. New York: Association Press.

Knowles, Malcolm S. (1975). Self-directed learning: A guide for learners and teachers. Chicago: Follett Publishing Company.

Knowles, M. S. (1980). The modern practice of adult education: From pedagogy to andragogy. Chicago: Follet.

Knowles, M. S. (1984). The adult learner: A neglected species (3rd ed.). Houston: Gulf.

Knowles, M. S., Holton, E. F., & the airlinenson, R. A. (2005). The adult learner: The definitive classic in adult education and human resource development. Burlington, MA: Elsevier.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3).

Lindeman, E. C. (1989). The meaning of adult education. Norman, OK: Oklahoma Research Center for Continuing Professional and Higher Education, University of Oklahoma. (Original work published 1926)

Linkenbach, J. W. (1995). Behind the Big Sky bar: The Montana alcohol servers' study. Unpublished doctoral dissertation, Montana State University, Bozeman.

Loukopoulos, L. D., Dismukes, R. K., & Barshi, I. (2009). The multitasking myth: Handling complexity in real-world operations. Burlington, VT: Ashgate Pub. Company.

McClellan, J. A., & Conti, G. J. (2008). Identifying the multiple intelligences of your students. Journal of Adult Education, 37(1), 13-32, insert.

McKeachie, W. J. (1988). The need for study strategy training. In C. Weinstein, E. Goetz, & P. Alexander (Eds.) Learning and study strategies. San Diego, CA: Academic Press.

Merriam, Sharan B. (2001). Andragogy and self-directed learning: Pillars of adult learning theory. In Sharan B. Merriam (Ed.), The New Update on Adult Learning Theory, New Directions for Adult and Continuing Education, 89, 5.

Merriam, S. B., & Caffarella, R. S. (1999). Learning in adulthood: A comprehensive guide (2nd ed.). San Francisco: Jossey-Bass.

Merriam, S. B, Caffarella, R. S., & Baumgartner, L. M. (2007). Learning in adulthood: A comprehensive guide (3rd ed.). San Francisco: John Wiley and Sons, Inc.

Mezirow, J. (2000). How critical reflection triggers transformative learning. In J. Mezirow & Associates, Fostering critical reflection in adulthood: A guide to transformative and emancipatory learning (pp. 1-20). San Francisco: Jossey-Bass Publishers.

Millbrooke, A. (1999). Aviation history. Englewood, CO: Jeppesen Sanderson, Inc.

Micthell, M., & Jolley, J. (1988). Research design explained. New York: Holt, Rinehart and Winston, Inc.

Norusis, M. J. (1988). SPSS/PC+ advanced statistics V2.0. Chicago: SPSS Inc.

Paul, L., & Fellenz, R. (1993). Memory. In R. Fellenz & G. Conti (Eds.), Self-Knowledge Inventory of Lifelong Learning Strategies (SKILLS): Manual. Bozeman, MT: Center for Adult Learning Research.

Rousseau, M. (2008). Structured mentoring for sure success. Tulsa, OK: PennWell Corp.

Schon, D. A. (1983). The reflective practitioner: How professionals think in action. New York: Basic Books.

Schon, Donald (1987). Educating the reflective practitioner. San Francisco: Jossey-Bass Inc.

Shaw, L. H. (2004). Learning strategies of youth in transitions to adulthood in the urban life-skills program of A Pocket Full of Hope®. Unpublished doctoral dissertation, Oklahoma State University, Stillwater.

Sheskin, D. J. (2007). Handbook of parametric and nonparametric statistical procedures (4th ed.). New York: Chapman and Hall.

Smith, R. M. (1983). Learning how to learn: Applied theory for adults. Milton Keynes, UK: Open University Press.

Spenser, J. (2009). The airplane: How ideas gave us wings. New York, NY: Harper Paperbacks.

Sternberg, R. J. (1990). Real life vs. academic problem solving. In R. A. Fellenz & G. J. Conti (Eds.), Intelligence and adult learning. Bozeman, MT: Center for Adult Learning Research, Montana State University.

Stolovitch, H. D., & Keeps, E. J. (2002). Telling ain't training. Alexandria, VA: American Society for Training and Development.

Tough, A. (1967). Learning without a teacher. Educational Research Series, No. 2. Toronto: Ontario Institute for Studies in Education.

Tough, A. (1971). The adult's learning projects: A fresh approach to theory and practice in adult learning. Research in education series, (1). Toronto, Canada: Institute for Studies in Education.

Tough, A. (1978). Major learning efforts: Recent research and future directions. Adult Education, 28(4), 250-263.

Tough, A. (1979). The adult's learning projects: A fresh approach to theory and practice in adult learning (2nd ed.). Toronto: Ontario Institute for Studies in Education.

U.S. Department of Defense. (1975). U.S. Department of Defense Training Document Pamphlet 350-30. Washington, D.C.: Author.

Wiersma, W., and Jurs, S. G. (2005). Research methods in education (8th ed.). Boston: Peason Education, Inc.

Weinstein, C. E. (1987). LASSI user's manual. Clearwater, FL: H & H Publishing.

Woodford, S., & Warner, C. (2009). The story of flight the development of aviation through the ages. London: Carlton.

York-Barr, J., Sommers, W. A., Ghere, G. S., & Montie, J. (2001). Reflective practice to improve schools: An action guide for educators. Thousand Oaks, CA: Corwin Press.

VITA

Matthew A. Wise

Candidate for the Degree of
Doctorate of Philosophy in Education

Dissertation: PILOT KNOWLEDGE OF AUTOMATED FLIGHT CONTROLS: IMPLICATIONS FOR DESIGNING TRAINING BASED ON ADULT LEARNING PRINCIPLES

Major Field: Occupational Education

Education:
- Master of Science; Oklahoma State University, Stillwater, Oklahoma 1994
- Bachelor of General Studies; Ball State University, Muncie, Indiana 1990

Experience:
- Tulsa Community College; Director/Chief Flight Instructor 2005-Present
- Oklahoma State University; Aviation Ground Instructor 2003-2005
- American Airlines/Trans World Airlines; Line Pilot 1997-Present (Furlough Status)
- Flight Management, INC; Line Pilot 1996-1997
- Mapco, INC; Line Pilot 1995-1996

Professional Certificates and Ratings:
- Airline Transport Pilot Certificate; B-767, B-757, CL-30, LR-45, LR-JET
- Commercial Pilot Certificate; Airplane Single Engine Land & Sea
- Flight Engineer Certificate; B-727
- Flight Instructor Certificate
- Master Certified Flight Instructor
- Advanced Ground Instructor

Professional Organizational/Memberships:
- Tulsa Air and Space Museum Board Member 2008-Present
- University Aviation Association Board Member 2011-Present
- Federal Aviation Administration Safety Team Lead Representative Oklahoma 2008-Present