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Cognitive Learning Styles and Their Relation to Air Traffic Control Screening and Training

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COGNITIVE LEARNING STYLES AND THEIR RELATION TO AIR TRAFFIC CONTROL SCREENING AND TRAINING

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This thesis was prepared under the direction of the candidate's thesis committee chairman, Dr. Charles Richardson, Department of Aeronautical Science, and has been approved by the members of his thesis committee. It was submitted to the School of Graduate Studies and Research and was accepted in partial fulfillment of the requirements for the degree of Master of Aeronautical Science.

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ABSTRACT

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The purpose of this study was to show a relationship between the type of cognitive learning style that an individual possesses and their subsequent success at simulated air traffic control practical exercises. Kolb's Learning Style Inventory was utilized to determine dominant learning styles of 30 college students enrolled in a laboratory-based air traffic control course. The instrument was administered during the first day of classes in the Fall of 1990. Students were placed in one of four groups for statistical purposes according to learning style. The scores of simulated micro-computer based air traffic control practical exercises given at semester's end were used to determine a mean score for each of the four groups. A t-distribution was used to establish significance between the groups. This study will be used as a preliminary step toward identifying and testing for more precise skills that are predictive of success in air traffic control for the purpose of developing a more effective method of screening air traffic control candidates.

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Introduction

Air Traffic Control (ATC) specialists are tasked with promoting the "safe, orderly, and expeditious" flow of air traffic. The ATC Specialists job consists of complex tasks demanding a high degree of skill and active application of unique cognitive abilities such as spatial perception, information processing, reasoning, and decision making. The hiring of an ATC Specialist requires a screening process that is meant to eliminate candidates who will be unable to successfully complete the training program. This filtering process has been the subject of much study and debate by civil and military aviation authorities who are concerned with keeping training costs down and success rates high.

According to a report filed by the United States General Accounting Office (1988), applicants for ATC must pass an aptitude test and meet certain age, medical, and security qualifications. They must also complete an eleven week program of instruction and testing called "screening" at the Federal Aviation Administration (FAA) Academy in Oklahoma City, Oklahoma. The FAA uses this process to eliminate individuals who do not demonstrate the ability to control air traffic before placing them at an FAA field facility. According to the General Accounting Office (GAO), fifty-six percent of those who enter ATC training fail or withdraw without being certified as full performance level (FPL) controllers. The cost to the U.S. taxpayer for the current training systems, including the attritions, is $14 million annually.

The purpose of this study is to investigate and report on the effectiveness of experiential learning theory, and more specifically, Kolb's Learning Style Inventory (LSI), as a framework for the development of a more efficient and cost-effective method of screening ATC candidates.

The theory of experiential learning maintains that learning is a process involving the resolution of dialectical conflicts between opposing modes of dealing with the world--action and reflection, concreteness and abstraction (Kolb, 1981). Learning styles represent individual preferences for one mode of adaptation over others (see appendices D through H for a complete description of learning styles and learning modes). These preferences do not, however, operate to the exclusion of other adaptive modes and will vary from time to time and situation to situation. Kolb believes that change and adaptation are essential to any concept of learning.

Extensive work has been done regarding individual learning styles. A basic concept that has emerged is that individuals approach learning situations in many different ways. People tend to use the type of learning mode that is most appropriate to them given a particular learning challenge. Furthermore, as adaptation to a particular learning environment is believed to be a reflection of past learning experience, the ability of an ATC candidate to adapt to the demanding learning environment in Oklahoma City during the ATC screening process may be a reflection of that person's learning style.

Kolb (1984) believes that optimal learning is a cyclical event which includes four basic modes of learning: (a) concrete experience (CE), (b) reflective observation (RO), (c) abstract conceptualization (AC), and (d) active experimentation (AE). That is:

1. A person must be able to become involved fully, openly, and without bias in new experiences (concrete experience).

2. A person must be able to reflect on and observe these experiences from many perspectives (reflective observation).

3. A person must be able to create concepts that integrate these observations into logically sound theories (abstract conceptualization).

4. A person must be able to use these theories to make decisions and solve problems (active experimentation).

When this cycle of learning occurs fully and actively, optimal learning opportunities increase. Appendix I depicts a model comparing the learning cycle with problem-solving skills. Many people tend to rely on one mode of learning more heavily than others. When a group of individuals are involved in an identical learning situation, each individual will approach the situation utilizing a mode of learning most comfortable to that person's learning style. Kolb (1976) believes that individuals develop different learning styles dependent on the influence of internal and external variables in their lives. "Through socialization experiences in family, school, and work, we come to resolve the conflicts between being active and reflective and between being immediate and analytical in characteristic ways" (p. 5). It is quite logical that developed learning styles influence the way that individuals accomplish tasks and plans, perform duties, and carry out other activities.

Each person's learning style is a combination of the four basic learning modes described earlier. Kolb (1984) describes four prevalent types of learning styles: (a) converger, (b) diverger, (c) assimilator, and (d) accommodator, each having varying degrees of strengths and weaknesses. An inclination toward one of these cognitive learning styles may be conducive toward being successful in the field of ATC.

There is a growing trend toward collaboration between the FAA and civilian universities. This research would be of benefit to any ATC related training program that Embry-Riddle Aeronautical University (E-RAU) might decide to undertake, as well as to the FAA or other civil or military aviation authorities who conduct ATC screening and training. If the hiring

authorities were better able to identify candidates with the skills, and/or learning styles necessary for success at ATC, those authorities would save a substantial amount of funding on trainees who have been partially trained and subsequently "wash out" of the system. Furthermore, as research into learning style typology becomes more significant, employers and educational institutions will consider designing training programs that are adaptive to individual differences among students, or that are more oriented toward a particular learning style. This study will identify those learning styles that are conducive toward success at ATC training.

Statement of the Problem

This study shows a relationship between an individual's cognitive learning style and his/her ability to do well on simulated ATC practical exercises. Because individual learning style is an important factor in determining an individual's ability to adapt to a particular learning challenge, and because it is believed that success or failure at ATC training is partly a reflection of adaptability and individual learning style, then identifying individual learning styles may serve to predict success at ATC training. This study could serve as a preliminary study for designing and implementing an effective screening instrument for ATC candidates. For the purposes of this study, cognitive learning styles will refer to Kolb's four prevalent types: (a) converger, (b) diverger, (c) assimilator, and (d) accommodator.

Review of Related Literature

Given the persistent controversy that surrounds the ATC profession, and the high attrition rate of the current ATC training system, it is appropriate to investigate the job itself and the people that make ATC their

career. In his book, Gessel (1987) describes in great detail the selection, hiring, training, salary, benefits, and other labor related issues. It is a comprehensive and accurate work that explains all facets of ATC in an understandable, straightforward manner. Biggs (1979), on the other hand, describes the emotional aspects of the career. He takes us into ATC facilities on busy days, and quotes supervisors, trainees, and controllers. The author explores some of the personal attributes of the people as he examines the job in a more subjective way. His book, Pressure Cooker, lends insight into the reasons why this particular occupation has been beset with some degree of controversy and labor strife. Biggs examines some of the uncommon attributes that may be necessary to be a successful ATC specialist. Nolan's (1990) description of the ATC system begins with the history and background of ATC and advances through the future of the system. Nolan's background as pilot, ATC Specialist, author, and college professor, makes him well qualified to write on ATC and related issues. The result is a comprehensive textbook on ATC.

Background of ATC Selection Procedures

FAA psychologists have been instrumental in providing a framework for the development of ATC specialist selection and training methods currently in use. Principles and methodologies from several specialized fields of psychology have been utilized to derive the research data upon which the current selection and training procedures are based. The development of the FAA's procedures for selecting ATC Specialists presents an example of a selection process which has undergone a number of refinements over time (Manning, Kegg, & Collins, 1988).

An investigation of ATC screening methods, and the history of the research behind these methods, presents a path leading to the current

screening procedures. This more technical review of the literature begins with a controversial report entitled Air Traffic Training Update (Federal Aviation Administration [FAA], 1988). In this report, the first nationally standardized policy for training, implemented in 1976, is reviewed. This national policy was to "once and for all" clearly spell out how all new hires would be handled from entry on duty until they became fully qualified controllers. The report refers to the screening methods developed and employed by the FAA in 1976 that are still in use today with some revision. In 1981, the selection test battery was revised to include the use of an abstract reasoning test in combination with an occupational knowledge test and a controller aptitude test. The report concludes that the national policy is doing what it was intended to do: "screening out the majority of those who do not have the potential to become full performance level controllers" (p. 9). If one looks at a report filed to Congress by the GAO (1988) in the same year as the aforementioned report, and which examines the recruitment and screening policies for ATC Specialists, a contradiction may become apparent. According to the GAO report, 56% of those who enter controller training either fail or withdraw without reaching full performance level. It was noted in the GAO report that current training policy is not targeted toward those candidates most likely to succeed as ATC Specialists.

At the time of the 1988 GAO report, it took about 100 applicants to produce one full performance level controller. In its recommendations to the Secretary of Transportation, the GAO report urged the development of a systematic and coordinated national recruiting strategy targeted to those individuals most likely to have the potential to be ATC Specialists. Reports such as this one by GAO clearly suggest that further research and

investigation into the kinds of abilities required by potential candidates for the position of ATC was, and still is, warranted.

In a journal article by Collins, Boone, and Vandeventer (1981), the results of research conducted by the FAA Civil Aeromedical Institute (CAMI), from 1960-1980, concerning proper standards for the selection of personnel for ATC training, are discussed. The history of the research effort on ATCS selection is rooted in a 1950s contract awarded by the Civil Aeronautics Administration (CAA) for the development of aptitude tests that could be used to select ATC trainees. The results of a study at that time indicated that these tests could make a contribution in the selection process. These tests, which were eventually developed, provided the format for an Air Traffic Problems (ATP) test. A continuing research program began in 1960 with the establishment of the Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma. In addition to the collection of data, extensive psychological testing of all ATC trainees to enter the FAA Academy in Oklahoma City for basic training was begun. During this early research, seven tests determined to have validity for prediction of ATC trainee performance were derived from an experimental battery of tests. One of these tests was the contractually developed ATP test, while the others were commercially available instruments. Three of the seven were subsets of the Psychological Corporations Differential Aptitude Test (DAT). These are the DAT Space Relations, DAT Numerical Ability, and DAT Abstract Reasoning tests. The first test measures a person's ability to visualize objects and forms in two or three dimensions. The second is a test of arithmetical computational skill, while the third provides a measure of nonverbal reasoning. The remaining four tests were taken from the California Test Bureau's Test of Mental Maturity (CTMM). These tests measure the ability to recognize relationships,

to develop logical conclusions, to solve word-presented arithmetic problems, and to measure the capacity for mental manipulation. A composite of these seven tests was developed and became known as the Civil Service Commission (CSC) battery. The CSC test battery is designed to assess a candidate's aptitudes for learning the types of tasks involved in air traffic control work (Cobb, Young & Rizzuti, 1976). Beginning in 1964, the CSC battery was incorporated into the screening of all ATC applicants. In 1966, Cattell's Sixteen Personality Factor Questionnaire was introduced and used in the screening of applicants to determine if any significant mental or emotional problems existed.

The current screen is a composite of tests partly derived from the older battery of CSC tests and includes a Controller Aptitude Test, an Abstract Reasoning Test, and an Occupational Knowledge Test. The Controller Aptitude Test consists of job sample items for ATC activities and tests for the ability, among other things, to recognize potential conflicts. Research at CAMI has been successful toward creating a test that is somewhat successful at predicting training success while proving the potential value of tests for screening.

In an attempt to develop a more valid screening method, the FAA has investigated testing methods using computer-based performance tests. In an executive report sponsored by the FAA (HumRRO International Inc. [HII], 1988), it is stated that the cost of the screen and the large proportion of failures suggest that much could be gained from using computer-based performance tests. These tests can be used to screen candidates before admitting them to the academy or as a replacement for the academy screen. The report points to recent research using microcomputers to obtain performance measures for tasks such as visualizing the intercept point of two moving objects. The

report indicates that this research shows promise for application to ATC selection.

Some of the more focused studies into ATC recruitment, selection, and training have attempted to look at brain function activity such as: left brain vs right brain, and cognitive abilities (spatial, perceptual, intuitive) and skills. One such study by Israel, Wickens, Chesney, and Donchin (1980) attempted to study task workload and reaction time. A study by Schneider, Vidulich, and Yeh (1982) investigated a program that attempts to develop spatial skills for ATC by using microprocessor-based trainers to develop automatic component skills and speed reaction time. The researcher's work suggests that substantial performance improvements can be obtained by careful analysis of complex tasks and identification of methods of representing the task.

The research of the history of screening methods leads to the latest attempt at developing a more efficient screen. This attempt would utilize the radar training facility (RTF) at Oklahoma City based upon the application of principles of ATC in a radar environment (Manning, Kegg, & Collins, 1988).

One very interesting study conducted by CAMI (Cobb, Young, & Rizutti, 1976) produced quite ironic results. The purpose of the study was to: (a) assess the validity of level of education as a selection factor; (b) to determine whether data relating to other aspects of education (e.g., recency or major courses of study) were sufficiently related to training attrition-retention status of ATC trainees to warrant consideration in the establishment of eligibility ratings; and if so, (c) to derive a set of factor weights. Out of the 2,352 ATC recruits studied, the 181 college graduates had the highest academy attrition rate, followed by the 208 non-graduates, whereas the lowest attrition rate pertained to the 876 subjects having high school diplomas only, followed closely by those having one full year of college only. The results of a further

analysis showed "no level-of-education category within which those subjects having rated pre-FAA ATC experience, failed to have a higher retention rate than those having pilot and/or communications (but no ATC) experience, and also those devoid of aviation related experience of any type" (p.17). These findings led Cobb, Young, and Rizutti to suggest that ATC training should be restricted to aptitude-screened applicants 30 years old or younger, and that the awarding of credit points for all types of education and experience, except ATC experience, be discontinued. The results of such a study indicate that formal education may cause an alteration in learning style as individuals either complement their original strengths or move in the opposite direction away from a strength. Several research studies indicate that college educated subjects have quite different learning preferences across academic disciplines. Gypen (1980) tentatively concluded from his studies that undergraduate and professional education have an important role in the development and strengthening of learning preferences.

Performance-Based Academy Screening Program

Controllers today are tasked with promoting the safe, orderly, and expeditious flow of air traffic. This is accomplished through accurate and effective application of rules and procedures for separation in a real-time, dynamic environment. The current ATC Specialist's job consists of complex tasks demanding a high degree of skill and active application of certain cognitive abilities such as spatial perception, information processing, reasoning, and decision making. The workforce that eventually carries out these duties is currently selected through a two-stage selection system. The first stage consists of the paper-and-pencil aptitude battery described earlier. The second stage is the performance-based measure consisting of a condensed

training-testing ATC task sample in a non-radar environment (Della Rocco, 1990).

Given all the research into creating an efficient screening instrument, it is still the second stage of the FAA's screen, the performance based academy screening program, that is considered the main predictor of later success. This screening program takes place at the FAA Academy in Oklahoma City and is restricted to candidates that have met all other requirements and have scored high on other screening instruments. All ATC candidates enter the same screen, called the generic screen, before a decision is made on which ATC specialty (Tower, Approach, or Enroute) the candidate will pursue (GAO, 1988). This process of screening at the academy takes approximately 13 weeks and is quite costly to the taxpayer while causing a great deal of distress and inconvenience to those candidates who do not perform successfully. Overall, pass rates at the academy are about 60%. Unacceptable candidates are released from the FAA as part of the pass/fail program that the candidate must agree to beforehand. Given the FAAs estimated per student cost of $8,700 for the 11-week academy program, the GAO estimates that student failures during fiscal year 1987 cost the government about $6.6 million.

Candidates entering the academy to proceed with the screening process are given basic instruction in aviation, navigation, weather, and regulations. On proceeding to the next and most critical phase, which lasts approximately four weeks, candidates are taught the fundamentals of ATC. These are often abstract concepts to candidates with no prior ATC experience and cover such topics as communication skills, separation standards, departure, arrival, and holding procedures. Candidates, having been prepared for laboratory screening, are placed in a simulated ATC environment. Instructors and candidates rotate through various positions and all instructors have the

opportunity to work with all candidates. As a conclusion to this four week session of practical ATC exercises, a series of graded practical exercises is given. The scores on these graded exercises consist of a technical assessment and an instructor assessment. Five of these graded exercises are actually used in calculation of the final score, however they comprise 60% of the comprehensive final grade (Della Rocco, 1990). In all, thirteen performance measures are indicated by the candidates over the nine week period. Five of these assessments are multiple choice tests on the academic portion of the screen; the sixth is a map test, the five graded exercises, and a controller skills test, which is a paper and pencil assessment of the student's ability to apply ATC rules and procedures. Those who receive a score of at least 70% on all phases of the 13 week program in Oklahoma City are given the opportunity to return to an ATC facility and continue training. Those who do not maintain a passing average are considered training failures.

Della Rocco (1990) describes the current screen as being initially developed based on non-radar procedures because these procedures were used more frequently at the time that this method of screening was introduced. Today, radar procedures are utilized almost exclusively in the majority of centers. Why is it then, Della Rocco asks, that the current screen based on non-radar procedures is indicative of success in the radar environment? A hypothesis may be offered that the skills needed for successful adaptation to the learning environment in Oklahoma City, and the skills necessary for success at ATC, are highly synonymous. Success is dependent on the way that a candidate carries out his/her cognitive processes, and develops the mental steps and constructs necessary to succeed. How the candidate accomplishes this may be dependent on past experience (experiential learning).

Because of the inability to identify and isolate the cognitive ability necessary for success at ATC training, the FAA is further unable to construct a cognitive approach to instruction and training for those ATC candidates who have succeeded at the screen. Unfortunately, ATC training methods are an outgrowth of the screen and employ many of the same methods and characteristics.

A review of this section begins with an acknowledgement of the contributions of the Civil Aeromedical Institute. They laid the foundations of the research toward a better ATC screen while demonstrating that aptitude test scores, as well as other psychological testing, can be successfully utilized in predicting success in the ATC profession. In their review of the approach used by the FAA towards developing a better screening procedure, Manning, Kegg, and Collins (1988) point out that "Air Traffic Control is a particularly high visibility occupation....The challenge to aviation psychologists involves balancing the requirements imposed by forces outside the FAA with internal, data-based actions necessary and sufficient to ensure that the selection/screening programs retain their validity" (p. 20). They go on to point to the challenges of the future in ATC, and the associated selection and training program requirements.

Review of Learning Styles and Experiential Learning Theory

DeBello (1989) defines learning style as "the characteristic cognitive, affective, and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (p. 5). DeBello compares eleven major learning style models. There have been a number of attempts at developing models for classifying

learning styles (Dunn, Dunn, & Price, 1977; Hill & Nunney, 1974; Kolb, 1976; National Association of Secondary School Principals, Schmeck's Inventory of Learning Processes, & McCarthy's 4 MAT System, DeBello, 1989). The model of the learning process which forms the theoretical basis for this thesis was created by David Kolb. Torrealba (1972) describes Kolb's model of the learning process as a four-stage, iterative process (see Figure 1).

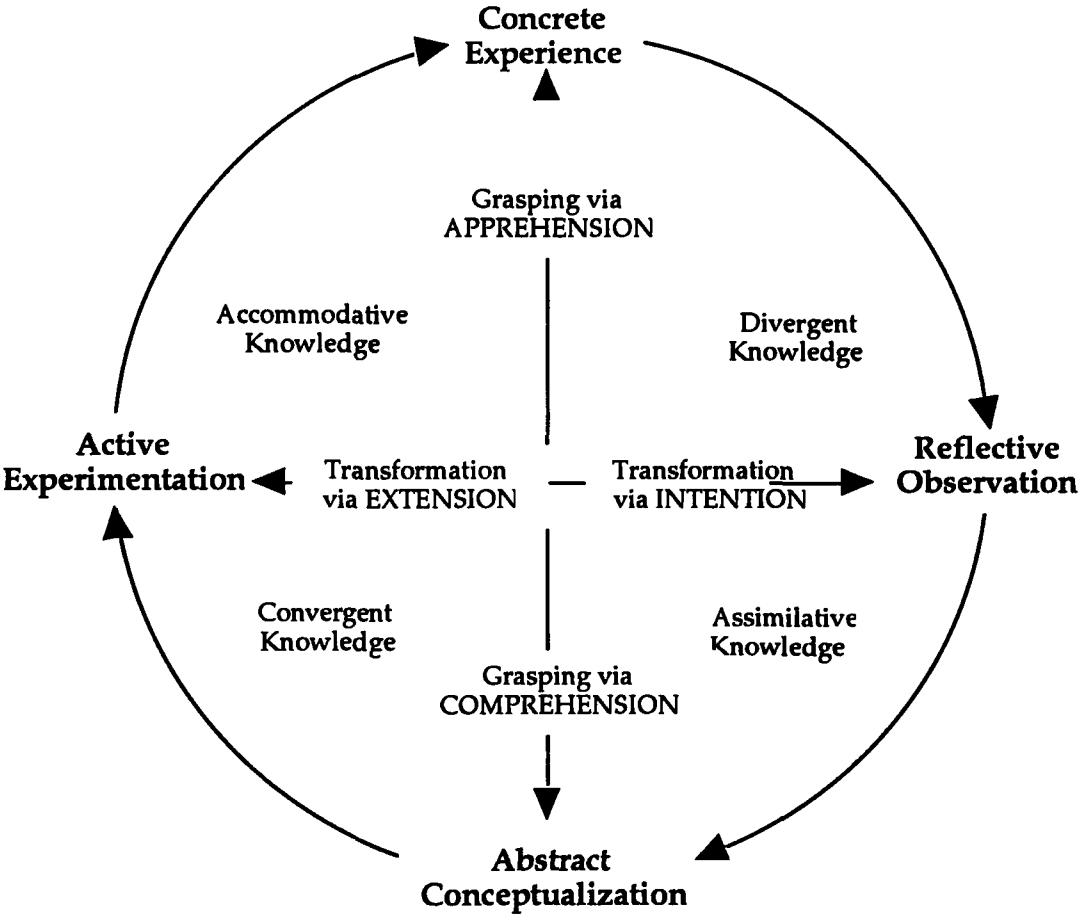

Figure 1. Structural Dimensions Underlying the Process of Experiential Learning and the Resulting Basic Knowledge Forms

From Experiential Learning (p. 42) by D. A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall. Copyright 1984 by Prentice-Hall. Reprinted by Permission.

An individual's concrete experience (what he/she does or feels) forms the data base for observation and reflection. The stage of reflective observation is one of the formation of mental images more or less representational of external reality (what is happening here?). The process then becomes governed by the logic of classes and relations. Observations and reflections are categorized, related to one another, and meaningful patterns found. Through the process of inductive reasoning, the learner forms abstract conceptualizations of his/her experience. These abstract concepts provide the basis for deducing hypotheses for future actions. Finally, active experimentation leads to new concrete experiences, and the learning process begins anew. From Torrealba's description, the learning process can be seen as being based on experience. Learning also takes on a very personal aspect since the individual learns from his/her own experience and must decide what to do next by himself/herself.

Kolb (1976), in The Learning Style Inventory, outlines the factors that cause individuals to develop different learning styles. He argues that learning style affects the way that individuals act and behave, as well as determines a person's strengths and weaknesses. It is logical that individual learning styles would also determine the jobs and activities that a person is best suited for.

> Human beings are unique among all living organisms in that their primary adaptive specialization lies not in some particular physical form or skill or fits in an ecological niche, but rather in identification with the process of adaptation itself-in the process of learning. We are thus the learning species, and our survival depends on our ability to adapt not only in the reactive sense of fitting into the physical and social worlds, but in the proactive sense of creating and shaping those worlds (Kolb, 1984, p. 1).

This quote by Kolb while global in nature is very appropriate to this research. It is hypothesized that candidates who successfully complete the ATC screening in Oklahoma City, do so at least partly because of their ability to adapt to the strenuous and uncertain learning environment that exists there. The ability to adapt to this learning environment is based partly on past learning experience and an individual's preferred style of learning. Harvey (1966) found that early experiences manifest themselves in differences in the ability to withstand stress, to be creative, and to behave flexibly and adaptively in the face of environmental complexity and change. Harvey's work is concerned with how variation in developmental histories and early experience may cause differences in cognitive structure and behavior styles.

Jean Piaget, the Swiss developmental psychologist, had a great impact on education and educators and is partly responsible for Kolb's theories on experiential learning. Piaget's most central concern was with the contributions of a person's activities while in the process of acquiring knowledge. Elkind (1974) refers to Piaget's belief that learning takes place in either a strict or broad sense. In the strict sense, behavior and thought are modified as a result of experience. In the broad sense, behavior and thought are modified as the result of experience and from other processes dealing with complex feedback activities between maturation and experience. From Piaget's work, experience and learning can be viewed as being inextricably tied together. Flavell (1963) offers a comprehensive evaluation of Piaget's work while pointing out his compelling, important, and sometimes controversial ideas and theories.

Much of current learning style theory is based on three distinctive and important models developed, one each, by Kurt Lewin, John Dewey, and Jean Piaget. Kolb (1984) describes Lewin's model of experiential learning which

suggests that learning, change, and growth are facilitated best by an integrated process that begins with here-and-now experience, followed by collection of data and observations about that experience. The data are then analyzed and the conclusions fed back for use in the modification of behavior and choice of new experiences.

> Learning is thus conceived as a four-stage cycle. Immediate concrete experience is the basis for observation and reflection. These observations are assimilated into a "theory" from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences (Kolb, 1984, p. 22).

"The structural bases of the learning process lie in the transactions among these four adaptive modes and the way in which the adaptive dialects get resolved" (1984, p. 41). Optimal learning is thus a cyclical event which includes four basic modes of learning: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). That is:

> 1. A person must be able to become involved fully openly, and without bias in new experiences (concrete experience).
>
> 2. A person must be able to reflect on and observe these experiences from many perspectives (reflective observation).
>
> 3. A person must be able to create concepts that integrate these observations into logically sound theories (abstract conceptualization).
>
> 4. A person must be able to use these theories to make decisions and solve problems (active experimentation) (1984, p. 9).

The importance of feedback in the learning process can be seen. Lewin and his followers believed that much individual ineffectiveness could be traced to a lack of adequate feedback processes (Marrow, 1969). Lewin found this ineffectiveness arose from an imbalance between observation and action. This is from a tendency for individuals to emphasize decision and action at the expense of information gathering, or from a tendency to become bogged down by data collection and data. This fundamental concept is crucial and relevant as these qualities may have a bearing on identifying weaknesses and strengths in individual's cognitive styles and their relation to success at ATC training.

Torbert (1972) describes the importance of feedback in addressing the question of how people learn from experience. People receive feedback from the environment by way of receptors (senses and feelings). Behavior is adjusted according to the feedback so that goals are accomplished. Torbert believes that the awareness of the experiential learning concept emphasizes the benefits it confers in overt learning situations and also in any goal-oriented enterprise. The importance of feedback has to do with the fact that we learn from examining our experiences. Torbert explores the psychological concepts that lie behind experiential learning theory as compared to the practical uses and concepts as presented by Kolb in his works.

Kolb (1984) describes experiential learning as not being an educational concept, but rather a concept that describes the central process of human adaptation to the environment. "It seeks to describe the emergence of basic life orientations as a function of dialectic tensions between basic modes of relating to the world" (1984, p. 31). For the purposes of this paper, dialectic tension refers to the reconciliation of opposite ideas and thoughts.

With ATC as the field of concern, it is interesting to examine Kolb's further observations of experiential learning theory. He asserts that experiential learning encompasses adaptive concepts such as creativity, problem solving, decision making, and attitude change. It is Kolb's assertion that learning is the process whereby knowledge is created through the transformation of experience (Kolb, 1976). The perfect learner involves himself/herself fully, openly, and without bias in new experiences from many perspectives. He/she further creates concepts that integrate observations into sound theories, and then uses these theories to make decisions and solve problems. Kolb addresses two dimensions involved in the learning process. The first represents the concrete experiencing of events at one end and abstract conceptualization at the other. The other dimension has active experimentation at one extreme and reflective observation at the other. He further points to the concrete/abstract dimension as being a primary one on which cognitive growth and learning occur.

The inclination toward a particular learning style tends to be an individual progression. The development of a preferred style of learning is a lengthy process, however, that spans many years of one's life as adjustments are made and adaptation is carried out.

> Over time, accentuation forces operate on individuals in such a way that the dialectic tensions between these dimensions are consistently resolved in a characteristic fashion. As a result of our hereditary equipment, our particular past life experience, and the demands of our present environment, most people develop learning styles that emphasize some learning abilities over others (Kolb, 1984 p. 5).

Kolb believes that our experiences in family, school, and work, and the way in which we come to resolve the conflicts between being immediate and analytical, active and reflective, are further responsible for the learning styles that we develop and acquire. Some develop minds that excel at assimilating facts into theories, yet they are incapable of deducing hypotheses for these theories. Others are logical and bright but find it difficult to involve themselves in an experience. "A mathematician may come to place great emphasis on abstract concepts while a poet may value concrete experience more highly....Each of us in a unique way develops a learning style that has some weak and some strong points" (1984, p. 5). Kolb has identified four statistically prevalent types of learning styles: converger, diverger, assimilator, and accommodator.

Debello (1989) describes learning style development as perhaps the most important development in American education today. In his paper, DeBello examines the efforts of the recognized leaders in the field. In describing the strength of Kolb's LSI, he refers to the psychometric analyses of Dr. Lynn Curry for the Canadian College of Health Services in Ontario, Canada. Curry reported strong reliability for the instrument. David Rule (1988) found that Kolb's inventory is one of the most frequently cited learning style instruments.

Chickering (1977) covers many facets of experiential learning. Beginning with roots and definitions, he examines the potentials for students, faculty, and institutions. Chickering's book, Experience and Learning: An Introduction to Experiential Learning, details the workings and creation of The Cooperative Assessment of Experiential Learning. That group today consists of 220 institutional members. The two primary purposes of that institution are: (a) to foster the development of educational programs

using better mixes of experiential learning with theoretical instruction and to foster more widespread use of such programs, and (b) to sophisticate further the understanding and practice of assessment of the outcomes of experiential learning. The network of organizations involved suggests that interest in experiential learning is broad-based, spanning a wide range of institutions and organizations involved in higher education.

Learning Style and Career Paths

Kolb and Fry (1975) found that early career choices tend to follow a path toward accentuation of one's learning style. They further found that learning styles shape behavior not only in traditional educational settings but shape an individual's basic mode of adaptation to the worlds around him/her. Kolb and Fry found evidence that early career choices tend to follow a path toward accentuation of one's learning style. On the other hand, those students who find a learning environment incongruent with their learning style tend to move away from that kind of environment in future learning and work choices. Kolb and Fry concluded that experiential learning typology seems to provide a useful grid for mapping individual differences in learning style and for mapping corresponding differences in the environmental demands for different career paths. It is, therefore, a potentially powerful tool for describing the differentiated paths for adult development.

> Researchers have in fact had great difficulty demonstrating that grades in school are related to any other behaviors of importance...Yet the general public, including many psychologists and most college officials, simply has been unable to believe or accept this fact...neither amount of education nor grades in school is related to vocational success as factory worker, bank teller, or air traffic controller. Even for highly intellectual jobs like scientific researcher, superior on-the-job performance is related in no way to better grades in college (McClelland, 1973).

In The Psychology of Occupations, Roe (1956) discusses the effects of the environment on our abilities. She points out that in addition to the differences in family background, there will be great diversity in experience in terms of sex, of education, and of social contacts. These factors add up to making each person's environment and experience different. Add to this the genetic variation and the situation is compounded. Roe discusses the major considerations of human differences, ranging from intelligence to physical differences, and how these relate to occupation. Occupations and humans are classified and categorized for the purposes of several studies. This is an in-depth work pertaining to the psychology of occupations.

In describing learning style theory and its relation to occupation, Kolb and Fry (1975) describe human growth as being divided into three developmental stages. The first stage is that of acquisition which extends to adolescence and entails the acquisition of basic learning abilities and cognitive structures. The second stage is that of specialization which extends through formal education and/or career training and the early experiences of adulthood in work and personal life. In this stage, development follows paths that accentuate a particular learning style. Individuals, by this stage, already show a preference for a particular learning style. People are shaped by educational, organizational, and other forces that develop increased competence in a specialized adaptation that enables them to master the particular life tasks they encounter in their chosen career. The third stage is that of integration and is marked by the expression of the non-dominant learning styles which were suppressed in favor of the development of the more rewarding learning styles. Examples of Kolb's research in attempting to

identify learning styles with choices for work and study are discussed in this work.

In "Experiential Learning" (1984) Kolb describes the results of collected data for a number of different professional groups that have been tested for learning style. The results of the study are shown (see Figure 2). Kolb's conclusions are that the professions in general have an active as opposed to a reflective learning orientation. The social professions are made up of people who are heavily accommodative in their learning styles. Professions with a technical or scientific base are made up of people who rely on convergent learning styles. Kolb has further found that the task demands and pressures of a job tend to shape a person's adaptive orientation and that there is evidence for a relationship between job demands and learning styles. Kolb's (1976) study on Massachusetts Institute of Technology (MIT) undergraduates found a correlation between college major and learning type.

Scores on the LSI for business majors placed them in the accommodator group, while scores for history, political science, English, and psychology majors placed them in the diverger group. Students majoring in economics, mathematics, sociology, chemistry, physics, and foreign languages tended to be assimilators, while students majoring in nursing and engineering were usually convergers.

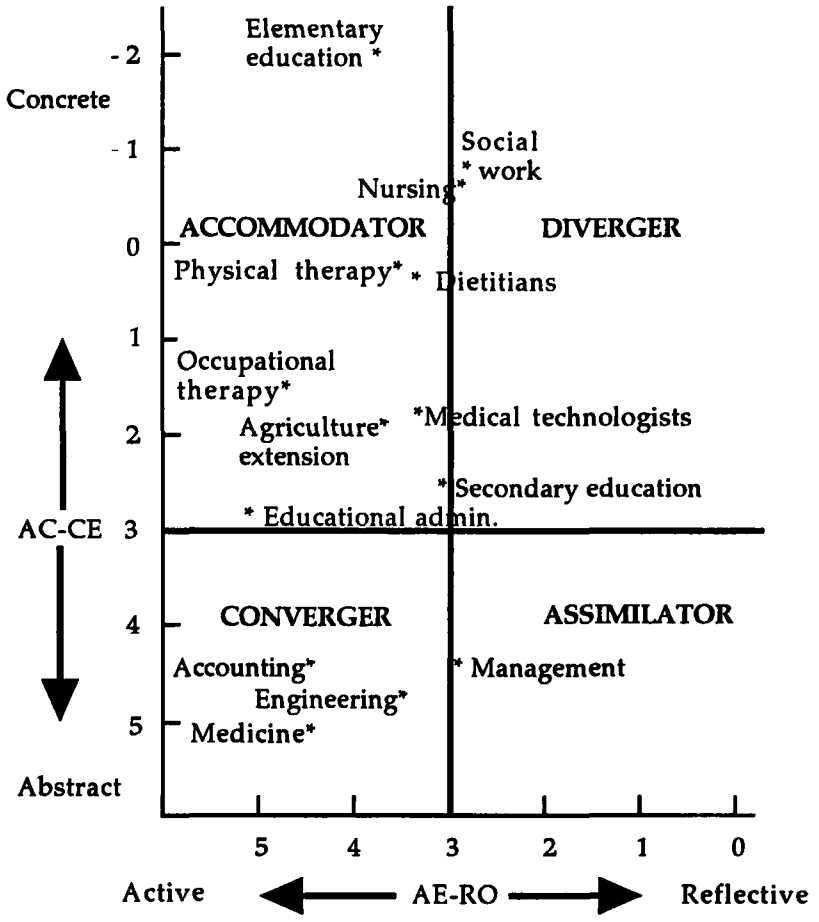

Figure 2. Learning-Style Scores for Various Professional Groups

From Experiential Learning (p. 89) by D. A. Kolb, 1984, Englewood Cliffs, NJ: Prentice-Hall. Copyright 1984 by Prentice-Hall. Reprinted by Permission.

Sims (1981) developed and tested a model for assessing person-job match. Two hundred and eighty-one engineers and one hundred and fourteen social workers from different organizations participated in the study. Sims' person-job match model developed in this study contends that organizations should view the person as a learner and the job as a learning environment. His basis for this view is that learning, adaptation, and problem-solving are the same basic process and that all jobs require learning,

adaptation, and problem-solving. In his study, Sims used experiential learning theory, developed by Kolb, as a framework for incorporating commensurate measures of the person's skills and the demand characteristics of the job along four dimensions identified in experiential learning theory. Sims' findings generally suggest that individuals whose personal skills and job demands are matched in pivotal skill areas report higher job satisfaction, job performance, and growth climate than individuals who are not matched in pivotal skill areas. He further reports that experiential learning theory has demonstrated its usefulness in measuring the person and job in commensurate terms by utilizing adaptive competency areas (affective, perceptual, symbolic, and behavioral) as a framework for viewing pivotal skill areas in jobs. Kolb and Fry (1975) describe adaptive competencies in the following way: Each task that we face requires a corresponding set of skills for effective performance. The effective matching of task demands and personal skills results in an adaptive competence. This concept represents a new approach to matching persons to jobs. Kolb and Fry believe that aptitude tests are too generalized and do not measure the person and the job demands in the same terms. The competency-assessment approach focuses on the person's repertoire of skills that relate to the specific demands of a job.

Bennet (1978) researched the individual differences among health professionals as to learner type. Bennet's study attempted to provide information about health care professionals as learners. Plovnick (1975) focused on the influence of medical students' learning styles on their choice of medical career type, and their sources of information and influence in making that choice. The study found that students with different learning styles are initially inclined toward careers in different specialties or in different types of medicine. Plovnick points to the evidence that cognitive

style differences between people can lead them to choose different kinds of careers in which their cognitive predilections will be most appropriate. Christensen, Lee, and Buggs' (1979) study, concerning professional development of nurse practitioners, revealed that 70 percent of the nurse clinicians studied were accommodators or divergers. They found this to be consistent with Plovnick (1975) who reported that medical students who were accommodators or divergers tended to choose medical careers in primary and family care. The data further revealed a consistent tendency of those with active or concrete learning styles to be more productive than those with abstract or reflective styles.

There is a great deal of evidence from the behavioral sciences that people vary in cognitive style along a number of dimensions. There is also evidence that these differences can lead people to choose different kinds of careers in which their cognitive predilections will be most appropriate (Plovnick, 1975). Because individuals tend to rely on a dominant style of learning over others, it may serve the hiring authority well to identify and consider individual learning style when matching the person to the job. This may be especially beneficial when the job to be performed requires a high degree of perceptual skill and cognitive ability.

Adapting Curriculum to Learners

Tobias (1981) describes the first record of instruction being adapted to individual differences as that of Socrates attempts to instruct the slave boy Meno in the mysteries of rectangles. Socrates adapted the instructional sequence to Meno's prior achievement. "To develop a theory of learning that is contingent on individual learning styles and specific subject matters, we need a typology of learning styles that can characterize both individual

differences in learning styles and differences in the learning environment created by different academic disciplines or subjects" (Kolb & Goldman 1973).

Kolb and Goldman believe that any true educational technology must be built on a valid model of the learning process. They point to the highly sophisticated and creative educational techniques designed to assist the learning process. Kolb and Goldman believe that the great weakness of nearly all the techniques is their failure to recognize and provide for the differences in learning styles that are characteristic of both individuals and subject matters.

Bennet (1978) feels that program developers can increase the effectiveness of continuing education activities by designing these activities in accordance with the methods by which practitioners perceive and process information or in accordance with their learning style. In such a situation, learners would be able to choose formats that complement their preferred style of learning.

Gordon (1959) found that continuous perceptual-motor (tracking) tasks (i.e., ATC) have come to present considerable conceptual difficulty to the theorist interested in extending accepted learning principles to them. This finding by Gordon is relevant to a study of ATC training because of the dynamic and changing nature of the ATC training environment.

At the heart of Sims' (1980) research is the proposition that individual job performance and job satisfaction is contingent upon a proper match between the person's skills and the job demands in pivotal skill areas. Sims' views of the workplace as learning environment are of significant importance in the context of training the successful ATC candidate. A method of training that considers individual learning styles may prove more valuable than other methods. In examining a person as a learner, and the job

as learning environment, Fry (cited in Simms, 1980) expressed two implications: (a) environments must be viewed in terms that learners perceive them, and (b) in analyzing person-environment interactions, individual as learner and the environment as learning press can be conceptualized in ways that relate to a pragmatic learning theory.

Current research indicates that different instructional strategies can lead to qualitatively different ways of processing information. Bell (1981) addresses the importance of planning strategies that anchor new information to the learner's store of previously acquired material. Wildman (1981) notes the virtual explosion of new information about the process of instructional design. And while the field of instructional design is functioning as a relatively mature field, Wildman believes that future work should be oriented toward better understanding of learners and how they interact with instructional programs.

In his paper on the acquisition of cognitive skills, Anderson (1982) states that it takes 100 hours of learning and practice to acquire any significant cognitive skill to a reasonable degree of proficiency. His study deals with the basic learning processes that are responsible for the changes in the nature of a skill over long periods of time and the basic progression of skill acquisition. Schneider (1983) describes a high performance skill as one in which over 100 hours of training are required and substantial numbers of individuals fail to develop proficiency. Schneider describes ATC as a high performance skill in which novice and expert display very different performance characteristics.

Tobias (1981) found in his research that adapting instruction to differences in psychological processes may be useful. Tobias focuses on the nature of individual differences and the determining of what practices in

various instructional methods actually account for differences in student achievement.

Kolb and Fry (1974) found that any educational program, course design, or classroom session can be viewed as having varying degrees of orientation toward each of the four learning modes in the experiential learning model. These learning modes are labeled as affective, perceptual, symbolic, and behavioral, to connote the overall climate they create and the particular learning skill or mode they require. The perceptually complex learning environment is one in which the goal is to understand something. A symbolically complex learning environment is one in which the learner is involved in trying to solve a problem for which there is usually a right answer or best solution. Behaviorally complex learning environments (ATC training) are ones in which the emphasis is upon actively applying knowledge or skills to a practical problem. According to Kolb and Fry, these learning environments vary in the degrees to which they are oriented to any of the four types. A student's reaction and success in a learning environment is heavily dependent on his/her preference and orientation toward a particular environment. It is believed that the academy screen in Oklahoma City, and subsequent practical ATC courses, offer unique learning environments. The reason that some ATC candidates do well in these environments and others do not is, to a large degree, dependent on the preference of the learner and their ability to adapt to this unique environment.

Williams (1984) attests to the excellent potential of Kolb's LSI for developing curriculum for educational settings having diverse learners. She credits the flexibility of the learning model and the fact that instructors can utilize the model to any degree they see fit. When a group of individuals is

involved in a learning situation, each individual will approach that situation utilizing a mode of learning most comfortable to his/her learning style. Williams uses the example of a group of individuals first learning computer skills. Certain individuals would not feel comfortable with the computer unless they had first read a book on the experts' opinions on developing computer skills. Others would want to watch those who are more competent than themselves before making their own attempts. Finally, there would be those who would simply sit down and feel comfortable learning from trial and error. The example shows that each person can and will approach a learning experience in his/her own unique learning style.

Whitaker (1978) believes that the ideal training program would allow professional educators to find and administer the appropriate combination of traditional and experiential education. To accomplish these goals, Whitaker feels that educators would need to know a great deal more than most of them have ever been taught about individual learning styles and preferences and about how to match these styles to appropriate learning activities and methods.

Summary

The review of the related literature begins with an acknowledgement of the contributions of the Civil Aeromedical Institute. They laid the foundations of the research toward a better ATC screen while demonstrating that aptitude test scores, as well as other psychological testing, can be utilized in predicting success in the ATC profession. CAMI has shown that there are certain skills, abilities, and characteristics necessary for success at ATC training. Unfortunately, however, the literature also substantiates the fact that success toward reaching the goal of creating a truly useful and efficient

screen has been very limited. Researchers are now beginning to study alternative paths and methods of screening and training ATC candidates.

The literature focuses on several studies that have obtained data relating learning style to personality type, educational specialization, professional career, current job, and adaptive competencies. The utility of Kolb's learning style inventory has been shown in several studies. Kolb (1984) describes experiential learning as not being an educational concept, but rather a concept that describes the central process of human adaptation to the environment. Learning styles represent preferences for one mode of adaptation over the others.

Finally, the literature suggests the effectiveness of adapting the curriculum to the learner. The focus of instructional design might be more productive if it shifted from the traditional emphasis on what the instructor must do during a traditional instructional episode, to an emphasis on the activities of the learner. Williams (1984) proposes that instructors examine their curriculums in terms of Kolb's Experiential Learning Model. She believes that by incorporating the four learning modes within one's curriculum, opportunities for optimal learning would be increased.

Statement of the Hypothesis

Research indicates that the screening of ATC candidates is far from being perfected. As long as the FAA Academy attrition rates remain high, there is every reason to continue to study and investigate alternative methods of ATC screening. Therefore, it is hypothesized that ATC students who possess the accommodator cognitive learning style, according to Kolb's LSI, will do better on ATC micro-computer based practical exercises than ATC students who do not possess this learning style. This is based on the

accommodators preferred modes of learning that accentuate concrete experience and active experimentation. It is anticipated that this study will lead to a more effective method of screening ATC candidates based upon individual learning styles.

Method

Subjects

This study was conducted on the E-RAU Daytona Beach campus. There are approximately 5000 students enrolled in all graduate and undergraduate programs at the Daytona Beach Campus. E-RAU is a unique institution in that it is the only independent, not-for-profit, accredited, totally aviation-oriented university in the world. It is dedicated to aviation education and is committed to preparing its students for positions in the aviation industry. E-RAU operates under a single-university, multi-campus concept with academic operations at Daytona Beach, Florida; Prescott, Arizona; and an international campus which operates a network of resident centers and other continuing education programs throughout the world (Richardson, 1985).

The Daytona Beach campus was used for this study because the researcher was associated with the university as adjunct faculty, research assistant, and graduate student. The student population of the Daytona Beach campus during the Fall 1990 semester was stratified into approximately 4600 United States and 400 foreign students. The U.S. students enrolled during the Fall 1990 and Spring 1991 semesters were from all 50 states, the District of Columbia, and Puerto Rico. The foreign students were from 82 different countries. The study was conducted using a sample of the aeronautical science student body which was a reflection of the total campus population.

E-RAU currently offers two ATC courses in its curriculum: AS 360, Introduction to Air Traffic Control, and AS 361, Enroute/Terminal Radar and Non-Radar Air Traffic Control. E-RAU also participates in a cooperative agreement with the FAA under the auspices of AS 359, Air Traffic Control Practicum (see appendices A, B, and C for a complete description of ATC

courses). Students entering into any of the ATC courses or the cooperative program are screened to the extent that E-RAU currently screens all college applicants. These students are of average intelligence as determined by their high school graduation and admission to E-RAU. Some have chosen ATC as a career goal worth pursuing. All have at least some interest in ATC as determined by their decision to pursue AS 361, which is an elective course under the 1990-91 E-RAU catalog. There were a total of 45 students enrolled in AS 361 at the beginning of the Fall 1990 semester. Sixteen attrited, leaving 29 students who successfully completed the course. In the spirit of enhancing their careers and pursuing their educational endeavors, all students enrolled in the course volunteered to be a part of the study.

All three sections, approximately 45 students enrolled in AS 361, were administered the Kolb LSI at the beginning of the Fall 1990 semester. The results from the 16 students that attrited were not used for the test, thereby leaving a total of 29 subjects. One hundred percent of the students who successfully completed AS 361 during the Fall 1990 semester at E-RAU were participants in this study.

Instruments

Kolb's Learning Style Inventory

Through experiences in family, school, and work, people tend to resolve the conflicts between being active and reflective and between being immediate and analytical in characteristic ways. Each individual develops a learning style that has some weak and some strong points (Kolb, 1976). Furthermore, learning style differences have been associated with different career choices (Plovnick, 1975). Encouraging results from past studies using

Kolb's LSI, have led to the use of the instrument for this study. Refer to Appendix J for a sample of Kolb's LSI.

For this research study, students enrolled in the Fall 1990 semester of AS 361 (Enroute/Terminal Radar and Non-Radar Air Traffic Control) were given a simple self-description inventory: The Kolb LSI. The LSI is designed to measure an individual's strengths and weaknesses as a learner. The LSI measures a person's relative emphasis on the four learning abilities described earlier: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE) by asking him/her, several different times, to rank order four words that describe these different abilities (Kolb & Goldman, 1973). For example, one set of words is "Feeling" (CE), "Watching" (RO), "Thinking" (AC), "Doing" (AE). The subject rank orders each set of four words assigning a "4" to the word which best characterizes their learning style, a "3" to the word which next best characterizes their learning style, a "2" to the next most characteristic word, and a "1" to the word which is least characteristic of the subject as a learner. There are a total of 12 questions yielding four columns of scores. The column totals produce scores for CE, RO, AC, and AE plus two combination scores that indicate the extent to which an individual emphasizes abstract conceptualization over concreteness (AC-CE) and the extent to which an individual emphasizes active experimentation over reflection (AE-RO). When these two combination scores are plotted on a matrix, the resultant coordinate will fall within one of the four classifications of learning styles: convergers, whose dominant learning styles are abstract conceptualization and active experimentation; divergers, whose ascendant learning styles are concrete experience and reflective observation; assimilators, who are best at abstract conceptualization and reflective observation; or accommodators,

whose dominant learning styles are concrete experience and active experimentation (Christensen, Lee, & Bugg, 1979). The characteristics of each of these types of learning styles have been summarized based on both clinical research and patterns of LSI scores.

To determine reliability, Kolb (1976) applied the Spearman-Brown prophecy formula to obtained correlations between halves for five different groups (see Table 1):

Table 1
Spearman-Brown Split-Half Reliability Coefficients for the Learning Style Inventory

Sample	n	CE	RO	AC	AE	AC-CE	AE-RO
MIT Sloan Fellows	47	.69	.37	.65	.64	.78	.78
MIT Sloan Fellows	50	.43	.59	.81	.61	.80	.81
Active Managers	90	.61	.58	.71	.62	.78	.85
Harvard MBAs	442	.50	.63	.74	.67	.75	.84
Lesley Undergrads	58	.48	.63	.74	.65	.82	.86
TOTALS	687	.55	.62	.75	.66	.74	.82

Two groups of about 50 Massachusetts Institute of Technology (MIT) Sloan Fellows (mid-career managers attending a one-year master's program in management), a miscellaneous group of 90 practicing managers, 442 Harvard MBA students and 58 female Lesley College undergraduates. From this analysis, Kolb (1976) concluded that the combination scores AC-CE and AE-

RO are highly reliable indices suitable for most research applications. The basic scales CE, RO, AC, and AE show greater variability and must be used more cautiously. The pattern of scores taken collectively across a variety of groups suggests that LSI scores show sufficient variability across different populations to be useful in assessing the learning styles that characterize many occupations and groups (Kolb, 1976).

Current data suggests that, on the average, men and women score differently on the LSI. Women tend to score higher on the concrete experience orientation while men tend toward abstract conceptualization (Kolb, 1976). No consistent differences between men and women have been identified on the active/reflective dimension. In order to explore how learning styles might vary as a function of age and educational level, Kolb computed mean scores on the Active-Reflective (AE-RO) and Abstract-Concrete (AC-CE) scales for different ages and educational groupings. Kolb found a slight tendency toward increasing abstractness as one grows older. From ages 16 to 35, the tendency toward an active orientation increases and then seems to taper off toward a more reflective orientation in later years.

The LSI scores by educational levels show a very strong relationship between amount of education and abstractness of learning orientation. The Active-Reflective dimension shows increasing tendencies toward activity through the master's degree. Individuals with more than a master's degree tend toward a more reflective orientation.

TRACON

TRACON is a micro-computer based ATC simulation of a Terminal Radar Approach Control. TRACON was designed primarily by Robert B. Wesson, Ph.D. Dr. Wesson's doctoral dissertation involved applying artificial

intelligence techniques to the problems of ATC. In 1977, he created a program, running on a mainframe, which simulated an Air Route Traffic Control Center's sector. The program solved separation problems and issued appropriate ATC clearances to aircraft (Wesson & Young, 1989). "This program was judged by professional controllers at Houston Center to perform better than human ATC personnel handling the same traffic in the same ATC sector" (Wesson & Young, 1989, chap.1, p. 4).

During the late 70's, at the Rand Corporation "Think Tank" in Santa Monica, California, Dr. Wesson led a research team which produced and evaluated scenarios for the evolution of the present-day ATC system to a modern computer-mediated control environment called Automated Enroute Air Traffic Control (AERA). AERA is the software concept associated with the Advanced Automated System (AAS). Together, these two systems will make up the next-generation ATC system in the United States, based largely on advanced computer concepts such as artificial intelligence. Much of Wesson's work is helping to guide the FAA's multi-billion dollar airspace and airway modernization program currently underway. Dr. Wesson is currently president of Wesson International, the company that created TRACON. TRACON was programmed in Microsoft C by Dale Young of Wesson International. Many of its most advanced, realistic features were suggested and tested by George Booth, a program Manager at the FAA's Advanced Concepts Division in Washington, D.C., and by a number of professional controllers at the Austin TRACON, an FAA facility in Texas (Wesson & Young, 1989).

TRACON was a finalist in PC magazine's 1989 Technical Excellence Award and has won U.S. Air Force and FAA contracts aimed at producing a professional training system based upon its technology. TRACON is

currently being used for ATC training by the U.S. Air Force, the FAA, and by some foreign nations.

Figure 3 depicts a simulation screen at the conclusion of an exercise. A performance review allows the student to see where mistakes were made.

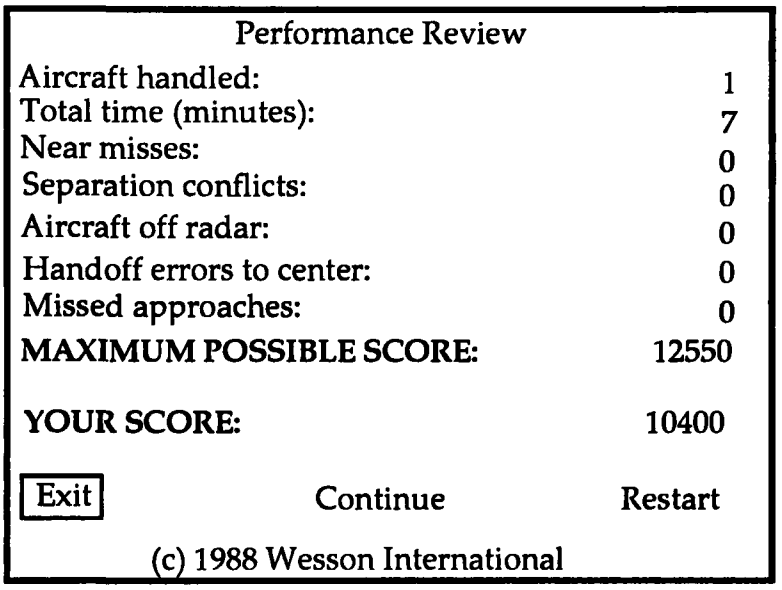

Figure 3. TRACON Performance Review

From TRACON II (3-18) by R. B. Wesson, 1990, Austin TX: Wesson Int. Copyright 1990 by Wesson Int. Reprinted by Permission.

The TRACON software and ten IBM PC micro-computers were used as the delivery systems for AS 361. Subjects were given equal amounts of time on the work stations throughout the course. As a final exam to the Fall 1990 semester, a comprehensive TRACON exercise was created by the instructor based on empirical knowledge. All students took this exercise as their final exam for the course with the same scoring parameters applying to all subjects.

TRACON has a built-in scoring methodology based on scoring parameters and variables. As aircraft are successfully handled, the individual's score rises. For example, each time a successful handoff is made, the score rises. Points are adjusted downward by the distance the aircraft was required to travel beyond its requested flightpath. Points are also subtracted according to how long the aircraft was held on the ground or at its inbound fix before being accepted. Finally, because it is believed that a controller's job should be carried out in an unobtrusive manner, points are deducted for every control command given to an aircraft. Since various types of aircraft consume fuel at different rates, the actual number of points awarded after handling an aircraft depends on its type. Because military aircraft consume fuel at the greatest rate, they usually merit the most fuel-related point adjustments. In descending order of importance, airline jets, corporate jets, twin engines, and single engine pistons also add points when they are successfully handled. The major negative point adjustments are made when serious errors occur (i.e., missed handoffs, vectoring-off-radar, approach altitude errors, missed approaches, and the various classes of separation conflict errors). Generally, aircraft must be handled in a safe, orderly, and expeditious manner for a student to gain the maximum amount of points.

Figure 4 shows the scoring parameters for TRACON. Each scoring item begins with the word "add" or "sub", which indicates whether that item is added or subtracted from the accruing score. After the underscore, the description of the item and then the number of points associated with it are shown. The first few items determine the basic point value of an aircraft that is handled.

SCORING PARAMETERS

add_enroute	500
add_depart	600
add_arrive	800
add_actype	100
sub_command	10
sub_delay	20
sub_pause	10,000
sub_enrwrongspeed	100
sub_enrwrongalt	250
sub_enrhandoff	500
sub_missedapp	250
sub_offradar	1500
sub_3mile	1000
sub_1mile	5000
sub_crash	0

Figure 4. Scoring Parameters for TRACON

From TRACON II (p. 8-12) by R. B. Weson, 1990, Austin TX: Wesson Int. Copyright 1990 by Wesson Int. Reprinted by Permission.

Each time an aircraft is successfully handed off to either an Airport Tower or Control Center, points are awarded. Overflights start with 500 points, departures 600, and arrivals 800 points. To that is added 100 points for each increasing aircraft type: 0 points for a single engine, 100 points for a twin engine, 200 points for a turboprop, and so forth until an additional 500 points is added for handling a military flight. From this basic aircraft score, 10 points are subtracted for each command that is issued to it, and 20 points for every minute that an aircraft is delayed from an optimal time of passage through a sector's airspace (Wesson & Young, 1989). TRACON computes a maximum possible raw score for each exercise that is generated. A student's raw score for the exercise, based on the scoring methodology described, is displayed below the maximum possible score. To obtain the post-test score used for this

study, the student's raw score was divided by the maximum possible score, thereby yielding a percentage.

Design

Individuals are endowed with varying degrees of perceptual, cognitive, mechanical, athletic, intellectual, and other skills and abilities. The purpose of this study was to establish a relationship between the cognitive learning style that a person possesses, and his/her success on simulated ATC practical exercises. The study further examined those identified cognitive learning styles and abilities considered necessary for success at ATC training. For the purposes of this study, cognitive learning styles refers to the four learning styles described by Kolb (1976): converger, diverger, assimilator, and accommodator.

The design approach to this study was carried out according to the causal-comparative research process. This method was indicated because the study attempted to determine the cause, or reason, for existing differences between groups of individuals. More precisely, the study attempted to determine if the accommodator style of learning would show a higher mean score on the simulated ATC practical exercise than the other groups. The identified learning style is considered to be the major determinant, or cause, for high ATC practical exercise scores within a group. As there was no deliberate attempt by the researcher to make the groups different, and no attempt to manipulate variables, the experimental method was not indicated. Four different groups, based on learning styles, were already formed (Gay, 1987).

The basic causal-comparative design involves selecting groups differing on some dependent variable. In this study, the groups were formed,

post-facto, according to learning styles (converger, diverger, accommodator, or assimilator) as determined by individual results on Kolb's LSI. Gay (1987) refers to these groups as comparison groups. They differ because of their learning styles. The subjects were all drawn from the same population and all have the same general characteristics. They were selected purely on the basis of their enrollment in AS 361.

Gay (1987) points out that the interpretation of the findings in a causal-comparative study requires considerable caution due to the lack of randomization, manipulation, and other types of control characteristics present in experimental studies. One important control factor to consider when conducting a causal-comparative study is the possibility that the groups are different on some other major variable besides the identified independent variable. The possibility exists that this other variable is the real cause of the observed difference between the groups.

Whether or not a candidate is successful at ATC training is determined by many variables, as established by the FAA's Civil Aeromedical Institute through numerous research studies on ATC candidates. Success toward identifying variables conducive toward success at ATC training has been very limited. It is believed, however, that a plausible relationship exists between the independent variable (learning style) and the dependent variable (simulated ATC practical exercises). This reasoning is based on the fact that the ability to adapt to the demanding ATC learning environment has an important influence on the chances of being successful at ATC training. Furthermore, learning style tests have proven to be useful indicators in determining a person's ability to adapt to a particular learning environment.

Other uncontrolled variables included the possibility that students would not approach AS 361, and the LSI, as seriously as they would a training

program at the FAA academy. Students were, however, concerned with their final grades for the course. This is believed to have offset any bias that may have been caused by a slight lack of interest in the study. This uncontrolled variable is not abnormal for a study of college students and was considered to be negligible.

Physical differences were controlled to minimize threats to experimental validity. The same classroom was used throughout the study and in accordance with the scheduled class times. Identical testing and test administration procedures were used for all class sections during the study. The researcher administered the LSI and was present during the final simulated ATC practical evaluation for all subjects. The setting for the study was a college classroom at E-RAU which allowed a great deal of stability. There were no other obvious identifiable extraneous variables that were considered to affect this study in a confounding manner.

While most college courses tend to reward those who work hard, ATC, by its very nature, requires an innate skill that is not easily identified and consciously perfected. So, regardless of the time and effort put into the course, it was expected that some subjects would find the simulated ATC practical exercises easier to master than others. Furthermore, the learning style instrument is of a completely different nature than ATC simulated exercises. Therefore, the two tests could not possibly have a bearing on each other. This fact would also preclude problems associated with maturation. The issues of statistical regression and differential selection of subjects were not relevant as subjects were chosen solely because of their enrollment in AS 361.

Procedures

The researcher was an assistant instructor for three sections of AS 361 during the Fall 1990 semester at E-RAU. Students taking this advanced course were introduced to basic ATC procedures for instrument flight rules (IFR), operations, separation standards, holding aircraft, arrivals, and departures. They were also given the opportunity to practice ATC skills. All students taking AS 361 must have also successfully completed AS 360, Introduction to Air Traffic Control. AS 360 is a basic ATC course which provides the student with an introduction to the ATC system at the operational level. During the first week of classes, all students were administered the Kolb LSI. The LSI was administered in a college classroom at E-RAU and the standard procedures for testing at the university level were applied. The time allowed for testing and explanation of the LSI was approximately 30 minutes.

The LSI consists of a nine-item self-description questionnaire. Each item consists of four words representing choices. The subject ranks the four choices beginning with the word that best describes his/her learning style (4), and the word that least describes his/her learning style (1). One word in each item corresponds to one of the four learning modes: concrete experience (sample word: feeling), reflective observation (sample word: watching), abstract conceptualization (thinking), and active experimentation (doing). The words were selected by a panel of four behavioral scientists acquainted with the theory. When all nine lines have been completed, the scores for each of the four columns are summed. The sum of column one yields the score for concrete experience (CE), column two yields the score for reflective observation (RO), column three, abstract conceptualization (AC), and column four, active experimentation (AE). From these four stage scores, two

additional combination scores are obtained by subtracting CE from AC (abstractness over concreteness), and subtracting RO from AE (action over reflection). These two combination scores are plotted on a matrix made available with the LSI. The AE minus RO score is plotted along the X-axis and the AC minus CE score is plotted along the Y-axis. The resultant coordinate falls into one of four quadrants indicating the subject's preference for a particular learning style. A description of learning styles was attached to each LSI for use by the subjects. The subjects were allowed to score their own tests to add a sense of participation and interest. Subjects were instructed in detail as to the procedures employed during testing.

The practical part of AS 361 consisted of simulated ATC practical instruction. Micro-computer based ATC simulation employing the TRACON software was used as the mode of delivery for this part of the course. A series of simulated ATC practical exercises, gradually increasing in complexity, was created. At the end of the semester, a final simulated ATC practical exercise was given to all subjects. The results of the Kolb LSI caused the subjects to be divided into one of four groups according to learning styles (converger, diverger, assimilator, or accommodator). A set of mean scores based on the results of the final simulated ATC practical exercise was calculated for each of the four groups. It was hypothesized that the mean scores would vary and that the variation would be due to the dependent variable, learning style. To determine if there was a significant difference between the mean scores of the four groups, and to further determine if one of the groups scored significantly higher than the others, t-ratios for independent means were computed.

The null hypothesis stated that there would be no significant difference between the ATC final simulation mean scores of the four learning style groups. An alternate hypothesis stated that the mean scores of

accommodators would be higher than the mean scores of the other learning style groups. The accumulated data was used to determine whether the results supported the research hypothesis that ATC students who possess certain measurable cognitive learning styles and abilities will do better on ATC micro-computer based practical exercises than ATC students who do not possess these learning styles and abilities. As there are no other known studies directly relating learning style with the ability to do well on ATC simulated exercises, the results may prove useful toward the design of a more effective ATC screening instrument.

The researcher is currently involved in a study at E-RAU, funded by the FAA, whose purpose is to develop a more efficient screening instrument. The results of this study will be used as a part of that project. This study will be repeated on future ATC students at E-RAU to add validity. It is hoped that the results will be useful toward the development of a newer and more effective screening instrument.

Analysis

The research hypothesis stated that students who possess the accommodative cognitive learning style will do better on a simulated ATC practical exercise than students who do not possess that learning style. The statistical results of this study showed support for the research hypothesis at P = .10. The accommodators mean scores were actually higher than the other three learning style groups in all cases, however, they were not shown to be significant in all cases.

There are two issues which should be addressed prior to continuing the analysis of the data. First, as reported earlier in the study, all students enrolled in the three sections of AS 361 at the beginning of the Fall 1990 semester were given Kolb's LSI as an integral part of this study. The total enrollment at that time was 45 students; an acceptable sample size for this study. Approximately one third, or 16 students attrited; an unusually high number to discontinue the course. The final sample size was therefore less than desired. Because of this small sample size, an Analysis of Variance (ANOVA) statistical technique was deemed inappropriate and a t-test was used to test significance. The groups varied in their size with the largest number of samples (10) being in the converger group and the least number (4) being in the diverger group. Small sample size can create some difficulty in establishing significance at P = .01 or even P = .05. Trends in the statistics did develop and significance was established at the P = .10 level. These trends concur with the research hypothesis. Second, the subjects used for this study were chosen because of their enrollment in AS 361. Many of these students have no present or future desire to pursue careers as ATC specialists, and all had little or no experience in ATC. A more valid test would have tested

active ATC Specialists and ATC trainees. A hypothesis in such a situation would more realistically correlate success at ATC with individual learning style. This research was only able to determine if students with a particular learning style, and no prior ATC experience, would perform better on a simulated ATC practical exercise than students who do not possess that particular learning style. If the current FAA workforce of ATC trainees and fully qualified controllers were tested for individual learning styles, more conclusive and realistic results would probably have ensued.

For the purposes of this study, subjects were initially divided into four groups according to learning styles (accommodator, diverger, assimilator, and converger). Four additional groups were formed based on the four learning modes (concrete experience, abstract conceptualization, active experimentation, and reflective observation). Whereas learning style is determined by a subject's plotted point within a quadrant on the matrix, the learning mode is based on where a student's plotted point falls in relation to the X or Y axes. That is: a score falling above the X-axis (accommodators and divergers) would indicate a tendency toward concrete experience, while a score falling below the X-axis (convergers and assimilators) indicates a tendency toward active experimentation. A score falling to the right of the Y-axis (divergers and assimilators) would indicate a tendency toward reflective observation, and a score falling to the left of the Y-axis (accommodators and convergers) indicates a tendency toward abstract conceptualization.

Accommodators had the highest mean scores and the significance between convergers and assimilators was established. This was the hypothesized result. The concrete experience group also showed some significance when measured against the active experimentation group. This finding is logical and also correlates with the accommodator and diverger

styles of learning. That is, accommodators and divergers both rely on concrete experience as a preferred mode of learning.

The t-test was used as the test of significance for this study. In all cases, a t-test was performed based on independent variables with equal variances. To test the statistical hypothesis that there would be a difference between the mean scores of groups, a two-tailed test of significance was calculated. To test the alternate hypothesis, that one of the groups would score significantly higher than the others, a one-tailed test was performed which tests the direction of the difference.

Table 2 shows the results of the statistical tests of significance carried out between convergers and accommodators. From this statistical test, it can be seen that no significant difference between means was found using a two-tailed test. The direction of the difference (one-tailed test) was found to be significant.

The next most likely area that significance was expected to be found was between accommodators and assimilators. This hypothesis is also based on the difference between strengths and weaknesses of these learning styles. Although significance was not conclusively established between means (two-tailed test), the direction of the difference (one-tailed test) was found to be significant. Table 3 shows the results of the statistical tests between assimilators and accommodators.

Table 2
t-test - Convergers-Accommodators

Independent means - variances equal

CONVERGERS:	mean of 10 cases:	63.8600
ACCOMMODATORS:	mean of 6 cases:	72.3500
Degrees of freedom:		14
Required t value for significance:		1.761
t-statistic:		1.4684

The difference between the means **is not** significant

Required t value to test direction:	1.345

The direction of the difference **is** significant

Table 3
t-test - Assimilators-Accommodators

Independent means - variances equal		
ASSIMILATORS:	mean of 9 cases:	67.5556
ACCOMMODATORS:	mean of 6 cases:	72.3500
Degrees of freedom:		13
Required t value for significance:		1.771
t-statistic:		1.3792
The difference between the means **is not** significant		
Required t value to test direction:		1.350
The direction of the difference **is** significant		

The remainder of the statistical tests comparing individual learning styles found no significant differences. Significance between means of all groups of learners was not expected, however, as only those learners whose strengths lie in concrete experience and, to some degree, active experimentation were expected to exhibit the strongest abilities in performance on the ATC exercises. Therefore, accommodators were expected to have the highest mean scores based on their preference for both concrete experience and active experimentation. The remainder of the statistical tests performed between the learning style groups are shown in Tables 4, 5, 6, and 7.

Table 4
t-test - Assimilators-Convergers

Independent means - variances equal

ASSIMILATORS:	mean of 9 cases:	67.5556
CONVERGERS:	mean of 10 cases:	63.8600
Degrees of freedom:		17
Required t value for significance:		0.7282
t-statistic:		1.740

The difference between the means is not significant

Required t value to test direction:	1.333

The direction of the difference is not significant

Table 5
t-test - Assimilators-Divergers

Independent means - variances equal

ASSIMILATORS:	mean of 9 cases:	67.5556
DIVERGERS:	mean of 4 cases:	70.9500
Degrees of freedom:		11
Required t value for significance:		1.796
t-statistic:		0.6116

The difference between the means **is not** significant

Required t value to test direction:	1.363

The direction of the difference **is not** significant

Table 6
t-test - Divergers-Convergers

Independent means - variances equal		
DIVERGERS:	mean of 9 cases:	70.9500
CONVERGERS:	mean of 6 cases:	63.8600
Degrees of freedom:		12
Required t value for significance:		1.783
t-statistic:		0.9000
The difference between the means **is not** significant		
Required t value to test direction:		1.357
The direction of the difference **is not** significant		

Table 7
t-test - Divergers-Accommodators

Independent means - variances equal		
DIVERGERS:	mean of 9 cases:	70.9500
ACCOMMODATORS:	mean of 6 cases:	72.3500
Degrees of freedom:		8
Required t value for significance:		1.859
t-statistic:		0.2464
The difference between the means **is not** significant		
Required t value to test direction:		1.397
The direction of the difference **is not** significant		

To determine if there was a difference between opposing learning modes (concrete experience versus abstract conceptualization and active experimentation versus reflective observation) subjects were divided into groups according to their relation to the X and Y axes on the matrix. Subjects whose scores on the LSI placed them in the accommodator or diverger groups were considered to have strengths that emphasize concrete experience. Assimilators and convergers were considered to have strengths that emphasize abstract conceptualization. Divergers and assimilators were considered to have strengths that emphasize reflective observation. Accommodators and convergers were considered to have strengths that emphasize active experimentation.

Four groups were formed and t-tests carried out to test opposing learning modes. The results of the concrete experience versus abstract conceptualization groups are shown in Table 8.

Table 8
t-test - Concrete Experience-Abstract Conceptualization

Independent means - variances equal		
CONCRETE EXPERIENCE:	mean of 10 cases:	71.7900
ABSTRACT CONCEPTUALIZATION:	mean of 19 cases:	65.6105
Degrees of freedom:		27
Required t value for significance:		1.703
t-statistic:		1.5636
The difference between the means **is not** significant		
Required t value to test direction:		1.314
The direction of the difference **is** significant		

As expected, the concrete experience group scored significantly higher than the abstract conceptualization group. This is based on the strengths and weaknesses of the two groups. No significant difference or trend was found between the reflective observation group and the active experimentation group. Table 9 depicts the results of the t-tests between these two groups.

Table 9
t-test - Reflective Observation-Active Experimentation

Independent means - variances equal		
REFLECTIVE OBSERVATION:	mean of 13 cases:	68.5923
ACTIVE EXPERIMENTATION:	mean of 16 cases:	67.0438
Degrees of freedom:		27
Required t value for significance:		1.703
t-statistic:		0.3935
The difference between the means **is not** significant		
Required t value to test direction:		1.314
The direction of the difference **is not** significant		

Another interesting finding in the study was that convergers formed the largest group and divergers made up the group with the least number of subjects. This fact was not surprising given the nature of academic qualifications and technical orientation of E-RAU.

Although numerous studies have been carried out using Kolb's and other learning style instruments, none have been specifically focused on ATC. As there is no study to measure this research study against directly, it cannot be deduced that this study is in disagreement or agreement with other studies. Studies that have used Kolb's LSI for various testing purposes have often found statistical significance between groups of individuals.

Appendix K depicts the basic statistical data for each of the four learning styles and four learning modes. These descriptions are identical in nature and are easily understood. Active cases, mean scores, sum of scores,

sum of squares, variance, standard deviation, and standard error are all used in the calculation of the t-distributions. The graphs below the statistical data in Appendix K represent the relationship between contiguous data points and the mean and standard deviation in their particular group.

Conclusions

Gay (1981) points out that the natural reaction of beginning researchers is to be very disappointed when the null hypothesis does not prove conclusive in the hoped for way. Gay also notes that this is an erroneous reaction. Without going on a "fishing expedition" or searching too desperately, this researcher was able to find significance at P =.10 and reject the null hypothesis when testing for the difference in direction (one-tailed test). That is: on the simulated ATC practical exercise, the mean score of the group of subjects who prefer the accommodative style of learning was significantly higher than the groups who prefer the assimilator and converger learning styles.

Whether the null hypothesis was rejected or accepted is immaterial as the literature makes a good case for the fact that an ATC candidate's success or failure on a simulated ATC practical exercise is in some way associated with learning style. This point would be made regardless of the statistical results. The statistics did show a definite trend however, and given the validity problems and small sample size of this test, it was pleasantly surprising to find that accommodators did have a higher mean score than the other learning style groups. It was even more rewarding to discover that this difference was significantly higher when tested against convergers and assimilators.

The research hypothesis for this study was based on the strengths and weaknesses of the various learning style groups and how that relates to their ability to adapt to the strenuous and demanding learning environment. Consider the strengths and weaknesses of the accommodator versus the strengths and weaknesses of convergers and assimilators. Accommodators

prefer "hands on" experience with a tendency to act on "gut" feeling rather than on logical analysis. Kolb (1981) points out that this learning style is important for effectiveness in action-oriented careers (such as ATC). Convergers, on the other hand, are best at finding practical uses for ideas and theories. Convergers strengths lie in their ability to solve problems and make decisions based on finding solutions to questions or problems (scientific). Assimilators are best at understanding a wide range of information and putting it into concise, logical form (information and science careers).

Accommodators showed no significance when tested against divergers, nor was any expected. This may be because these two groups share an inclination toward concrete experience. Those who prefer concrete experience as a mode of learning rely more on feelings than on a systematic approach to problems and situations. They rely more on their ability to be open-minded and "adaptable to change;" a very important quality for an ATC specialist. The remainder of the statistical tests comparing individual learning styles found no significance between means. Significance between means of all groups of learners was not expected, however, as only those learners whose strengths lie in concrete experience and, to some degree, active experimentation were expected to exhibit the strongest abilities in performance on the ATC exercises. Accommodators were expected to have the highest mean scores based on their preference for both concrete experience and active experimentation. It is logical that divergers had the second highest mean score.

Predictably, a trend developed toward a higher mean score within the concrete experience group. When tested against the abstract conceptualization group, significance was established in the direction of the

difference. As pointed out earlier, those who emphasize concrete experience rely more on their ability to be open-minded and adaptable to change.

One interesting but not very surprising finding in the study was the fact that the convergers comprised the group with the largest sample size while the divergers had the smallest sample size. It should be noted that E-RAU is a very technically oriented university. The school does not promote liberal arts. Students attending E-RAU are doing so primarily to gain highly specialized and technically oriented qualifications and accreditations. Kolb (1984) sums up the above finding very appropriately in the following way:

> That disciplines incline to different styles of learning is evident from the variations among their primary tasks, technologies, and products, criteria for academic excellence and productivity, teaching methods, research methods, and methods for recording and portraying knowledge. Disciplines, as we have seen, show socio-cultural variation--differences in faculty and student demographics, personality and aptitudes, as well as differences in values and group norms. For students, education in an academic field is a continuing process of selection and socialization to the pivotal norms of the field governing criteria for truth and how it is to be achieved, communicated, and used, and secondarily, to peripheral norms governing personal styles, attitudes, and social relationships (p. 162).

Kolb found evidence from research done at a major technical university that career choices tend to follow a path toward accentuation of one's specialized approach to learning. He further concluded that students who find a learning environment incongruent with their learning styles tend to move away from that kind of environment in future learning and work choices. Kolb (1984) has found that the science-based professions, especially Engineering, requires a convergent orientation while the social and humanities type professions require a diverger orientation. Sims (1980)

obtained two cross-sectional samples of more than four hundred engineering and social work alumni of a major, Midwestern university and compared their scores on the learning style inventory. He found that engineering alumni tend to rely more strongly on abstract conceptualization and active experimentation (convergers) and the social workers rely more highly on concrete experience and reflective observation (divergers). The fact that the largest sample size in this study were convergers, and the smallest sample size divergers, both validates the LSI and confirms the academic nature and type of students who attend E-RAU.

This study never intended to portray Kolb's or any other learning style instrument as being capable of utilization as a screen for ATC. In fact, there are many reasons why learning style tests may not make good screening instruments. The purpose of this study was only to show the significance of learning styles as a possible indicator of future success at ATC training. This hypothesis is based mainly on the researcher's experience as ATC Specialist and Air Traffic Services Instructor. The researcher has always found it amazing that many otherwise intelligent people find ATC training so difficult. Why is it that individuals, who are alike in so many other ways, fare so differently in ATC training? It was obvious to the researcher that some candidates adapt to the rigorous ATC training environment more easily and readily than others. After embarking on a course of research that would study the "why's" of adaptability, it became apparent to the researcher that individual learning style has a significant impact on a person's ability to adapt to a particular learning situation or environment. This fact is indicated clearly and significantly in the literature.

Therefore, it is hypothesized that research into individual learning styles would offer new avenues of insight for ATC hiring and training

authorities in their attempts to develop a more effective screening instrument. The literature also points to research being done into adapting learning situations to specific learners. Perhaps training authorities could develop an environment more conducive to ATC training if they were better able to identify the learning style or mode that is most responsive to ATC training. They could then develop a curriculum around this style of learning.

Recommendations

As with all beginners, this researcher learned a great deal about testing, statistics, and research during the course of this study and thesis research. The one area, more than any other, that the researcher would have liked to have had significant prior experience, however, is in choosing subject/samples. During the performance of meeting graduate degree requirements, conducting research, and writing a thesis, it became apparent that there was a significant and important finding to be had from this research process. Adaptability and learning style began to appear more relevant to ATC training than first thought. The researcher would have liked, during the conduct of the study, to have been able to go back and give an exceedingly valid test to a great many more subjects. It was too late and unrealistic, given the time restraints, however, and it was decided to make the most out of what was already obtained. Amazingly enough, the results did begin to show the tendency that was initially anticipated. There was a feeling of excitement and relief in knowing that this study would at least warrant further research. In this regard, the following suggestions are made:

1. Rather than study subjects who have no particular inclination toward ATC, qualified FAA controllers should be tested. The most logical place to carry out such a test for a student in Central Florida would be the Jacksonville Air Route Traffic Control Center. Centers are responsible for controlling the air traffic in the upper airspace. The Center controller uses sophisticated radar and radio equipment to control fast-moving jets. The

training requirements for the Center are the most difficult of the air traffic control options. If there are truly specific skills necessary for success at ATC, it is at the Center where they become most apparent. The Center controller represents the "epitome" of what it takes to be an ATC Specialist.

2. Ideally, a follow-up study to this one would involve testing different levels of ATC Specialists with a learning style instrument. Additionally, a large sample size should be obtained to add validity to the study. Several hypotheses could be developed along with determining the dominant learning style. For example, one could attempt to determine if the learning style was developed by the controller prior to beginning work in ATC, or if a non-dominant learning style became apparent as the individual adapted to the job.

3. A questionnaire should be constructed that would determine how difficult the controllers found the ATC training program. The results of the questionnaire could be correlated with individual learning styles to determine if individuals with certain learning styles found ATC training easier to grasp than others. The researcher believes that the findings of such a study would be significant.

In summary, it should again be noted that the FAA currently operates a technical training academy in Oklahoma City, Oklahoma. Prior to being accepted into the academy, prospective candidates must take a civil service

examination for the position of ATC Specialists and score in the top 10%. The exam is meant to be the first step in a screening process that does not end until the ATC candidate has reached the full performance level ATC Specialists. This screening process is quite expensive. It would appear that with a 40% attrition rate at the academy in Oklahoma City and an overall ATC training attrition rate of 56%, there is ample reason for more study and improvement on screening procedures.

The FAA has always been interested in keeping costs down while keeping success rates high. If a more reliable and inexpensive method were employed to screen potential candidates, the FAA, and in turn the U.S. taxpayer, would save a substantial amount of funding on the training of those candidates who would eventually fail and be terminated. Furthermore, the quality of ATC candidates could also be expected to rise, as only those with necessary skills to be successful would be considered.

The researcher will attempt to monitor the training and progress of those E-RAU students who pursue careers with the FAA in ATC. Learning styles will be correlated against future ATC training performance. It is predicted that students who are successful at AS 361, Enroute/Terminal Radar and Non-Radar Air Traffic Control, and who possess certain learning styles or modes will have a higher success rate at the Federal Aviation Administration academy than those students who do not possess those learning styles. This study will act as a catalyst toward developing a more efficient and accurate method of testing and screening air traffic control candidates. The results of the study will prove significant to Embry-Riddle Aeronautical University as it considers expansion of its ATC program.

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APPENDIX A

AS 360 INTRODUCTION TO AIR TRAFFIC CONTROL

COURSE DESCRIPTION

AS 360 - Introduction to Air Traffic Control

This course provides the student with an introduction to the ATC system at the operational level. It describes the components of the National Airspace System with emphasis on interrelationships between enroute, terminal, tower, flight service functions, and the pilot. Students enrolled in AS360 are either seeking careers as ATC specialists through a cooperative program with the FAA, or they are students interested in rounding out their aviation educations. The course is intended to give the student a general idea as to how the ATC system operates, and comprises no practical or laboratory training.

APPENDIX B

AS361- ENROUTE/TERMINAL NON-RADAR AND RADAR AIR TRAFFIC CONTROL

COURSE DESCRIPTION

AS 361 - Enroute/Terminal Non-Radar and Radar Air Traffic Control

This course covers the basic ATC procedures for instrument flight rules (IFR) operations, separation standards, holding aircraft, departures/arrivals, and general and special controls. Students are given the opportunity to practice ATC skills. Students enrolled in this course have decided to explore ATC in more depth and are considering it as a career. They are exposed to ATC situations in radar and non-radar simulated environments. Students who successfully complete this course are well prepared to take the FAA, ATC Exam, and will also be prepared for training at the Academy in Oklahoma City, Oklahoma.

APPENDIX C

AS396- AIR TRAFFIC CONTROL PRACTICUM

COURSE DESCRIPTION

AS - 396 Air Traffic Control Practicum

This course consists of instruction/training conducted for a period of six months at a FAA enroute or terminal facility. It includes facility training in a non-radar environment to prepare the student for Assistant Controller Certification while being operationally productive. This course is intended for those students who have made decisions to pursue ATC as a career. When they are finished with the degree program, they are ready to begin careers with the FAA as ATC specialists.

APPENDIX D

DESCRIPTION OF CONVERGERS

DESCRIPTION OF CONVERGERS

The converger combines the learning steps of abstract conceptualization and active experimentation. People with this learning style are best at finding practical uses for ideas and theories. If this is your preferred learning style, you have the ability to solve problems and make decisions based on finding solutions to questions and problems. You would rather deal with technical tasks and problems than with social and interpersonal issues. These learning skills are important to be effective in specialist and technology careers. (Kolb, 1976).

APPENDIX E

DESCRIPTION OF DIVERGERS

DESCRIPTION OF DIVERGERS

Divergers combine the learning steps of concrete experience and reflective observation. People with this learning style are best at viewing concrete situations from many different points of view. Their approach to situations is to observe rather than to take action. If this is your style, you may enjoy situations that call for generating a wide range of ideas, as in a brainstorming session. You probably have broad cultural interests and like to gather information. This imaginative ability and sensibility to feelings is needed for effectiveness in the arts, entertainment, and service careers (Kolb, 1976).

APPENDIX F

DESCRIPTION OF ASSIMILATORS

DESCRIPTION OF ASSIMILATORS

Assimilators combine the learning steps of abstract conceptualization and reflective observation. People with this learning style are best at understanding a wide range of information and putting it into concise, logical form. If this is your learning style, you probably are less focused on people and more interested in abstract ideas and concepts. Generally, people with this learning style find it more important that a theory have logical soundness than practical value. This learning style is important for effectiveness in information and science careers Kolb, 1976).

APPENDIX G

DESCRIPTION OF ACCOMMODATORS

DESCRIPTION OF ACCOMMODATORS

Accommodators combine the learning steps of concrete experience and active experimentation. People with this learning style have the ability to learn primarily from "hands on" experience. If this is your learning style, you probably enjoy carrying out plans and involving yourself in new and challenging experiences. Your tendency may be to act on "gut" feelings rather than on logical analysis. In solving problems, you may rely more heavily on people for information than on your own technical analysis. This learning style is important for effectiveness in action-oriented careers such as marketing and sales (Kolb, 1976).

APPENDIX H

DESCRIPTION OF THE FOUR STAGES OF THE LEARNING CYCLE

Concrete Experience

This stage of the learning cycle emphasizes personal involvement with people in everyday situations. In this stage, you would tend to rely more on your feelings than on a systematic approach to problems and situations. In a learning situation, you would rely more on your ability to be open-minded and adaptable to change.

Reflective Observation

In this stage of the learning cycle, people understand ideas and situations from different points of view. In a learning situation you would rely on patience, objectivity, and careful judgement but would not necessarily take any action. You rely on your own thoughts and feelings to form opinions.

Abstract Conceptualization

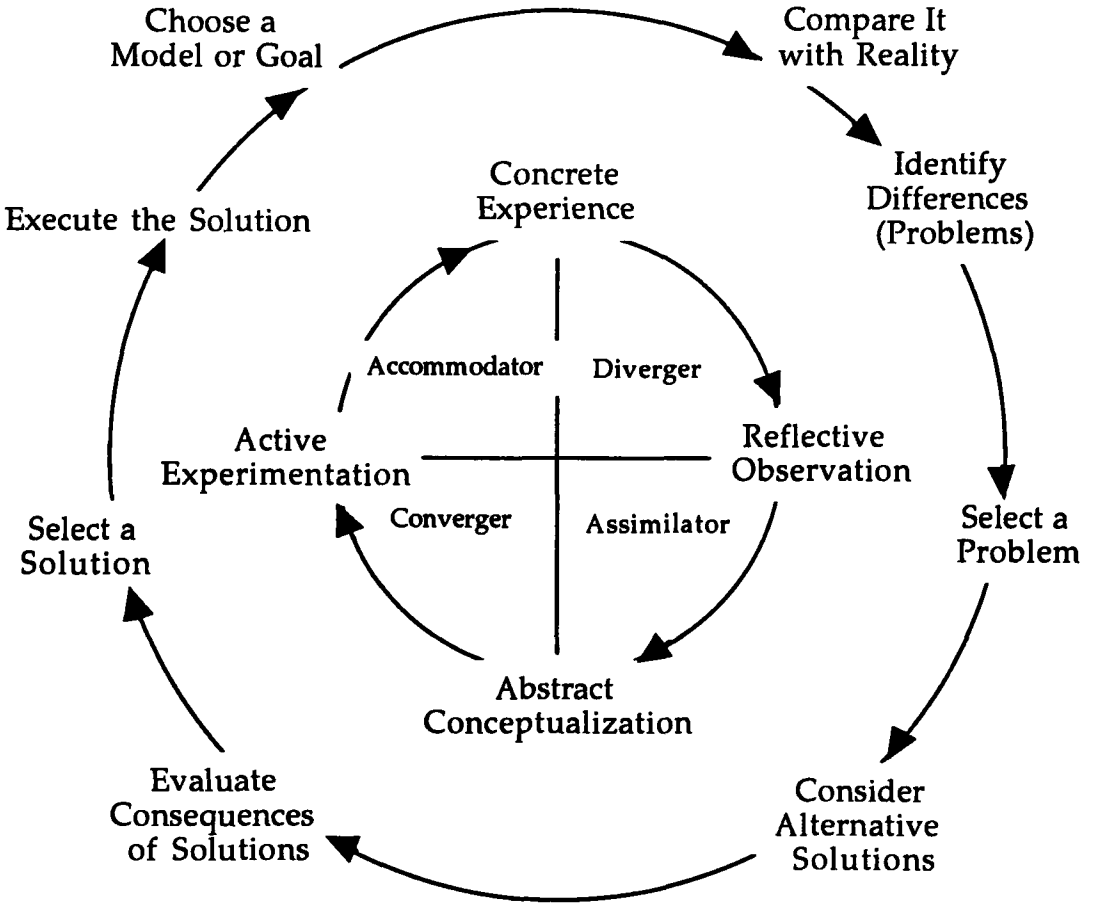
In this stage, learning involves using logic and ideas, rather than feelings, to understand problems and situations. Typically, you would rely on systematic planning and develop theories and ideas to solve problems.

Active Experimentation

Learning in this stage takes an active form, experimenting with influencing or changing situations. You would have a practical approach and a concern with what really works, as opposed to watching a situation. You value getting things done and seeing the results of your influence and ingenuity (Kolb, 1976).

APPENDIX I

COMPARISON OF THE LEARNING CYCLE WITH PROBLEM-SOLVING SKILLS



From The Learning Style Inventory by D. A. Kolb, 1976, Boston, MA: McBer and Company. Copyright 1976 by McBer and Company. Reprinted by Permission.

APPENDIX J

SAMPLE OF KOLB'S LEARNING STYLE INVENTORY

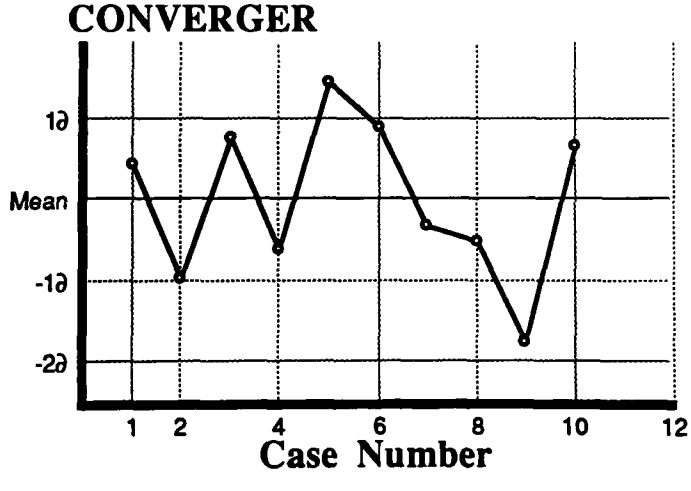
1 When I learn	____ I like to deal with my feelings	____ I like to watch and listen	____ I like to think about ideas	____ I like to be doing things
2 I learn best when	____ I trust my hunches and feelings	____ I listen and watch carefully	____ I rely on logical thinking	____ I work hard to get things done
3 When I am learning	____ I have strong feelings and reactions	____ I am quiet and reserved	____ I tend to reason things out	____ I am responsible about things
4 I learn by	____ feeling	____ watching	____ thinking	____ doing
5 When I learn	____ I am open to new experiences	____ I look at all sides of issues	____ I like to analyze things, break them down into their parts	____ I like to try things out
6 When I am learning	____ I am an intuitive person	____ I am an observing person	____ I am a logical person	____ I am an active person

APPENDIX K

BASIC STATISTICS

Basic Statistics for Converger

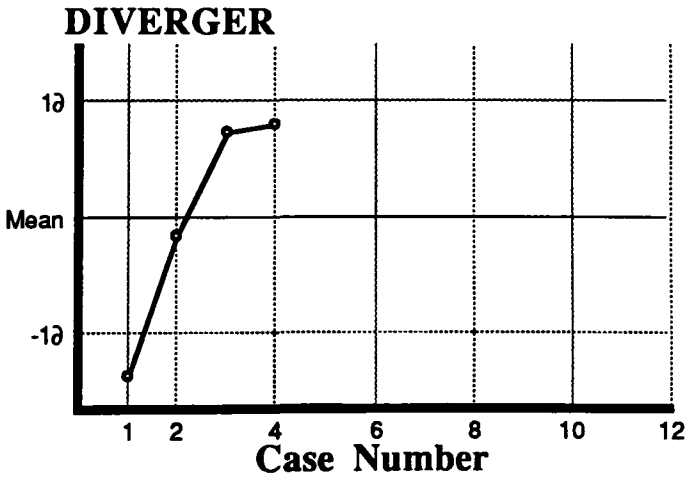
Active cases:	10
Mean:	63.8600
Sum:	638.6000
Sum of squares:	42412.6400
Variance:	181.2938
Std deviation:	13.4645
Std error:	4.2579
Skewness:	-0.2677
Kurtosis (norm=3):	2.0697
Median:	64.5000
Minimum:	40.0000
Maximum:	83.5000
Range:	43.5000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Diverger

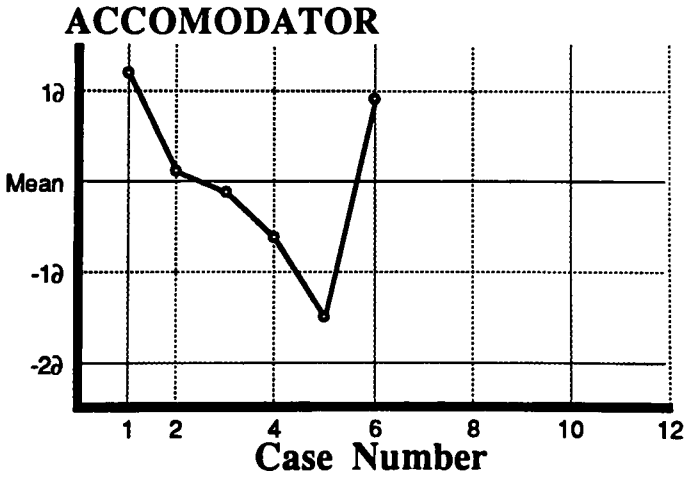
Active cases:	4
Mean:	70.9500
Sum:	283.8000
Sum of squares:	20631.8800
Variance:	165.4233
Std deviation:	12.8617
Std error:	6.4309
Skewness:	-0.6086
Kurtosis (norm=3):	1.7702
Median:	74.5000
Minimum:	53.6000
Maximum:	81.2000
Range:	27.6000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Accommodator

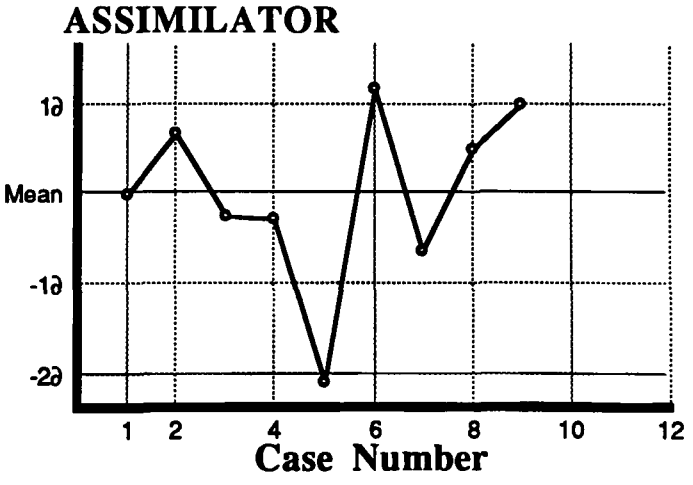
Active cases:	6
Mean:	72.3500
Sum:	434.1000
Sum of squares:	31530.4700
Variance:	24.6670
Std deviation:	4.9666
Std error:	2.0276
Skewness:	-0.2309
Kurtosis (norm=3):	1.9515
Median:	72.3500
Minimum:	64.9000
Maximum:	78.4000
Range:	13.5000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Assimilator

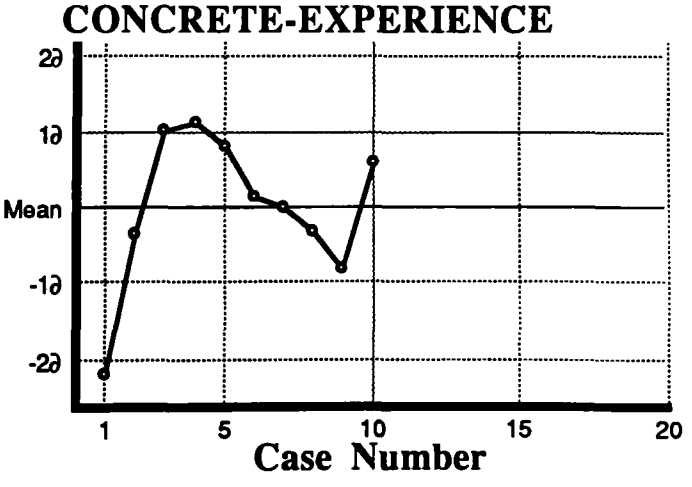
Active cases:	9
Mean:	67.5556
Sum:	608.0000
Sum of squares:	41515.9800
Variance:	55.2753
Std deviation:	7.4347
Std error:	2.4782
Skewness:	-0.8833
Kurtosis (norm=3):	3.2255
Median:	67.5000
Minimum:	51.9000
Maximum:	76.3000
Range:	24.4000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Concrete-Experience

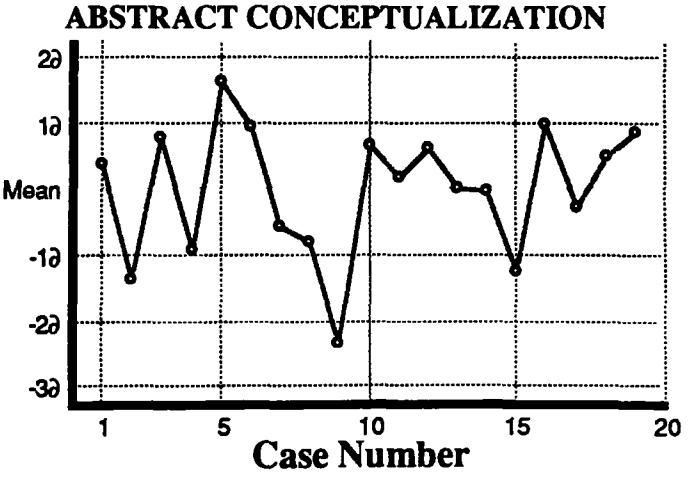
Active cases:	10
Mean:	71.7900
Sum:	717.9000
Sum of squares:	52162.3500
Variance:	69.3677
Std deviation:	8.3287
Std error:	2.6338
Skewness:	-0.9200
Kurtosis (norm=3):	3.2659
Median:	72.3500
Minimum:	53.6000
Maximum:	81.2000
Range:	27.6000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Abstract-Conceptualization

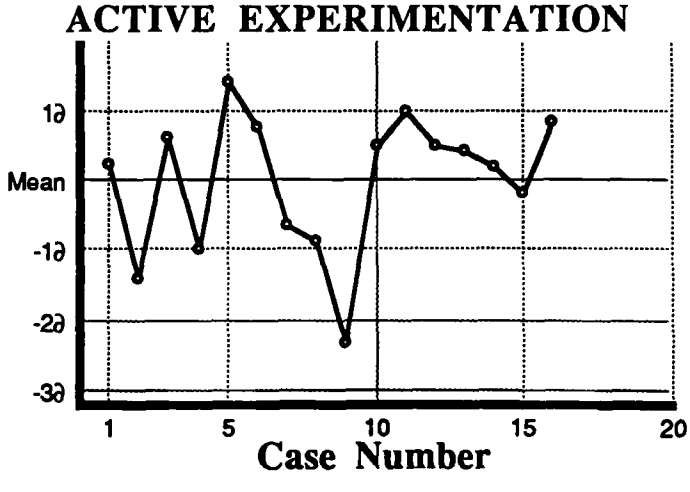
Active cases:	19
Mean:	65.6105
Sum:	1246.6000
Sum of squares:	83928.6200
Variance:	118.8077
Std deviation:	10.8999
Std error:	2.5006
Skewness:	-0.6299
Kurtosis (norm=3):	2.8214
Median:	67.5000
Minimum:	40.0000
Maximum:	83.5000
Range:	43.5000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Active-Experimentation

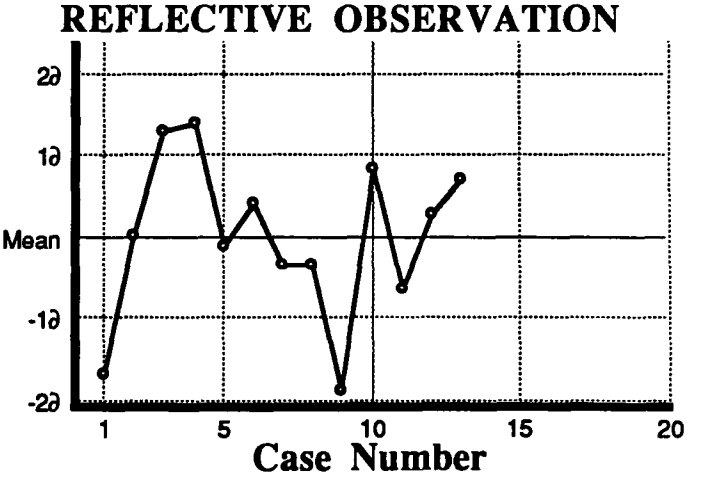
Active cases:	16
Mean:	67.0438
Sum:	1072.7000
Sum of squares:	73943.1100
Variance:	135.0186
Std deviation:	11.6198
Std error:	2.9049
Skewness:	-0.8231
Kurtosis (norm=3):	2.9260
Median:	70.6500
Minimum:	40.0000
Maximum:	83.5000
Range:	43.5000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.

Basic Statistics for Reflective Observation

Active cases:	13
Mean:	68.5923
Sum:	891.7000
Sum of squares:	62137.1500
Variance:	81.1158
Std deviation:	9.0064
Std error:	2.4979
Skewness:	-0.4740
Kurtosis (norm=3):	2.4642
Median:	68.8000
Minimum:	51.9000
Maximum:	81.2000
Range:	29.3000



Sequence Chart Depicting Mean and Standard Deviations Above and Below.