EFFECT OF AN INHIBITION TESTING MODEL ON PRIVATE PILOT, AIRPLANE SINGLE ENGINE LAND, GROUND SCHOOL STUDENTS

By

TODD P. HUBBARD

Bachelor of Arts
Oklahoma State University
Stillwater, Oklahoma
1974

Master of Aeronautical Sciences
Embry-Riddle Aeronautical University
Daytona Beach, Florida
1987

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Thesis Approved:

H. C. McClure
Thesis Adviser

Nelson J. Ehrlich

James D. White

Steven K. Murphy

Wayne B. Powell
Dean of the Graduate College

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NOMENCLATURE

ADD	Attention Deficit Disorder
ADHD	Attention-Deficit/Hyperactivity Disorder
AT-SAT	Air Traffic-Standardized Aptitude Test
BFITS	Basic Flight Instruction Tutoring System
DSM	Diagnostic and Statistical Manual
ERP	Event-Related Brain Potentials
FAA	Federal Aviation Administration
ISD	Instructional Systems Design
LOFT	Line Oriented Flight Training
MRI	Magnetic Resonance Imagery
MSL	Mean Sea Level
OSU	Oklahoma State University
OU	University of Oklahoma
PC	Personal Computer
PCATD	PC-based Aviation Training Devices
RSC	Rose State College

CHAPTER I

INTRODUCTION

To become a successful airplane pilot, an individual must learn how to focus on selected stimuli while inhibiting others, to process the selected information, and store that information for immediate or later use (Telfer & Biggs, 1988). Attention-Deficit/ Hyperactivity Disorder (ADHD) illustrates what might occur if one could not inhibit properly.

Diehl and Lester (Civil Aeromedical Institute, 1987), in Private Pilot Judgment Training In Flight School Settings, used a curriculum that discussed—among other subjects—three mental processes that should be in operation within a pilot's brain. They listed these processes as automatic reaction, problem resolving, and repeated review.

Edwards (1997), in Fit to Fly, suggested that pilots were not prepared to fly unless there existed an awareness of reality. He used what he called cognitive exercises to make pilots aware of their propensity to deny reality and to replace that denial with a better appreciation of the reality around them. The subject of denial may appear to be far afield from what will become a more robust discussion of general aviation pilot training, but denial is the root concept attached to the term called compartmentalization.

Compartmentalization is a learned response to the flood of daily stimuli. It is described, to some degree, by Telfer and Biggs (1988) as necessary to pilot an airplane, but entails a more profound level of inhibition. This phenomenon is also at work to allow pilots to discretely solve problems while surrounded by a flurry of activity. This particular concept of inhibition does not indicate that all reality is selectively ignored; it merely prioritizes stimuli and events as either pertinent or inappropriate to the task at hand. If a domestic squabble occurs in the morning before a planned flight, the domestic event is temporarily dismissed to allow a more intense concentration on flight duties.

Compartmentalization is not peculiar to aviators, but is also observed in surgical suites, science laboratories, and any event requiring an individual to hyperfocus. Surgeons might banter with the staff during routine procedures, but when complications occur they will compartmentalize their thoughts and actions according to the task at hand. During times of intense investigation through the lens of a microscope or staring at radiographic images on wet film, a scientist or medical technician will completely divorce thoughts extraneous to the task at hand. Students emerging from finals might experience a momentary spatial disorientation. Cognitively, they were infused with the testing task. As they processed other stimuli, such as buildings and landscape, they became gradually aware of things other than the questions on the test.

Telfer and Biggs (1988) described the opposite of inhibition as attending. If pilots must stop thinking or ignore seeing certain stimuli, then they must at the same time pay attention to other stimuli. This is the idea behind attending. The length of time spent in attending is determined by a number of variables present in the flying environment. Usually those variables which require immediate attention in time and space are given higher attending priority. If an airplane is flying in a straight and level flight path at 10,000 feet Mean Sea Level (MSL) and the area over which the airplane will fly is flat terrain, then vigilance of flight altitude is not as high a priority as perhaps is airspeed. However, if the airplane is flying at 3,000 feet MSL through the Colorado Rockies, then altitude is far more important and must be attended to throughout the entire flight.

A successful takeoff, flight, and landing is the combination of skill and experience. Whether flying high above the terrain or amongst the hills and mountains, a pilot does not unconsciously maneuver the airplane. Distractions to the task at hand are inhibited through experience. Flight instructors of new students often tell their students that they were behind the airplane during the entire flight. This statement indicates to the student that thinking about flying and flying must occur simultaneously in space-time. An airplane with enough power applied to the throttle will become airborne even if the student is unprepared for the event.

When are student pilots capable of controlling the array of distractions and attending to those tasks necessary for flight? If all goes well, this occurs by the time the student is to solo the airplane. A better question to ask is, when did the student begin to practice inhibition?

A number of studies have been conducted (Berlin, Gruber, Holmes, Jensen, Lau, Mills, & O'Kane, 1982; Buch & de Bagheera, 1985; Diehl & Lester, 1987) that have shown a positive effect in subsequent flight operations when judgment training was introduced in the ground school curriculum. Santiago (1996) advocated the use of Line Oriented Flight Training (LOFT) similar to that used by the airlines during flight training. His cockpit resource management approach to the subject indicated that a change in how general aviation pilots are trained might improve the overall quality of pilots.

It would appear by the literature cited that pilots must be able to inhibit stimuli not needing attention. We also know that at some time during the course of training a pilot learns how to use this behavior. We also know that introducing special training during ground school can have positive results during flight training.

Santiago (1996) suggests using flight simulators during flight training and spending more time explaining flight objectives during preflight briefings. Flight simulators are indeed a wonderful aid, but their use is financially out of the question for most certified ground or flight schools. Even part-task trainers are often deemed unfeasible due to maintenance costs and insufficient space. Large aviation schools such as the University of South Dakota and Embry-Riddle Aeronautical University can afford training aids that enhance the overall effect of training. Relatively low cost alternatives, such as computer-based training, have been introduced to some ground and flight schools (Glaeser, Gum, & Walters, 1993) by organizations who specialize in aviation education.

Problem Statement

There appears to be a relational dichotomy between the classroom environment and the aircraft environment in aviation training. Cognitive processes practiced in the classroom do not transfer well to the aircraft. Perhaps the underlying reason for this lack of cognitive transference is the change that occurs when a student moves between the classroom and the aircraft during training.

Before pilot candidates can receive their pilot certificate they must successfully complete the Airman Knowledge Test. They must be able to recognize correct answers from among several distractors and compute answers to questions given sufficient information. To date, the practice for this test is based on rehearsal of the FAA test bank.

Knowledge-based curriculum is required for ground and flight duties (Federal Aviation Administration, 1997a; 1997b; 1997c; Jeppesen-Sanderson, 1996a; 1996b). The testing method used during many of the general aviation private pilot ground schools does not introduce the concept of distractibility nor does the method adequately practice inhibition. This has been thought to be the domain of the flight instructor, but given the ability of computer-based software, this is no longer true.

Purpose Statement

The purpose of this study was to determine if, and to what extent, a relationship or difference existed between the cognitive contexts of private pilot ground school and private pilot flight lessons.

Research Hypotheses

H-1. The context of cognition differs in relationship and degree between the private pilot classroom and private pilot flight lessons.

H-2. There is a strong relationship between subjects in the same context of learning.

H-3. There is a weak relationship between subjects in different learning contexts.

Assumptions

For the purpose of this study, the investigator accepted the following assumptions:

1. Not all subjects are equally distracted by stimuli.
2. Some subjects, by temperament, have better innate ability to inhibit.
3. Some subjects, by previous training, will inhibit faster than others.
4. Some subjects may have learning disabilities or other disorders not known to the subject or reported before the test.

Limitations

The investigator accepts the following limitations:

1. Only certified ground schools, Part 141 or 61, in Oklahoma were chosen for this study.
2. Only students enrolled in ground school in 1999 were used in this study.

Definitions

The following definitions of terms are furnished to provide, as nearly as possible, clear and concise meanings of terms as used in this study:

ADHD – Attention Deficit/Hyperactivity Disorder (ADHD) is a neurological syndrome whose classic defining triad of symptoms include impulsivity, distractibility, and hyperactivity or excess energy (Hallowell & Ratey, 1994).

Connectionist Theory – A theoretical notion that the brain processes information in a parallel distribution.

Computer-Based Training – An instructional method which uses the computer as the medium for presentation.

Computer-Managed Instruction – An administrative device which regulates the sequence of learning, stores user responses, and compiles reports on individual participants.

Disinhibition – An inability to selectively disallow attention to a specific stimulus.

Instructional Systems Design – A systematic approach to create instructional units.

Executive Control – The central control function of the brain which theoretically directs the flow of information along the neural nets.

Kinesthetic Learning Style – A style of learning where the participant interacts with the medium of instruction.

Long-Term Memory – Storage area for permanent information.

Neurotransmitter – A protein based chemical on which segments of information pass between neurons.

Parallel Processing – Simultaneous processing of information along two or more paths.

Prefrontal Cortex – The portion of the cortex found right behind the forehead (Castellanos, 1996).

Serial Processing – The notion that information passes from neuron to neuron in sequence, with a definite beginning point and an ending point.

Short-Term Memory – Transitory storage for acquisitional information.

Synapse – The place where two neurons in a neural pathway communicate (Castellanos, 1996).

Visual Learning Style – A learning style where the participant either reads text silently from a textbook or observes the text from some other medium.

Scope of the Study

The study focused on the development and use of the Inhibition Testing Model within the certified ground school environment in Oklahoma.

Organization of the Study

Having thus laid a ground work for the study in Chapter I, Chapter II will review literature pertaining to inhibition, pilot characteristics, testing strategies in the field of aviation, characteristics of FAA testing, requirements for ground school instructors, and various curricula available for pilot candidates. Chapter III will describe the design of the study (see also Appendixes A, B, and C), sampling techniques, how the data was collected, and the statistics used to measure the results. In addition chapter three will discuss the procedures taken to develop the Inhibition Testing Model (see also Appendix D), how the lesson was developed, and how the lesson was programmed into the computer. Chapter IV is an analysis of the collected data (see also Appendixes E, F, and G) and a list of the findings. Chapter V summarizes the study, draws some conclusions, and offers recommendations for further study.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

There are not enough computer-based tools in general aviation private pilot ground school with which to practice aviation inhibition. Personal computers (PC) as simulation tools have been debated between the FAA and industry for some time (Williams, 1994). What the FAA desired for industry to do since 1994 was to develop more computer tools at the low end of training, where most general aviation student pilots would derive the most benefit. This chapter presents a number of theoretical constructs of cognition, which eventually resulted in the development of a low end Flight Deck Cognitive Emulator through the medium of the personal computer. Additionally, the review was designed to educate and prepare the reader for the development of the method by which this study was conducted.

The review was far ranging. In order to create a cognitive emulator, one needed to be familiar with instructional design for computer-based instruction. As the computer door of knowledge was opened through the literature, instructional techniques and design strategy information were revealed.

Inhibition, as a central subject to this study, took on a life of its own. Inhibition was investigated using the following four questions.

1. How was inhibition selected as a subject of interest?
2. What were the issues surrounding the subject of inhibition?
3. What did the literature say about the training needs of student pilots in private pilot ground school, in terms of inhibition?
4. What did the literature say about computer-based testing strategies as a method to convey technical information? This introduction provides a quick overview of these questions.

Question One

Two events stimulated an interest in inhibition: first, a conference at the University of Oklahoma (Phelan, 1998); and second, a review of work by Telfer and Biggs (1988). During a two-day conference Phelan presented the characteristics of Attention Deficit/ Hyperactivity Disorder. Chief on the list, describing the disorder, was a neurological inability to inhibit stimuli. Weeks later while the author was investigating aviation psychology sources, a chapter from Telfer and Biggs crystalized a thought. If ADHD individuals are being successfully educated while having a known inability of inhibition, then perhaps some of those methods could be used to better train general aviation student pilots.

Information regarding inhibition was not a new subject within the world of aviation. However, the idea that aviation inhibition involved targeting specific types of stimuli during the course of flying provoked an interest in how that process could be accomplished. What followed was an investigation into the subject of inhibition. The subject of inhibition is fully developed later in this chapter.

Question Two

Inhibition was a subject with deep research roots in cognitive psychology, a domain connected to this study, but not the center of interest. As already indicated, the subject of ADHD provided an example of inhibited disruption, or what Phelan (1998) and Barkley (1990) called disinhibition, which had very strong ties to numerous psychological and neurological studies (Barkley & Grodzinsky, 1994; Shelton & Barkley, 1994; Aylward, Reiss , Reader , Singer , Brown , & Denckla , 1996; Swanson, Castellanos , Murias, LaHoste, & Kennedy, 1998). As fortune would have it, educational specialists (Chesapeake Institute & Widmeyer Group, 1994) had already been commissioned by the Department of Education to determine how to deal with ADHD individuals suffering from disinhibition. These strategies were reviewed and analyzed for further development within this review.

Healthy groups with varying ability to inhibit stimuli could also have been studied, but these individuals would not have presented as sharp a contrast between inhibition and disinhibition as ADHD individuals. It is paramount to this chapter of the study that the reader comprehend the importance of the inhibiting process and its critical relationship to human factors in aviation. More will be said about inhibition in ADHD individuals and pilots in sections one and two later in this chapter.

Question Three

The third question, regarding the training needs of student pilots in ground school, stimulated thought on a number of related issues within the domain of training. Any review involving training had to establish a frame of reference for training within the subject area studied. Learning styles, the aviation learning environment, learning theory, and instructional systems design were some of those subject areas related to training. Gagné, Briggs, and Wager (1988) presented an excellent example of how training could be sewn together to produce a given outcome. Their work knitted together knowledge-based concepts with their psychomotor results. Much of section three was developed to further investigate theoretical approaches to learning.

Current aviation training methods and media were reviewed by investigating techniques and strategies used by Jeppesen Sanderson Training Systems, pilot instructor Bill Kershner, and the Invitation to Fly program (Glaesar, Gum, & Walters, 1993). Additionally, the FAA approach to training was reviewed to determine whether federal regulations and standards affected how ground training was conducted or whether the regulation influenced curriculum design in general aviation training schools. Section four was created to report on current aviation training.

Beyond the design and development of training, student pilot educational or cognitive needs were also reviewed. Telfer and Biggs (1988) offered a unique insight into the cognitive needs of the student pilot. Several other points of view were captured from training programs referred to in the previous paragraph. These other points of view illustrated how training companies try to sell a cognitive training philosophy along with their commercial hardware, software, and paper-based materials (Glaesar, Gum, & Walters, 1993; Jeppesen-Sanderson., 1997b).

Question Four

The last major area of interest, computer-based testing models, was an area of interest added to this study after the author reviewed an intelligent tutoring model illustrated by Mandl and Lesgold (1988). While contemplating the mechanics of computer-based testing, the author determined that more had to be known about paper-based testing models, especially the multiple-choice test used so much by the FAA. Thorndike and Hagen (1977) provided a solid basis for understanding the requirements of a testing model, particularly the multiple-choice model. Yet the multiple-choice model neglected to assess other cognitive dimensions—a point made by Frederiksen and White (1990) in Intelligent Tutors as Intelligent Tester, and Frederiksen , Glaser, Lesgold, and Shafto (1990) in Diagnostic Monitoring of Skill and Knowledge Acquisition.

Frederiksen, Glaser, Lesgold, and Shafto (1990) provided encouragement to look for alternatives beyond the traditional multiple-choice testing model. Lesgold, Lajoie, Logan, and Eggan (1990), and Frederiksen and White (1990) approached learning from a problem-solving paradigm. A computer model, according to their studies, had to provide the viewer with enough knowledge-based information with which to make a decision, but still allow the viewer to navigate by intuition or skill until reaching a point where outside help was needed. It was up to the programmer or creator of the problem-solving routine to help the student find the correct path once again, if a false direction had been taken. This approach appeared to offer another dimension to testing that could not be provided by a paper-based multiple-choice test. It also provided a possible modal device and design by which inhibition could be tested in a highly distracting environment.

The visual design of the Inhibition Testing Model was strongly influenced by a depiction of the multiple dimensional scaling analysis in a chapter by Johnson and Reeder (1997) called "Consciousness as Meta-Processing." The horizontal and vertical dimensional depictions, resembling the semantic organization of mental concepts, provided a snapshot of a possible testing concept. The graph was logically laid out with an X and Y axis to represent the differences between control and complexity or attention and complexity. If this depiction were used as the distractor environment, then the correct response could be embedded within the distractor array. The viewer would have to scan the field, inhibit all of the incorrect responses, and select the only correct one. Work by Mayer and Moreno (1998), regarding evidence for split-attention in multimedia learning, suggested ways to orchestrate auditory and visual effects to keep working memory operating at a constant—not over-stimulated—rate. More will be said about the design of this model in Chapter III.

A review of the literature has been divided into five sections. The first four sections more extensively delve into specific perspectives of inhibition. Section Five uses the four perspectives as a cognitive backdrop for the development of a cognitive emulator—the Inhibition Testing Model. The four questions reviewed in the introduction to this chapter were a preview of the major knowledge-based themes of this study.

The five sections have been arranged to help the reader see aspects of inhibition from several perspectives. Section One investigates the subject of ADHD from three points of view. Section Two describes the characteristics of the successful pilot—the target outcome of ground and flight school. Section Three takes the reader into the cognitive domain of inhibition. Information gained from this domain was used to create features within the computer-based lesson similar to those used in other research. Section Four displays for the reader what is educationally required to conduct ground school. The Fifth section is dedicated to cognitive design strategies pertaining to computer-based education. The look and feel of the computer-based instruction and the Flight Deck Cognitive Emulator, described in Chapter III, were derived from this review.

Section One

Inhibition and the ADHD Individual

A scientific exploration of inhibition would require the use of subjects who demonstrate either successful inhibition or unsuccessful inhibition based on prescribed parameters. Many studies have done just that. However, in this applied educational study the researcher is looking for a practical application of the method whereby one inhibits selected stimuli.

There is a group of people in the world who have a disorder which denies the victim adequate use of cognitive inhibition. That disorder is called Attention-Deficit/ Hyperactivity Disorder or ADHD. Special interest groups within the United States, such as Children and Adults with Attention Deficit Disorder (CH.A.D.D.), have communicated extensively about the disorder—by volume, certainly more than other countries. A discussion of ADHD and inhibition follows.

The following review was designed to provide the reader with information about disinhibitional problems occurring with ADHD individuals from three different perspectives. The first perspective is what psychologists say about ADHD and inhibition;

second, neurobiological reasons behind disinhibition in ADHD individuals; and finally, educational strategies used to counteract the effects of disinhibition.

The Psychology of ADHD

The definition for Attention-Deficit/Hyperactivity Disorder is not a settled issue. Russell Barkley (1990) presents two definitions, one a consensus of symptoms and the other a conceptual summary. His 1990 conceptual definition follows:

> ADD [acronym before Diagnostic and Statistical Manual of Mental Disorders (DSM) IV] consists of developmental deficiencies in the regulation and maintenance of behavior by rules and consequences. These deficiencies give rise to problems with inhibiting, initiating, or sustaining responses to tasks or stimuli, and adhering to rules or instructions, particularly in situations where consequences for such behavior are delayed, weak, or nonexistent. The deficiencies are evident in early childhood and are probably chronic in nature. Although they may improve with neurological maturation, the deficits persist in comparison to same-age normal children, whose performance in these areas also improves with development. (p. 71)

In 1994 Barkley conducted a seminar in Cleveland sponsored by the Institute for Adult Development and the Institute for Child & Adolescent Wellness in Beachwood, Ohio. Diaz, an attendee, compiled notes on what Barkley shared at that meeting. Diaz reported that Barkley de-emphasized the attention-deficit attributes of ADHD while emphasizing the lack of impulse control as a primary descriptor of the disorder. ADHD learners immediately respond with their first thought. They have difficulty waiting. A difficulty in waiting cascades into a poor short-term memory, a lack of objectivity, an underdeveloped ability to reflect, and a poor ability to create new ways of doing things based on stored memory. He was adamant that classroom instructors should not tell the ADHD learners to try harder. Rather, the instructors should change the design of their courses to increase interest and motivation. Barkley went on to say that those with ADHD might be "deficient in self-regulation, impaired in organizing their behavior toward the future, and diminished in social effectiveness and adaptation" (Barkley, 1994, p.4).

Diaz presented an overview of the seminar in a short abstract immediately before his notes, but also included his own opinions of Barkley's presentation. He disagreed with Barkley's single cause explanation—underlying ADHD—in light of distinct neurological subtypes of the disorder. This was an important and timely comment given that DSM IV was published in the same year. DSM IV revised the diagnostic protocols of DSM III, giving equal attention to a combined type of ADHD that included any two subtypes of ADHD. Diaz also provided a counterpoint opinion causing thoughtful readers to pause and evaluate both ideas.

Hartmann (Hartmann, Bowman, & Burgess, 1996), primary systems operator for the ADD Forum on *CompuServe* and author of several books about ADD, described ADD this way:

> At its core, ADD is generally acknowledged to have three components: distractibility, impulsivity, and risk-taking/restlessness . . . Distractibility is often mischaracterized as the inability of a child or adult to pay attention to a specific thing. Yet people with ADD can pay attention, even for long periods of time . . . but only to something that excites or interests them. It's a cliché—but true—that "there is no ADD in front of a good video game." . . . A better way to describe the distractibility of ADD is to call it scanning . . . While this constant scanning of the environment is a liability in a classroom setting, it may have been a survival skill for our prehistoric ancestors. (p. 23)

It should be clear by now that ADHD may appear as an attention deficit, impulsivity, hyperactivity, a combination of any two of the first three types, distractibility, lack of motivation, or a lack of a sense of time. This study has culled distractibility and lack of motivation from the list and focused on the problems of disinhibition. What follows is a review of the neurological point of view and a more clinical description of ADHD.

Neuroscientist's Point of View

There are a number of neuroscientists working in the field of ADHD. Denckla, working in the Department of Psychiatry and Behavioral Sciences at Johns Hopkins University, has participated in a number of studies on ADHD subjects. A list of recent studies and findings is presented in Table I below.

TABLE I

DENCKLA'S FINDINGS

Study	Date	Finding
Basal ganglia volumes in children with attention-deficit hyperactivity disorder.	1996	Small globus volume on the left side is associated with ADHD. (Aulward et al., 1996)
The child with developmental disabilities grown up: adult residual of childhood disorders.	1993	The central neuropsychologic issues in adult learning-disability studies are executive dysfunction and social imperception/ ineptitude. (Denckla, 1993)
Attention deficit hyperactivity disorder–residual type.	1991	Proposed assessment of the neuropsychological domain of executive function which may offer cognitive correlates of ADHD-residual type. (Denckla, 1991)

Note: The term *executive control function* appeared in Denckla's 1991 and 1993 studies.

Denckla associated the abilities to prioritize, organize, and strategize with the executive function of the brain. De Jong and Simons (1990) referred to executive control as the steering and control of cognitions and actions. The work for which De Jong and Simons were noted dealt with self-regulated learning—especially that related to cognitive and metacognitive processes. According to their studies, preparation, orientation, planning, choice of learning goals, self-motivation, the finding of relevant prior knowledge and skills, and attentional, volitional and emotional strategies comprised self-regulation.

Executive control in ADHD individuals, as indicated in the 1991 and 1993 studies, was known to be impaired. Denckla's (Aylward, Reiss, Reader, Singer, Brown, and Denckla, 1996) observations of the operation of the executive control function were congruent with De Jong and Simons in the area of attentional, volitional, and emotional strategies. According to Denckla, subjects having an executive dysfunction exhibited impairment to initiating, sustaining, and shifting behavior.

Kiss, Pisio, Francois, and Schopflocher (1998) in Central Executive Function in Working Memory measured DIFFERENCE event-related brain potentials (ERP) to determine whether the central executive function was involved in processing control and in updating the memory. Their results revealed that the central executive function processed information not related to memory storage while also, at the same time, updating the memory.

The prefrontal cortex is part of a pathway thought to be the foundation of the executive functions. Positive and negative feedback travel along this pathway to other regions of the brain. Castellanos, et al. (1996), a team of researchers from the National Institute of Mental Health, observed differences between the prefrontal cortex of ADHD boys and those of non-ADHD boys. This 1996 Magnetic Resonance Imagery (MRI) study provided evidence for the disorder, apart from psychological studies, and isolated an area of the brain for further research. The MRI study showed that the prefrontal cortex in ADHD subjects was underdeveloped when compared with the control subjects. It would appear that an underdeveloped prefrontal cortex would inhibit proper functioning of the executive function of the brain.

Zametkin et al. (1990) began an investigation into the cerebral metabolism of glucose. As recorded in the New England Journal of Medicine in 1990, these researchers discovered that glucose metabolism was reduced in adults who had been hyperactive since childhood. The area showing this decreased metabolism was the prefrontal cortex. Many other treatments have been completed using the same cerebral metabolism of glucose (Matochik et al., 1993; Ernst, Zametkin, Phillips, & Cohen, 1998).

What do these studies have in common? By the late 1980s Denckla participated in studies that pointed to an executive dysfunction in ADHD adult subjects. The studies within which Denckla contributed (1991, 1993; Aylward, et al., 1996) indicated that a dysfunction would impair initiating, sustaining, and shifting behavior. During the same time Zametkin et al. (1990) measured cerebral metabolism and found that there was a reduced metabolism in the prefrontal cortex of adults having been hyperactive from childhood. Castellanos et al. (1996) measured differences in the prefrontal cortex of ADHD boys when compared to healthy boys. Castellanos associated the prefrontal cortex to a pathway that provided positive and negative feedback to other regions of the brain and represented the foundation of the executive function.

Based on the views of neuroscientists, there is a dysfunction in the executive control function that can be related to an impairment of the prefrontal cortex in ADHD individuals. Psychologists have reported the behavior related to this region of the brain to be impaired in ADHD individuals. Have educators observed similar behavior?

Educator's Point of View

When the 101st Congress was debating amendments to the Education of Handicapped Act of 1990 it became clear that much of the information available about ADHD was confusing or incomplete. To remedy the situation, the Office of Special Education Programs, U.S. Department of Education, funded research to study effective educational practices that would directly support the education of ADHD children. The Chesapeake Institute was chosen to compile the results of the data collected in the numerous studies. What resulted was a how-to guide called 101 Ways to Help Children with ADD Learn: Tips from Successful Teachers (Chesapeake Institute & Widmeyer Group, 1994; Levin, 1996). According to Levin the Department of Education Information Kit is available from the ERIC Clearinghouse on Disabilities and Gifted Education.

This study is not focused on ADHD children or adults, but on pilot candidates. Yet the reader should be made aware of listed practices of effective teachers and what accommodations for disinhibition were advised by the Chesapeake document. As Barkley (1994) pointed out, 70-80% of children diagnosed with ADHD will exhibit chronic symptoms of the disorder as adults. What was effective for a child's educational experience may still be effective for adult education.

According to Levin (1996), a member of the Chesapeake Institute, effective teachers:

> . . . help prepare their students to learn when they introduce, conduct, and conclude each academic lesson . . . individualize their instructional practices based on the needs of the students in different academic subjects . . . use behavior management techniques to help these children learn how to control their behavior . . . use behavioral prompts with their students with ADD [ADHD], as well as with other students in the class . . . use different environmental prompts to make accommodations within the physical environment of the classroom . . . make accommodations in the learning environment by guiding children with ADD [ADHD] with follow-up directions . . . use special instructional tools to modify the classroom learning environment and accommodate the special needs of their students with ADD [ADHD]. (pp. 137-148)

The Chesapeake document, as reprinted by Levin (1996), also listed 15 strategies to use in classrooms when teaching ADD [ADHD] children. The strategies listed were:

> (1) Review Previous Lessons; (2) Set Learning Expectations; (3) Set Behavioral Expectations; (4) State Needed Materials; (5) Explain Additional Resources; (6) Use Audio-visual Materials; (7) Check Student Performance; (8) Ask Probing Questions; (9) Perform On-going Student Evaluation; (10) Help Students Self-Correct Their Own Mistakes; (11) Focus Dawdling Students; (12) Lower Noise Level; (13) Provide Advance Warnings; (14) Check Assignments; and (15) Preview the Next Lesson. (pp. 137-139)

The practices of an effective teacher appear to be as useful for adult education as for educating children. Likewise, the strategies employed for teaching ADD [ADHD] children were very similar to strategies listed by Gagné and Briggs (1988) in <u>Principles of Instructional Design</u>, and Silberman and Auerbach (1990) in <u>Active Training</u>—two works targeting adults as well as children.

Most of the list of accommodations for the classroom, in the Chesapeake tips document, were aimed at younger children. However, there were two accommodations, which could as easily apply to adults as children. First, effective teachers follow up oral directions by asking the ADHD individuals whether or not they understood the directions. Second, effective teachers follow up written instructions with an additional written explanation. Both of these accommodations targeted a need for clarification.

Adult learners with ADHD also have problems with directions. They need directions to be repeated and they need to see and hear them. The cause for missing directions may be associated with distractibility. In Suggested Diagnostic Criteria for Attention Deficit Disorder in Adults (Hallowell & Ratey, 1994), the eighth criterion was, "easy distractibility, trouble focusing attention, tendency to tune out or drift away in the middle of a page or a conversation, often coupled with an ability to hyperfocus at times" (p. 201).

Hallowell and Ratey (1994) also furnished a list for teachers of children of all ages called Fifty Tips on the Classroom Management of ADD. What follows are excerpts from the list.

> . . . make sure what you are dealing with really is ADD . . . build your support . . . know your limits . . . ask the child what will help . . . remember the emotional part of learning . . . remember that ADD [ADHD] kids need structure . . . they need reminders . . . post rules . . . repeat directions . . . set limits, boundaries . . . have as predictable a schedule as possible . . . eliminate, or reduce the frequency of timed tests . . . allow for escape-valve outlets such as leaving class for a moment . . . monitor progress often . . . break down large tasks into small tasks . . . watch out for overstimulation . . . seek out and underscore success as much as possible . . . memory is often a problem with these kids . . . use outlines . . . simplify instructions . . . make expectations explicit . . . when possible, arrange for students to have a study buddy . . . repeat, repeat, repeat. (pp. 254-261)

There are similarities between the Chesapeake tips document and the tips offered by Hallowell and Ratey. Notice that both lists mentioned repeating directions, monitoring progress or checking assignments, setting limits or stating expectations. Besides distractibility, there may be a need for structure, and a need for a coach to watch the boundaries for the ADHD learner.

Summary of Section One

To adequately cover the different perspectives on ADHD three points of view were expressed: the psychologist's, the neuroscientist's, and the educator's. Barkley represented the psychologist's point of view. He helped to define ADHD for purposes of this study. One could easily conclude that there are many opinions about ADHD, but few subjects on which many agree. Most agreed on what Barkley (1990) calls the "holy trinity" of attention, impulsivity, and hyperactivity.

Neuroscientific studies by Zametkin et al. (1990, 1998), Denckla (1991, 1993; Aylward et al., 1996), and Castellanos et al. (1996) showed biological evidence of differences between ADHD subjects and healthy subjects. Each study singled out the prefrontal cortex as the main area of difference. As Denckla (Aylward et al.,1996) pointed out, the prefrontal cortex appears to be the center for initiating, sustaining, and inhibiting functions.

The U.S. Department of Education (Chesapeake Institute & Widmeyer Group, 1994; Levin, 1996) presented a federal point of view of how educators might better serve their ADHD customers. Hallowell and Ratey (1994) also provided a list of tips for educators. Both sources focused on strategies that would lessen the impact of distractibility. It is interesting that Barkley (1994) also highlighted distractibility as the number one symptom of ADHD.

The next section will look at the cognitive composition of a successful pilot.

Section Two

Cognitive Composition of a Successful Pilot

The intent of this section is to adequately describe the cognitive composition of a successful pilot. Several points of view will be represented in the following pages. Only flight instructor and aviation educator comments will be used to define the cognitive composition of a successful pilot.

A cognitive, rather than skill, approach was chosen to describe a pilot because judgment and decision making come from the cognitive, not psychomotor domain (Bloom & Krathwohl, 1984). Pilot cognition was also chosen because knowledge gained in the classroom is used, in concert with specific skills, to perform flight.

Three areas of interest were captured in this review. Several instructor pilots and writers (Kershner, 1993; Glaeser, Gum & Walters, 1993) contributed definitions of standard characteristics necessary to become a pilot. These definitions were showcased in the opening chapters of pilot instruction course materials. Second, a review of the psychology of a pilot was captured from a number of sources. Telfer and Biggs (1988) presented an excellent review of the psychology of a pilot, learning and memory, motivation, and evaluating training. Finally, a review of the official description of medical, mental, and neurologic standards (Federal Aviation Administration, 1998) presented a third perspective by indicating what cognitive characteristics were not acceptable.

Observable Characteristics

Kershner (1993) opened his first chapter with what he calls the big three.

> As you go through any flight program, particularly in a military flight program, you will hear three terms used many times: headwork, air discipline, and attitude toward flying. (p. 1)

In an accompanying figure he inserted the following line, "Headwork is remembering to put the landing gear down" (p. 2).

Pilots need to be analytical. For this study, substitute the concept of analysis for Kershner's "headwork." Bloom and Krathwohl (1984) included analysis as an element of the cognitive domain taxonomy.

> Analysis emphasizes the breakdown of the material into its constituent parts and detection of the relationships of the parts and of the way they are organized. (p. 144)

Proper analysis of any situation prepares the pilot to make good decisions. Watching weather patterns and knowing how much fuel will be consumed for a planned cross-country flight are two constituent parts that, if analyzed together, might keep an aircraft from landing in some farmer's field. In private pilot ground school, instructors build relationships between constituent parts that were unrelated before training occurred. The student pilot is taught how to analyze a situation.

In the realm of cockpit resource management, analysis is part of the decision making process. Turner (1995) described the elements of the DECIDE model as a systematic example of making decisions. Each step could be applied to any decision event, but Turner adapted the list for aviation purposes. Pilots must be able to:

> Detect that a decision needs to be made. Evaluate the options available. Choose an option that best meets [their] goals. Implement that choice. Detect any changes that come about as a result of that implementation. Evaluate those outcomes to determine whether [their] decision was a good one or if you need to begin the process anew. (pp. 21-22)

Jeppesen-Sanderson (1996b) used the DECIDE model in their Private Pilot Manual, but also included a five-subject area events list for making decisions.

> 1. Pilot – As a pilot, you are continually making decisions about your own competency, state of health, level of fatigue, and many other variables.
>
> 2. Aircraft – Your decisions are frequently based on evaluations of the aircraft, such as its power, equipment, or airworthiness.
>
> 3. Environment – This encompasses may of the items not included in the two previous categories. It can include such things as weather, air traffic control, and runway length or surface.
>
> 4. Operation – The interaction of you, your aircraft, and the environment is influenced by the purpose of each flight operation. You must evaluate the three previous areas to decide on the desirability of undertaking or continuing the flight as planned. Is the trip worth the risks?
>
> 5. Situation – Situational awareness is the accurate perception of the conditions affecting you and your aircraft during a specific period of time. More simply, it is knowing what is going on around you. (pp. 9-10)

From a cognitive point of view, a pilot's cognition dwells chiefly in the higher cognitive elements of analysis, synthesis, and evaluation (Bloom & Krathwohl, 1988; Jeppesen-Sanderson, 1996b). The *pilot* event listed in the Jeppesen (1996a) description of decision-making assumes that the pilot is self-aware. A pilot must be able to assess his or her own state of health and level of fatigue. The *aircraft* event assumes a pilot's ability to evaluate the relationship between complex systems. Event three, *environment*, requires the pilot to analyze the relationship between the constituent parts of weather, air traffic control, and runway length or surface conditions. Event four assumes the pilot can relate the gestalts of pilot, aircraft, and environment to determine whether a flight can be performed. Lastly, the *situational* element, assumes the pilot can accurately judge the effect of all stimuli acting on the environment.

Glaeser, Gum, and Walters (1993) attributed similar cognitive capabilities to pilots. They said the best pilots are knowledgeable and prepared.

> They know the appropriate regulations and the valid reasoning behind them. They know the performance characteristics and limitations of their aircraft and observe them carefully. They also know their own limits of ability as pilots and do not try to overstep those limits . . . They review and practice their flying skills regularly. They plan each flight and fly their plan. (pp. 18-19)

Glaesar, Gum, and Walters also called pilots self-confident and team players. When defining safe flying they said that pilots use ". . . careful, deliberate action and self-discipline" (p. 19).

Based on the review, standard cognitive characteristics of a successful pilot included most elements of Bloom's (1984) cognitive taxonomy. The elements most heavily in play are analysis, synthesis, and evaluation. The review indicated that a pilot is continuously planning, preparing, and performing tasks from preflight planning to postflight debriefing.

The next review of the cognitive composition of a pilot approaches the subject from a psychological point of view.

<u>Psychological Process in Operation in a Pilot's Brain</u>

Telfer and Biggs (1988) described three stages of learning how to fly. In their review of learning and memory they defined mental processing requirements necessary for safe flight. The first requirement was called attending. During flight, a pilot needs to ignore some stimuli while selectively paying attention to, attending to, other stimuli. Secondly, pilots also need to process information they receive. Discrete chunks of information must be encoded for later storage. Third, a pilot must store processed information in short or long-term memory. It is hoped the information was properly encoded and properly stored. However, according to Telfer and Biggs, a pilot's response to verbal inquiry may not be adequate proof that the pilot is concentrating on the task at hand. The following situation illustrates the problems of attention and concentration.

> John is gazing out of the window, apparently miles away. The instructor knows that he is not attending. With quick questions he knows John will be caught.
> Instructor: So there are three basic aspects in the safe recognition of and recovery from stalls: angle of attack, stall recognition clues, and recovery techniques. What are those three basics, John?
> John: Angle of attack, stall recognition clues, and recovery techniques . . .
> John undoubtedly recognized the importance of a knowledge of stall characteristics and recovery methods, but he still lapsed into a lack of concentration on the topic. (pp. 17-18)

Pilots compartmentalize. It is not surprising that pilots can dismiss emotional issues in their daily lives during the course of one flight. If one were to follow a pilot through his or her weekly routine, what would become obvious is the sameness of behavior from day to day. Every behavior has its place and is repeated nearly identically each time. A pilot will rise in the morning at about the same time, perform hygiene duties in the same order, eat the same breakfast selection, talk or not talk to the family, take the same route to work, and continue ad nauseam through the day.

However, the elements that make pilots dull and routine in their land life are strengths in their flying life. A pilot performs procedural steps from a flight checklist with the same clock-like precision, but this routine ensures that each step is indeed performed and not left out. Radio transmissions are made using standard phraseology, the landing gear is raised and lowered at predetermined locations along an approach or departure, a call to the weather station is always made so many minutes before letdown, and the scanning technique used to clear for other aircraft always starts from the same quadrant.

A review of the standard cognitive characteristics indicated a pilot was always busy analyzing, synthesizing, and evaluating. Next, a review of the psychology of a pilot indicated that attention, processing, and storage of information was dependent on concentration on the right information. Over time this concentration takes the form of compartmentalization.

Summary of Section Two

The successful pilot can be described as disciplined, analytical, behaviorally routine, and incredibly aware of everything in his or her surrounding environment (Kershner, 1993; Turner, 1995; Jeppesen-Sanderson, 1996b). A pilot must routinely make accurate decisions. Characteristics normally associated with pilots are the result of training, not the result of specific pilot biology or neurology.

The ADHD individual, because of neurobiological pathology, has impairment in initiating, sustaining, and stopping behavior (Aylward, 1996; Castellanos, 1996). They also exhibit distractibility behavior (Barkley, 1994).

A successful pilot is self-confident, self-disciplined, analytical (Turner, 1995), situationally aware (Jeppesen-Sanderson, 1996b), and predictively routine.

By comparing the individuals of section one with section two, the reader can see similarities between behaviors of the two groups. Whereas the ADHD individual has to learn how to compensate for a neurological inability to inhibit specific stimuli, the pilot—already possessing the ability to inhibit—must also learn how to inhibit specific stimuli. ADHD individuals and their teachers are acutely aware of the need to inhibit. Pilots are also aware of this need. The hypersensitivity of the two groups to inhibition provided fertile ground for further examination.

Section Three

Exploring Synthesis

During a review of Telfer and Biggs (1988), a synthesis area of interest emerged. Pilots, by training, learn how to inhibit unnecessary stimuli that compete for attention. ADHD individuals are impaired in their ability to inhibit stimuli (Barkley, 1990, 1994; Shelton & Barkley, 1994; Hallowell & Ratey, 1994). Therefore, it was necessary to review enough literature to grasp the concept of inhibition. A review of inhibition cascaded into a review of memory, which continued into verbal learning and semantics. What follows are thoughts from only those areas that offered ideas for synthesis—closing the cognitive gap between what was required of a pilot and what the ADHD individual needed to overcome.

Inhibition

The psychological definition for inhibition depended on one's theoretical position. The serial processing theorists explained inhibition differently from the parallel distribution processing theorists. For this study, inhibition was described as a restraint of attention to exogenous sensory stimuli or endogenous cognitive stimuli (Kausler, 1974; Rafal & Henik, 1994). More clearly, to inhibit is the ability to selectively ignore stimuli externally or internally perceived by a person.

Kausler (1974), a serial processing advocate, explained inhibition using the Lepley-Hull process. Lepley, in 1934, and Hull, in 1935, described inhibition as inhibition of delay. The subjects in their research, who were presented with more than one stimulus competing for attention, demonstrated a delay in response. It was theorized that an endogenous process of choice caused the delay. Since the process required some time in the cognitive sorting routine, these serial-processing theorists believed that each stimulus was attended to in order, or in a sequential series. The Lepley-Hull process helped Kausler explain events that occurred during his paired-associative research.

Kausler, McLaughlin and Kulik, in 1962, studied whether subjects could correctly associate word-pairs by using various treatments to measure interference, forgetting, transference, and memory. Their strong connection to the stimulus-response paradigm permeated their assumptions and testing instruments.

Inhibition and Verbal Learning

Another competing paradigm in the late 1960s was information processing. Kausler (1974) explained this paradigm during lectures at the University of Missouri in his course, Psychology of Verbal Learning and Memory–also the title of his book. He related that some researchers saw parallels between how a computer works and how the human brain might function. Vocabulary changed from a concentration on stimulus-response to processes of input-output, processing routines, or memory storage. Mandl and Lesgold (1988) were good examples of Kausler's description. In their research on the intelligent tutor model, they used the computer to tutor the human–an ironical situation where the creator was now receiving help from the created device.

Other serial processing advocates, Rafal and Henik (1994), explained inhibition as though it were a separate and distinct function external to, but cooperating with, the central executive function. They viewed attention as two interrelated operations. The first, posterior, was the spatial determinant. The second, anterior, judged the inputs to derive meaning and determine action. Inhibition, as a process, played on these two interrelated actors.

The Rafal and Henik studies looked at the affect of (1) exogenous and endogenous cueing, (2) the effects of simultaneous, bilateral cueing, (3) the function of inhibition of return, (4) the Stroop Effect in inhibitory word processing, and (5) semantic priming. Exogenous tests measured how the brain processed external stimuli such as suddenly appearing light sources or text or object movement. Endogenous tests used stationary visual references that required the brain to determine the meaning from memory.

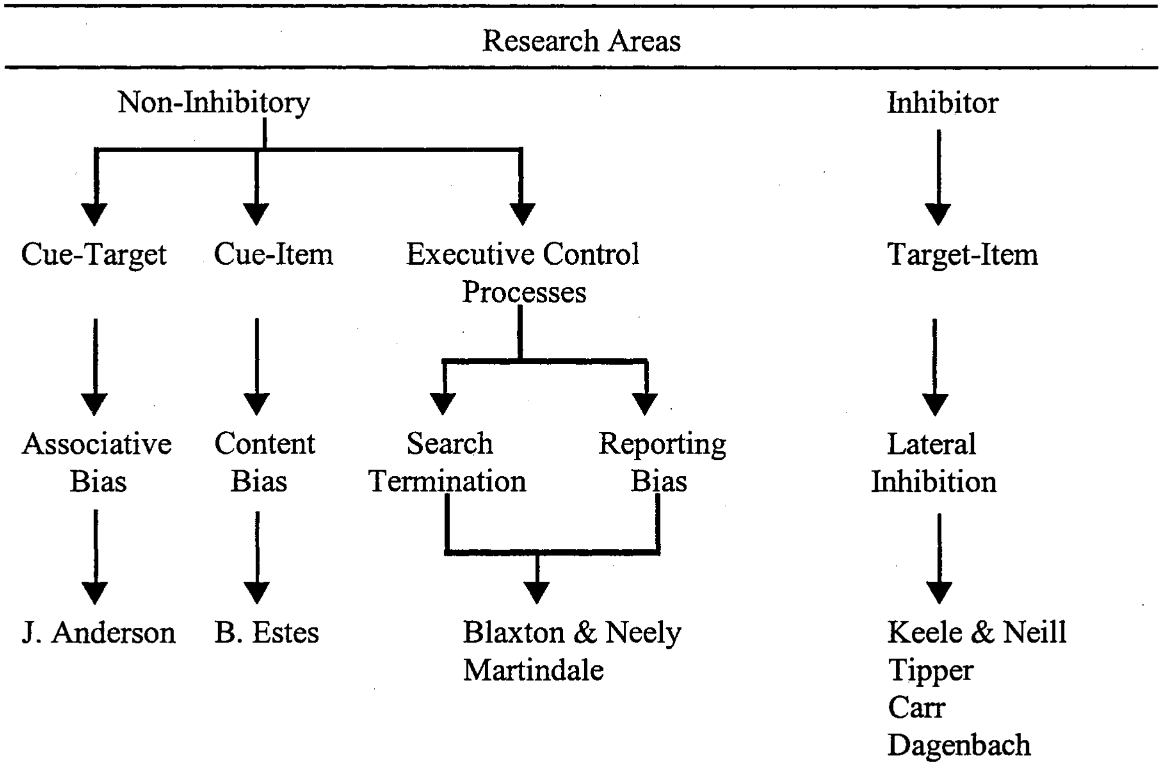
Bilateral cueing treatment results showed that subjects ignored two cues when shown simultaneously, one in each visual hemisphere. According to Rafal and Henik, inhibition of return was described as the ability to voluntarily discriminate stimuli at the endogenous level. Exogenous visual cues, in one hemisphere, could be endogenously inhibited while selecting to attend to another exogenous cue. Rafal and Henik measured the active inhibition of extraneous information with the Stroop Effect test. It required, for example, the subjects to verbally identify the word *blue* when the word was displayed in the color red. The cognitive interference, caused by the red color of the printed word identified as *blue*, resulted in an increased completion time. Semantic priming tests indicated that if subjects could rehearse the association of a prime word and its associated word, they could decrease recognition time–even when distractor primes were displayed. The process of ignoring words not associated with the primes was explained as inhibition.

Inhibition and Memory

Anderson and Bjork (Anderson & Bjork, 1994; Anderson, Bjork, & Bjork, 1994) surveyed the studies conducted within the domain of retrieval inhibition and memory. They separated the research into two camps: those who believed impairment to be non-inhibitory and those who believed impairment to be inhibitory. Their work helped to associate groups of researchers with their area of research. Further, it explained the scientific methods and hypotheses used to conduct the different studies. Following each explanation there was a critique of method, results, and conclusions. The following table represents the field of research on inhibition.

TABLE II

MODELS OF RETRIEVAL INHIBITION



Note: Derived from Anderson and Bjork (1994, p. 271).

Associative and cue biases were particularly interesting for their apparent adaptability to ADHD learning strategies. Associative bias studies, as described by Anderson and Bjork (1994), weakly associated linguistic dyads; whereas cue bias studies formed a strong association between the cue word and the target word. The results of both of these studies indicated that there were associative links between a cue and an anticipated target, but according to Anderson and Bjork they failed to provide sufficient empirical evidence that memory retrieval was based on cue and association.

In contrast to noninhibitory type studies, Anderson and Bjork hypothesized that the brain performed endogenous pre and post-synaptic inhibitory processes, not based on a strong priming word, but on targeted information stored in episodic memory. Dagenbach and Carr (1994), in Inhibitory Processes in Perceptual Recognition: Evidence for a Center-Surround Attentional Mechanism, expressed this view in their center-surround theory on memory retrieval.

According to Dagenbach and Carr (1994), retrieval of information occurs when all unrelated information stored in memory is less attractive than the targeted information. Non-targeted information is separated from the targeted information by an inhibitory mechanism. They cited a study by Jacoby and Brooks (1984) in which subjects were given priming words that activated more than one episodic node of memory. However, before giving the subjects the priming word, they had associated one particular priming word with one expected target. The targets were stored in semantic memory and the subjects were tested within a few weeks. Upon being tested with the priming word, the subjects were able to differentiate other episodic possibilities from the correct episodic node or target. Dagenbach and Carr called this differentiation, center-surround.

There were alternative explanations for how information is stored in and retrieved from memory.

Auditory word recognition, as indicated in studies by Eberhard (1994), was measured to occur before the entire word was spoken. At the phonemic level, it was theorized that a subject accesses a lexical reference stored in memory every time a word is spoken. Of the 30,000 or more word possibilities a speaker could use, the listener can, by means of the lexical reference, decide what words will be spoken in the next millisecond and in the next several minutes. As Eberhard explained, subjects retrieve information based on semantic cues. If the subject of a lecture were the life-cycle of the oak tree, then it is theorized that the listeners access all lexical references to trees, oak trees, and life-cycles from their semantic or long-term memory. Portions of this list are theorized to be retained in short-term, or acquisition memory. When the speaker begins the lecture, the listener expects to hear words contained within these lexical references.

Studies by Glanzer, Fischer, and Dorfman (1984) indicated that short-term memory also stored recent textual information and predicted the occurrence of related references. Subjects retained two sentences of information in their short-term memory. When follow-on information was presented, the subjects showed an ability to quickly integrate recent information with similar information. The results were measured in terms of time. The faster the response, the stronger the indication that short-term memory was accessed. What Eberhard did not explain was why the subjects responded faster. An explanation for the speed of response was found in two studies, one by van Dijk (1977) and one by Keenan, Baillet, and Brown (1984).

Causal cohesion studies by van Dijk demonstrated that a knowledge-based relationship rather than a coreferential relationship produced cohesion. In other words, a subject did not interpret new textual references based on similarities between the subject of the old textual reference. Instead, the subject interpreted the new text selection from stored knowledge. This phenomenon was partially explained in studies by Keenan, Baillet, and Brown (1984).

Keenan, Baillet, and Brown concluded that subjects made knowledge-based relationships even when there was referential cohesion between sentences. Findings also indicated that as knowledge-based relations were made between sentences, comprehension time decreased. Their conclusions supported the notion advanced by Estes (Murdock, 1992) that information was excited and inhibited in parallel. Queries for information, in that case, involved two processes working in a connected fashion. An excitatory process and an inhibitory process worked in simple relation with each to retrieve information from semantic memory. Those who agree with Estes are called connectionists–for obvious reasons.

Townsend (1992) provided a very different view of how the brain stores and retrieves information from memory. His explanation was neither serial nor parallel in nature. In his tutorial he reviewed the last 70 years of theories dealing with brain processes. At the end of his review he asked the reader to contemplate the origin of random, unexplained behavior. In his view, there were perhaps two explanations. First, random behavior could have been an outcome of connectionist theory. An interaction between excitation and inhibition could have produced a random behavior. However, this would infer that a person's random behavior was nothing more than the emergence of a forgotten memory. Townsend explained that for randomness to truly exist, it could not belong to any pre-established, cue-target association. The random behavior would have to be generated from a dynamic association between not-previously-associated nodes. For Townsend the logical explanation for this occurrence was found in what chaos theoreticians call dynamic systems theory.

An analysis of chaos theory was not included in this review. Townsend's tutorial, comprising a brief glance at dynamic system theory, was included to let the reader know that no matter how concrete one's research method might have been, there are no methods that can account for every variable.

Summary of Section Three

The Telfer and Biggs (1988) analysis of cognitive processes said that pilots had to learn how to inhibit specific stimuli while attending to others. Barkley (1990) and Hallowell and Ratey (1994) had already established inhibition as impaired in ADHD individuals. The cognitive domain of the pilot and the cognitive domain of the ADHD individual were joined by a common cognitive referent of inhibition.

Inhibition, as described in section three, was part of a triad of brain processing functions. Inhibition studies had common boundaries with verbal learning and memory (Kausler, 1974; Rafal & Henik, 1994). Verbal learning studies by various researchers accounted for inhibition during treatments designed to measure memory (Kausler, 1974; van Dijk, 1977; Keenan, Baillet, & Brown, 1984). Memory studies often used linguistic cues from verbal learning theory to determine how the brain stored or accessed information (Jacoby & Brooks, 1984; Anderson & Bjork, 1994; Dagenbach & Carr, 1994).

Section Four

An Investigation of Current Practices in Ground School Education

A review of current practices in ground school education was included in this study to give the reader an instructional design benchmark. This section reviewed statistical information on numbers of students between 1987 and 1996, training philosophies and instructional design of several training schools, requirements for ground school instruction, and the testing design and philosophy for the FAA Airman Knowledge Test.

Training Load

According to Stamas (1998a), compiler of statistics for the Statistical Handbook of Aviation and the U. S. Civil Airmen Statistics publications, in the inclusive years 1987-1996, 761,231 student pilot certificates were issued. An undisclosed number of ground and flight school instructors taught the ground school curriculum to those 761,231 students. The mean age of student pilots during the same 10-year span was 33 years old (Stamas, 1998b). Student pilots between the ages 14-24 numbered 24,142 in 1996. The largest representative group of ages of students was between 25 and 29 years old.

FAA records indicated that a number of institutions of higher learning had comprehensive aviation training programs other than ground school. A telephone poll of several of these institutions confirmed that ground school courses were routinely offered each semester. Sufficient numbers of individuals had been available to ensure a continuation of this program.

Training Philosophies and Instructional Designs

Jeppesen-Sanderson training materials were reviewed by the author while auditing a ground school course in 1997 given by a Rose State College certified ground school instructor. In the preface of the 1997 Private Pilot FAA Practical Test Study Guide, Airplane Single-Engine Land, the following training philosophy statement was found:

> Flight training in the developing years of aviation was characterized by the separation of academics from flight training in the aircraft. The introduction of Jeppesen Sanderson Training Products changed all this. (Jeppesen, 1997a, p. iii)

Apart from the advertisement for their training materials, it appeared that this company was determined to make a difference in aviation training.

> Our proven professional, integrated training materials include extensive research on teaching theory and principles of how people learn best and most efficiently. (Jeppesen, 1997a, p. iii)

This statement appeared to incorporate the necessary elements of a good training program: integrated materials, competency in teaching and learning theories, and an emphasis on the student (Gagné & Briggs, 1988; West, Farmer & Wolff, 1991). There was one major weakness in their assertions. They were not in control of delivering the actual classroom instruction.

The Jeppesen training philosophy continued to describe how the curriculum was designed.

> Effective instruction includes determining objectives and completion standards. We employ an important principle of learning a complex skill using a step-by-step sequence known as the building block principle. Another important aspect of training is the principle of meaningful repetition, whereby each necessary concept or skill is presented several times throughout the instructional program. Jeppesen training materials incorporate this principle using different teaching tools such as textbooks, videos, exercises, exams, and this Study Guide. (Jeppesen, 1997a, p. iii)

These explanations revealed an understanding of the tasks to be taught, the complex nature of the curriculum, and the importance of integrating skill with knowledge. Appendix 2 of the Study Guide (Jeppesen, 1997a) provided an example of task analysis–used by instructional systems designers to determine what should be taught in the classroom or in the flight training.

Appendix 2 was a reprint of the FAA's Private Pilot Practical Test Standards. The introduction to the appendix cited all of the reference documents, instructions on how to use the standards, a list of prerequisites, and an explanation of terms of reference. The rest of the appendix listed each major task on the practical test, the references in which knowledge-based information about the task could be found, the evaluation objective of the task, and a list of the cognitive and psychomotor objectives that described the performance of the task.

The FAA's practical test standards failed to adequately describe cognitive performance. On page 12 of Appendix 2 the task described was power-on stalls. It was the third task in a list of four tasks in the area of operation called slow flight and stalls. The main objective for power-on stalls stated,

> To determine that the applicant: 1. Exhibits knowledge of the elements related to power-on stalls. This shall include an understanding of the aerodynamics of a stall which occurs as a result of uncoordinated flight. Emphasis shall be placed upon recognition of and recovery from a power-on stall . . . (Jeppesen, 1997a, p. 12)

Bloom and Krathwohl (1984) highlighted several terms that could not be observed or measured by any performance criteria. In their view, good training objectives had to allow the student to perform a task, had to allow the instructor to measure the performance of the task, and had to allow the instructor and student to measure mastery of the task by some external criterion. Words such as knowledge or understanding were understandable as concepts, but were too general to use as performance elements in an objective. In the FAA example, a student preparing for the practical test would not be able to determine the evaluation criteria for successful or unsuccessful knowledge or understanding of stalls or aerodynamics.

Since the FAA standards were the only official standards, it was assumed–logically–that Jeppesen used the standards as a guide for their curriculum. This assumption was tested by a review of other Jeppesen training materials devised for the same course.

Rose State College furnished a complete set of Jeppesen training materials in their bookstore. The package of materials consisted of the Private Pilot FAA Practical Test Study Guide: Airplane (Jeppesen-Sanderson, 1997a), Single-Engine Land; Private Pilot FAA Airmen Knowledge Study Guide for Computer Testing (Jeppesen-Sanderson, 1997b); the Private Pilot Manual (Jeppesen-Sanderson, 1996b), the Federal Aviation Regulations Explained (Jeppesen-Sanderson, 1996c), a Private Pilot Exercise Book (Jeppesen-Sanderson, 1996a), a navigation chart, and a protractor.

The practical test guide was designed to prepare a student for the flight evaluation while the computer test study guide was designed to prepare the student for the knowledge test. Most of the ground school course was centered on readings from the pilot's manual. This text was logically arranged with ample illustrations, tables, and figures. Important text was highlighted in each chapter. At the end of each chapter certain terms were listed with their definitions.

What was missing from the package of resources was a Jeppesen instructor. A video instructor was available for an additional fee, but the ground school instructor observed in this study preferred to teach the course from her lesson plan. Videos were used only when they enhanced the presentation of material.

It was observed, during actual ground school sessions, that the FAA airmen knowledge test bank of questions was often used to summarize blocks of instruction or to prepare for unit tests. This observation did not indicate the standard for ground school instructional strategies, nor was it meant to. Instead, it indicated why this test guide was included in the Jeppesen training materials.

Another training package of materials was reviewed. Glaeser, Gum and Walter (1993) have also authored a training text for the private pilot. The preface clearly listed changes to FAA publications and offered acknowledgments. Next, in a section titled Ancillaries, the authors listed materials for the instructor and other materials for the student. A materials list is shown in the following table.

TABLE III

MEDIA SELECTION FOR GROUND SCHOOL

Instructor	Student
Instructor's Manual -Semb, Taylor and Glaesar -Sample syllabi and reading assignments	*Study Guide* -Semb and Taylor -Examination questions, exercises, summaries, discussion questions, etc.
Computerized Testing System -Semb and Trilogy Systems -Includes all FAA exam questions	*FAA Test Software* -Self-guided test practice for FAA exam
Update Newsletter -Late-breaking information and aviation education topics of interest	*Sectional Navigation Chart* -For practice
Videotape Guide -Correlates instructor manual with videos	*Flight Maneuvers Manual* -Practical flying instructions for flight evaluation
Interactive Software -Wilbur's Flight School: An Interactive Exploration of Flight (Soft)	*Simplifying the FAR/AIM* -Guilkey and Snyder -Simplified version of FAA complex texts

Note: This is an abbreviated version of the information in Glaesar, Gum, and Walter. (1993)

Gum, a Doctor of Education, and co-author of the text, presented the course design strategy in an inserted reprint of the preface for the first edition. The description followed a logical format of instruction. He described how training aids and other visual media would be used in the course, what materials were provided to help study for the FAA examination, and other materials designed to evaluate the student's understanding.

The assortment of training materials for this ground school course was adequate to convey all of the necessary information. The use of technology, like the interactive software, had the potential of enhancing the look and feel of the course. And the main text provided plenty of quality illustrations, figures, and tables to explain complex concepts.

The only element missing from this course was personal interaction with a resident teacher. Thirty half-hour videos were available for the instructor's use.

One other review was conducted on training materials. Bill Kershner, General Aviation Flight Instructor of the Year, 1992, offered an alternative to the formal ground school. In his single volume flight manual for student pilots (Kershner, 1993) he incorporated most of the written material normally contained within several volumes. His instructional approach might be described as "operational." Everything was tailored for one clear objective: to prepare for and pass the written test or the flight evaluation. The manual consisted of 5 parts and 28 chapters with ample illustrations, tables, and graphs.

Part five was exclusively dedicated to the written and practical FAA tests. He used an explanation technique for the practical test standards that made the student's expected performance crystal clear. Instead of printing the FAA standards in a task list format, Kershner talked himself through the whole event and recorded the events in text form.

> The examiner will want to know that you understand the principles of these stalls and what can contribute to aggravating them (slips and skids) and will look at your recovery effectiveness. Again, don't get below 1500 AGL at any time during the demonstration. Basically, these stalls are the takeoff and departure stalls covered in Chapter 12. (Kershner, 1993, p. 418)

The three sets of training materials reviewed showed, in the first example, a very formal and compliance oriented approach used by Jeppesen Sanderson. The second set of training materials, described by Glaeser, Gum, and Walters (1993), were also formalized, but allowed the student and the instructor to interact with innovative computer software. The third training program (Kershner, 1993) was designed for home study. Its tailored design included the necessary textual materials, but lacked any interaction between the instructor and the student. Kershner expected the student to be involved in flight instruction with a certified flight instructor.

Requirements for the Ground School Instructor

Parts 61 and 141 of the Code of Federal Regulations (Federal Aviaition Administration, 1998b; 1998c; 1998d; 1998e; 1998f) described the requirements for FAA training schools, the courses to be taught, and the course requirements levied on ground school instructors during class sessions. AC 61-112, Flight and Ground Instructor Knowledge Test Guide–a product of the FAA Flight Standards Service–was developed to prepare applicants with knowledge requirements in anticipation of the flight and ground school certification test. A more thorough review of those documents follows (FAA, 1997d).

CFR Part 141, Section 141.55 (FAA, 1998d) described the contents of a training course. Before training was authorized, the FAA required a full description of the course curriculum, the environment in which training will be conducted, the media used during instruction, a description of each training device, the minimum qualifications of the instructors, and the training syllabus. The training syllabus had to include a list of enrollment prerequisites for the ground school course; a detailed description of each lesson's objectives, standards, and duration; a list of student learning outcomes; expected accomplishments for each stage of training; and a description of the tests used to measure expected accomplishments.

Special curricula were acceptable (FAA, 1998e) as long as the course contained features that would assure an equivalent level of proficiency.

Basic ground school curriculum requirements were found in Part 61, Sections 61.97 and 61.105 (FAA, 1998b; 1998c). The course curriculum included requirements for the recreational pilot and the private pilot. These two sections were copied to display the similarity between the two lists and to prepare the reader for a more rigorous treatment in the procedures and methods chapter.

> (A) General. A person who applies for a recreational pilot certificate must receive and log ground training from an authorized instructor or complete a home-study course on the aeronautical knowledge areas of paragraph (b) of this section that apply to the aircraft category and class rating sought.
> (B) Aeronautical knowledge area. (1) Applicable Federal Aviation Regulations of this chapter that related to recreational pilot privileges, limitations, and flight operations; (2) Accident reporting requirements of the National Transportation Safety Board; (3) Use of the applicable portions of the Aeronautical Information Manual and FAA advisory circulars; (4) Use of aeronautical charts for VFR navigation using pilotage with the aid of a magnetic compass; (5) Recognition of critical weather situations from the ground and in flight, windshear avoidance, and the procurement and use of aeronautical weather reports and forecasts; (6) Safe and efficient operation of aircraft, including collision avoidance, and recognition and avoidance of wake turbulence; (7) Effects of density altitude on takeoff and climb performance; (8) Weight and balance computations; (9) Principles of aerodynamics, powerplants, and aircraft

systems; (10) Stall awareness, spin entry, spins, and spin recovery techniques, if applying for an airplane single-engine rating; (11) Aeronautical decision making and judgment; and (12) Preflight action that includes–(i) How to obtain information on runway lengths at airports of intended use, data on takeoff and landing distances, weather reports and forecasts, and fuel requirements; and (ii) How to plan for alternatives if the planned flight cannot be completed or delays are encountered. (FAA, 1998b)

This next section, 61.105, described course requirements for the private pilot.

General. A person who applies for a private pilot certificate must receive and log ground training from an authorized instructor or complete a home-study course on the aeronautical knowledge areas of paragraph (b) of this section that apply to the aircraft category and class rating sought. Aeronautical knowledge area. (1) Applicable Federal Aviation Regulations of this chapter that relate to private pilot privileges, limitations, and flight operations; (2) Accident reporting requirements of the National Transportation Safety Board; (3) Use of the applicable portions of the Aeronautical Information Manual and FAA advisory circulars; (4) Use of aeronautical charts for VFR navigation using pilotage, dead reckoning, and navigation systems; (5) Radio communication procedures; (6) Recognition of critical weather situations from the ground and in flight, windshear avoidance, and the procurement and use of aeronautical weather reports and forecasts; (7) Safe and efficient operation of aircraft, including collision avoidance, and recognition and avoidance of wake turbulence; (8) Effects of density altitude on takeoff and climb performance; (9) Weight and balance computations; (10) Principles of aerodynamics, powerplants, and aircraft systems; (11) Stall awareness, spin entry, spins, and spin recovery techniques, if applying for an airplane single-engine rating; (12) Aeronautical decision making and judgment; and (13) Preflight action that includes–(i) How to obtain information on runway lengths at airports of intended use, data on takeoff and landing distances, weather reports and forecasts, and fuel requirements; and (ii) How to plan for alternatives if the planned flight cannot be completed or delays are encountered. (FAA, 1998c)

Section 61.105 was noted to be slightly different in the knowledge area of aeronautical charts for VFR navigation and radio communication procedures.

To achieve certification as a ground school instructor, an applicant had to be able to instruct aeronautical knowledge items listed in Sections 61.97 and 61.105. If an applicant received his or her certification from an FAA approved training course, the applicant received training in the learning process, elements of effective teaching, student evaluation and testing, course development, lesson planning and classroom training techniques (FAA, 1998f).

Certified ground school instructors who taught for an FAA approved training school had to maintain an 80% pass rate for all students taking the FAA Airman Knowledge Test. The training school also had to ensure that at least 10 students had been enrolled in the last 24 months (FAA, 1998d).

FAA testing was conducted separately from those tests administered by a FAA approved ground school. The procedures for administering the computer-assisted Airman Knowledge Test were available in FAA Order 8080.6B (1997d). The complete listing of all possible questions on the computer-assisted Airman Knowledge Test was available on the www.fedworld.gov/pub/ faa-att/pvt_plt FAA website. An answer key was not available. However, an answer key with explanations was available in Private Pilot FAA Airmen Knowledge Study Guide for Computer Testing (Jeppesen-Sanderson, 1997b).

Summary of Section Four

Student pilots by the thousands received their student pilot certificates in the last year (Stamas, 1998b). Thirty-three percent of these applicants were 29 years of age or younger. Seven FAA approved training schools in Oklahoma conducted ground schools on a regular basis.

A student applicant for ground training could either enroll in an approved ground school course or be self-taught. Three training programs were evaluated. Two of the programs, the Jeppesen-Sanderson Training System and the Invitation to Fly (Glaeser, Gum & Walters, 1993) program represented formal curricula that satisfied all of the requirements levied by CFR Parts 61 and 141. One training program reviewed (Kershner, 1993) was applicable to the self-taught student.

Section Four ended with a review of ground school requirements for the classroom environment, the instructor, and the conduct of the FAA Airman Knowledge Test.

Most of what has already been reviewed can be identified with either the subject of inhibition or with regulatory mandates within federalized aviation training. A review of these subjects provided a knowledge base on which other information could be added later. This next section explores more fully the realm of computer-based instructional design and practice.

Three propositions formed the structure of Section Five. First, computer-based instruction is a legitimate medium for training; two, computer-based instruction is a legitimate medium for some, but not all, aviation training; and three, cognitive inhibition–used by pilots in the cockpit–can be practiced by using increased distractibility during ground school testing.

Section Five

Legitimate Medium for Training

The person/machine link was not immediately addressed during an investigation of the realm of the personal computer and how it had been used in education. The reason for the detour was instigated by comments made by Frederiksen and White (1990) regarding the insufficiency of paper-and-pencil tests. Their observations of the increased use of criterion referenced testing highlighted, for them, the inadequacies of the standard multiple-choice test, while also suggesting an alternative to be found in an already popular training method called individualized learning.

Criterion referenced testing was a logical outcome of criterion referenced curriculum. The use of an external criterion for learning has been the underlying principle of Instructional Systems Development (ISD) for several decades within the federal government and is still in use today (Department of the Air Force, 1993; Department of Defense, 1997; FAA, 1998g). The federal government criterion referenced curriculum allowed trainers to equip a large number of students with uniform competencies in technical skills. Paper-and-pencil testing was the most expedient testing method for mass administration, and the testing results were statistically friendly for assessment. However, the most commonly used testing instrument, the multiple-choice test, lacked the ability to assess the connection between knowledge-based and psychomotor-based competencies. The shortfall in this curriculum was most often visible in areas not accessible during training, namely, judgment. A remedy for this shortfall was found in the personal computer.

Individualized learning during the late 1980s and early 1990s was most often associated with the medium of the personal computer (Mandl & Lesgold, 1988; de Jong & Simons, 1990; Barker, 1994). The personal computer was affordable, was being used in the classrooms of many schools, and was supported by an expanding base of educational software. However, the advent of the more accessible computer was not fully accepted by all parties involved. Computers appeared to be a technological encroachment. "The challenge, then, is to be alert to ways in which computer technology might be restructuring our experience of familiar exchanges" (Crook, 1987, p. 35). As indicated by this quote from Crook the subject of interest was not how to get rid of technology, but how to survive it.

Therefore, it was not surprising that cognitive, behavioral, and developmental psychologists were eager to use this medium to further their research (Crook, 1987; de Jong & Simons, 1990; Lesgold, Lajoie, Logan, & Eggan, 1990; Venezky & Osin, 1991). Aviation psychologists have focused on human behavior from a slightly different perspective. Their interests as scientists appeared similar to their counterparts working with primary and secondary school students, but the subjects of their observations were far more complex due to the nature of flight. Their observations have helped that community to examine how and why they function in ways unique to the flight medium.

Already Part of the Instructional Design Process

According to the Instructional Systems Development (ISD) process, determination of the medium of learning was a decision made separately from designing and developing course content (Department of the Air Force, 1993; Department of Defense, 1997; FAA, 1998g). The United States Air Force used a matrix to determine the usefulness of computers as a learning medium. Cost of development, timeliness of product delivery, and the intended learning outcome of the session were some of the elements analyzed.

In practice, it was observed that the U.S. Air Force and other federal agencies did not always adhere to their process when choosing a medium for training. Shrinking employee pools within the federal system energized management to look for other training options. Tinker Air Force Base in Midwest City, Oklahoma, used defense contractors

Ratheon and Boeing to train their military members. At the Mike Monroney Aeronautical Center's Academy, Oklahoma City, Oklahoma, the FAA used employees of the University of Oklahoma to train controllers. A shrinking federal budget in some agencies reduced the overall number of employees within those agencies yet did not shrink the workload. Training dollars were easiest to cut and most trainers went back to work in operations. Those federal employees formerly used as trainers were often at a higher pay grade and appeared to be costing more while not contributing directly to the operation. To make up the shortfall, contractors were hired. Contractors too found that to stay competitive they had to economize. Computer automation allowed contract management to hire fewer people and be more competitive for other business opportunities.

In summary, individualized learning was born from a perceived need to measure more than a paper-and-pencil instrument could measure. Criterion referenced testing had proven its usefulness in training and had provided an open door to a more individualized medium. A medium which appeared to fit the parameters of the criterion referenced approach and individualized learning was the personal computer. Already one of the accepted mediums within the ISD process, the computer-based training provided an opportunity for trainers to economize in terms of personnel while directly affecting the learning environment. Shrinking dollars in the federal system forced managers to investigate alternative ways to train their employees. Contract management observed an opportunity to reduce employee costs by more extensive use of the personal computer and provided a lower cost solution to training for federal agencies.

Compatible Design Characteristics

Upon closer investigation of the ISD process, several characteristics emerged as being useful for both paper-based and computer-based lesson development. For purposes of this review, more emphasis was placed on those characteristics most useful to computer-based lesson development.

Characteristics compatible to computer-based lesson development were found to be: specifically stated learning objectives, hierarchy of learning categories within each learning domain, and connectivity between knowledge-based learning and retrieval during psychomotor response. A work by two aviation psychologists and another by three experts from the field of ISD were used as a backdrop to further explain how these characteristics were compatible to computer-based instruction.

Telfer and Biggs (1988) used a fictitious meeting between a student and an instructor to illustrate the interaction between these individuals. The instructor had in his possession a copy of the chief flying instructor's notes on the subject of stalls. He intended to cover these items during a session with his student, named Martin. The objectives of the lesson were specifically stated as follows:

> By the end of the instructional period, the student will be able to:
> [1] Accurately identify in sequence the symptoms of the approach to the stall and the symptoms of the stall.
> [2] Demonstrate a standard stall recovery with an altitude loss of less than 200 feet. (Telfer & Biggs, 1988, p.4)

The lesson also had some aims–what some instructional systems designs might call learning outcomes.

> This lesson aims to teach three aspects of stalling:
> [1] Recognition of the symptoms of the approach to the stall

> [2] Recognition of the symptoms of a stall
> [3]Recovery from a stall by standard method
> Additionally, these procedures will be carried out so that the student is not left with apprehension about either stalling an aircraft or recovering it. While all stalls in this exercise will be conducted from straight and level flight, the preflight briefing will include reference to stalls in other configurations and speeds. (Telfer & Biggs, 1988, p. 4)

The scenario used by Telfer and Biggs represented how curriculum could be individualized for the intended learner. The use of objectives and learning outcomes focused the student on only those elements necessary to achieve a greater competency within the given subject area. These learning outcomes were also testable during paper-and-pencil tests and during psychomotor skill tests while in flight. Although Telfer and Biggs used the traditional instructor-student personal attention training method in their scenario, the knowledge-based information could have been as easily administered using a personal computer.

The computer-assisted method has been in use by the An Invitation to Fly group in the form of Wilbur's Flight School: An Interactive Exploration of Flight (commercial software) (Glaeser, Gum, & Walters, 1993). The use of the computer in aviation training will be explored later in this section.

Gagné, Briggs, and Wager (1988) theoretically supported the learning approach indicated by the Telfer and Biggs scenario. They listed nine events of instruction with a definite order of presentation. Notice that element two linked the learning process to learning objectives. The elements are:

> 1. Stimulation to gain attention to assure the reception of stimuli;
> 2. Informing learners of the learning objective, to establish appropriate expectancies;
> 3. Reminding learners of previously learned content for retrieval from LTM [long-term memory];

4. Clear and distinctive presentation of material to assure selective perception;
5. Guidance of learning by suitable semantic encoding;
6. Eliciting performance, involving response generation;
7. Providing feedback about performance;
8. Assessing the performance, involving additional response feedback occasions; and
9. Arranging variety of practice to aid future retrieval and transfer. (Gagné, Briggs, & Wager, 1988, p.12)

The third element of instruction listed above–dealing with reminding students of what had already been learned–indicated another use for the personal computer. Proper encoding of the brain's memory for accurate retrieval at a later time had to be accomplished in a controlled environment. Individualized learning would disconnect the learner from unnecessary stimuli while focusing on only those elements of the lesson directly related to the lesson's objectives. This hyperfocus on only the relevant facts of the lesson would be best controlled by use of the personal computer. As indicated by Lien (1976), teachers have exhibited a tendency to flaw learning by changing the instruction or the testing instrument. Lien advocated structural discipline as a key element in design and development of lesson materials. Other learning theorists provided that structure in separate learning domains.

Bloom and Krathwohl (1984) explored the cognitive domain of learning, not directly mentioned in the Telfer and Biggs (1988) or the Gagné, Briggs, and Wager (1988) contributions, but indirectly attended to by drawing attention to lesson objectives. Bloom and Krathwohl listed six major categories of the cognitive learning taxonomy as: knowledge, comprehension, application, analysis, synthesis, and evaluation. Each category represented another cognitive employment process. Knowledge was dispensed differently from Comprehension, which was different from Application. Likewise, learning from each category was measured differently from other categories within the cognitive domain.

Lien (1976), using an earlier edition of the Bloom and Krathwohl work, addressed the discontinuity between the desired learning outcome and the testing instrument brought into play by some teachers. According to Lien, teachers often failed to match the learning outcome with what was asked on the testing instrument. An analysis of test results in that case indicated that the students did not learn what the teacher had intended for the students to learn. Lien went on to offer help in devising tests that were linked to specific verbs contained within the lesson's objectives. The hierarchical pattern appeared to be easily emulated by the computer.

Curriculum developers have used lesson objectives in criterion referenced curriculum as a means of keeping track of those nodes of learning directly related to later testing. For curriculum specialists involved in criterion referenced curriculum, any information taught outside of the objectives is irrelevant and potentially damaging to the student.

For the individual learner, pin-pointing cognitive requirements during instruction would aid in later retrieval of that information for psychomotor responses.

In practice, Telfer and Biggs (1988) used a learning process approach that combined knowledge-based information with elements of the psychomotor domain. In theory, Gagné, Briggs, and Wager (1988) presented a learning process approach that not only allowed the instructor to interrelate the cognitive and psychomotor domains, but also indicated what memory processes were being actuated during the process.

Intelligent Tutor

Given specifically phrased learning objectives, the desired learning outcomes, and an established hierarchical learning path, it would appear from the literature that the computer is an adequate tutor. Much has been written on the subject of the computer as an intelligent tutor. Those who agreed with this notion also warned their future customers that the computer could not replace the human in the learning equation. Humans and computers had to learn to work together (Crook, 1987). In every case where the intelligent tutor design has been used, there was a clearly defined task and an expected skill outcome.

Mandl and Lesgold (1988) showed particular interest in the work of Gagné (1962), especially how instructional design could be manipulated to incorporate different methods within the same instructional lesson while using the personal computer. They used Gagné's (1962) term of *connective glue* when describing this melding together of the cognitive and psychomotor. As described by Mandl and Lesgold (1988), connective glue is making a direct relationship between a knowledge-based informational unit and its corresponding psychomotor outcome. A good example of this was already shown in the Telfer and Biggs (1988) lesson plan on stalls.

To be a useful tutor, the computer must be designed to meet the viewer's needs. Venezky and Osin (1991) pointed to the following six steps as an adequate design:

> . . . (1) task specification; (2) skill analysis; (3) learner strategies; (4) assessment design; (5) instructional strategy and tactics; and (6) course organization. (p. 96)

Their steps agreed with elements of instructional design advocated by Gagné, Briggs, and Wager (1988) and West, Farmer, and Wolff (1991). Barker's interactive design (1994) incorporated six stages of a design schema nearly resembling the steps used by Venezky and Osin (1991). Barker's approach expected the learner to achieve expert skill. The six stages were represented by MAPARI, ". . . an acronym for Mimicry, Apprenticeship, Practice, Assessment, Refinement and Improvement" (p. 2). Gerson (1995) used a design similar to Barker to create a selective task trainer that focused on a specific cognitive/psychomotor event. According to Gerson, current part task training had not supported the expert's performance needs–an interest in common with Barker. Gerson's approach to computer training went beyond the scope of this review except for one important point. For training to be effective, it had to be designed to more closely approximate actual requirements influencing the student. The computer was for Barker and Gerson a tool to tutor the student to an expert level of performance.

The computer has been a significant medium for training within the past two decades. It has also been a recognized medium for training for programs using the Instructional Systems Development process. Specifically defined objectives, learning outcomes, and the hierarchical nature of learning have been adapted by computer-based instructional designers to provide individualized learning.

Legitimate Tool for Aviation Training

In 1994 a group of people who represented the personal computer development community, various universities involved in aviation training research, and the FAA met together at a conference in Oklahoma City, Oklahoma (Williams, 1994). The subject of the conference was the use of PC-based aviation training devices (PCATDs). Summaries of several discussions are directly related to the aim of this literature review.

One developer, representing Bruce Artwick Organization, Ltd., explored using the PCATDs for private pilot training. According to the account, the individual, who had already developed a useful tool for training, was unable to gain approval through the FAA in Washington, although having already gained approval at the local Flight Standards District Office.

Another conferee from the University of Central Florida presented the Basic Flight Instruction Tutoring System (BFITS). The microcomputer-based flight trainer was designed to teach both knowledge-based information and those tasks directly related to flight performance. It also incorporated a flight simulator and a performance evaluator.

Williams (1994) presented the government's position. Several significant points were made during the address. Until 1994 there had been insufficient evidence to support transfer of learning from PCATDs to actual flight. Any future studies, after 1994, had to be based on criterion-referenced flight tasks. Williams continued with:

> The PCATD should have a more active role in ensuring that task objectives and outlines are presented to the trainee, that feedback regarding performance of a specific task is given, and that the trainee establishes the correct patterns of behavior and learns to coordinate movements and anticipate actions in the same manner as the actual flight tasks. (p. 11)

Another important find from the Williams (1994) summary was the request for further data by the FAA's National Simulation Program. The representative from the National Simulation Program listed 12 multi-partitioned questions. Many of the pertinent questions centered around the manipulation of cues and the need for testing.

The Williams (1994) summary represented only the PC-based training devices and did not address the already approved main-frame computers used to train commercial pilots. Additionally, the summary largely addressed simulation training and nearly ignored other aviation training programs. However, Williams left room for further development at lower-end training where criterion-referenced tasks could be taught and tested without simulation.

Basis for Testing Cognitive Inhibition and Comprehension

The brain's capacity to store information and then retrieve that information based on some retrieval mechanism was the subject of this review. Work by Anderson and Spellman (1995) and Anderson, Bjork, and Bjork (1994) formed one opinion regarding cognitive inhibition. Other views regarding the testing of cognitive inhibition were gathered from studies conducted by Keenan, Baillet, and Brown (1984); Glanzer, Fischer, and Dorfman (1984); Rosenberg (1968); Le Ny and Carfantan (1982); and Dong and Kintsch (1968). A series of questions was posed to help give structure to diverse views of memory and comprehension. Each question is represented by another study from the list above. A summary at the end of this section highlights the features of the Inhibition Testing Model and its usefulness to this study.

Was there evidence that another mechanism was at play in memory, other than simple stimulus? Causal cohesion on comprehension and memory was the effect tested by Keenan, Baillet, and Brown (1984). Their research departed from hypotheses studied earlier by Kintsch and van Dijk (1978). Kintsch and van Dijk expected the subject to make a coherent relationship between the subject and another referent if the referent were repeated in two consecutive sentences. What Keenan, Baillet, and Brown found was that subjects attempted to form knowledge-based cohesion even if the texts were referentially coherent. No causes were associated with this finding although the study welcomed further research into the causes for this phenomenon.

The presence of another mechanism other than what was introduced in the study suggested either another definition for how memory is accessed or that Townsend's (1992) chaos explanation for processing was nearer the truth. In either case cohesion appeared to be acted upon by an outside force.

What impact did retrieval cue relevance have on free recall? Dong and Kintsch (1968) had determined by use of the Thorndike-Lorge two-syllable noun instrument, that recall was more effective when the retrieval cue was relevant. Subjects who either did not receive a retrieval cue or were given an irrelevant retrieval cue showed no significant difference. The results of these later groups were less effective than the group receiving a relevant retrieval cue. For purposes of this study, it would appear that relevant retrieval cues should be used.

How was meaning determined? Le Ny and Carfantan (1982) found that subjects determined meaning not from information apparent in a given sentence or phrase, but from the cognitive activity stimulated by the appearance of the sentence or phrase. Subjects appeared to begin comprehension based on semantic importance. Then the separate semantics were aggregated according to some cognitive activity which recombined the semantic elements into a new semantic synthesis. This was explained only slightly differently by Murdock (1992) when describing convolution-correlation and how it related to information chunking. Rosenberg (1968) had a simpler explanation for chunking and sentence comprehension. Subjects in the Rosenberg study appeared to recode information for storage by chunking large portions of the sentence according to semantic or syntactic structure. Glanzer, Fischer, and Dorfman (1984) argued that subjects retained the surface structure of sentences read, but retained a verbatim memory of the most recent sentences. The meaning of the most recent sentences helped to interpret those sentences which followed.

The central mechanism common to all of these theories of comprehension is the idea of synthesis. Whether by recoding, or chunking, comparison, or semantic synthesis each person seemed to interpret and store linguistic cues by some cognitive synthesis mechanism.

What effect did retrieval have on inhibition and forgetting? Anderson, Bjork, and Bjork (1994) in a study of 148 university students found that retrieval inhibition is directly related to long-term forgetting. Forgetting was more pronounced when output interference was controlled and with high-frequency members of learned categories. The forgetting phenomenon was further explained by Anderson and Spellman (1995) as not related to associative interference, but by means of an inhibitory process. Perhaps, for the aviator, this inhibitory process explained the ability to suppress or compartmentalize events from memory.

In order for an Inhibition Testing Model to function properly, it had to incorporate the theories of how information is comprehended. Based on the literature, not enough is truly known about how memory works. However, it would appear that there is substantial evidence for the notion that information chunking and memory storage are linked (Rosenberg, 1968; Le Ny & Carfantan, 1982; Murdock, 1992). It would also appear that there is enough evidence for recall based on relevant retrieval cues (Dong & Kintsch, 1968). And it would appear that some memory process, regardless of its name, is at work independent of referential cohesion (Keenan, Baillet, & Brown, 1984; Anderson, Bjork, & Bjork, 1994; Anderson & Spellman, 1995).

Two additional studies of memory theory were reviewed. These studies added another element to the mix. Hodes (1994) looked at the effect of visual imagery on processing retrieval time. According to Hodes' findings, subjects used more time during the learning process, but showed faster retrieval times during the posttest. Hodes' conclusions directly related to the central theme of this dissertation:

> At present, there are no specific examples of applications of imagery in technology-based learning systems. Further research will reveal the optimal time and place for imagery cues within instructional systems. Computer-based systems can display imagery cues during tutorials at a frequency that will maintain the strategy. Trainees destined to work on a simulator may need additional preparation time prior to entering the simulator. The additional time would be used to have the trainees image a part of the system, for example, the control panel, to ensure knowledge of the location of critical controls. A drawing test can verify the learning before simulator experience. Using imagery prior to simulator experience may increase the speed of responses without sacrificing accuracy. (p. 59)

Another view of visual memory was presented by Mayer and Moreno (1998). Their explanation of the difference in auditory and visual memory follows:

> According to the dual-processing theory, visually presented information is processed–at least initially–in visual working memory whereas auditorily presented information is processed–at least initially–in auditory working memory. For example, in reading text, the words may initially be represented in visual working memory and then be translated into sounds in auditory working memory. (p. 312)

The major advance, according to Mayer and Moreno, was an identification of techniques for presenting of verbal and pictorial information that minimize working-memory load. The chief technique presented was the discovery that visual animation should be accompanied by auditory narration and not text.

Basis for Lesson and Inhibition Testing Model

Based on the findings of the Hodes (1994) investigation and the Mayer and Moreno (1998) study, together with findings from the other memory studies in this review, any future multimedia lesson design effort would have to devise a strategy whereby long-term and working memory were systematically attended to. Working memory stimulation was to be kept at manageable levels by using visual and auditory techniques to keep working memory at a constant level of activity.

Therefore, the lesson design was patterned after findings from the Mayer and Moreno study. The Inhibition Testing Model was based on another dimension of the Mayer and Moreno explanation for how visual images were translated to auditory sound or how auditory sound was translated to visual image. This split-attention between these memory domains could prove to be useful as a device to depict detractors in a visual and auditory framework. According to Le Ny and Carfantan (1982) the activation of working memory is a cognitive activity, which can be manipulated.

Measuring Dimensionality

A question was raised by Thissen, Wainer, and Wang (1994) regarding the nature of free recall and the measurement of multidimensionality. They found that to a small degree free recall measured something other than what was measured by the standard multiple-choice test. Thissen, Wainer, and Wang did not expound on what that "something other" really was. To some degree the Inhibition Testing Model offers the measurement of something other than what is measured on a standard multiple-choice test.

Speededness in Testing

Oshima (1994) warned that speededness affected the estimation of ability. The Inhibition Testing Model was designed to probe not only knowledge-based retrieval, but also the parameter of metacognitive activity. If responses by subjects were timed, there would not be adequate information to indicate whether the subject lacked the metacognitive ability or lacked knowledge in the area tested.

Summary of Chapter II

The review of literature was far ranging–incorporating thoughts and concepts normally left unrelated, but for this study having been shown to have relationship. A preview of the chapter was encapsulated within the answers to four questions.

The reader was made aware of the world of the Attention Deficit/Hyperactivity Disorder individual in Section One. The cognitive composition of a successful pilot painted a picture of the desired outcome of any pilot training program. Section Three used the information given in the first sections to further investigate literature revealing more about learning theory and inhibition. Section Four returned to the realm of aviation education by reviewing current practices in ground school education. Finally, Section Five presented information discussing the use of the personal computer in aviation training.

Chapter III will assume the reader's understanding of the material presented in this chapter. The procedures outlined in the next chapter will show how the study was constructed.

CHAPTER III

PROCEDURES

Introduction

The purpose of this study was to determine if, and to what extent, a relationship or difference existed between the cognitive contexts of private pilot ground school and private pilot flight lessons. The research hypotheses were derived from working hypotheses–using a qualitative research design strategy, the theoretical constructs of which are amplified in the review of the literature and later discussed in this chapter. A quasi-experimental design, employing pretest-posttest of nonequivalent groups, was used to collect and analyze data. Thirty-four volunteers from intact groups of private pilot students from the University of Oklahoma, Rose State University, and Oklahoma State University formed the subject pool of the purposive sample. The research hypotheses tested were:

H-1. The context of cognition differs in relationship or degree between the private pilot classroom and private pilot flight lessons.

H-2. There is a strong relationship between subjects in the same context of learning.

H-3. There is a weak relationship between subjects in different learning contexts.

From Foreshadowed Problems to Hypotheses

Wiersma (1969/1995) suggested the use of foreshadowing problems as a tool toward formulating a working hypothesis. Data were collected during the course of several mini-studies to better apprehend the cognitive environments of the private pilot classroom and flight training. The following foreshadowing problems were put into the form of questions, a mini-study was conducted, data were analyzed for relevance to the problem and purpose, and a working hypothesis was created. Five foreshadowing questions are shown below.

1. What were the training needs of student pilots in private pilot ground school?
2. Could some training be successfully accomplished through computer-aided instruction and testing?
3. What word or concepts are consistent among private pilot instructional texts?
4. How would one devise an instrument to emulate the flight training environment, short of actually being in a simulator or aircraft?
5. Was there a cognitive link between the classroom and the flight deck?

The first question was discussed by Telfer and Biggs (1988) in <u>The Psychology of Flight Training</u>. The discussion of inhibition, a key element in pilot training, was amply covered in the review of the literature under the titles: *Inhibition and the ADHD Individual*, *Inhibition*, *Inhibition and Verbal Learning*, *Inhibition and Memory*, *Basis for Testing Cognitive Inhibition and Comprehension*, and *Basis for Lesson and Inhibition*

Testing Model. The cognitive theories for verbal learning and memory provided support for the Inhibition Testing Model–used to construct the Flight Deck Cognitive Emulator. The working hypothesis derived from this mini-study was put in the following form: student pilots in the private pilot program need to learn how to inhibit stimuli in a very specific pattern.

Question two was also answered in Chapter II in the section titled *Legitimate Tool for Aviation Training*. Just recently FAA restrictions have been relaxed on Personal Computer-based aviation training devices. During the 1999 International Aviation Training Symposium hosted by the FAA, vendors from many of the leading simulator training companies demonstrated how these devices could enhance aviation training. The working hypothesis derived from a review of the literature was put in the following form: personal computers can be used to effectively disseminate training in private pilot ground school.

Question three required a thorough search for key words and concepts that were relevant to private pilot ground and flight training. Work by Jacoby and Brooks (1984) on priming words and the interaction of episodic and semantic memory during retrieval provided the backdrop for a comparative study. Baddeley's (1999) book, Essentials of Human Memory, was reviewed to compare work by Jacoby and Brooks with others in the same field. The theoretical basis for stimulating semantic primers and episodic memory in concert was deemed sound, allowing for continued work on the comparative study.

Word Study: Referent Pairs

A word count was conducted using the 1997 Private Pilot FAA Practical Test Study Guide (Jeppesen-Sanderson, 1997a), the Private Pilot Manual, Chapter 1, Section C (Jeppesen-Sanderson, 1996b), and the AC 61-23C, Pilot's Handbook of Aeronautical Knowledge, Chapter 1 (Federal Aviation Administration, 1997c). The specific areas reviewed in each text were slow flight, power-off stalls, power-on stalls, and spin awareness. It was postulated that to know whether a referent word was a primer or associative referent, one had to determine whether one textual concept (associative referent) logically followed another textual concept (primer).

A semester of private pilot ground school was observed to understand how the Jeppesen-Sanderson Private Pilot Manual was taught by a ground school instructor (C. Murphy, personal communication, January-March 1998). The training format was observed to follow a sequential pattern where concepts were built upon concepts. For example, the four aerodynamic forces of lift, weight, thrust, and drag were taught by referencing flight controls and the power plant on an airplane. Days after covering aerodynamic principles, the instructor used those principles to explain slow flight and stalls. It was determined then that the sequential format of private pilot ground training could be reduced to sets of primer and associative referent pairs of terms. To test that hypothesis, a word analysis was conducted.

An initial skim of the three texts revealed that some words were used more often than others and perhaps were primers. These repeated words were listed together with how many times they were used in each text (Appendix D, Tables D1-D12). Then the word lists were combined to show similarities and differences between texts (Appendix D, Table D13).

An analysis of the word lists was conducted. Referents with higher occurrences generally indicated a specific word was technical and had few, if any, alternatives. For example, *airspeed* can also be shown as *speed*, but the idea is still tied to speed through the air. *Airspeed*, of itself, was different from *ground speed*, and could not be used interchangeably. The concept *load factor* was a similar example. *Load factor* was a very specific calculation based on a number of variables. The word *load* could be substituted for *load factor*, but the concept had to be introduced first before reducing the concept to just *load*. Referents with lower times of occurrence seemed to indicate two things. The word was not very important, or the word introduced a larger body of information. The referent, *indications*, let the reader know that what followed was a list of indications of some other event. The referent, *coordinated*, could have had more than one meaning, but when used in relation to aircraft maneuvering, the word *coordinated* was used together with *turns*.

Each reference used key words to describe the same event. The <u>1997 Private Pilot FAA Practical Test Study Guide</u> (Jeppesen-Sanderson, 1997a) did not use *load factor* very often, the <u>Private Pilot Manual</u> (Jeppesen-Sanderson, 1996b) used the term *load factor* moderately, and <u>AC 61-23C</u> (FAA, 1997c) used the term *load factor* extensively to describe many aerodynamic events. It was surmised that the number of times a word was used, among the three references, suggested the word was a primer and not an associative referent.

Slow Flight. A list of prime referents was compared with those words that were associated with that term in the three references (Appendix D, Table D14). An analysis was conducted to determine which words were most likely the principal associative referent for a given primer. The analysis indicated that some prime referents acted as primers for other prime referents. For example, the term *slow flight* was a primer. The 1997 Private Pilot FAA Practical Test Study Guide (Jeppesen-Sanderson, 1997a) was written to tell the student pilot the parameters for psychomotor skill demonstration during an FAA practical test in the aircraft. It, therefore, repeated the term *slow flight* many times. However, neither the Private Pilot Manual (Jeppesen-Sanderson, 1996b) nor AC 61-23C (FAA, 1997c), both written as cognitive domain texts, mentioned *slow flight* at all. In all cases when *slow flight* was mentioned, it was associated with the word *maneuvering*. *Control*, in its verb form, was interspersed with *control* as used as a noun. *Wheel* was most often used with *control* used in its noun form. *Flight* was most often used with the transitive verb, *controlled*. *Control* was often used together with *coordinated* flight and *maneuvering*. The concept of *attitude*, describing the relative position of an aircraft's nose to the artificial or real horizon, was used only once. All other references were associated with the aircraft's pitch relative to the horizon. *Pitch* was the word most associated with *attitude*. *Airspeed* was primarily used in one of two ways. It was either associated with a mandatory or specific speed, or it was connected with maneuvering flight. Most often *airspeed* was presented in the imperative, such as "maintain airspeed." When associated with a specific speed, the word *speed* was presented as an adjective. For example "on departure, *maintain climb speed* until reaching level off." Or another example, "the pilot performed a *constant airspeed descent* until reaching the final approach fix." *Altitude* was used in a similar fashion to *airspeed*. When *maintain* was associated with *altitude*, it was used in the imperative, "maintain altitude." *Climb*, *descend*, and *maintain* were all used in conjunction with *altitude*. *Maneuvering* was used in either its verb or noun form. In its verb form it described the movement of an airplane. In its noun form, it was combined with another word to form a discrete entity. For example, "while *maneuvering* in slow flight, be aware that flight controls are less effective (intransitive verb)." Or another example, "due to turbulence in the area, the pilot elected to fly at *maneuvering* speed (adjective)." *Power* was normally preceded by an imperative. For example, "apply power" or "add power" were often associated. *Load factor* was viewed as a technical term describing a composite of terms. Linguistically, the term was loosely associated with lift. It was conceptually very connected to *lift* and *aerodynamics* and was, therefore, a good candidate as a prime referent. *Pitch* was often combined with *attitude* to describe a position or was associated with *power* to show a procedural link during *slow flight maneuvering*. *Turns*, in its noun form, was associated with either the descriptor, *coordinated*, or with the concept of *load factor*. *Maintain*, as mentioned earlier, was the imperative for *airspeed*, *altitude*, and *pitch attitude*. *Indications* was a word related to *slow flight*, but only indirectly. *Indications* was a word generally related to *instrument readings* inside the cockpit rather than stimuli related to a *stall*. However, it could have also been related to *instrument readings*, which as a term invites the cognitive process of synthesis with, hopefully, a resultant action. *Instrument readings*, in its noun form, was a good candidate as a prime referent. It was mentioned infrequently, but explanations cascaded from its mention–indicating some degree of primacy. *Stabilized*, in its adjective form, described an unchanging (not fluctuating) *flight condition*. This flight condition was normally related to *turns*, *airspeed control*, *altitude control*, *climbs*, *descents*, or any other *maneuver*. *Flight*, in its adjective form, described *attitude* or appeared as a noun when combined with *coordinated*. *Simulate* was used only once, but had a very refined meaning when related to a *slow flight* demonstration. Therefore, *simulation* was viewed as the over-arching performance term for the task called *slow flight* and held a more prominent position in the semantic hierarchy. *Demonstrate* (verb) was found to be an associative referent, even if it preceded the prime referent, *simulate*. *Coordinated*, in its adjective form, related mostly to *turns*. It was also related to basic aerodynamics in that it referred to the use of ailerson, elevator, and rudder to complete a turn in the airplane. *Heading*, in its noun form, was related mostly with *control*. It was also related to the imperative, *maintain*. Both *heading* and *maintain* subsumed other cognitive and psychomotor events such as sensing heading, turning to a heading, and meeting performance standards during the event. *Climb*, as a noun, was determined to be an associative referent for *attitude* and *rate*. In its verb state, *climb* became the prime for the associative referent, *altitude*. In most cases, *climb* was used as an associative referent when describing the concepts of *attitude control* or *constant rate climb*. *Descent* was similar to *climb* and was normally an associative referent for *pitch attitude* or *rate*. Finally, *configuration* was a key word in describing landing, but was not a strong candidate as a prime or associative referent.

Power-Off Stalls. Table D15 (Appendix D) shows a three-way comparison of words based on the notion that the words on the left column of the table are prime referents. Each word group was analyzed to determine whether it was a prime or associative referent. *Stall* appeared to be a prime referent. In all cases *stall* was so specific that no other term could be used in place of it. *Control*, as a noun, usually followed referential words for particular *recovery maneuvers* after the stall had been recognized. *Attitude* was associated with *pitch*, and was found to be a prime referent. *Power* was a prime referent when used to describe engine power. However, the word *engine* was never used together with *power*; it was always assumed to be the power giver. *Drag* was a prime referent when describing specific types of drag, such as *parasite* drag, *induced* drag, or describing the *total* drag curve. *Turns* was similar to its usage in the section on slow flight words. *Turns* was associated with *load factor*, and depending on which was used first, either one could be a prime or associative referent. *Indications* was associated with *stall*. However, only one reference used these words in a referent pair sense. *Angle-of-attack* was normally associated with *lift* and *airspeed*. It was often viewed as a prime referent when describing aerodynamic effects caused by *angle-of-attack*. *Lift* was an associative referent to *angle-of-attack* and *load factor*. *Recognize* was a prime referent verb for *stalls* when describing the concept of recognition. The same was true regarding *recover* and *stalls*. *Recognition* and *recovery* were by far the strongest prime referents. Finally, *altitude* was normally associated with the associative referent phrase, "minimum loss of" altitude.

Power-On Stalls. Table D16 (Appendix D) shows a three-way comparison between a suspected prime referent and potential associative referents. This list is similar to power-off stalls. However, the power-on stall concept assumes the pilot has departed the parameters of equilibrium between aerodynamic forces. *Control* was a prime referent associated with *maneuvers*. In this case, *control* assumed the pilot had established the proper parameters and, therefore, gave primacy to the word *climb* over that of *maneuvers*. *Attitude* was an associative referent to *stalling*, but was a prime referent when associated with *pitch*. *Airspeed* was an associative referent to *angle-of-attack*. *Lift* was also an associative referent to *angle-of-attack*. *Power*, inferred a throttle setting to establish *climb power*. *Climb*, in this case, was an associative referent to *power*. *Drag* had the same prime referent effect when describing the aerodynamic effects of a *stall*. However, if *parasite*, *induced*, or the *total drag curve* were described, *drag* would be considered an associative referent. *Turns* and *load factor* were prime referents when aerodynamic forces of *lift*, *weight*, *drag*, or *thrust* were mentioned. *Turns* were also considered a prime referent for *power*, *airspeed*, and *angle-of-attack*. *Indications* was a prime referent for *stalls* unless combined with *recognition* and *recovery*. In that case, *recognition* and *recovery* became the prime referent and *indications* was an associative referent. Finally, *altitude* was the prime referent for the associative referent phrase *minimum loss of*.

Spin Awareness. Table D17 (Appendix D) shows a three-way comparison of suspected prime referents and potential associative referents from three sources. The texts used the same prime referents to describe spin awareness. *Recognition*, *recovery*, *awareness*, and *coordinated* were prime referents. In every case, except for *coordinated*, *spin* was the associative referent. *Coordinated* was the prime referent for *maneuver*.

Grouping Pairs. Table D18 shows those prime and associative words that appeared to have the strongest linguistic connection. Since there existed a connection between specific words, and each of those words could be labeled as a prime or associative referent, then perhaps two prime referents could have the same associative referent. For example, *turns* and *angle-of-attack* are two prime referents that share *lift* and *airspeed* as associative referents. Prime referent "A" might be associated with associative referent "B," and prime referent "C" might be associated with the same associative referent "B." If that were true, then prime referent "A" and "C" may also be associated. Table D19 (Appendix D) shows the relationship if A = C. In every case, the prime referents were associated.

Results. It was quite possible that the classroom environment for all three private pilot ground school courses would be different. This would be largely due to the effect of the instructor on the students and the students on each other. However, an application of the prime/associative referent paradigm to a computer-generated instructional lesson, might create a uniform classroom environment. Additionally, the test and instruction could be paired for an exact fit of cause and effect. What was instructed was also tested and what was instructed and tested was precisely what the best private pilot texts communicated. The working hypotheses derived from the word study were put in the following form: (1) aviation training can be described as the purposeful association of primary cognitive cues with psychomotor skill development, (2) there is a learning context difference between the private pilot classroom and flight training, (3) the sequential format of private pilot ground training could be reduced to sets of primer and associative referent pairs of terms.

Question four is explained in this chapter under the heading, *Type of Design*. As will be explained, the medium of the instrument was a personal computer, because it provided the best chance for consistency among all subjects and could capture data as the subject was interacting with the program. The aircraft environment, like the computer program, is also very interactive. Feedback, such as increasing or decreasing airspeed after moving the throttle forward or aft, allows the pilot to make follow-on decisions. There is always an input and always an output generated by the pilot or the environment surrounding the pilot.

The key to the answer to question five was found in the FAA Airman Knowledge test bank. Jeppesen-Sanderson used the FAA test bank to guide each review of the material in its courseware. It became apparent that the commonality between the FAA test bank and the Jeppesen-Sanderson courseware for private pilot candidates provided an excellent cognitive baseline. The next hurdle was to find a link with the flight deck. This link was found in the 1997 Private Pilot FAA Practical Test Study Guide (Jeppesen-Sanderson, 1997a). The contents of the study guide linked the FAA performance standards for a flight check with cognitive objectives tested by the FAA on the FAA Airman Knowledge test. Therefore, what was taught in the classroom was presumably necessary for the flight check and showed a crossover between the classroom context of learning to the flight context of learning. The hypothesis derived from this study was put in the following form: a cognitive link exists between the classroom and the flight deck in the private pilot training program.

From Working Hypotheses To Research Hypotheses

The qualitative research foreshadowing questions and the mini-studies conducted as a result, formed a number of working hypotheses. They were:

1. Student pilots in the private pilot program need to learn how to inhibit stimuli in a very specific pattern.

2. Personal computers can be used to effectively disseminate training in private pilot ground school.

3. Aviation training can be described as the purposeful association of primary cognitive cues with psychomotor skill development.

4. There is a learning context difference between the private pilot classroom and flight training.

5. The sequential format of private pilot ground training could be reduced to sets of primer and associative referent pairs of terms.

6. A cognitive link exists between the classroom and the flight deck in the private pilot training program.

Among the six working hypotheses there existed several explicit and implicit themes. Explicitly, every hypothesis was focused on the private pilot program. There was also a heavy emphasis on cognitive development of the student, whether in the classroom or the airplane. Learning objectives were defined in very specific terms, which allowed the student to both know and do. Implicitly, a connection existed between the use of the personal computer and the learning requirement to accurately associate primary and associative referents.

The explicit and implicit themes indicated a need for a reorganization of the six working hypotheses. During the reduction process, each proposed hypothesis was matched with the purpose and problem statements to establish relevance. The resultant set of research hypotheses derived from the working hypotheses are listed at the beginning of this chapter.

Summary of Qualitative Studies

One could not assume that what was taught in the private pilot classroom was relevant to private pilot flight training. However, one could investigate the nature of the private pilot classroom, the textual relationships between major aeronautical concepts and their associated terms, and establish a relationship between the cognitive requirements of the classroom and the flight deck.

The remainder of this chapter will explain the type of design of the instrument, revisit learning requirements in different cognitive environments from another point of view, show how the hypotheses were tested, discuss how the sample was selected, explain how the Flight Deck Cognitive Emulator was constructed, explain how the instrument was evaluated and validated, explain how data were gathered, discuss how the study ensured internal and external validity and reliability, discuss the statistics used to measure the results, and list limitations to the study.

Type of Design

Transition From Model to Emulator

The Inhibition Testing Model, discussed in the review of literature, is illustrated in Figure 1. The theoretical construct incorporated methodology from verbal cue theory (Jacoby & Brooks, 1984), the Scan Test (Caliber Associates, 1999), and the use of time in testing (Rafal & Henik, 1994). Conceptually, the model represented the elements also present on the flight deck of an aircraft. However, the model only provided the theoretical basis for the Flight Deck Cognitive Emulator. What remained was the development of a cognitive commonality between the contexts of learning.

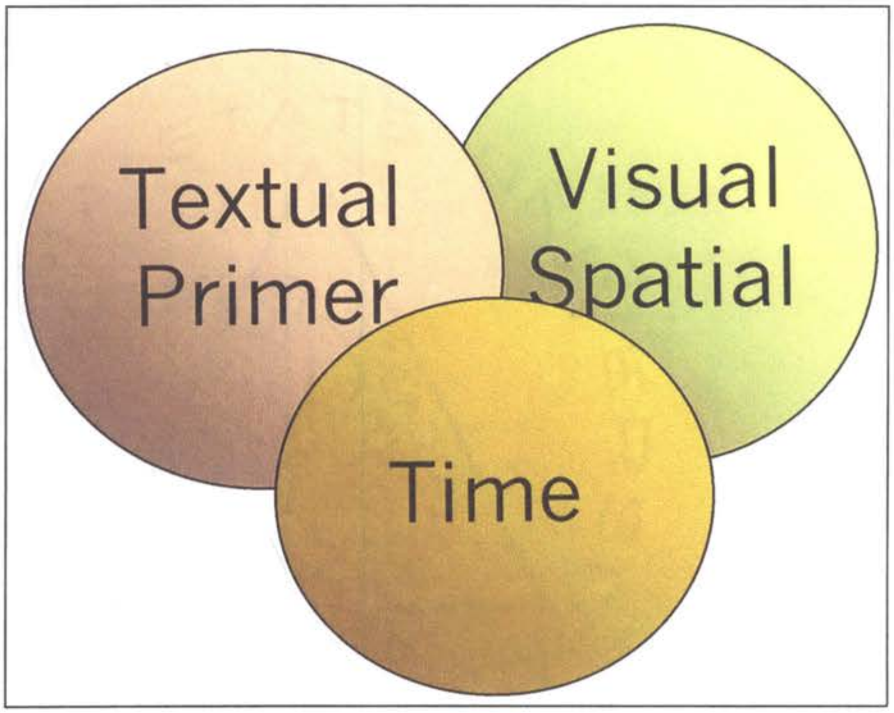


Figure 1. Inhibition Testing Model

Determining Learning Requirements in
Different Cognitive Environments

A review of three private pilot ground school approaches to training was conducted to determine the nature of cognitive learning in the classroom and aircraft. In addition, pilot judgment studies were reviewed since they too discussed the transference of cognitive learning from the classroom to the aircraft (Diehl & Lester, 1987; Berlin et al., 1982).

Jeppesen-Sanderson training materials were used as a traditional training baseline, and because so many Part 141 ground schools in Oklahoma used these materials. A text by Glaeser, Gum, and Walters (1993), An Invitation to Fly: Basics for the Private Pilot, was used as an alternative source of information to Jeppesen-Sanderson. The writers of this last text described a slightly different training philosophy than that of Jeppesen-Sanderson–providing another approach to the same subject. Lastly, Kershner's (1993), The Student Pilot's Flight Manual, provided yet another view of training. Kershner appeals to the student who does not plan to attend a formal classroom. A word study, explained at length earlier in this chapter, was used to determine whether or not each of the sources used similar words and phrases to describe the same concepts or terms. The study showed that each of the sources used strikingly similar words to describe the same term or concept.

The word pairs were incorporated within a set of 30 questions, which sampled information from the introductory chapters of the Private Pilot Manual (Jeppesen-Sanderson, 1996b). Objectives were derived from the 30 questions and an instructional module was developed based on the list of objectives (Appendixes A and C).

Quantitative Design

Testing the Hypotheses: Quasi-Experimental Design

A quasi-experimental study was conducted, using a pretest-posttest, nonequivalent groups paradigm. The posttest was administered from 2 days to 3 weeks after initial instruction and the pretest. A control group was used to measure the relationship between low arousal testing and high arousal testing. Relational differences between a moderate arousal and a high arousal environment were also measured. The pretest was used to measure the relationship between the classroom cognitive context of learning and the aircraft context of learning.

Pretest

Three intact groups of subjects were selected using a purposive sampling technique. Two Part 141 ground schools, those offered by the University of Oklahoma and Oklahoma State University, were used. Part 141 requirements for aviation training schools ensured a high degree of confidence that training would be similar among subjects from those schools. Rose State College, a Part 61 ground school, was also included. An interview with the ground school instructor verified that the course content would be similar to that of the Part 141 schools. Additionally, all of the intact groups used the same reference text.

Each student received instruction over the first three chapters of the Jeppesen-Sanderson text used for an introduction to aviation. Each class site was visited and instruction monitored. All three instructors used similar training aids and explanations for aeronautical concepts and terms, similar to those reviewed during earlier study (Appendix D). Each intact group was given a pretest over the three chapters from the text.

Each classroom was visited to determine similarity of teaching methods and course content. All classroom instructors were competent with no less than three years experience teaching private pilot ground school. All instructors were certified at no less than the basic ground school instruction certification level awarded by the FAA.

Posttest

The posttest was administered to all volunteers who represented the three intact groups in two parts. A briefing guide was used (Appendix H). The control group received a low arousal three-distractor multiple-choice test (untimed), followed by the timed Flight Deck Cognitive Emulator test (Appendixes A and B). The experimental group received a moderate arousal three-distractor multiple-choice test (timed), followed by the timed Inhibition Testing Model test.

Test Reliability. A portion of the FAA Airman Knowledge examination was used as the three-distractor multiple-choice test and also served as the basis for the Inhibition Testing Model test (Appendix A). The FAA Airman Knowledge examination was compared to the Jeppesen-Sanderson (1997b) guide, 1997 Private Pilot FAA Airmen Knowledge Study Guide for Computer Testing, to ensure that only questions referring to aerodynamics and basic flight maneuvers were specifically culled from the total body of questions in the FAA test bank (FAA, 1998h). The FAA test has been established to be a highly reliable assessment instrument (.85).

The Flight Deck Cognitive Emulator posttest used a combination of assessment techniques. It consisted of 30 fill-in-the-blank questions, each equipped with a list of 12-distractors (Appendix B). The correct answer text was derived directly from the FAA Airman Knowledge test bank of questions, enhancing internal and external reliability. Wrong answer distractors were purposefully designed to force the subject to scan rapidly between the distractor list and the fill-in-the-blank question stem at the bottom of the screen (Appendix B) and to induce anxiety. These distractors acted like small rocks over which the mind would stumble during the search pattern scan for the correct answer.

Selection of the Sample

A purposive sample of students enrolled at certified ground schools in the state of Oklahoma during the fall semester of 1999 was used for this study. Students were randomly divided to participate in the experimental group or the control group. Data collected from each subject were confidentially stored within the memory of a laptop computer, according to the letter of agreement with the Institutional Review Board (Appendix J). Students disenrolled before the end of the testing phase were eliminated from the study.

Selection/Development of the Instrument

Designing an Assessment Instrument Strategy

A search for an instrument to measure the difference in cognitive inhibition between the classroom and the aircraft was conducted. The FAA had incorporated a number of tests in their Air Traffic-Standardized Aptitude Test (AT-SAT), which had measured information processing, metacognition, visual-spatial ability, attention, memory, computational skills, applied reasoning, and communication (Caliber Associates, 1999). Attributes of the Scan Test were used to develop the Inhibition Testing Model (Caliber Associates, 1999). The Scan Test measured an individual's ability to click on numbers on the screen only within the range shown at the bottom of the screen (see Figure 2). The numbers randomly appear on the screen and remain on the screen for varying times before being erased. The range of numbers, as indicated in the instruction at the bottom of the screen, changes without warning during the test. This requires the individual to invest scanning time to the instructions as well as the numbers on the screen. The Scan Test measured an individual's visual-spatial ability, an ability needed to control air traffic (Caliber Associates, 1999). This same ability was needed by pilots of aircraft (Telfer & Biggs, 1988). It was, therefore, decided that a visual-spatial element should be incorporated within an inhibition test. The visual-spatial element would emulate visual-spatial cues presented while in flight. It was reasoned that although visual-spatial cues are also presented in the classroom, the instructor, to a large extent, intentionally

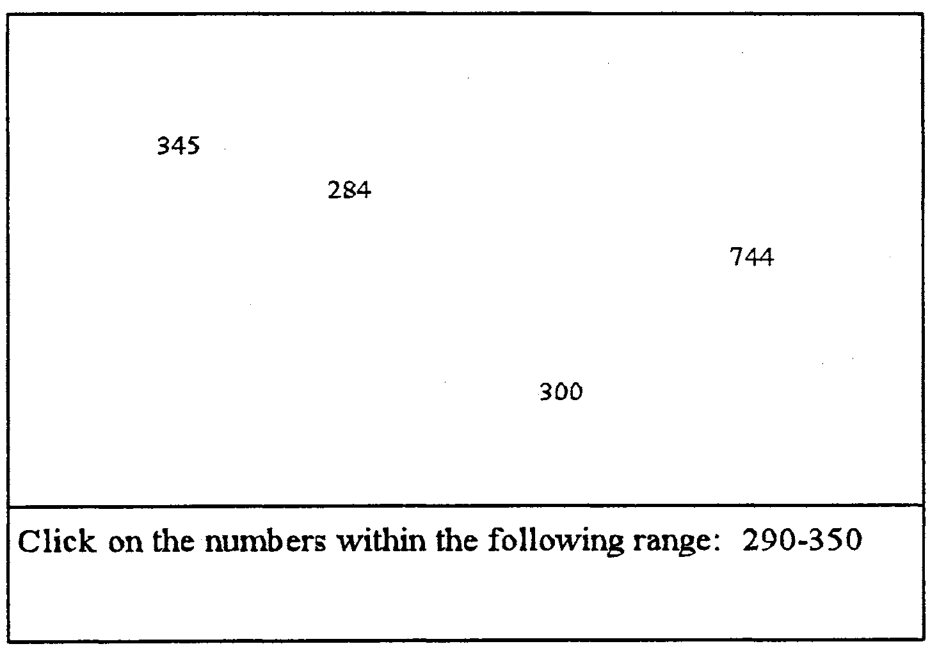


Figure 2. Scan Test (Caliber Associates, 1999).

reduces the number of cues to promote focused attention. In the airplane visual-spatial cues occur despite attempts to limit their effect. Therefore, a true emulation of the aircraft environment would need to force the visual-spatial effects.

Another characteristic resident in the classroom and aircraft cognitive environments was memory recall. A study conducted by Jacoby and Brooks (1984), using the textual priming cue paradigm to target semantic memory, provided another element for the testing model. The Flight Deck Cognitive Emulator would have the ability to measure the effects of visual-spatial stimulation and memory retrieval by incorporating elements of the Scan Test (Caliber Associates, 1999) and the memory retrieval test (Jacoby & Brooks, 1984).

One more element was included in the testing model, the effects of short-term memory. The testing model had to be able to assess the effects of short-term memory when changing from one cognitive environment to another. The case considered was the transference of knowledge-based information from the ground school context to the aircraft context. Knowledge information received in the classroom would have some residual effect on the student when changing from one environment to another. Additionally, flight instructors are known to prebrief the maneuvers of the intended flight, during which they review knowledge information necessary to the maneuver. This meant that it was highly likely that the short-term memory would also be active in both cognitive environments. Studies by Glanzer, Fischer, and Dorfman (1984) were reviewed to determine the effect of short-term information on tested individuals.

It was thought that the Flight Deck Cognitive Emulator could measure the effect of short-term memory, but could not introduce the knowledge-based elements in the same environment. To remedy this shortfall, a practice test was introduced. During data-collection, the control group received a three-distractor multiple-choice test, similar to that given by the FAA or given in the classroom. The experimental group also took a three-distractor multiple-choice test, but moderate-level visual-spatial distractors were introduced, which emulated the prebriefing environment observed to occur between an instructor pilot and his or her student. Following the practice test, the control and experimental groups were given the posttest (aircraft context). The aircraft context was emulated with a combination visual-spatial stimulation and textual cues priming, as described in the preceding paragraphs. The Flight Deck Cognitive Emulator can be illustrated as shown in Figure 3.

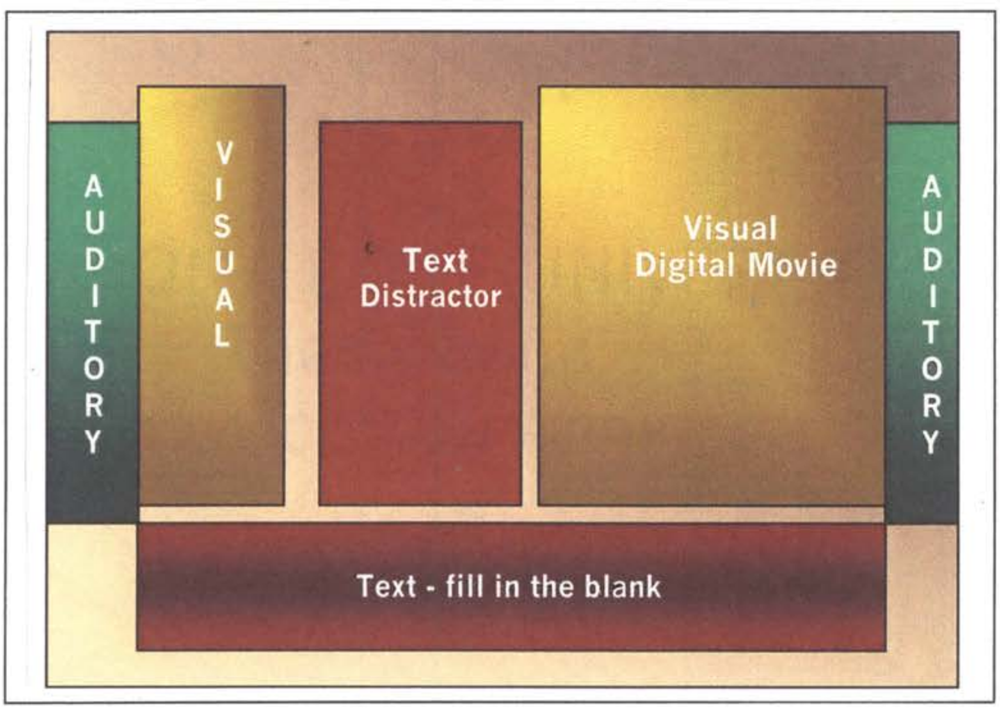


Figure 3. Flight Deck Cognitive Emulator.

Evaluation and Validation of the Instrument

The Flight Deck Cognitive Emulator was validated using a three-judge review process, peer review, and small group analysis. The three principal judges represented the fields of cognitive psychology, educational testing and evaluation, and aviation education. Instructors from each of the targeted institutions reviewed the instrument in the post-development testing phase. No notable exceptions were made at that time.

A lesson plan dealing with the subject of aerodynamics, stalls, slow flight, and spins was designed and developed for review by two instructional systems designers and one curriculum specialist employed at the Mike Monroney Aeronautical Center, Oklahoma City, Oklahoma. The results of their formative evaluation of the lesson were analyzed and the lesson modified to incorporate the suggested changes. One multimedia designer, one FAA instructor, and one multimedia programmer, each of whom develops or reviews lessons for the FAA, conducted a peer review of the modified lesson.

The sections of the Airman Knowledge examination used for the posttest were derived directly from the FAA Airman Knowledge Test bank (FAA, 1998h). A complete list of the questions extracted from the reference is presented in Appendixes A and C.

The instructional module and Flight Deck Cognitive Emulator were designed using techniques and information presented in the review of the literature. Authorware 4.0 (Macromedia, Inc., 1997) was used as an authoring tool to present the testing model. Descriptions of terms and concepts used by Jeppesen-Sanderson (1996a) in their study manual were used within the computer-based lesson and testing model to prepare the student for the Airman Knowledge examination. The on-line computer-based lesson and testing model were reviewed by three judges. Comments for change, offered by the three judges, were incorporated and another review was conducted (K. Williams, personal communication, September 9, 1999). A small group of individuals not familiar with aviation were used to perform a formative evaluation of the lesson and testing model.

Data Gathering

Appointments were made with the volunteers from each testing site. Each subject was briefed from the same briefing guide (Appendix H), and each subject was given an opportunity to complete a consent form (Appendix I). Control group subjects were given unlimited time to complete the practice test, but were timed (45 seconds per question) on the posttest. Experimental group subjects were timed on the practice test and the posttest, using the same 45-second timing criteria. After each testing session, each subject was allowed to express his or her opinion regarding the testing instrument or aviation training in general. Since the subjects' comments were not part of the study, no formal record was kept. Each testing session lasted 30 minutes on average, if the subject did not require any additional study; or about 50 minutes if additional study was needed. The additional study materials were administered via the personal computer. The format of the instructional preparatory lesson can be found in Appendix C.

Pretest scores, from chapter tests given at each location by the resident instructor, were collected from each of the ground school instructors between September 16, 1999, and November 11, 1999. Posttest scores were collected from 34 volunteers from three different intact groups of private pilot students. The posttest scores and interaction times were collected using a Computer-Managed Instruction (CMI) software and did not involve human interference. Test results were kept confidential within the CMI and were downloaded on a 3.5" diskette at a neutral site. Test scores for each location were downloaded following completion of testing. The test results from each location were analyzed and then compared to results from the other sites.

Validity and Reliability

Validity

Content and construct validity were judged by certified ground school instructors. Course content was found to be consistent with approved material used at each Part 141 school and the Part 61 school. Flight and ground school instructors reviewed the lesson plan of the course and instrument. No exceptional comments were noted. Criterion-related validity was evaluated during the peer review process of design and development. Each member of the peer review had knowledge of FAA standards for lesson plan development and testing and were professional instructional systems designers.

Pretest data was used to compare the mean of test scores on the pretest with those of the control and experimental groups to determine similarity among the three institutions and the subjects. Practice test scores were also analyzed to determine similarity among groups. In addition, time-in-interaction was compared between intact groups and individuals within groups to determine irregularities. The data were also used to determine relationships between institutions, since two institutions were Part 141 aviation training schools and one was a Part 61 training school.

Reliability

All 30 test questions used for the practice tests for the control and experimental groups were derived from the FAA Airman Knowledge test bank (FAA, 1998h). Incidentally, the FAA reported a .85 reliability factor for all 1998 tests in this category (L. McCoy, personal communication, February, 29, 2000). Jeppesen-Sanderson Training Systems put a portion of the same bank of test questions in their 1997 Private Pilot FAA Airmen Knowledge Study Guide–routinely used by private pilot students (Jeppesen-Sanderson, 1997b). Appendix A shows how each specific test question is related by code to a specific location in the training objectives. For example, a question regarding frost on the wings and how it influences takeoff performance is cross-referenced to the major subject area of principles of flight (H300), can be found in AC 61-23C, Pilot's Handbook of Aeronautical Knowledge (FAA, 1997c), and has the specific question address of 2.3.2.0.6.A.1. The systematic nature of FAA and Jeppesen-Sanderson tests provided a very stable basis for testing in this study and could be replicated easily. More will be said regarding internal and external validity in chapters four and five.

Statistical Analysis

Correlation comparisons of pretest and posttest scores from all group subjects from each location were analyzed using the Pearson *r* descriptive statistic. The Pearson *r* statistic also provided a tool to measure relationships between and among lesson plans used by the three schools. A T-test statistic was used to compare the means of test scores. The T-test provided evidence for or against a relationship difference between learning environments. Each set of scores was analyzed for central tendency and compared with other groups and members within groups.

Limitation

The collateral effect of combining unidimensional and multi-dimensional tests was not accounted for in this study. However, both the control and experimental groups were given equal exposure to the multi-dimensional testing instrument. Normative data already exists for the unidimensional multiple-choice test administered by the FAA. The Inhibition Testing Model and Flight Deck Cognitive Emulator have not been used outside of this study and may contain deficiencies not yet discovered.

Summary

The review of the literature provided an academic basis for the theory underpinning the Inhibition Testing Model and the Flight Deck Cognitive Emulator. Despite the absence of a normed testing instrument in this study, the Flight Deck Cognitive Emulator was supported by solid theory and practice. Measuring devices were in place to assess the cognitive context of the classroom and that of the aircraft.

Chapter IV displays the results of the data collection and presents an analysis of the data in textual form.

CHAPTER IV

FINDINGS

Introduction

The Flight Deck Cognitive Emulator program was developed and scripted during the summer of 1999. During August 1999, the program underwent testing and validation trials. After successful completion of the validation process, the emulator was introduced to the students enrolled in ground school courses at three separate institutions.

Data were collected from subjects enrolled at the University of Oklahoma (OU) (N = 9), Rose State College (RSC) (N = 13), and Oklahoma State University (OSU) (N = 12) between September 9, 1999, and November 11, 1999. Each class session of students at the University of Oklahoma and Oklahoma State University was given a briefing regarding the goals of the study. Department heads and instructors encouraged their students to participate in the study. The department head/instructor at Rose State College allowed students to participate in the study while class was in session. The subects who volunteered for the study represented 14% of OU students, 92% of RSC students, and 29% of OSU students enrolled in introductory aviation classes.

This chapter will first review the responses regarding the validation of the Flight Deck Cognitive Emulator. Next, data will be presented that indicated the nature of each group, relationships between and among subjects from the three institutions, the relationship between the private pilot classroom cognitive context of learning and the private pilot flight lessons cognitive context of learning, relationships of individual performance within a context of learning, and the relationships of individual performance between contexts of learning.

The Instrument

Responses During Functionality Testing

The Flight Deck Cognitive Emulator functioned as programmed during the functionality evaluation phase. A Winbook XL, 266Hz, Pentium laptop computer was used to improve portability and flexibility during data collection. The laptop had an internal 3.5 cassette drive and an internal CD ROM drive. Ground instruction .avi files (digital movie), from disk 2 of the Pro-Pilot '99 (Dynamix, 1998) flight simulator software, were played as external files from the internal CD ROM in the laptop computer. The computer program was scripted to preload the movies at the beginning of the test to avoid loading delays.

Program functionality was evaluated by three computer programmers before small group validation. In all validation tests, the program wrote to an external .txt file, recording the answers and the times for each test subject. Some scripting errors had been made, which limited the use of the collected data. These errors were corrected and the program was tested again. In further trials, all testing times and answers were found to be accurate in each trial. All scripting discrepancies were corrected before final testing. All programming judges found that the program had performed accurately in every trial.

Responses During Small Group Validation

One judge, a Ph. D. in Physics Education and a programmer in Macromedia Authorware 4.0, made recommendations regarding the visual effects of the instruction module and recommended a decrease in the use of instructions. Another judge, a Ph. D. in Cognitive Psychology, recommended restructuring the practice tests for the control and experimental groups. The three certified flight instructors/ground school instructors, who evaluated the emulator at the end of the development phase, had no comments regarding the content or context of the instructional module nor any comments on the content or context of the practice tests or Flight Deck Cognitive Emulator.

Responses During Data Collection

During data collection, three subjects had minor problems with the program. In each case the subject had performed an operation outside the parameters of the instructions. Each situation was very quickly remedied and the subject was able to complete the tests without further incident. One subject had difficulty logging into the test. In this case the subject had made a spurious input that the computer did not accept. The procedure was reaccomplished under supervision and the subject was able to successfully enter the program.

No feedback form was used to capture each subject's comments regarding the content or context of the emulator. However, a verbal debrief was conducted after each session. The most common comment made was in regard to the employment of each subject's coping strategy during the Flight Deck Cognitive Emulator test. In every case, the subject tried to read the question before the digital movie began. For example, each digital movie had a beginning title screen, which delayed the playing of the movie by three seconds. As soon as the title screen erased, the visual and audio elements of the digital movie commenced. This gave the subjects a narrow window of opportunity within which to quickly read the question without distraction. Most of the other debriefing comments centered on the subject's feelings about how well or poorly he or she performed on the practice test or Flight Deck Cognitive Emulator test. No comments were made that suggested that the tests were invalid or irrelevant.

Inter and Intra-Group Relationships

A purposive sampling technique was used to gather subjects for this study. Except for Rose State College, the sample sizes were small in relation to the total population at OU and OSU. Subjects were randomly divided into control and experimental groups. As recommended by Wiersma (1995) and Gay (1976/1996), a relationship between the performance ability of the sample and the total population was drawn. All results were derived from the raw data collected by the Computer-Managed Instruction software and is available for review in Appendix D.

University of Oklahoma

Sixty-three students, enrolled in the private pilot course, completed the pretest. The class demographics were 8 female and 55 male students with a mean age of 21 years. From the total number, 9 students (N = 9) volunteered for the study with a mean age of 24 years. Of the volunteer group there were three females and six males. Two of the females were 18 year old freshman subjects and one was a 22 year old junior. The female subjects represented 37.5% of the female population. The male subjects represented 10.9% of the male population. The age range of male subjects was 19-34 years of age. Three of the male subjects were post-undergraduate degree students (ages 24, 24, & 32), another male subject was a freshman (age 19), another a sophomore (age 34), and still another a junior (age 27). Figure 4 indicates the distribution of pretest scores in an ascending order with mean = 84, median = 84.5, and mode = 70 (Figure 5). The range of scores on the pretest was 59-103.

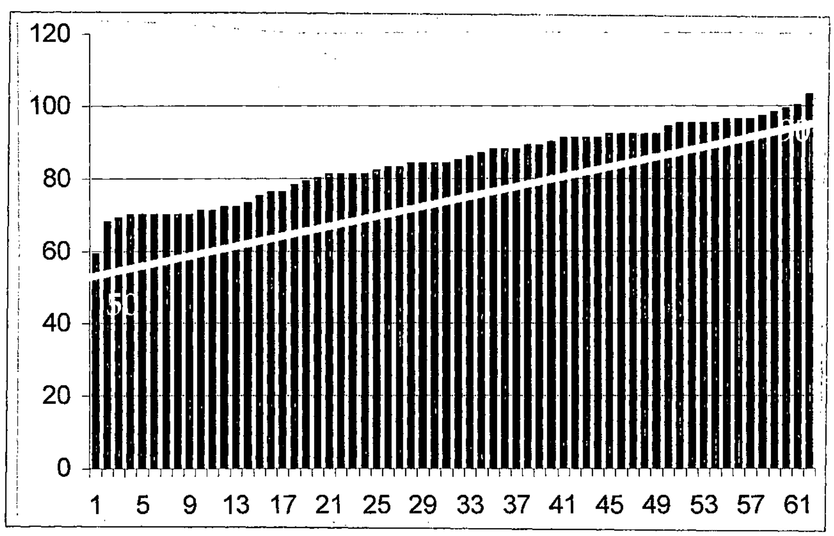


Figure 4. University of Oklahoma Pretest Score Distribution.

Figure 6 shows how these scores relate to all of the students enrolled in the private pilot courses taught at OU, Rose State College, and Oklahoma State University. The subject group range of posttest scores was 50-90, indicated by the line on Figure 4 and Figure 6. The pretest/posttest distributions are illustrated on Figure 5.

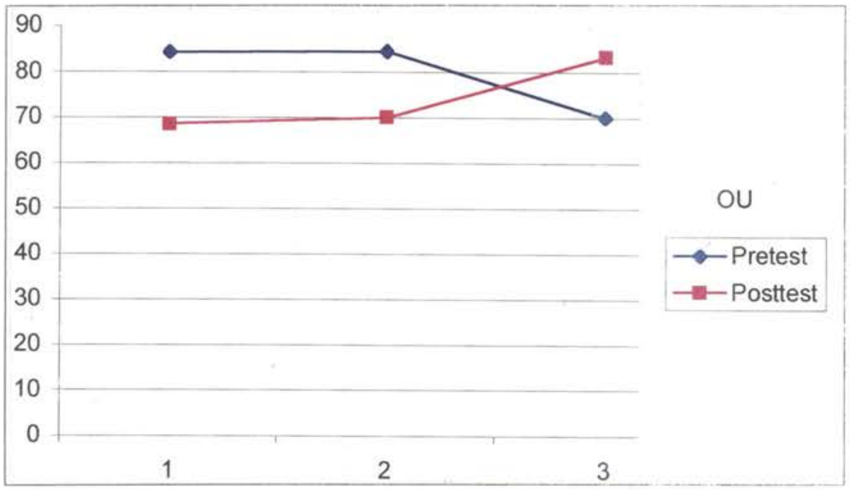


Figure 5. University of Oklahoma Pretest/ Posttest Distribution.

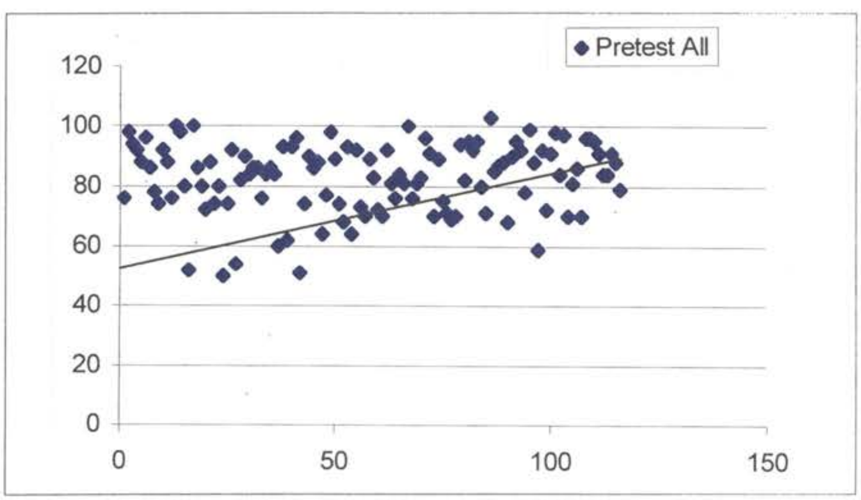


Figure 6. Pretest Scores for All Students.

Rose State College

Fourteen students, enrolled in the private pilot course, completed the pretest. The class demographics were 1 female and 13 male students with a mean age of 30 years. From the total number, 13 students (N = 13) volunteered for the study with a mean age of 31 years. Of the volunteer group there was 1 female and 12 males. The female subject was 54 years old with hours toward an undergraduate degree and represented 100% of the female population. The age range of the male subjects was 19-43 years. Two of the male subjects were post-undergraduate students (ages 37 & 38), four freshman students (ages 34, 23, 34, & 25), four sophomore students (ages 21, 19, 38, & 20), one junior (age 20), and one senior (age 43). The subject males represented 92% of the male population. The following figure (Figure 7) indicates the distribution of pretest scores in an ascending order.

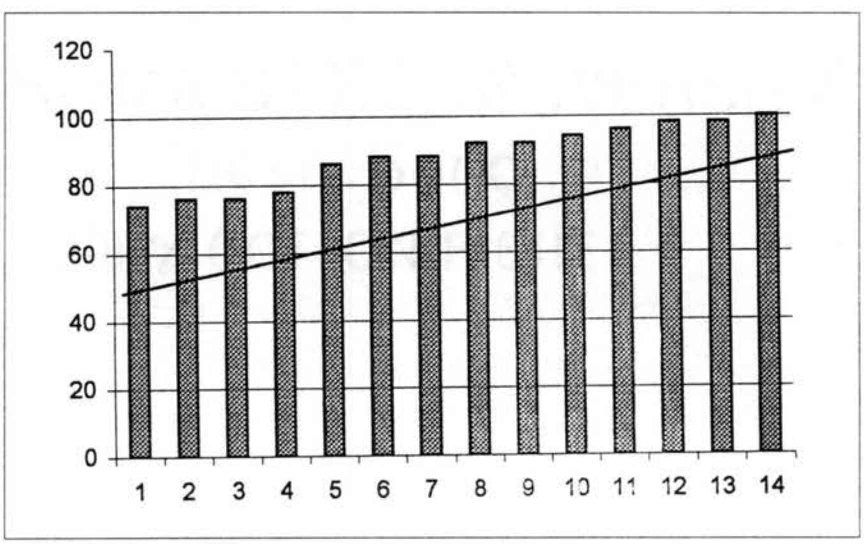


Figure 7. Rose State College Pretest Score Distribution.

The measures of central tendency were mean = 88, median = 90, and mode = 76. The range of pretest scores was 74-100 (see Figure 7). The Rose State range is depicted on Figure 8 along with the OU range.

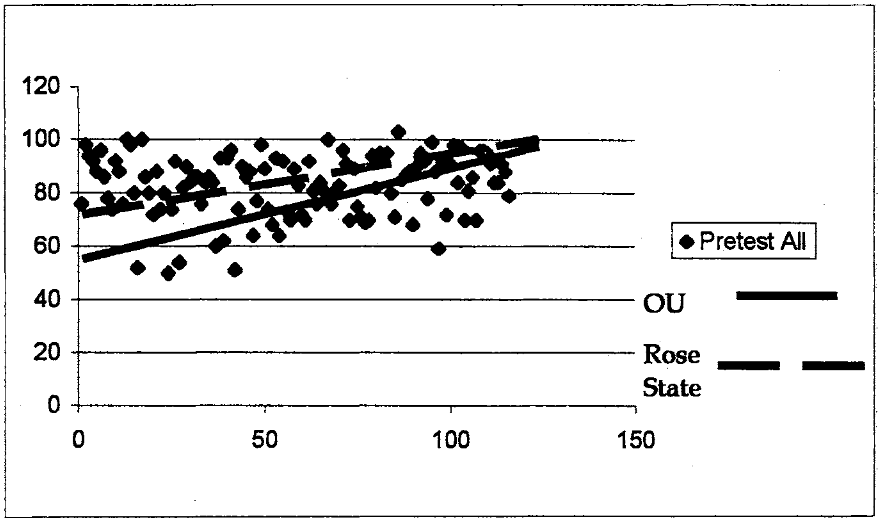


Figure 8. Pretest Scores For All Students (OU & Rose State).

The range is compared with all students taking the pretest.

Figure 10 shows a comparison between pretest and posttest scores for Rose State subjects. The range of scores on the posttest was 43-90. Figures 9 and 10 show pretest mean, median, and mode.

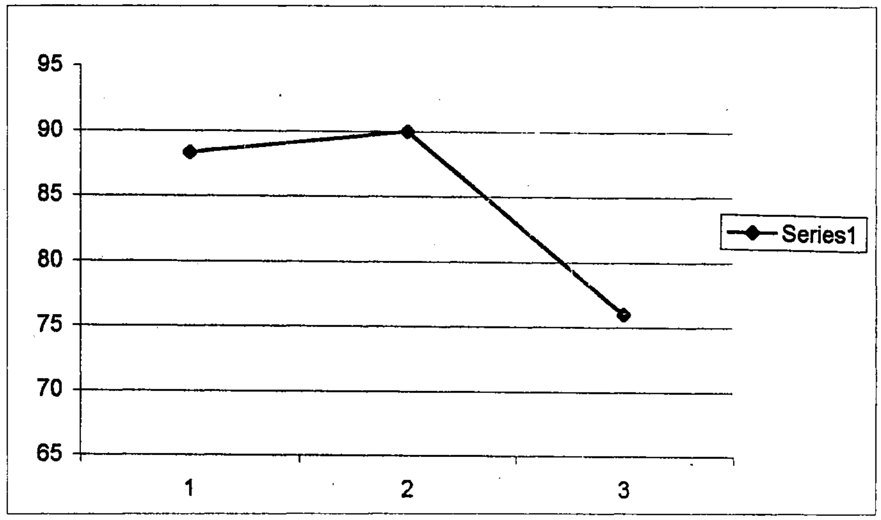


Figure 9. Rose State College Mean, Median, Mode.

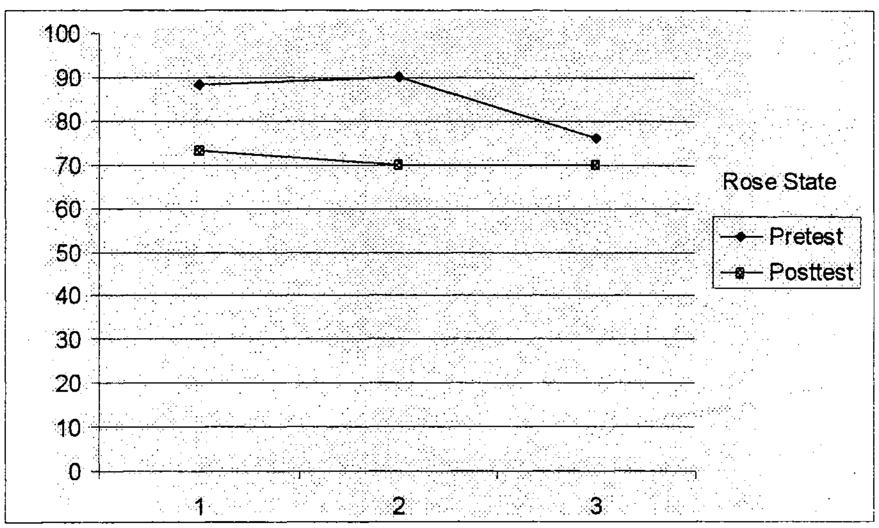


Figure 10. Rose State College Pretest/Posttest Mean, Median, Mode.

Oklahoma State University

Forty-one students, enrolled in the private pilot course, completed the pretest. The class demographics were 4 female and 37 male students with a mean age of 19.5 years. From the total number, 12 students (N = 12) volunteered for the study with a mean age of 18.91 years. Of the volunteer group there was 1 female and 11 males. The female subject was an 18 year old freshman and represented 25% of the female population. There were seven freshmen (ages 17, 21, 18, 18, 18, 20, & 18), two sophomores (ages 19 & 20), and two seniors (both 21 years old). The male subjects represented 29.7% of the male population.

Figure 11 indicates the distribution of pretest scores in an ascending order. The measures of central tendency were mean = 79, median = 83, and mode = 86. The range of scores on the pretest was 50-100. Figure 12 indicates the mean, median, and mode of the pretest/posttest distribution.

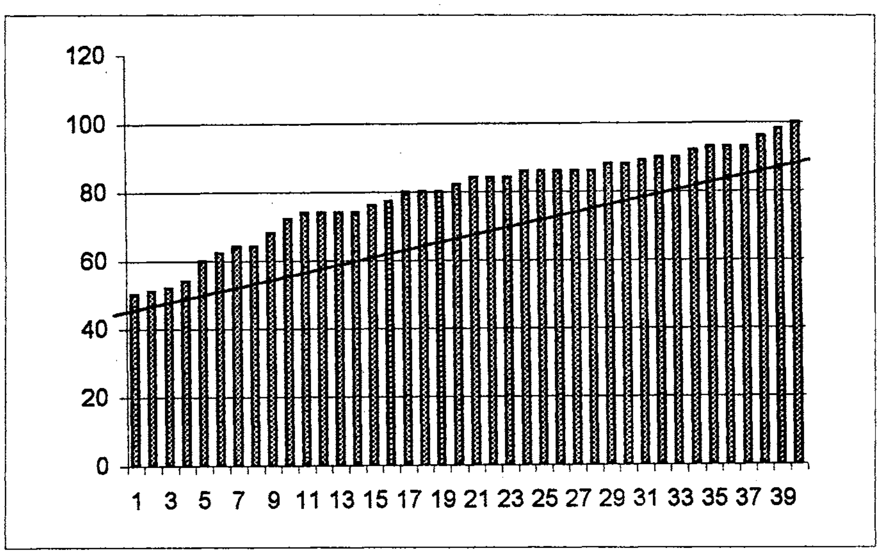


Figure 11. Oklahoma State University Pretest Distribution.

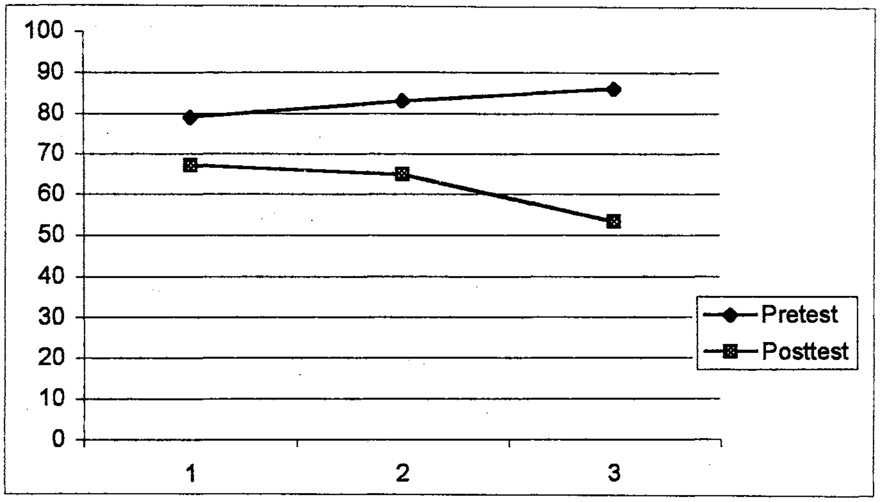


Figure 12. Oklahoma State University Pretest/Postest
Mean, Median, Mode.

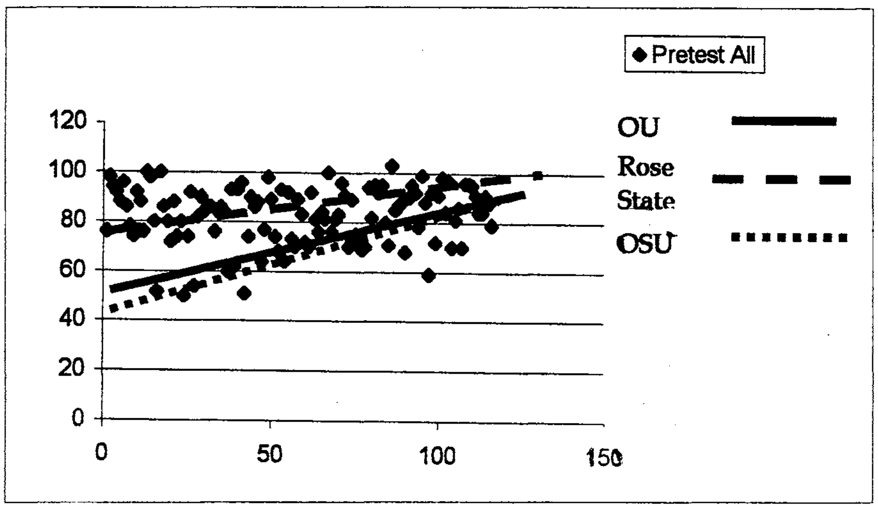


Figure 13. Pretest Scores For All Students (OU,
Rose State, and OSU).

Figure 13 shows how the posttest scores relate to all of the students enrolled in the private pilot courses taught at the three schools. The subject group range of posttest scores was 46-93, indicated by the line on Figure 11 and Figure 13

The 80% Standard Among Groups

OU and OSU are Part 141 aviation training schools that must ensure that 80% of their students pass the end-of-course test the first time or the Flight Standards District Office of the FAA will remove the school's Part 141 certification. Rose State College is a Part 61 training school–not governed by the same standard at Part 141. Figure 14 shows the posttest scores of all three institutions in relation to a 70% pass/fail line (assuming 70 is the lowest possible passing grade).

Pretest scores from OU (mean = .84) and Rose State (mean = .88), and OSU (mean = .79) are above the performance standard. Posttest scores showed a uniform decrease by nearly 10 points from pretest means. An illustration of the means for pretest/posttest scores is shown in Figure 14. OU and OSU posttest score means are below the passing mark.

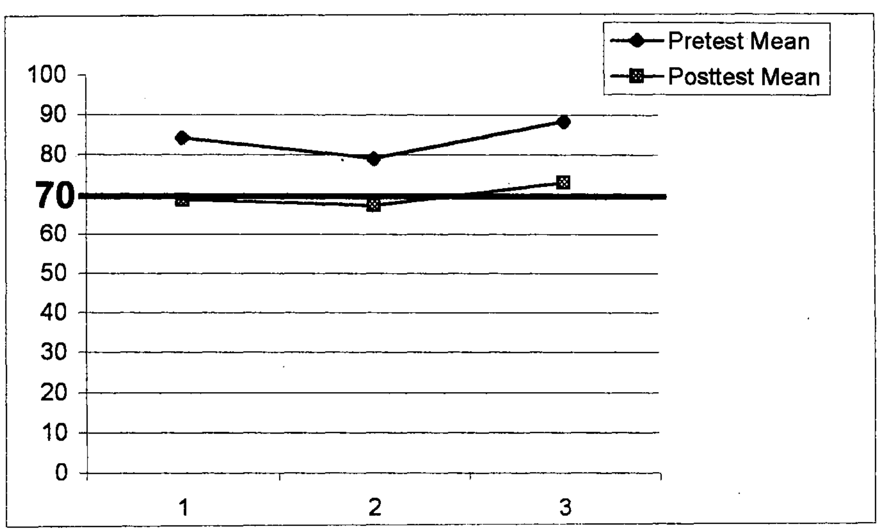


Figure 14. Pretest/Posttest Comparison, All Three Schools.

Findings Between Groups, Pretest

Pretest scores showed a variance between schools. OU (Figure 1) and OSU (Figure 11) students appeared to be more related than Rose State (Figure 7) students and OSU students. An age variance also existed, as indicated in Figure 15. Most of the subjects were under the mean age of 25 years. Rose State students were above the mean,

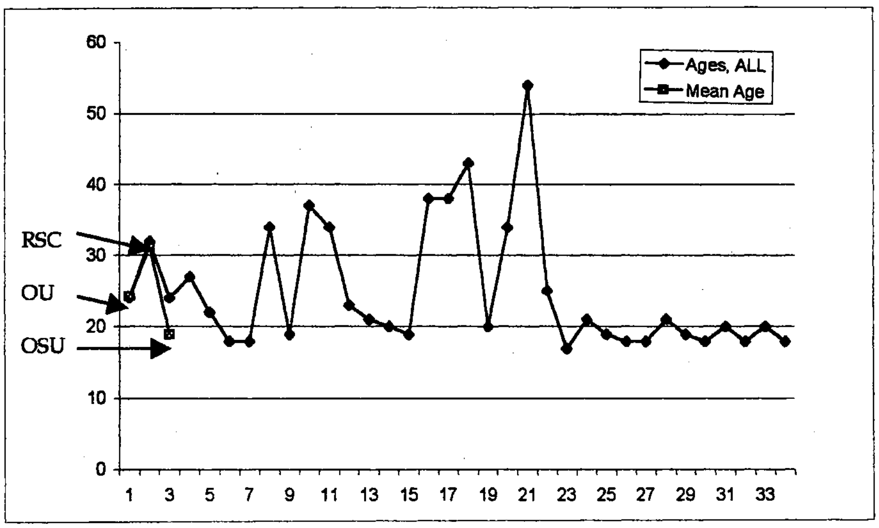


Figure 15. Age Comparison Chart, All Three Schools.

OU was nearly at the mean, and OSU was below the mean. Another variance was education (Figure 16). Most of the subjects were undergraduate students at the sophomore level. Figure 16 is divided by two vertical lines at the 9 and 23 subject part of the scale. This division makes it easier to see the education/age differences between groups. The heavier horizontal line indicates the mean age of the subject pool. Again, it is easier to see the difference between groups with a horizontal indicator of average age.

Another variance accounted for in this study was motivation. The students of all three programs could enroll in the course using elective credit hours or core course credit hours. Appendixes E and F show the individual testing patterns of each subject. In Appendix E, the distraction test is the same as the posttest. The number "3" indicates the

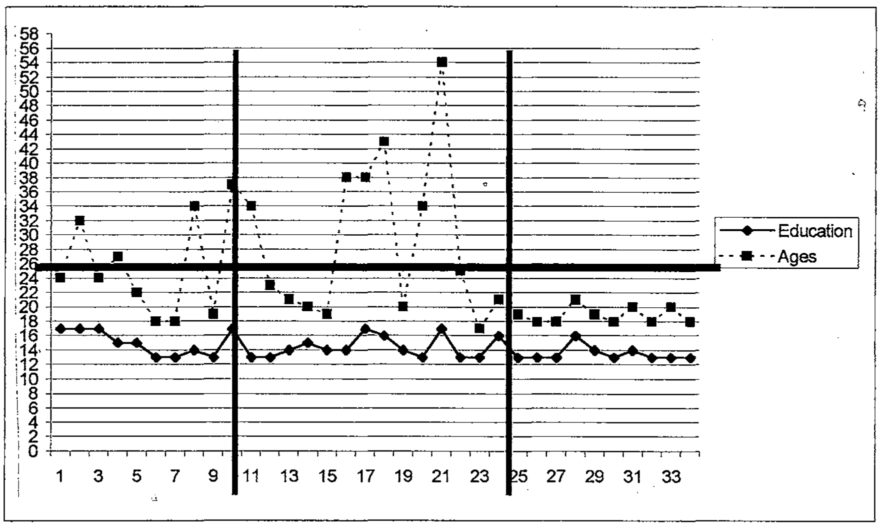


Figure 16. Education and Age Comparison, All Three Schools.

the subject did not answer within the 45-second time limit and the questions were graded as incorrect. A "0" indicates an incorrect answer, while a "1" indicates a correct answer. In Appendix F, incorrect answers are on the bottom of the scale, while correct answers are at the top. The indications of incorrect/correct choices in Appendix F resemble a sawtooth pattern. This graphing technique made it easier to see latent tendencies for individual test-taking.

Individuals were assessed by age group. The subjects of all three intact groups were divided into five sub-groups: group 1 (17-21), group 2 (22-25), group 3 (26-30), group 4 (31-36), and group 5 (37-55). Posttest scores were collected by age group and a mean was determined. The following results were collected: group 1 (mean = 68), group 2 (mean = 66), group 3 (mean = 83), group 4 (mean = 77), and group 5 (mean = 67).

Testing time was also assessed and showed differences between groups. Appendix G shows these differences in Figures G1, G2, and G3.

Short-term memory was measured by test score variances between the experimental practice test and the posttest. Feedback, displayed as correct or incorrect, was given to each subject who completed the 15-question experimental practice test. The control group were not given any feedback for correct or incorrect answers. The same 15 questions were given to the experimental group using the Flight Deck Cognitive Emulator format. Differences between control and experimental groups were noted. Figure 17 shows the difference between practice test (mean = 80)/posttest scores (mean = 69) for the experimental group.

Figure 18 shows the difference between practice test (mean = 82)/posttest scores (mean = 70) for the control group.

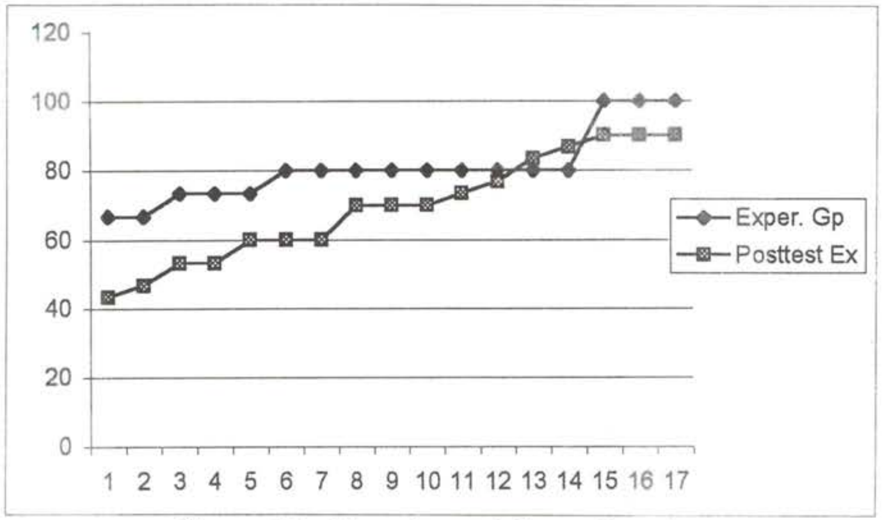


Figure 17. Experimental Group Practice Test/Posttest Comparison.

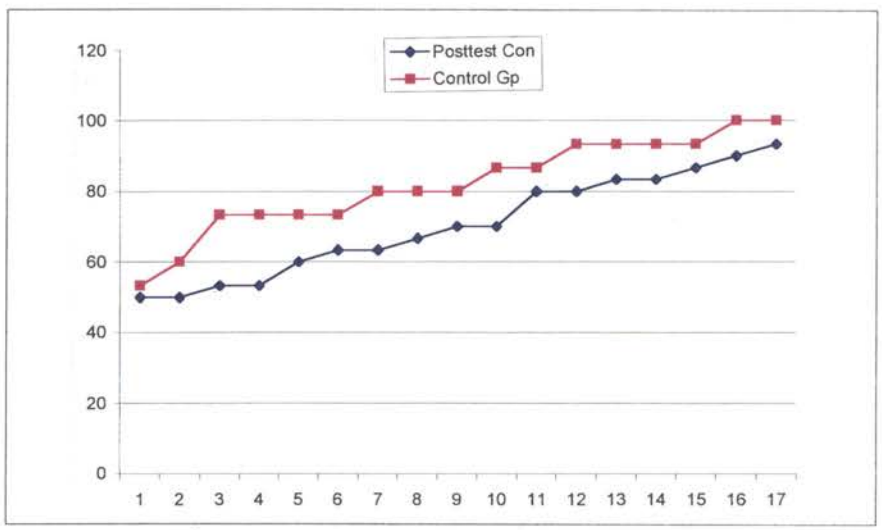


Figure 18. Control Group Practice Test/Posttest Comparison.

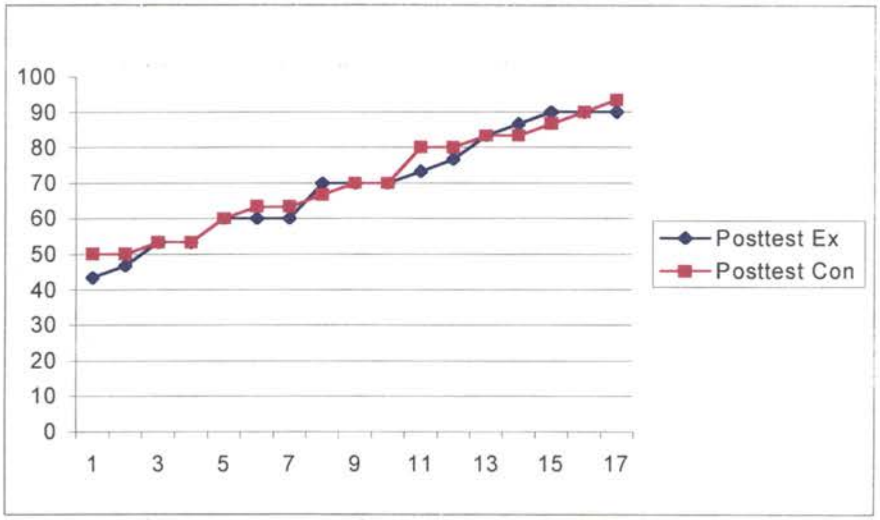


Figure 19. Experimental and Control Posttest Comparison.

Figure 19 shows the difference between the experimental group and control on posttest scores.

Correlation

Hypothesis One

Does the context of cognition differ in relationship or degree between the private pilot classroom and private pilot flight lessons in the aircraft?

The context of the classroom was assessed from pretest scores, and the context of private pilot flight lessons (aircraft or flight deck environment) was assessed from the posttest scores. The intact groups were divided into control and experimental groups. Correlation coefficients were derived using the Pearson *r* statistic.

The pretest population was larger in every case from that sampled. To remedy this disparity a random sample of pretest scores, not to exceed an intact group sample size, was used to determine a correlation. The sample size (N = 34) was compared with a randomized sample of pretest scores from the three schools. The correlation coefficient, using the Pearson *r* statistic, was $r = 0.98$ between pretest and all posttest scores for all intact groups. Figure 20 indicates the relationship graphically. Pretest and experimental group posttest correlation was calculated at $r = 0.969$, and pretest and control groups pretest correlation was $r = 0.965$. Degrees of freedom were 32. Based on a level of significance of $p = .05$–a correlation coefficient had to be above .3306 to show a relationship (see Table A.2 in Gay, 1996).

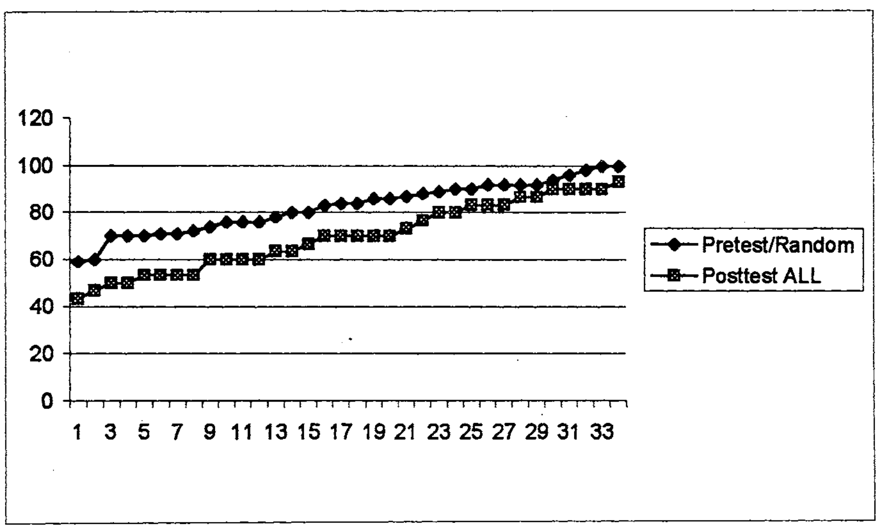


Figure 20. Pretest/Posttest Scores For All Groups.

Hypothesis Two

There is a strong relationship between subjects in the same context of learning.

Pretest scores showed a variance between groups. Mean/Median/Mode indicators of central tendency for OU pretest scores were 84/84/70 (SD = 10.11). For Rose State College the split was 88/90/76 (SD = 9.04). For OSU the indicators of central tendency were 79/83/86 (SD = 13.44).

Experimental group scores (N = 17) on the practice and posttest showed a correlation coefficient of $r = .85$. The level of significance was computed at $p = .05$ and $df = 15$. A .4821 or greater coefficient was needed to indicate a level of significance (Gay, 1996). T scores were calculated on pretest/posttest scores for the experimental group ($t = 3.49$; $p = .01$; $df = 15$) and the control group ($t = 2.25$; $p = .01$; $df = 15$) (Table A.4, Gay, 1996). Control group scores (N = 17) on the practice and posttest showed a correlation of $r = .94$. A .4821 or greater coefficient was needed to indicate a level of significance (Table A.2, Gay, 1996), computed at $p = .05$ and $df = 15$.

A nearly straight-line relationship between posttest scores for experimental and control groups (N = 34) of all three schools showed a correlation coefficient of $r = .98$. A .3396 or greater coefficent was needed to indicate a level of significance (Gay, 1996), computed at $p = .05$ and $df = 32$.

Hypothesis Three

There is a weak relationship between subjects in different learning contexts.

A correlation coefficient of $r = .98$ was derived from pretest/posttest test scores. A slightly different correlation was derived from pretest/control group posttest scores for all schools ($r = .965$). An average of pretest and practice tests were correlated. The data were correlated using $p = .05$ and $df = 15$ to determine the level of significance. Based on Table A.2 (Gay, 1996) a correlation coefficient of .4821 or higher had to be achieved to show significance.

The relationships changed when individual school control groups were compared with pretest averages from the same school. The correlation coefficients were: OU, $r = .87$ ($df = 4$); Rose State, $r = .94$ ($df = 4$); and OSU, $r = .88$ ($df = 5$). Based on Table A.2 (Gay, 1996) a correlation coefficient of .8114 (OU, Rose State) and .7545 (OSU) had to be achieved to indicate a level of significance. An additional computation was completed to determine the relationship between the prestest and the experimental group practice test scores within the same school. The correlation coefficients were: OU, $r = .70$ ($df = 4$); Rose State, $r = .89$ ($df = 4$); and OSU, $r = .83$ ($df = 5$). The same test of significance ($p = .05$) was applied to the experimental group as was applied to the control group.

This chapter supplied the reader with the raw data gleaned from pretest and posttest scores from volunteers culled from three intact groups of students. Chapter V will summarize the study, make conclusions based on the data in this chapter, and list recommendations for further study.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study was conducted to investigate if, and to what extent, a cognitive difference existed between the classroom environment and the flight deck environment in the private pilot training program. There appeared to be differences between the two environments based on how inhibition was employed. The classroom was characterized as a learning environment with low arousal and low sensory stimuli. The aircraft or flight deck was characterized as a learning environment with moderate to high arousal and moderate to high sensory stimuli. It was reasoned that traditional assessment tools, like multiple-choice tests, could adequately measure the results of classroom cognition. However, no cognitive instrument was available to emulate or assess the flight deck environment. Therefore, a review of the literature was completed to discover what theoretical basis would best fit the parameters of a flight deck cognitive emulator, and to derive a methodology for constructing such a device.

Throughout the review of the literature, numerous theories were presented, which drew from aviation psychology (Telfer & Biggs, 1988) and cognitive psychology (Glanzer, Fischer, & Dorfman, 1984; Jacoby & Brooks, 1994; Keenan, Baillet, & Brown, 1984; Rafal & Henik, 1994; Townsend, 1992). One result of the review was the discovery that inhibition was a characteristic existent in the classroom and the aircraft. Yet the employment of inhibition techniques was not found to be equal for the classroom and the aircraft (Telfer & Biggs, 1988).

A study of the differences between contextual environments of learning needed not only a theoretical basis, but a conceptual model. The classroom model had already been defined by the literature, as viewed through the work conducted by the Chesapeake Institute and Widmeyer Group (1994) for Attention Deficit/Hyperactivity Disorder individuals. This group, deficit in inhibition ability, provided a unique insight into inhibition learning.

Telfer and Biggs (1988) indicated in The Psychology of Flight Training that student pilots needed to learn how to inhibit the vast number of stimuli present in the aerial environment. An Inhibition Testing Model was, therefore, developed. It was based on a review of cognitive theory and personal experience with the flight deck environment. Personal observations were compared to other characterizations of the flight deck by certified flight instructors in the private pilot training programs at the University of Oklahoma and Oklahoma State University. Chapter III , Figure 1 shows an illustration of the Inhibition Testing Model.

The model incorporated elements from the Scan Test, used by the Caliber Associates (1999) to test potential air traffic controllers and cue theory (Jacoby & Brooks, 1984), controlled by and measured against time. From the model a computer program was developed to emulate the model. The emulated model was called the Flight Deck Cognitive Emulator.

A representative cognitive baseline of knowledge was derived from the FAA Airman Knowledge test bank and Jeppesen-Sanderson courseware. A 30-question test was developed and inserted within the Flight Deck Cognitive Emulator.

Three schools participated in the study: the University of Oklahoma, Rose State College, and Oklahoma State University. From these schools 34 students volunteered to undergo testing. Between September 16 and November 11, 1999 the Flight Deck Cognitive Emulator was used to gather data. The findings from that data were listed in Chapter IV. What follows are the conclusions based on those findings.

Conclusions

This study was designed to determine if, and to what extent, a relationship or a difference existed between the classroom and the aircraft in private pilot training. Three hypotheses were formulated.

H.1. The context of cognition differs in relationship and degree between the private pilot classroom and private pilot flight lessons.

H.2. There is a strong relationship between subjects in the same context of learning.

H.3. There is a weak relationship between subjects in different learning contexts.

Future Use of the Flight Deck Cognitive Emulator

The intial use of the Flight Deck Cogntive Emulator was successful in two ways. First, the program presented the media efficiently and effectively, while recording each subject's scores and time duration within each question. Second, the validation process and the data collection results both suggested that the instrument could provide an alternative cognitive environment. However, in future testing, the program will be enhanced to improve the impact of the distractions.

Relationships and Differences: Conclusions Of the Two-Study Approach

The evolving nature of this study apprehended useful elements of qualitative and quantitative research designs. The working hypotheses were tested and retested using cogent studies like the one shown in Appendix D. That study tested the relationship between existing courseware and cognitive theory. When relationships were found, as they were in the Jeppesen-Sanderson material, the content was adjusted to reflect best practices in the area of aviation training. These best practices were further evaluated by certified flight and ground instructors during the small group validation phase. All of these studies and processes were absolutely vital to the development of an instrument that would help quantify the results. In essence, a qualitative study was performed to help develop the quantitative study. The qualitative study helped to establish relationships between theory and practice and the quantitative study helped to measure the difference.

The two-study approach proved to be effective in containing the boundaries of the review of the literature. In a similar fashion, the instructional systems design method provided a systematic approach, which resulted in the selection of the medium, creation of the instrument, and the development of the instructional module.

In another way, the two-study approach was more scientific, in that the scientific method of unrestricted inquiry guided the overall process. The qualitative design allowed new hypotheses to be formulated, tested, and either accepted or rejected based on the light of compelling results from related studies. For example, the introduction of retrieval-cue theory into the inhibition testing model was realized only after carefully examining studies that indicated this theory's relevance to aviation training. The same was true for the introduction of visual and auditory distractors.

What follows are a number of conclusions based on the effect of the findings of Chapter IV on the stated hypotheses.

Hypothesis One: Conclusions

A pretest/posttest design was used to measure the relationship between the context of cognition in the classroom and the aircraft. Each cognitive context consisted of two elements, the learning environment and the lesson plan. The pretest/posttest scores were used to compile statistics which represented indications of the learning environment and the impact of the lesson plan on an experimental group and a control group. A pretest was administered by the faculty of each school represented in the study. A posttest was administered by the author of this study within weeks of the pretest.

Homogeneity Among Groups

Most of the subjects were under the age of 25. More students were freshmen and sophomores than juniors and seniors. OU and OSU subjects were mostly freshmen and sophomores. Rose State's mean age was 31 years, slightly higher than the mean age. OU's mean age was 24 and OSU's was 19.

The results of the pretest indicated a slight but negligible difference in relationship among the three groups. The University of Oklahoma students who completed the pretest numbered 63. The pretest mean was 84 with a range from 59-103. Rose State students who completed the pretest numbered 14. Their pretest mean was 88 with a range from 74-100. Oklahoma State University students who completed the pretest numbered 41. The OSU pretest mean was 79 with a range from 50-100. Rose State's range of scores and mean score were slightly higher than OU and OSU. A graphic representation of the ranges within all pretest scores is available in Chapter IV, Figure 13.

Scores from the control group, using a traditional multiple-choice instrument, were used to compare the subjects to their peers from each of the three schools. The University of Oklahoma pretest/practice test ranges were 59-103 and 53-100. Rose State pretest/practice test ranges were 74-100 and 73-100. Oklahoma State University pretest/practice test ranges were 50-100 and 73-93. Except for OSU, the range comparison indicated the subjects from each school approximated the total population in knowledge of the subject.

Course Content Differences Among Schools

Differences among schools were indicated by a comparison of pretest and control group test means. The prestest means were OU (84), Rose State (88), and OSU (79). The control group practice test means were OU (76), Rose State (86.6), and OSU (83).

The lack of continuity between test score means for the two tests provided a first indication that course content may have been different for each group. The pretest measured course content based on the Jeppesen-Sanderson text and class lectures, while the control group practice measured course content based on what the FAA determined to be important. If the instructors from each group used the Jeppesen-Sanderson practice test book for pretest questions, then control group test results should nearly approximate pretest scores. Based on that logic, it would appear that OU did not use the Jeppesen-Sanderson practice test, while Rose State's pretest and control group means would indicate the pretest contained many of the Jeppesen-Sanderson practice test questions. OSU's showing on the control group test might indicate that the FAA test was easier than the pretest.

A posttest item analysis revealed differences in lesson content between schools. OU indicated a weakness in airspeed definitions, stability, load factor related to stalls, stall and spin characteristics, effects of ground effect, and aerodynamic forces caused by the propeller (questions 1, 3, 9, 11, 13, 18 & 29). Rose State indicated a weakness only in aerodynamic forces caused by the propeller (question 29). OSU showed weaknesses in relationships between kinds of airspeed, load factor related to stalls, the effect of torque, stability, and aerodynamic forces caused by the propeller (questions 5, 13, 23, 24, & 29).

Age and Experience Differences

Rose State and OU were more closely aligned in age. None of the OSU subjects was older than 21. The oldest subject was a 54-year-old female from Rose State. Many of the subjects from Rose State worked full time and were going back to school to get a degree. This was true of nearly 50% of the OU subjects. OSU subjects were all undergraduate degree students; some had an outside job and others did not.

Correlation Between Pretest and Posttest

A pretest analysis of subjects extracted from each group indicated that each intact subject group resembled the greater population of students enrolled in the private pilot course within the same school (Figure 13). However, when these students were given a posttest, their test score means dropped by more than 10 points.

TABLE IV

PRETEST/POSTTEST MEANS

School Name	Pretest/Posttest Means
University of Oklahoma	84/68
Rose State College	88/73
Oklahoma State University	79/67

A correlation between pretest and posttest scores ($r = 0.98$) indicated a strong relatedness between the pretest subject matter and that on the posttest. Therefore, it was surmised that the input of each instructor at each school made no significant impact on relatedness. The course text, being consistent among schools, provided a constant of information. However, the differences between pretest and posttest means, as shown in Table IV, indicated a difference in the other element of the cognitive context, the learning environment.

Accounting For Variances Among Groups

Three specific variances between groups emerged during the study. These variances characterized each school as a distinctive learning environment. First, course content among the schools was not the same. The difference in pretest/posttest score means between schools indicated that Rose State was better prepared for the FAA test than were OU or OSU. Appendixes E and F show that more than 50% of Rose State subjects missed question 29. However, more than 50% of OU subjects missed questions 1, 3, 9, 11, 13, 18, and 29. At OSU, more than 50% of the subjects missed questions 5, 13, 23, 24, and 29. In Appendix G, Figure G1 shows a more uniform range of testing times for Rose State. A slight dip in times occurred for questions 17-21, but was not as pronounced as OU and OSU. OU and OSU, Figures G2 and G3, show more variation among subjects and a pronounced dip in the 17-21 range of questions for OU and a pronounced dip in the 15-22 range for OSU. It would appear that these questions were easier or had been covered in class.

Second, the age difference between Rose State and the other schools may have affected the outcome on the test. The data indicated that Rose State's students were more knowledgeable about material tested on the pretest and posttest than were OU and OSU. Statistically, the two age groups, 26-30 and 31-35, represented the higher mean scores for the posttest and practice tests. Rose State's mean age was 31 years. The older subjects may have had prior aviation knowledge or greater overall knowledge on a variety of subjects. Testing time may also show a difference in age. The uniform nature of testing times shown in Appendix G, figure G1, may indicate that Rose State subjects had more confidence with the material or were not rattled by the distractions on the posttest.

A third variable, which may have affected the lack of relationship between the pretest and posttest environments, may have been the significant change in instruments. The pretest was a multiple-choice test given in a quiet classroom environment. The posttest used similar course content, but in addition emulated the cognitive distractions most often observed on the flight deck of an aircraft while requiring the subject to answer fill-in-the-blank questions.

Many of the variances were remedied by the inclusion of an instructional module. All subjects were afforded time to review course content before taking the posttest. The instructional module (Appendix C) was reviewed by eight of nine testing subjects at the University of Oklahoma. However, only one subject from Rose State reviewed the instructional module and none of the Oklahoma State University subjects desired to review the course material.

Short-Term Memory Assessment

A practice test, modified for the experimental and control groups, was administered to measure the effectiveness of short-term memory on the posttest scores. The experimental group received a correct or incorrect remediation after answering each practice question. Those same questions were included in the posttest, but in the form of a fill-in-the-blank question. It was surmised that the added benefit of remediation would help the students do better on the posttest. However, as Figures 21 and 19 indicate, the presence of remediation did not have as great an effect as seeing 50% of the questions, no matter what the form.

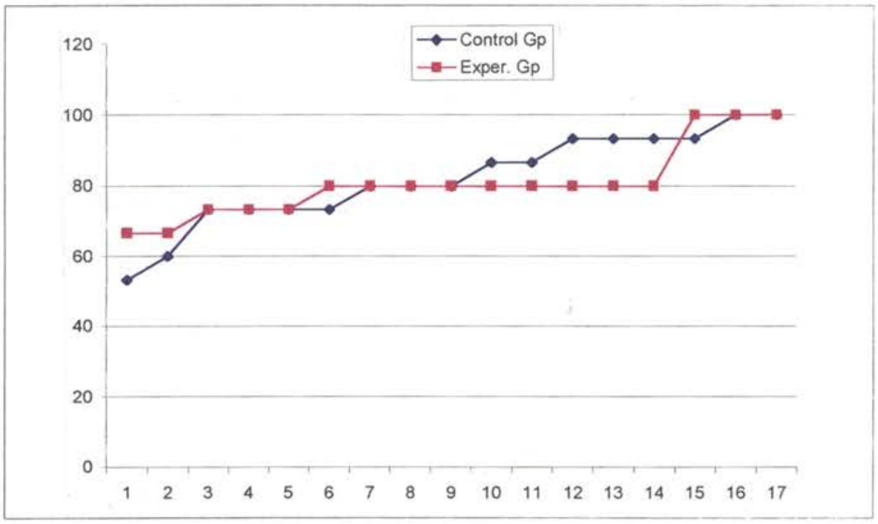


Figure 21. Practice Test Comparison For Experimental and Control Groups.

Hypothesis Two: Conclusions

The findings indicated that a strong relationship existed among the three schools on pretest/posttest scores. T scores were calculated on pretest/posttest scores for the experimental group ($t = 3.49$; $p = .01$; $df = 15$) and the control group ($t = 2.25$; $p = .01$; $df = 15$) (Table A.4, Gay, 1996).

Relationships weakened within the same context of learning within the same school. For example, OU's mean (84), median (84), and mode (70) indicated that students within the OU private pilot course had done well on the three-chapter test (pretest). However, the standard deviation (SD = 10.11) indicated that the individual scores were wide ranging. The same was true with Rose State. Their students' scores were represented by a mean of 88, median of 90, and a mode of 76. But the standard deviation indicated some distance between individual scores (SD = 9.04). OSU's student scores were represented by a mean of 79, media of 83, and mode of 86, the lowest mean of the three schools. Their standard deviation indicated an even greater disparity among individuals (SD = 13.44).

The correlation coefficients of the pretest/practice test for the experimental group (r = .85) and control group (r = .94) indicated a high level of relationship at a significance level of p = .05 and df = 15.

The correlation coefficient of posttest scores (r = .98; N = 34; df = 32; p = .05) for the experimental and control groups suggests a significant relationship within the flight deck cogintive environment.

Hypothesis Three: Conclusions

Was there evidence of a weak relationship between subjects in different learning contexts? To assess significance, each control subject group from each school was compared with an average of the pretest group from the same school. The schools were assessed separately because of the variance in course content and age identified between groups.

As indicated in Chapter IV, a level of significance was established based on the correlation coefficients for pretest/control group posttest scores (r = .965) of all the schools. This relatedness linked the subjects of the three schools in a general sense. It would appear that, despite variances between and among classrooms, the Jeppesen-Sanderson text gave each student an equal chance of succeeding. However, the variance of lecture content interfered with the text in ways which were discernible only by measuring the differences between means.

To determine the extent of the content interference variance between schools another computation was completed, this time accounting for pretest/control group practice test scores within the same school. The correlation coefficients were different from the cumulative coefficient. The correlation coefficients were: OU, $r = .87$ ($df = 4$); Rose State, $r = .94$ ($df = 4$); and OSU, $r = .88$ ($df = 5$). Based on Table A.2 (Gay, 1996), if $p = .05$, then all three schools showed a level of significance in relationship between the pretest environment and the control group environment. This was not surprising given that the control group test was the closest approximation to the pretest.

An additional computation was completed to determine the relationship between the pretest and the experimental group practice test scores within the same school. The same test was given to the control and experimental groups, but the experimental group test included low-arousal distractions. The resultant correlation coefficients were: OU, $r = .70$ ($df = 4$); Rose State, $r = .89$ ($df = 4$); and OSU, $r = .83$ ($df = 5$). In this case, OU did not indicate a relationship, however, Rose State and OSU did show a relationship.

All three schools showed a decrease in relationship when a new contextual environment was introduced. This was important since it approximated a similar change when subjects were given the posttest (Chapter IV, Figure 14). Therefore, based on the diminution in relationship between pretest and the experimental group practice test scores and a similar diminution between pretest and the control group practice test scores for each school, it would appear that a weaker relationship exists when contexts of learning are changed.

Recommendations

Several areas of concern were noted during the study–concerns that should lead to further study. The numbers of subjects of this study were adequate to show correlation, but may not be sufficient in number to generalize the results. Therefore, this study should be replicated using three different intact groups of private pilot students. Subject characteristics of age and experience should be similar to subjects in this study. The researcher should note testing variations between schools as an indication of instructor influence and teaching effectiveness. A second element of the study should evaluate the general knowledge of instructors at each location. Further, the lesson plans of each instructor should be reviewed to determine whether all of the objectives are included for instruction. The researcher should also write the pretest instrument to be administered by all three schools. This pretest instrument should be controlled and used each time the study is replicated.

Another area of concern was the use of the Flight Deck Cognitive Emulator. It was effective in showing differences between learning environments; however, it has yet to be established whether the emulator truly replicates the cognitive environment of the flight deck. In principle, the emulator appeared to contain many of the distraction elements of the flight deck, but no tests were conducted between the emulator and a simulator or between the emulator and an actual flight whereby one could ascertain a relationship between the emulator and the flight deck. Therefore, before the emulator can be used for routine training in the classroom, it must be further validated in flight trials.

Another area of concern was the difference between Part 141 and Part 61 ground schools. It appeared that Rose State's Part 61 ground school students were better informed than the Part 141 ground school students attending the University of Oklahoma or Oklahoma State University. It was not clear whether the better test scores of Rose State were indicative of better instruction, or the lack of pressure to meet the FAA standard of 80%. Therefore, a three-year longitudinal study of the three schools should be conducted. It is recommended that the researcher compare the classroom test scores against test results on the FAA Airman Knowledge test for each Part 141 and Part 61 school.

Semantics and episodic memory were two areas of concern that were not fully tested in this study. The word study on referent pairs needs to be validated by ground and flight instructors. The prime and associative referents appeared to be logically derived; however, the relationships were theoretical in nature and not practical. One should determine what words each instructor associates during the course of instruction in the classroom or in the airplane. It is recommended that classroom instruction and flight instruction be taped while teaching a specific block of training. The dialogues would be compared and refined to determine what words are absolutely essential to communicate the subject and what other words support the essential words.

Finally, the last area of concern is what to do with the personal computer in a training environment. An instructional module was created for this study, but few subjects used it. A more effective use of the computer would be to substitute a block of training in the classroom with a computer-aided version of the instruction. The control group would receive classroom instruction, and the experimental group would receive their instruction by computer. Each group could be tested with a traditional multiple-choice test, or each group could receive a test using the Flight Deck Cognitive Emulator.

A door of opportunity has been opened by this study, but more must be known about how students think or learn in the classroom and in the airplane. The Flight Deck Cognitive Emulator introduced one way to measure learning effectiveness, but more must be done to ensure that what is learned in the classroom is retained and readily available during flight training.

REFERENCES

Anderson, M. C., & Bjork, R. A. (1994). Mechanisms of inhibition in long-term memory. In D. Dagenbach, & T. H. Carr (Eds.), Inhibitory processes in attention, memory, and language (pp. 265-320). San Diego, CA: Academic Press, Inc.

Anderson, M. C., & Spellman, B. A. (1995). On the status of inhibitory mechanisms in cognition: Memory retrieval as a model case. Psychological Review, 102, 68-100.

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: Retrieval dynamics in long-term memory. Journal of Experimental Psychology: Learning, Memory, & Cognition, 20, 1063-1087.

Aylward, E. H., Reiss, A. L., Reader, M. J., Singer, H. S., Brown, J. E., & Denckla, M. B. (1996). Basal ganglia volumes in children with attention-deficit hyperactivity disorder. Journal of Child Neurology, 11, 112-115.

Baddeley, A. (1999). Essentials of human memory. East Sussex, UK: Psychology Press Ltd, Publishers.

Barker, P. (1994). Designing interactive learning. In T. de Jong, & L. Sarti (Eds.), Design and production of multimedia and simulation-based learning material. Boston, MA: Kluwer Academic Publishers.

Barkley, R. A. (1990). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment. New York, NY: Guilford Publications.

Barkley, R. A. (1994). ADHD [On-line]. In D. Diaz, Institute for Adult Development and the Institute for Child & Adolescent Wellness. Symposium conducted at Cleveland, OH. Available at: http://www.realtime.net/cyanosis/ add/barkley_seminar.html

Barkley, R. A., & Grodzinsky, G. M. (1994). Are tests of frontal lobe functions useful in the diagnosis of attention deficit disorders? Clinical Neuropsychologist, 8, 121-139.

Berlin, J. I., Gruber, E. V., Holmes, C. W., Jensen, P. K., Lau, J. R., Mills, J. W., & O'Kane, J. M. (1982). Pilot judgment training and evaluation. Daytona Beach, FL: Embry-Riddle Aeronautical University. (NTIS No. AD-A117508)

Bloom, B. S., & Krathwohl, D. R. (Eds.). (1984). Taxonomy of educational objectives: Handbook 1: Cognitive domain. White Plains, NY: Longman, Inc..

Buch, G., & de Bagheera, I. J. (1985). Judgment training effectiveness and permanency. Third International Symposium on Aviation Psychology, 337-343.

Caliber Associates. (1999). Documentation of validity for the AT-SAT computerized test battery (Contract No. DTFA01-95-C-00052). Fairfax, VA: Author.

Castellanos, F. X., Geidd, J. N., Marsh, W. L., Hamburger, S. D., Vaituzis, A. C., Dickstein, D. P., Sarfatti, S. E., Vauss, Y. C., Snell, J. W., Lange, N., Kaysen, D., Krain, A. L., Ritchie, G. F., Rajapakse, J. C., & Rapoport, J. L. (1996). Quantitative brain magnetic resonance imaging in attention-deficit hyperactivity disorder. Archives of General Psychiatry, 53, 607-616.

Chesapeake Institute & Widmeyer Group. (1994). 101 ways to help children with ADD learn: Tips from successful teachers (Contract #HS92017001). Washington, D.C.: Office of Special Education Programs.

Crook, C. (1987). Computers in the classroom: Defining a social context. In J. Ruthowsha, & C. Crook (Eds.), Computers, cognition, and development: Issues for psychology and education. New York, NY: John Wiley & Sons.

Dagenbach, D., & Carr, T. H. (1994). Inhibitory processes in perceptual recognition: Evidence for a center-surround attentional mechanism. In D. Dagenbach, & T. H. Carr (Eds.). Inhibitory processes in attention, memory, and language (pp. 327-355). San Diego, CA: Academic Press, Inc.

De Jong, G., & Simons, P. (1990). Cognitive and metacognitive processes of self-regulated learning. In J. M. Pieters, P. R. J. Simons, & L. de Leeuw (Eds.), Research on computer-based instruction. Amsterdam, Netherlands: Swets & Zeitlinger.

Denckla, M. B. (1991). Attention deficit hyperactivity disorder--residual type. Journal of Child Neurology, 6, 44-50.

Denckla, M. B. (1993). The child with developmental disabilities grown up: Adult residua of childhood disorders. Neurological Clinical, 11, 105-125.

Department of Defense. (1997). Department of defense handbook: Instructional systems development/systems approach to training and education. Washington, D.C.: Government Printing Office.

Department of the Air Force. (1993). Instructional systems development. Washington, D.C.: Government Printing Office.

Diehl, A. E., & Lester, L. F. (1987). Private pilot judgment training in flight school settings (DOT/FAA/AM-87/6). Washington, D.C.: Office of Aviation Medicine.

Dong, T., & Kintsch, W. (1968). Subjective retrieval cues in free recall. Journal of Verbal Learning and Verbal Behavior, 7, 813-816.

Dynamix. (1998). Pro-Pilot '99 [Computer software]. Bellevue, WA: Sierra On-Line, Inc..

Eberhard, K. M. (1994). Phonological inhibition in auditory word recognition. In D. Dagenbach, & T. H. Carr (Eds.). Inhibitory processes in attention, memory, and language (pp. 383-406). San Diego, CA: Academic Press, Inc.

Edwards, D. (1997). Fit to fly: Cognitive training for pilots. Brisbane, Australia: Copywright Publishing Company Pty Ltd.

Ernst, M., Zametkin, A. J., Phillips, R. L., & Cohen, R. M. (1998). Age-related changes in brain glucose metabolism in adults with attention deficit-hyperactivity disorder and control subjects. Journal of Neuropsychiatry and Clinical Neuroscience, 10, 168-177.

Federal Aviaition Administration. (1998b). Part 61, Section 61.97. In FAA (Ed.), Code of federal regulations. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1995). Aeronautical information manual: Official guide to basic flight information and ATC procedures. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1997a). Student pilot guide (AC 61-12M). Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1997b). Conduct of airman knowledge tests (FAA Order 8080.6B). Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1997c). Pilot's handbook of aeronautical knowledge (AC 61-23C). Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1997d). Flight and ground instructor knowledge test guide (AC 61-112). Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998a). Part 67. In FAA (Ed.), Code of federal regulations. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998c). Part 61, Section 61.105. In FAA (Ed.), Code of federal regulatons. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998d). Part 141, Section 141.55. In FAA (Ed.), Code of federal regulations. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998e). Part 141, Section 141.57. In FAA (Ed.), Code of federal regulations. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998f). Part 141, Appendix H. In FAA (Ed.), Code of federal regulations. Washington, D.C.: Government Printing Office.

Federal Aviation Administration. (1998g). FAA academy guidelines for the development, delivery, and evaluation of training. Oklahoma City, OK: Mike Monroney Aeronautical Center.

Federal Aviation Administration. (1998h). Airman knowledge test question bank [On-line]. Available at: http://www.fedworld.gov/pub/faa-att/pvt_plt

Frederiksen, J. R., & White, B. Y. (1990). Intelligent Tutors As Intelligent Testers. In N. Frederiksen, R.Glaser, A. Lesgold, & M. G. Shafto, (Eds.), Diagnostic monitoring of skill and knowledge acquisition (pp. 1-25). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Frederiksen, N., Glaser, R., Lesgold, A., & Shafto, M. G. (Eds.). (1990). Diagnostic monitoring of skill and knowledge acquisition. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Gagné, R. M. (1962). The acquisition of knowledge. Psychological Review, 69, 355-365.

Gagné, R. M., Briggs, L. J., & Wager, W. W. (1988). Principles of instructional design (3rd ed.). New York, NY: Holt, Rinehart and Winston.

Gay, L. R. (1996). Educational research: Competencies for analysis and application (5th ed.). Upper Saddle River: Merrill. (Original work published 1976)

Gerson, C. W. (1995). The selective task trainer: The expert solution. Journal of Educational Technology Systems, 23, 201-217.

Glaeser, D., Gum, S., & Walters, B. (1993). An invitation to fly: Basics for the private pilot (4th ed.). Belmont, CA Wadsworth Publishing Company.

Glanzer, M., Fischer, B., & Dorfman, D. (1984). Short-term storage in reading. Journal of Verbal Learning and Verbal Behavior, 23, 467-486.

Hallowell, E. M., & Ratey, J. J. (1994). Driven to distraction: Recognizing and coping with attention deficit disorder from childhood through adulthood. New York, NY: Touchstone.

Hartmann, T., Bowman, J., & Burgess, S. (Eds.). (1996). Think fast: The ADD experience. Grass Valley, CA: Underwood Books.

Hodes, C. L. (1994). The role of visual mental imagery in the speed-accuracy tradeoff: A preliminary investigation. Journal of Educational Technology, 23, 52-61.

Jacoby, L. L., & Brooks, L. R. (1984). Nonanalytic cognition: Memory, perception, and concept learning. In G. H. Bower (Ed.), The psychology of learning and motivation: Advances in research and theory (Vol. 18). New York, NY: Academic Press, Inc. As cited in Dagenbach & Carr, 1994).

Jeppesen-Sanderson (1996c). Federal aviation regulations explained. Englewood, CO: Jeppesen-Sanderson Training Products.

Jeppesen-Sanderson. (1996a). Private pilot exercises. Englewood, CO: Jeppesen-Sanderson Training Products.

Jeppesen-Sanderson. (1996b). Private pilot manual. Englewood, CO: Jeppesen-Sanderson Training Products.

Jeppesen-Sanderson. (1997a). 1997 private pilot FAA practical test study guide: Airplane single-engine land. Englewood, CO: Jeppesen-Sanderson Training Products.

Jeppesen-Sanderson. (1997b). Private pilot FAA airmen knowledge study guide. Englewood, CO: Jeppesen-Sanderson Training Products.

Johnson, M. K., & Reeder, J. A. (1997). Consciousness as meta-processing. In J. D. Cohen, & J. W. Schooler (Eds.), Scientific approaches to consciousness (pp. 261-268). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Kausler, D. H. (1974). Psychology of verbal learning and memory. New York, NY: Academic Press.

Kennan, J. M., Baillet, S. D., & Brown, P. (1984). The effects of causal cohesion on comprehension and memory. Journal of Verbal Learning and Verbal Behavior, 23, 115-126.

Kershner, W. K. (1993). The student pilot's flight manual: Including FAA written test questions (airplanes) plus answers and explanations (7th ed.). Ames, IA: Iowa State University Press.

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. Psychological Review, 85, 363-394.

Kiss, I., Pisio, C., Francois, A., & Schopflocher, D. (1998). Central executive function in working memory: Event-related brain potential studies. Cognitive Brain Research, 6(4), 235-247.

Le Ny, J-F., & Carfantan, M. (1982). Accessibility from working memory and role of reprocessing in sentence comprehension. In J-F. Le Ny, & W. Kintsch (Eds.), Language and comprehension. New York, NY: North-Holland Publishing Company.

Lesgold, A., Lajoie, S., Logan, D., & Eggan, G. (1990). Applying cognitive task analysis and research methods to assessment. In N. Frederiksen, R. Glaser, A. Lesgold, & M. G. Shafto. (Eds.), Diagnostic monitoring of skill and knowledge acquisition (pp. 325-350). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Levin, D. (1996). 101 ways to help children with ADD learn: Tips from successful teachers. In T. Hartmann, J. Bowman, & S. Burgess (Eds.), Think fast: The ADD experience (pp. 133-149). Grass Valley, CA: Underwood Books.

Lien, A. J. (1976). Measurement and evaluation of learning. Dubuque, IA: Brown Company Publishers.

Macromedia, Inc. (1997). Authorware (Version 4.0) [Computer software]. San Francisco, CA: .

Mandl, H., & Lesgold, A. (Eds.). (1988). Learning issues for intelligent tutoring systems. New York, NY: Springer-Verlag.

Matochik, J. A., Nordahl, T. E., Gross, M., Semple, W. E., King, A. C., Cohen, R. M., & Zametkin, A. J. (1993). Effects of acute stimulant medication on cerebral metabolism in adults with hyperactivity. Neuropsychopharmacology, 8, 377-386.

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. Journal of Educational Psychology, 90, 312-320.

Murdock, B. B. (1992). Serial organization in a distributed memory model. In S. F. Healy, S. M. Kosslyn, & R. M. Shiffrin (Eds.). From learning theory to connectionist theory: Essays in honor of William K. Estes. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Oshima, T. C. (1994). The effect of speededness on parameter estimation in item response theory. Journal of Educational Measurement, 31, 200-219.

Phelan, T. (1998). All about attention deficit disorder. In Department of Developmental Psychology, Attention Deficit Disorder Conference. Proceedings conducted at University of Oklahoma.

Rafal, R., & Henik, A. (1994). The neurology of inhibition: Integrating controlled and automatic processes. In D. Dagenbach, & T. Carr (Eds.), Inhibitory processes in attention, memory, and language (pp. 1-44). San Diego, CA: Academic Press, Inc.

Rosenberg, S. (1968). Association and phrase structure in sentence recall. Journal of Verbal Learning and Verbal Behavior, 7, 1077-1081.

Santiago Jr., M. (1996). Application of crew resource management and line oriented flight training concepts to general aviation flight training. [On-line]. Available at: http://www.inficad.com/~force1/humfact/crm1ftga.htm

Shelton, T. L., & Barkley, R. A. (1994). Critical issues in the assessment of attention deficit disorders in children. Topics in Language Disorders, 14, 26-41.

Silberman, M. L., & Auerbach, C. (1990). Active training: A handbook of techniques, designs, case examples, and tips. San Francisco, CA: Pfeiffer.

Stamas, G. (1998a). U.S. civil airmen statistics (p. 1-27). Washington, D.C.: Department of Transportation.

Stamas, G. (1998b). U.S. civil airmen statistics (p. 1-19). Washington, D.C.: Department of Transportation.

Swanson, J., Castellanos, F. X., Murias, M., LaHoste, G., & Kennedy, J. (1998). Cognitive neuroscience of attention deficit hyperactivity disorder and hyperkinetic disorder. Current Opinion in Neurobiology, 8, 263.

Telfer, R., & Biggs, J. (1988). The psychology of flight training. Ames, IA: Iowa State University.

Thissen, D., Wainer, H., & Wang, X-B. (1994). Are tests comprising both multiple-choice and free-recall items nessarily less unidimensional than multiple-choice tests?. Journal of Educational Measurement, 31, 113-123.

Thorndike, R. L., & Hagen, E. P. (1977). Measurement and evaluation in psychology and education (4th ed.). New York, NY: John Wiley & Sons.

Townsend, J. T. (1992). Chaos theory: A brief tutorial and discussion. In S. F. Healy, S. M. Kosslyn, & R. M. Shiffrin (Eds.). From learning theory to connectionist theory: Essays in honor of William K. Estes (pp. 65-96). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Turner, T. P. (1995). Cockpit resource management: The private pilot's guide. New York, NY: Tab Books.

van Dijk, T. A. (1977). Text and context: Explorations in the semantics and pragmatics of discourse. London, UK: Longman.

Venezky, R., & Osin, L. (1991). The intelligent design of computer-assisted instruction. White Plains, NY: Longman.

West, C. K., Farmer, J. A., & Woff, P. M. (1991). Instructional design: Implications from cognitive science. Englewood Cliffs, NJ: Prentice Hall.

Wiersma, W. (1995). Research methods in education: An introduction (6th ed.). Needham Heights, NJ: Allyn and Bacon. (Original work published 1969)

Williams, K. W., (1994). Summary proceedings of the joint industry-FAA conference on the development and use of PC-based aviation training devices. Oklahoma City, OK: Federal Aviation Administration.

Zametkin, A. J., Nordahl, T. E., Gross, M., King, A. C., Semple, W. E., Rumsey, J., Hamburger, S., & Cohen, R. M. (1990). Cerebral glucose metabolism in adults with hyperactivity of childhood onset. New England Journal of Medicine, 323, 1361-1366.

APPENDIXES

APPENDIX A

ABBREVIATED AIRMAN KNOWLEDGE TEST

1.3.0.1.0.A.1 A02 (Ref.: CFAR Part 1, Definitions and Abbreviations; Abbreviations and Symbols) Ans. A

V_{SO} is defined as the
A. stalling speed or minimum steady flight speed in the landing configuration.
B. stalling speed or minimum takeoff safety speed.
C. stalling speed or minimum steady flight speed in a specified configuration.

2.3.2.0.6.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. B

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

2.3.2.1.0.A.1 H302 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. C

An airplane said to be inherently stable will
A. not spin.
B. be difficult to stall.
C. require less effort to control.

2.3.2.1.8.A.1 H303 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

Which basic flight maneuver increases the load factor on an airplane as compared to straight-and-level flight?
A. Turns.
B. Climbs.
C. Stalls.

2.3.2.6.3.A.1 H312 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Flight Instruments) Ans. C

As altitude increases, the indicated airspeed at which a given airplane stalls in a particular configuration will
A. decrease as the true airspeed decreases.
B. decrease as the true airspeed increases.
C. remain the same regardless of altitude.

2.3.2.6.9.A.1 H312 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Flight Instruments) Ans. B

(Refer to figure 4.) Which color identifies the power-off stalling speed in a specified configuration?
A. Upper limit of the white arc.
B. Lower limit of the green arc.
C. Upper limit of the green arc.

2.3.2.8.7.A.1 H315 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Airplane Performance) Ans. C

An airplane has been loaded in such a manner that the CG is located aft of the aft CG limit. One undesirable flight characteristic a pilot might experience with this airplane would be
A. a longer takeoff run.
B. stalling at higher-than-normal airspeed.
C. difficulty in recovering from a stalled condition.

2.3.3.0.9.A.1 H60 (Ref.: AC 61-21, Flight Training Handbook; Proficiency Flight Maneuvers) Ans. A

In what flight condition must an aircraft be placed in order to spin?
A. Stalled.
B. Partially stalled with one wing low.
C. In a steep diving spiral.

2.3.3.1.0.A.1 H60 (Ref.: AC 61-21, Flight Training Handbook; Proficiency Flight Maneuvers) Ans. B

During a spin to the left, which wing(s) is/are stalled?
A. Only the left wing is stalled.
B. Both wings are stalled.
C. Neither wing is stalled.

2.3.3.1.1.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. C

The angle of attack at which an airplane wing stalls will
A. change with an increase in gross weight.
B. increase if the CG is moved forward.
C. remain the same regardless of gross weight.

2.3.3.1.3.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. B

Floating caused by the phenomenon of ground effect will be most realized during an approach to land when at
A. a higher-than-normal angle of attack.
B. less than the length of the wingspan above the surface.
C. twice the length of the wingspan above the surface.

2.3.3.1.4.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. B

What must a pilot be aware of as a result of ground effect?
A. Wingtip vortices increase creating wake turbulence problems for arriving and departing aircraft.
B. Induced drag decreases; therefore, any excess speed at the point of flare may cause considerable floating.
C. A full stall landing will require less up elevator deflection than would a full stall when done free of ground effect.

2.3.3.1.6.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. A

During an approach to a stall, an increased load factor will cause the airplane to
A. be more difficult to control.
B. stall at a higher airspeed.
C. have a tendency to spin.

2.3.2.0.1.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. B

The four forces acting on an airplane in flight are
A. lift, gravity, power, and friction.
B. lift, weight, thrust, and drag.
C. lift, weight, gravity, and thrust.

2.3.2.0.5.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

What is the relationship of lift, drag, thrust, and weight when the airplane is in straight-and-level flight?
A. Lift equals weight and thrust equals drag.
B. Lift, drag, and weight equal thrust.
C. Lift and weight equal thrust and drag.

2.3.2.6.4.A.1 H312 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Flight Instruments) Ans. A

What does the red line on an airspeed indicator represent?
A. Never-exceed speed.
B. Maneuvering speed.
C. Turbulent or rough-air speed.

2.3.2.7.4.A.1 H312 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Flight Instruments) Ans. C

What is an important airspeed limitation that is not color coded on airspeed indicators?
A. Never-exceed speed.
B. Maximum structural cruising speed.
C. Maneuvering speed.

1.3.0.0.6.A.1 A02 (Ref.: CFAR Part 1, Definitions and Abbreviations; Abbreviations and Symbols) Ans. C

Which V-speed represents maneuvering speed?
A. V_{LO}.
B. V_{NE}.
C. V_{A}.

2.3.2.0.2.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

When are the four forces that act on an airplane in equilibrium?
A. During unaccelerated flight.
B. When the aircraft is accelerating.
C. When the aircraft is at rest on the ground.

2.3.2.0.3.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

(Refer to figure 1.) The acute angle A is the angle of
A. attack.
B. dihedral.
C. incidence.

2.3.2.2.0.A.1 H305 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Airplanes and Engines) Ans. A

What is one purpose of wing flaps?
A. To enable the pilot to make steeper approaches to a landing without increasing the airspeed.
B. To decrease wing area to vary the lift.
C. To relieve the pilot of maintaining continuous pressure on the controls.

2.3.2.1.9.A.1 H305 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Airplanes and Engines) Ans. A

One of the main functions of flaps during approach and landing is to
A. increase the angle of descent without increasing the airspeed.
B. permit a touchdown at a higher indicated airspeed.
C. decrease the angle of descent without increasing the airspeed.

2.3.2.0.7.A.1 H300 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. C

In what flight condition is torque effect the greatest in a single-engine airplane?
A. High airspeed, high power, high angle of attack.
B. Low airspeed, low power, low angle of attack.
C. Low airspeed, high power, high angle of attack.

2.3.2.1.1.A.1 H302 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

What determines the longitudinal stability of an airplane?
A. The location of the CG with respect to the center of lift.
B. The effectiveness of the horizontal stabilizer, rudder, and rudder trim tab.
C. The relationship of thrust and lift to weight and drag.

2.3.2.1.3.A.1 H302 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. C

What is the purpose of the rudder on an airplane?
A. To control roll.
B. To control overbanking tendency.
C. To control yaw.

2.3.3.1.2.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. C

What is ground effect?
A. The result of the disruption of the airflow patterns about the wings of an airplane to the point where the wings will no longer support the airplane in flight.
B. The result of an alteration in airflow patterns increasing induced drag about the wings of an airplane.
C. The result of the interference of the surface of the Earth with the airflow patterns about an airplane.

2.3.3.1.5.A.1 H66 (Ref.: AC 61-21, Flight Training Handbook; Characteristics) Ans. C

Ground effect is most likely to result in which problem?
A. Inability to get airborne even though airspeed is sufficient for normal takeoff needs.
B. Settling to the surface abruptly during landing.
C. Becoming airborne before reaching recommended takeoff speed.

5.3.7.1.1.A.1 H58 (Ref.: AC 61-21, Flight Training Handbook; Landing Approaches and Landings) Ans. C

The most important rule to remember in the event of a power failure after becoming airborne is to
A. quickly check the fuel supply for possible fuel exhaustion.
B. determine the wind direction to plan for the forced landing.
C. immediately establish the proper gliding attitude and airspeed.

2.3.2.1.2.A.1 H302 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Principles of Flight) Ans. A

What causes an airplane (except a T-tail) to pitch nosedown when power is reduced and controls are not adjusted?
A. The downwash on the elevators from the propeller slipstream is reduced and elevator effectiveness is reduced.
B. When thrust is reduced to less than weight, lift is also reduced and the wings can no longer support the weight.
C. The CG shifts forward when thrust and drag are reduced.

2.3.2.8.8.A.1 H315 (Ref.: AC 61-23, Pilot's Handbook of Aeronautical Knowledge; Airplane Performance) Ans. C

Loading an airplane to the most aft CG will cause the airplane to be
A. less stable at slow speeds, but more stable at high speeds.
B. less stable at high speeds, but more stable at low speeds.
C. less stable at all speeds.

APPENDIX B

FLIGHT DECK COGNITIVE EMULATOR, SCREENS

The correct word or phrase can be found in Appendix A by matching the question found in Appendix B with the question in Appendix A. The space allotted to the digital movie has been left blank to protect copyrighted material. The digital movies were in an AVI format and were called to from the scripted program within the Flight Deck Cognitive Emulator.

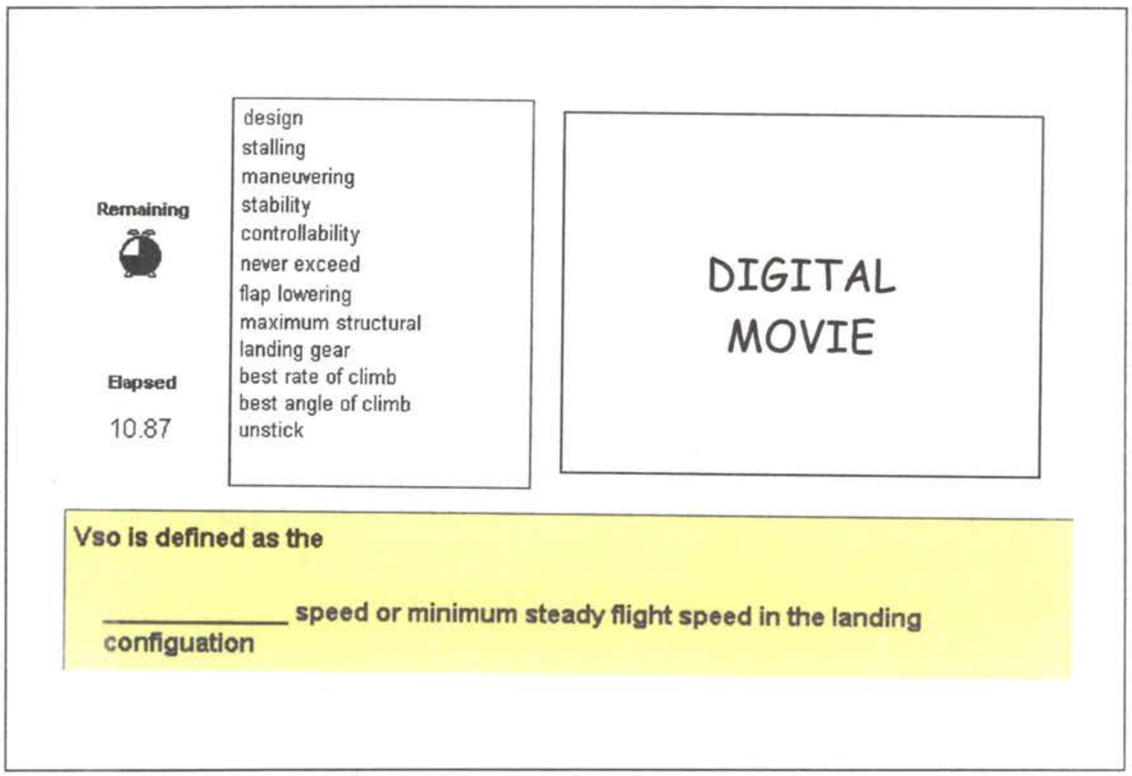


Figure B1. Question One.

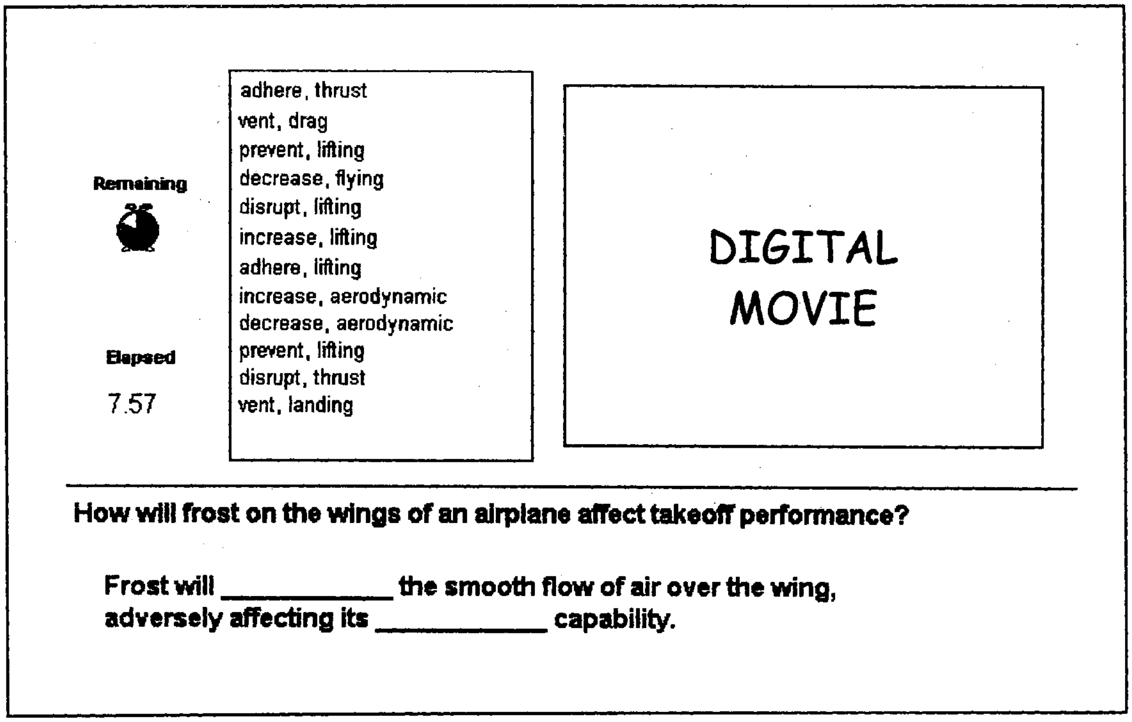
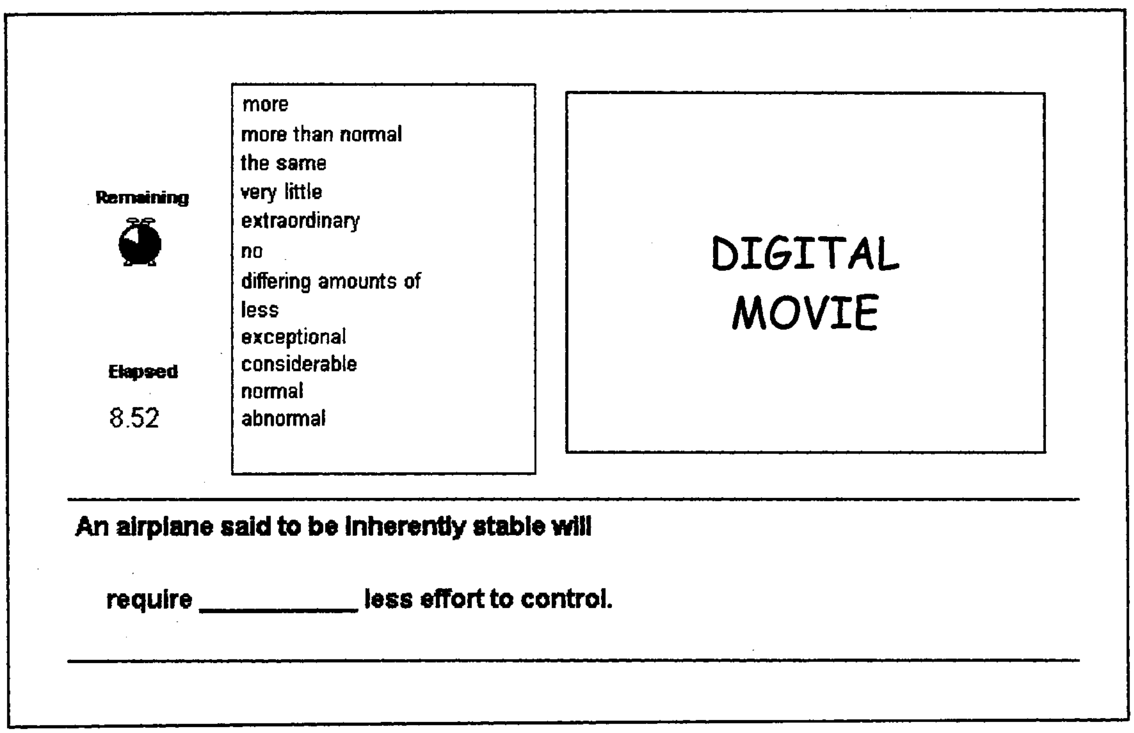


Figure B2. Question Two.



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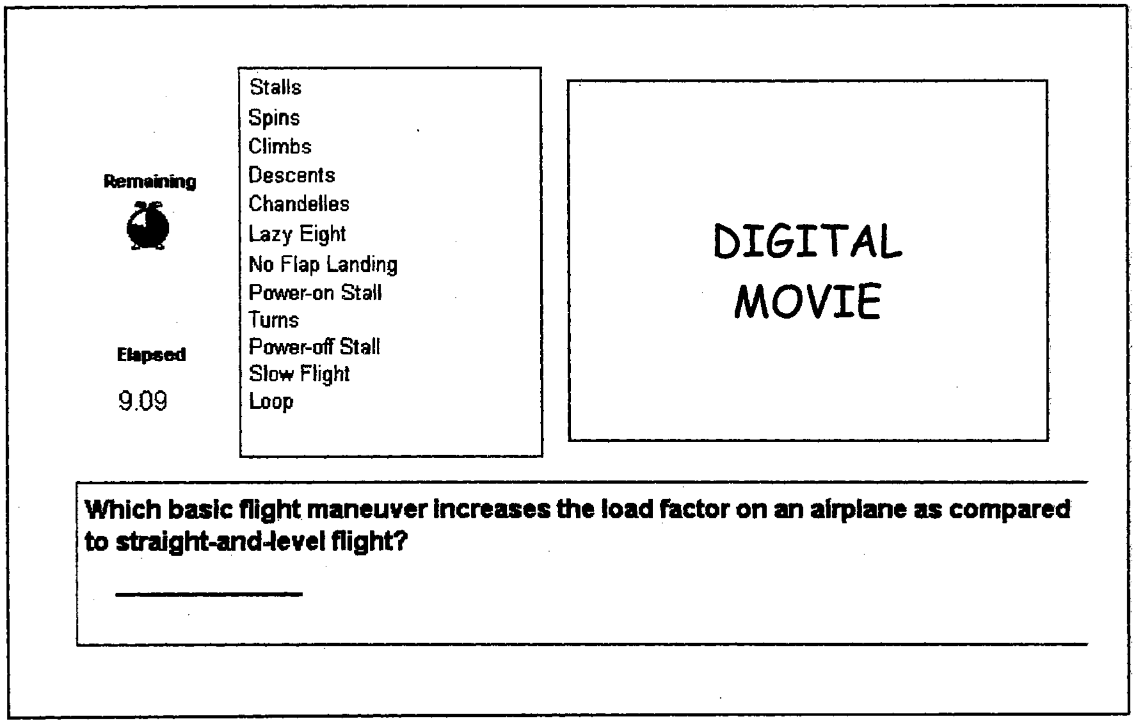


Figure B4. Question Four.

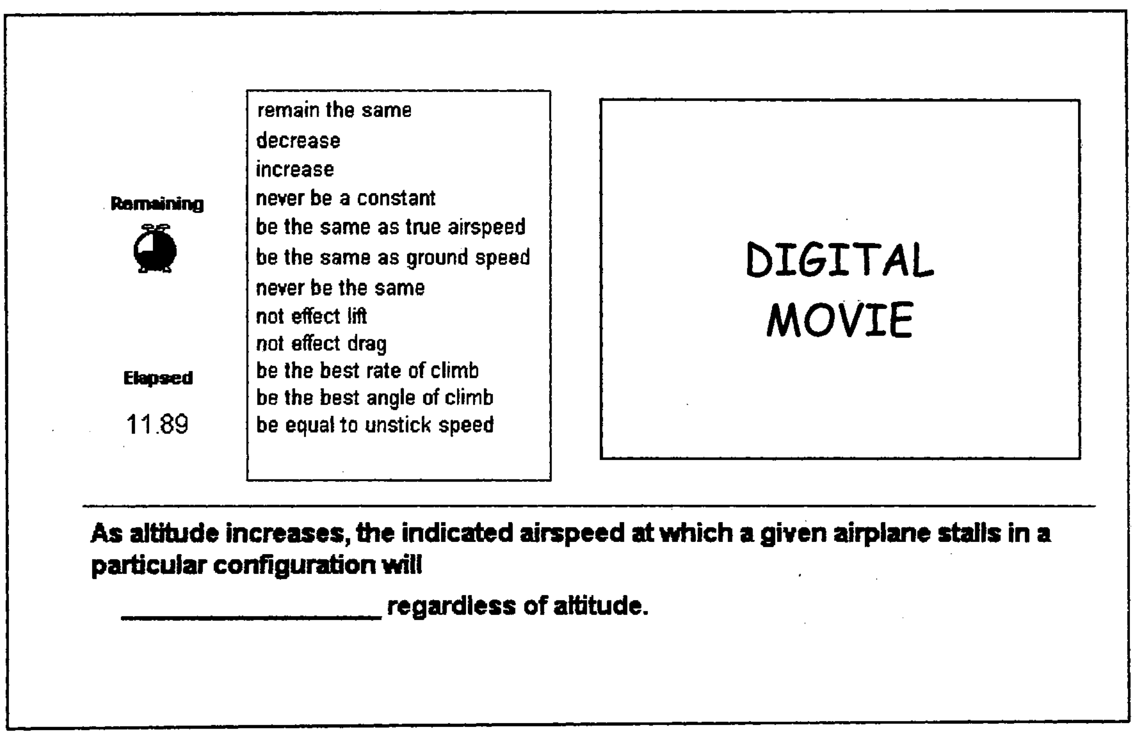


Figure B5. Question Five.

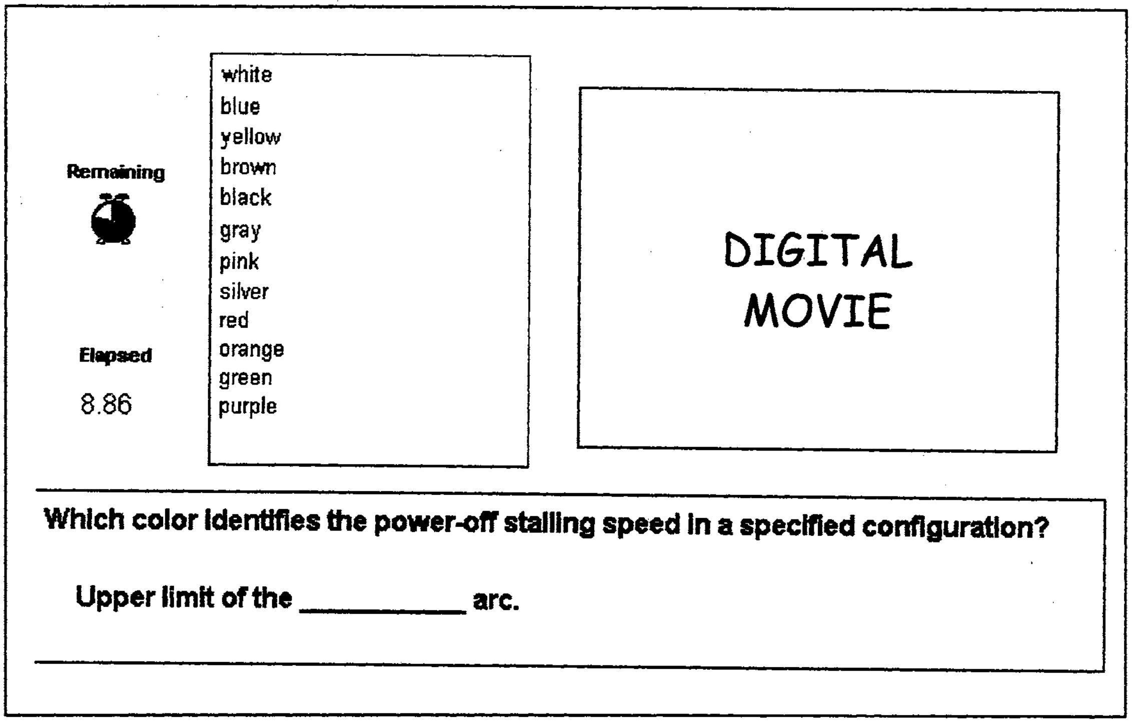
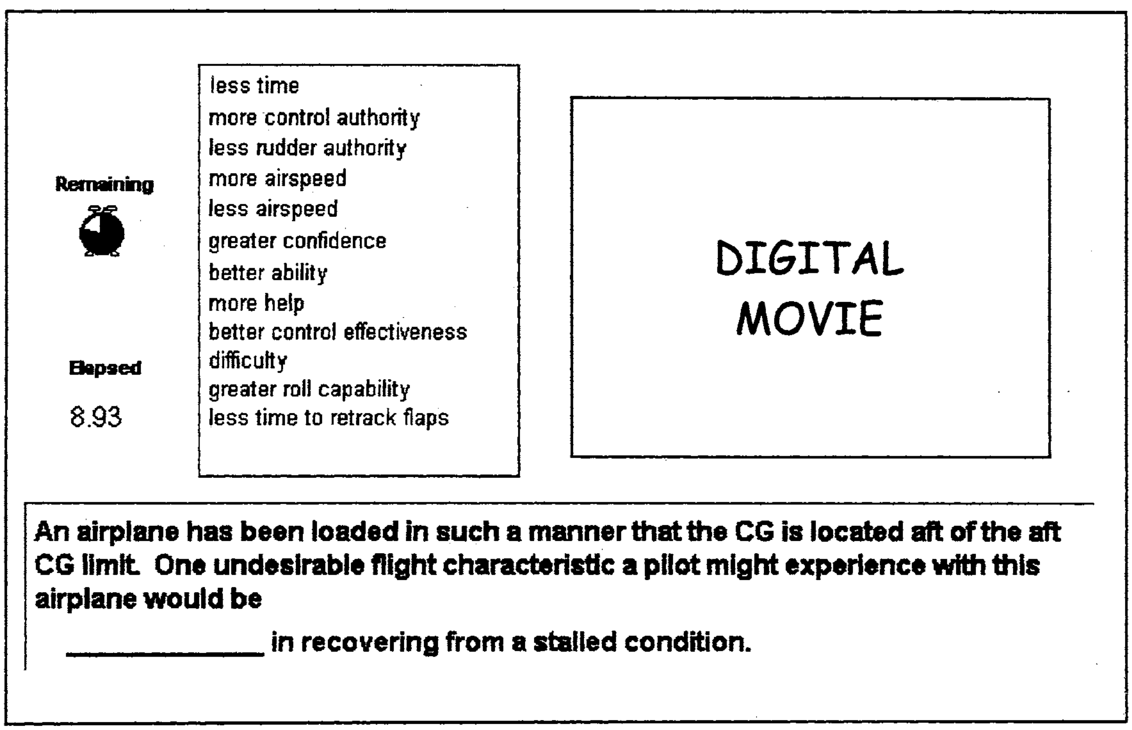


Figure B6. Question Six.



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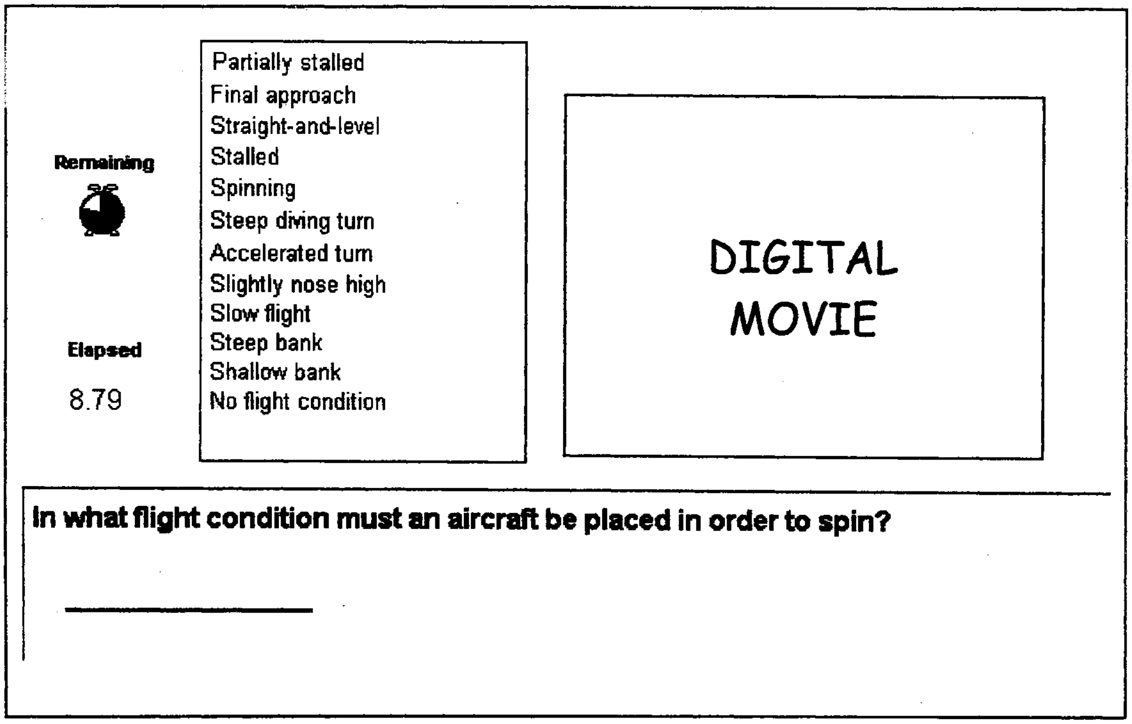

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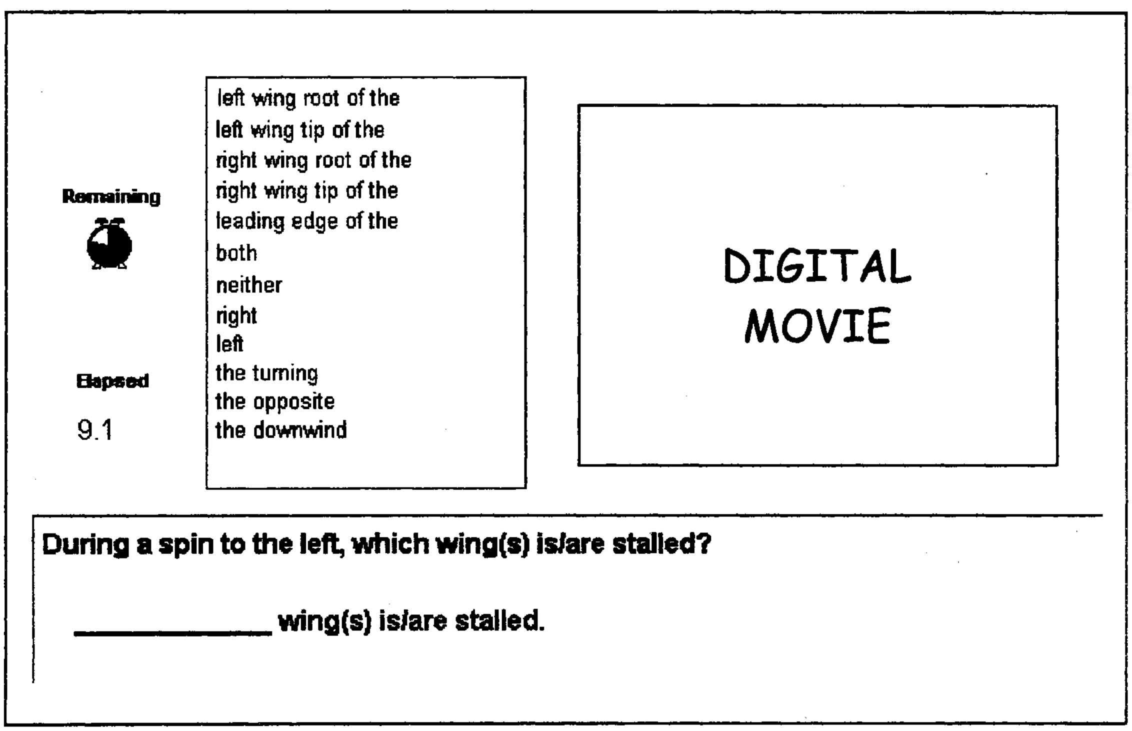

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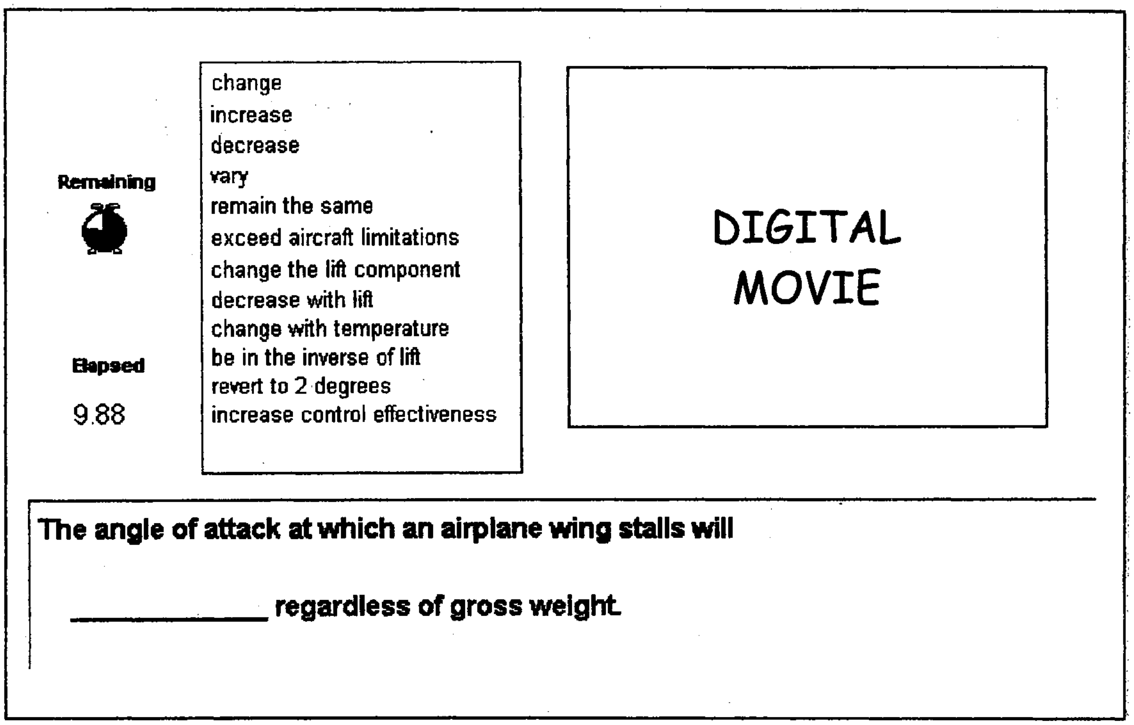

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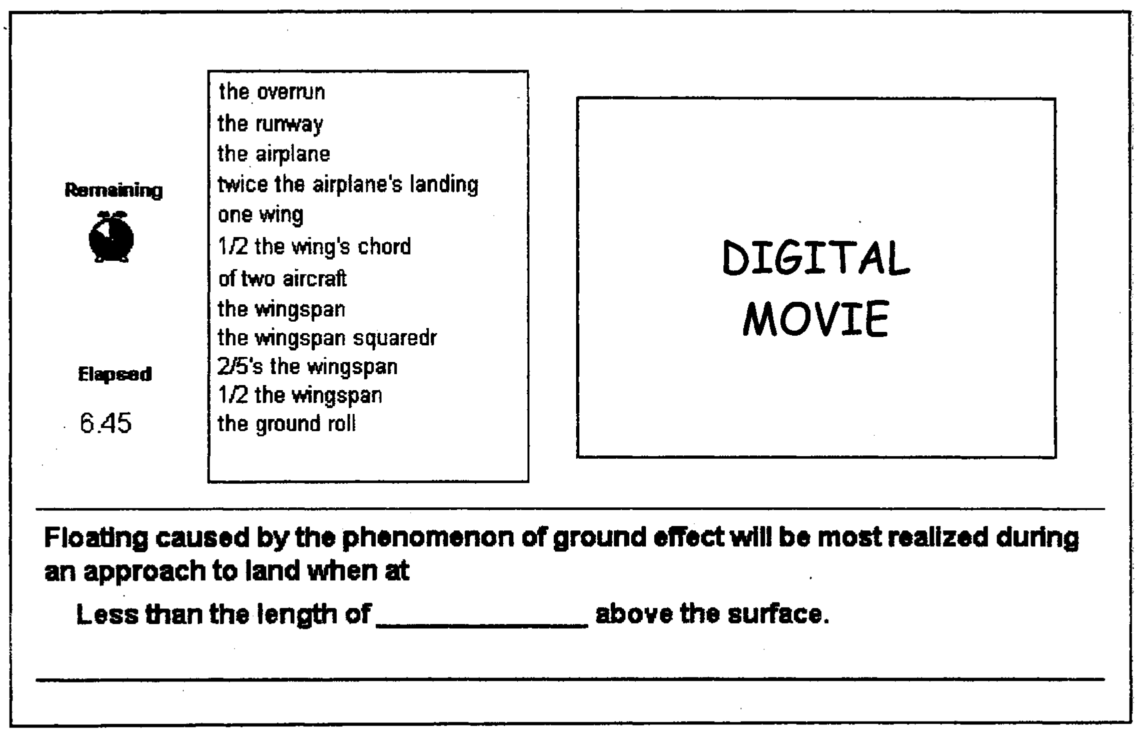

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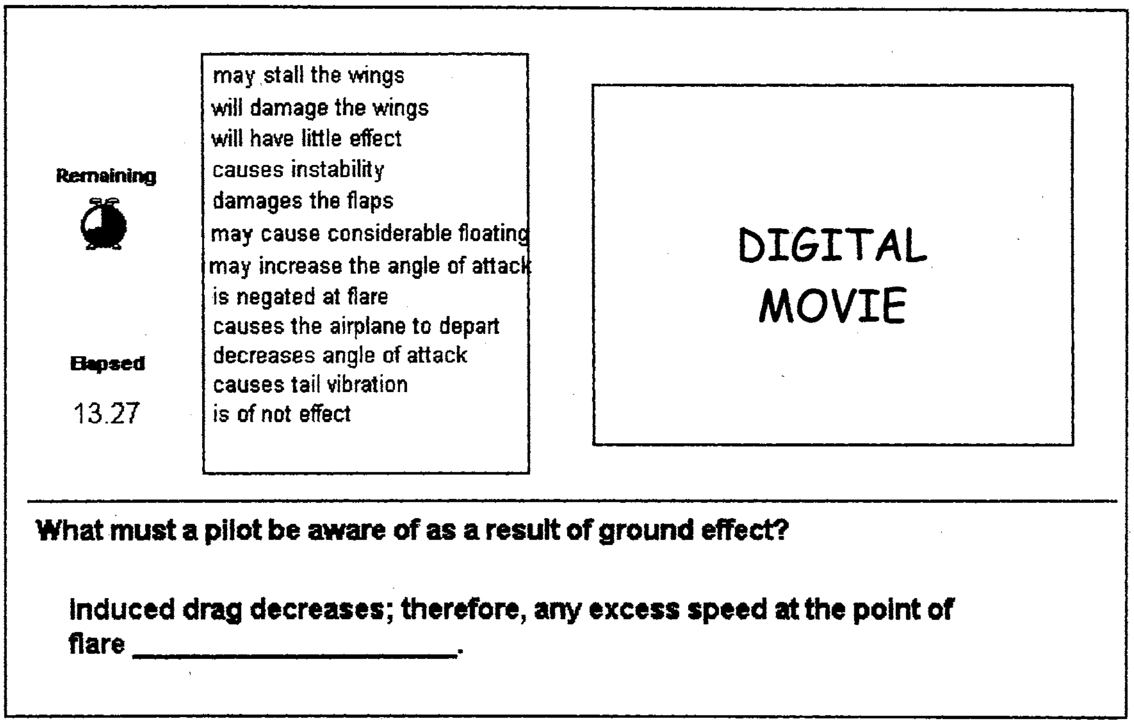

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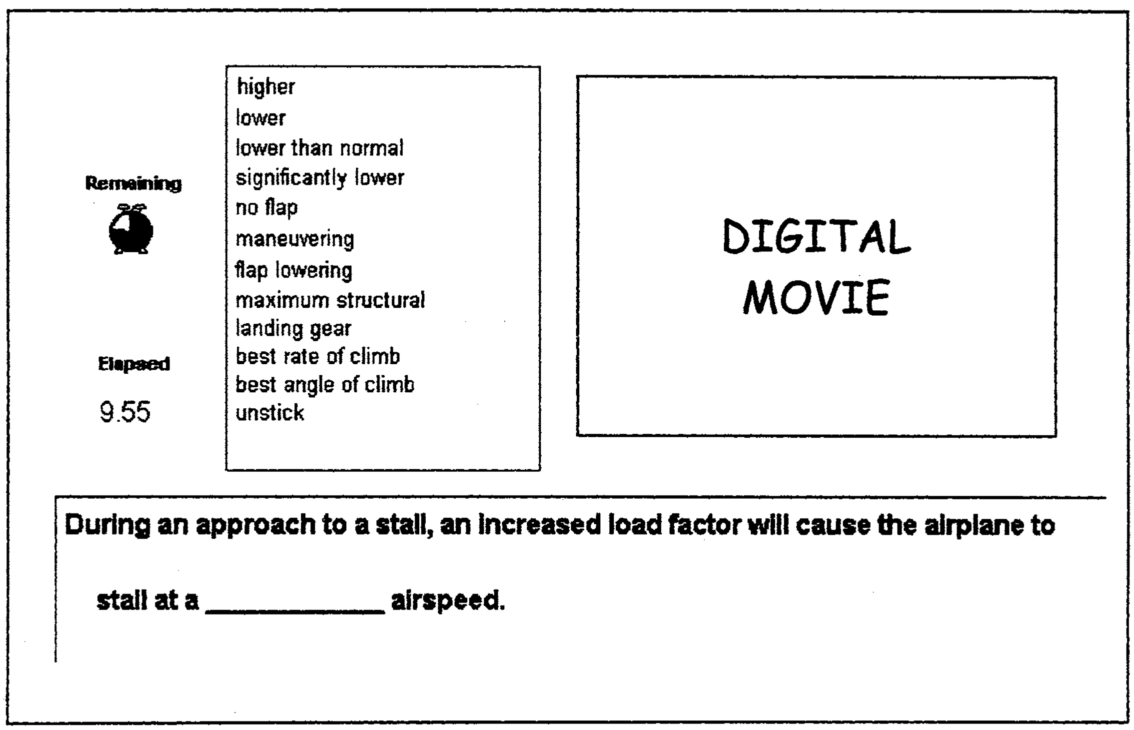

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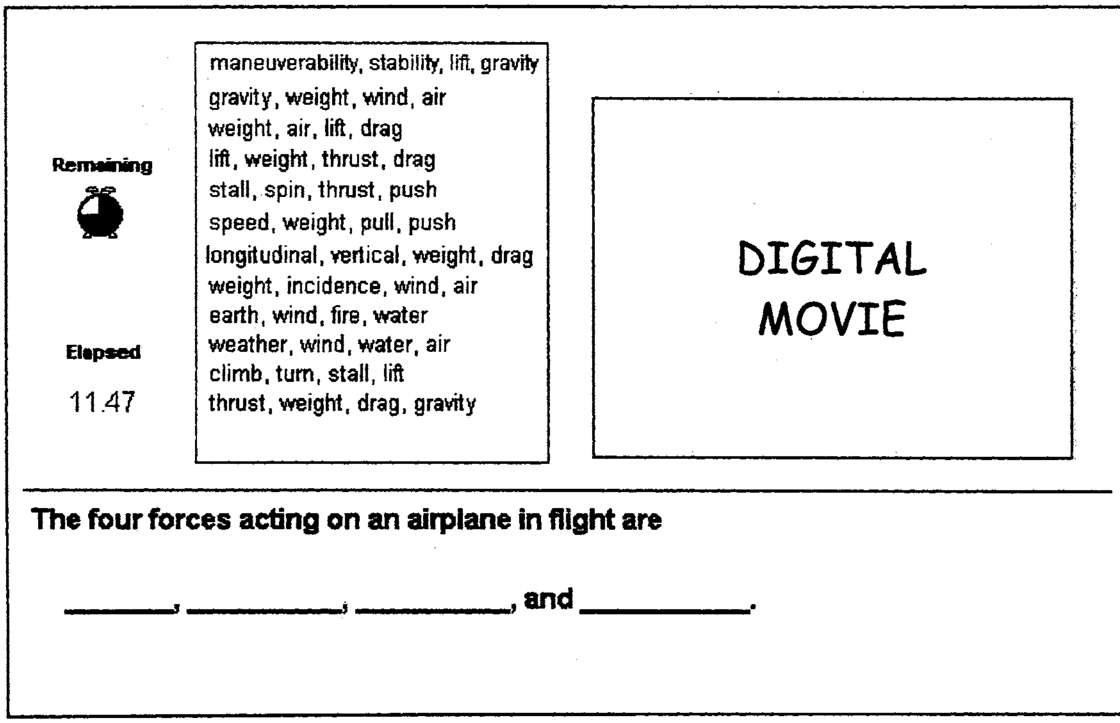

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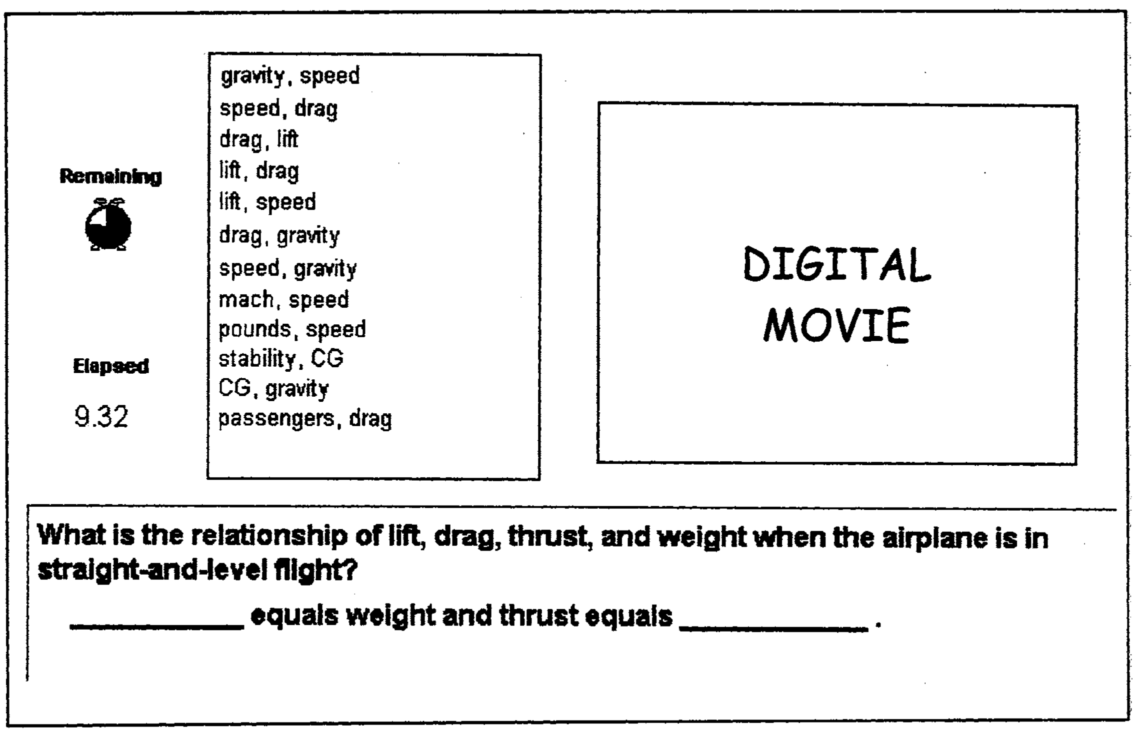

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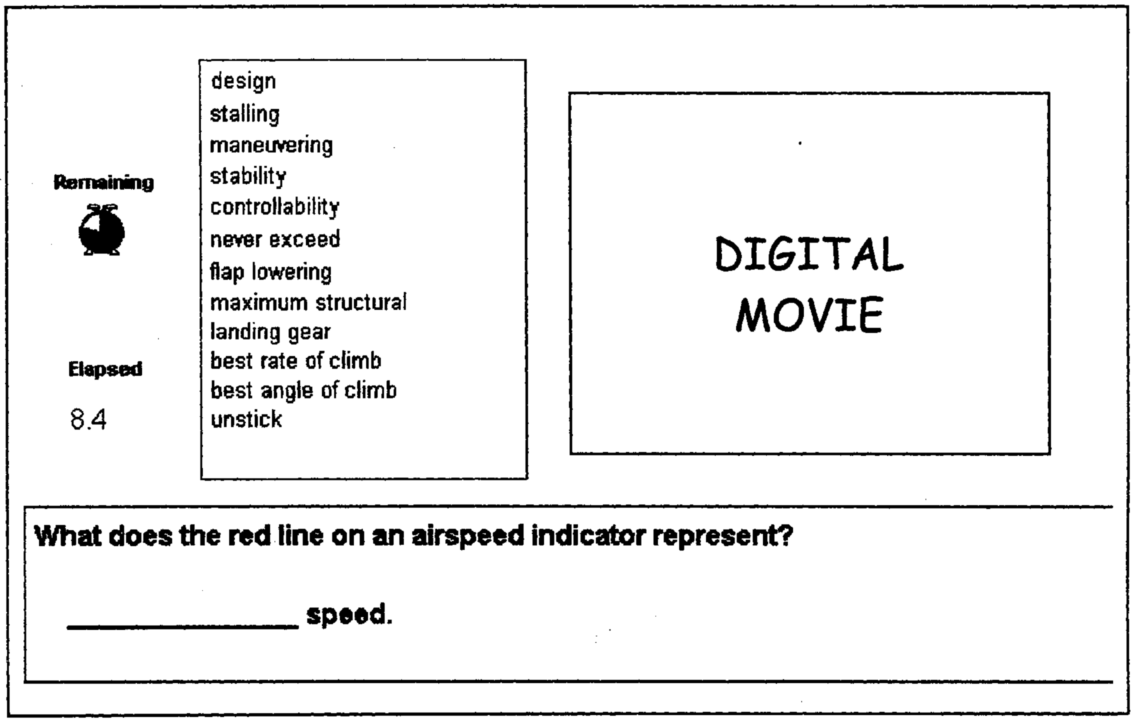

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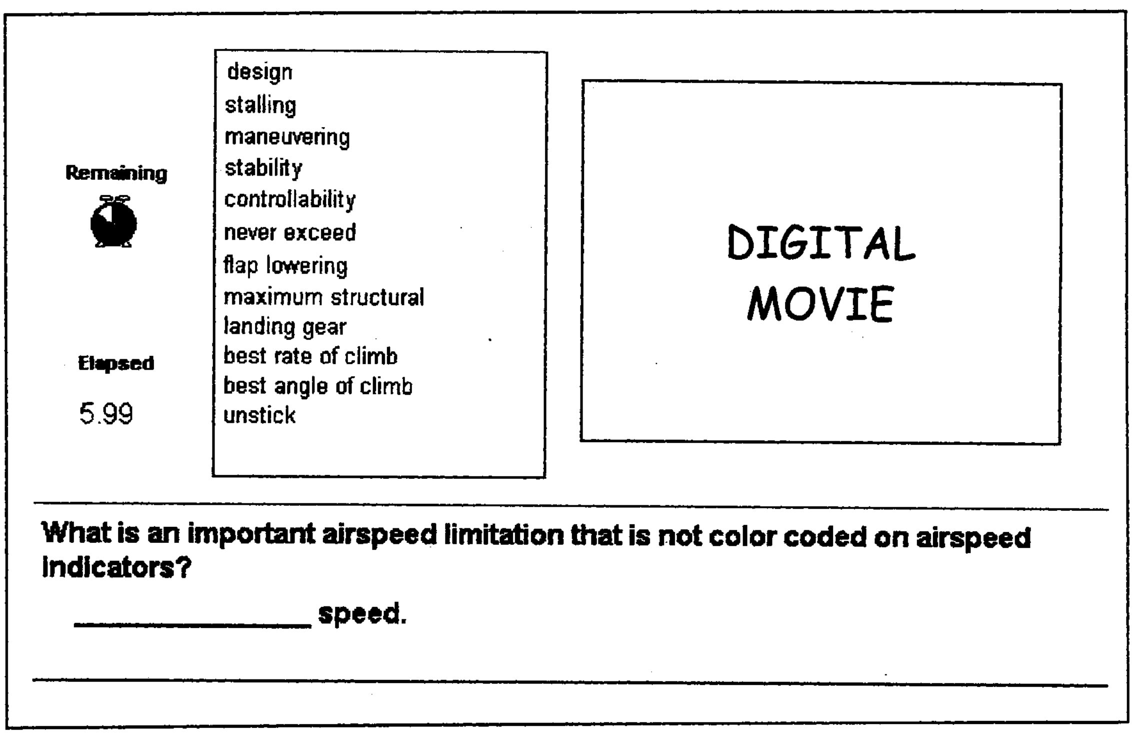

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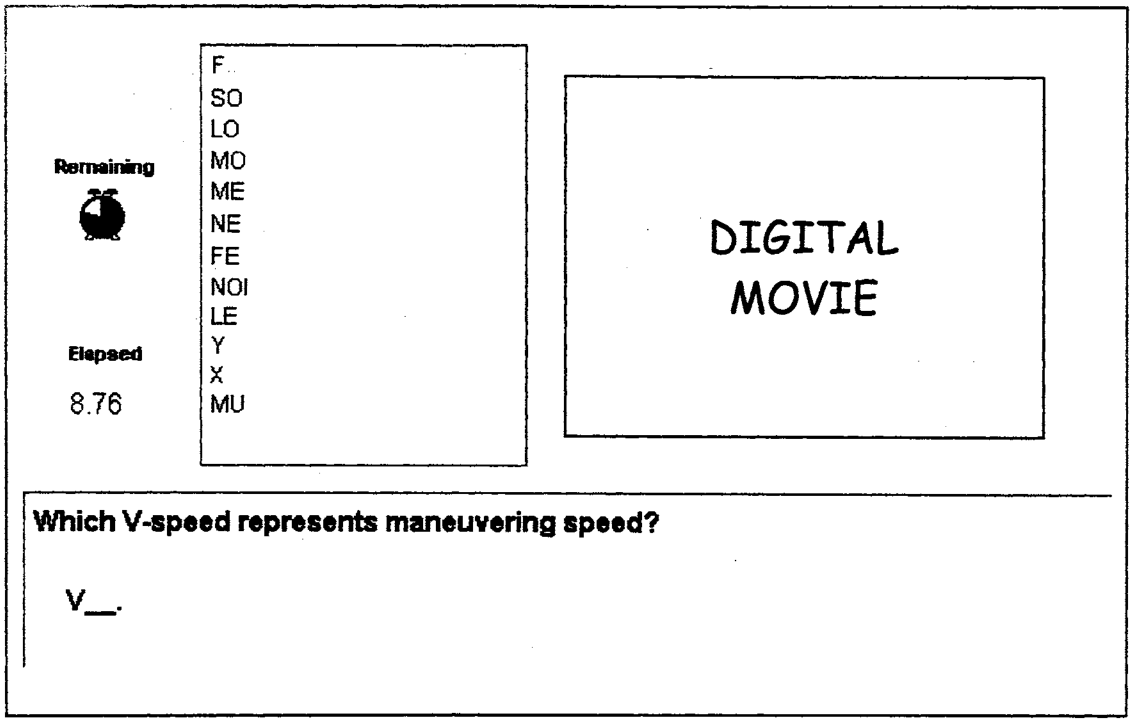

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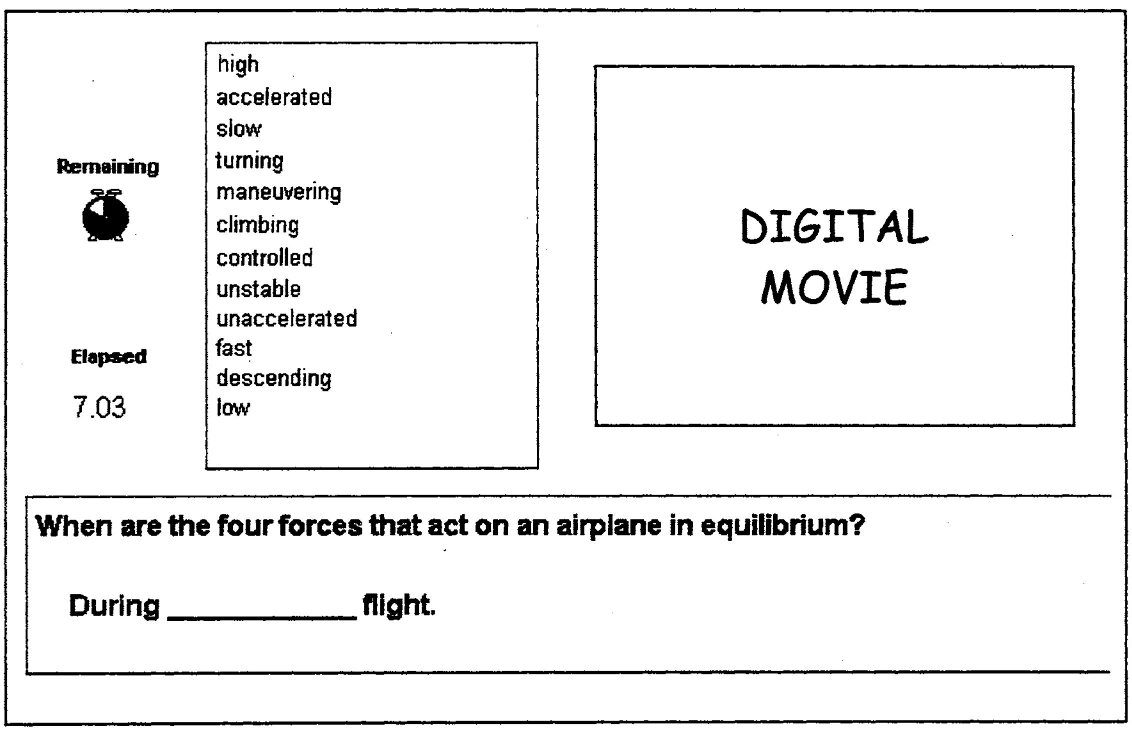

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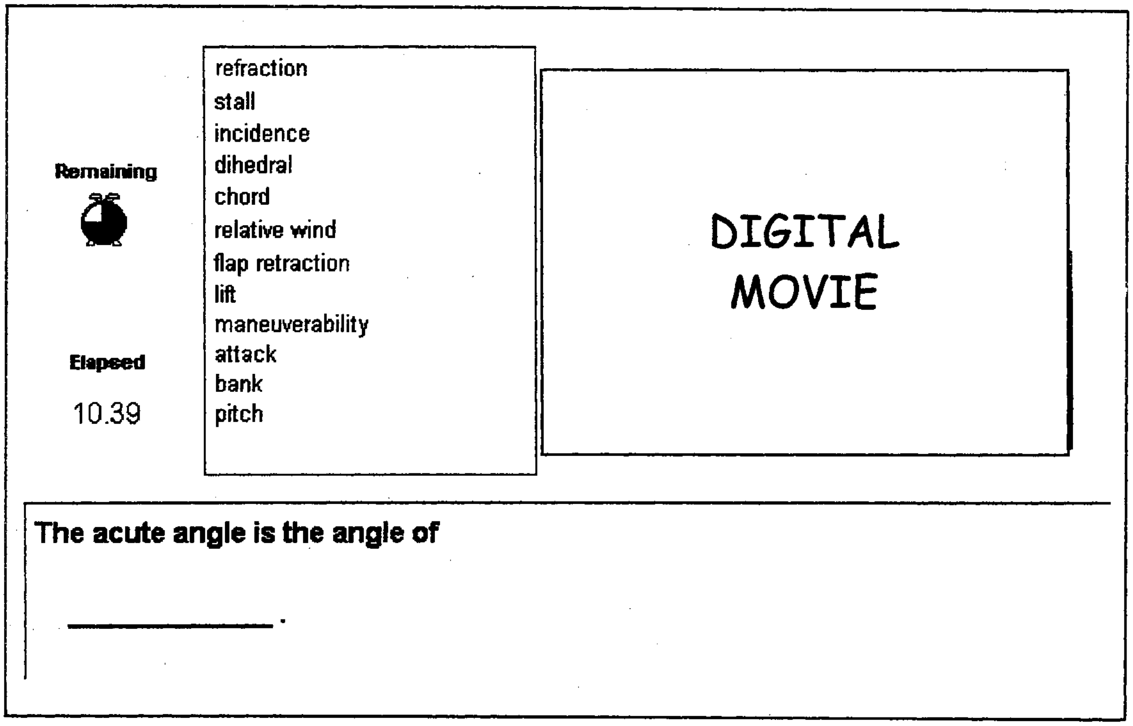

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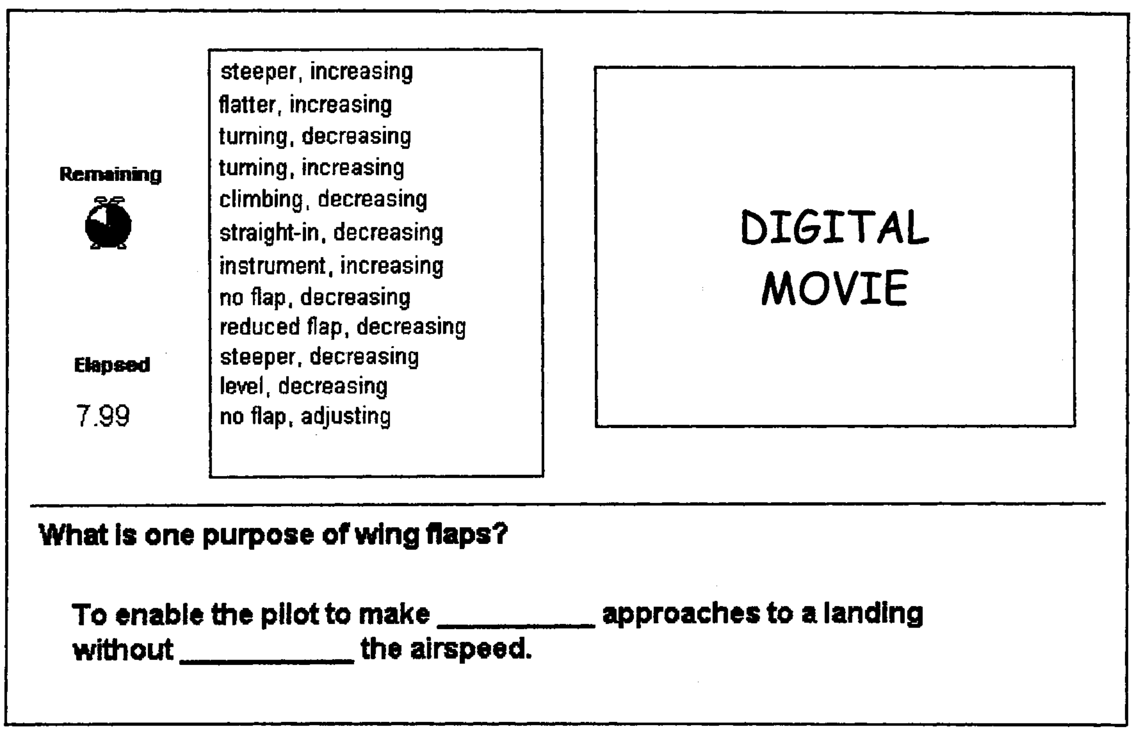
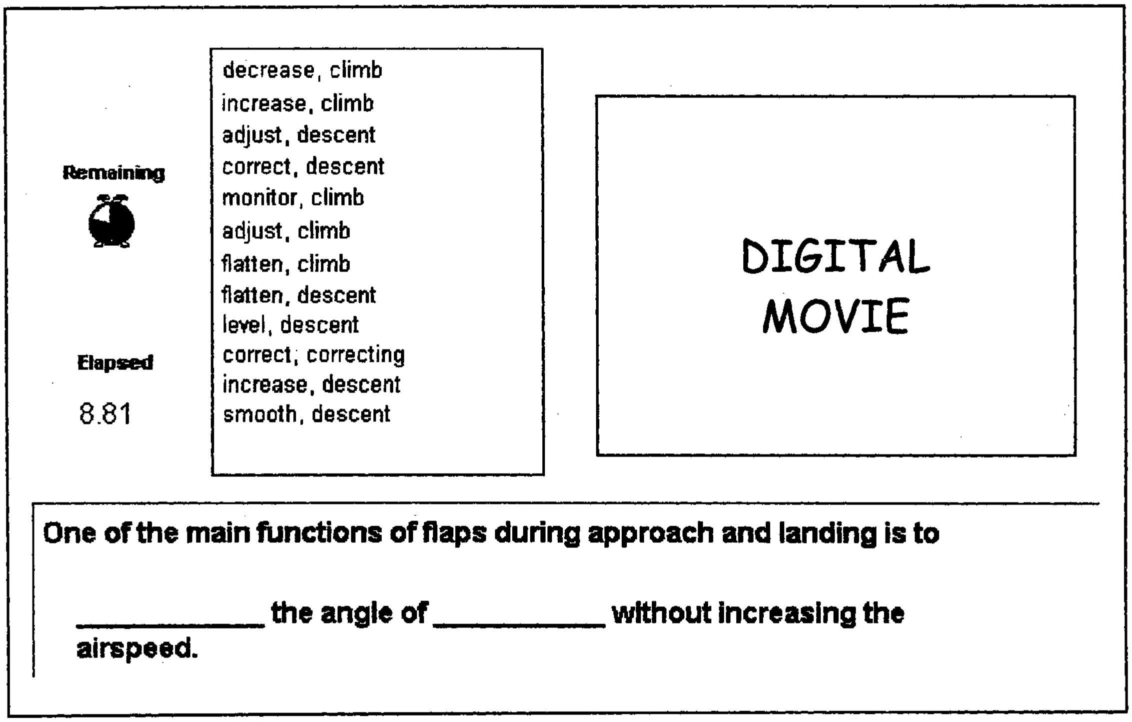


Figure B21. Question Twenty-One.



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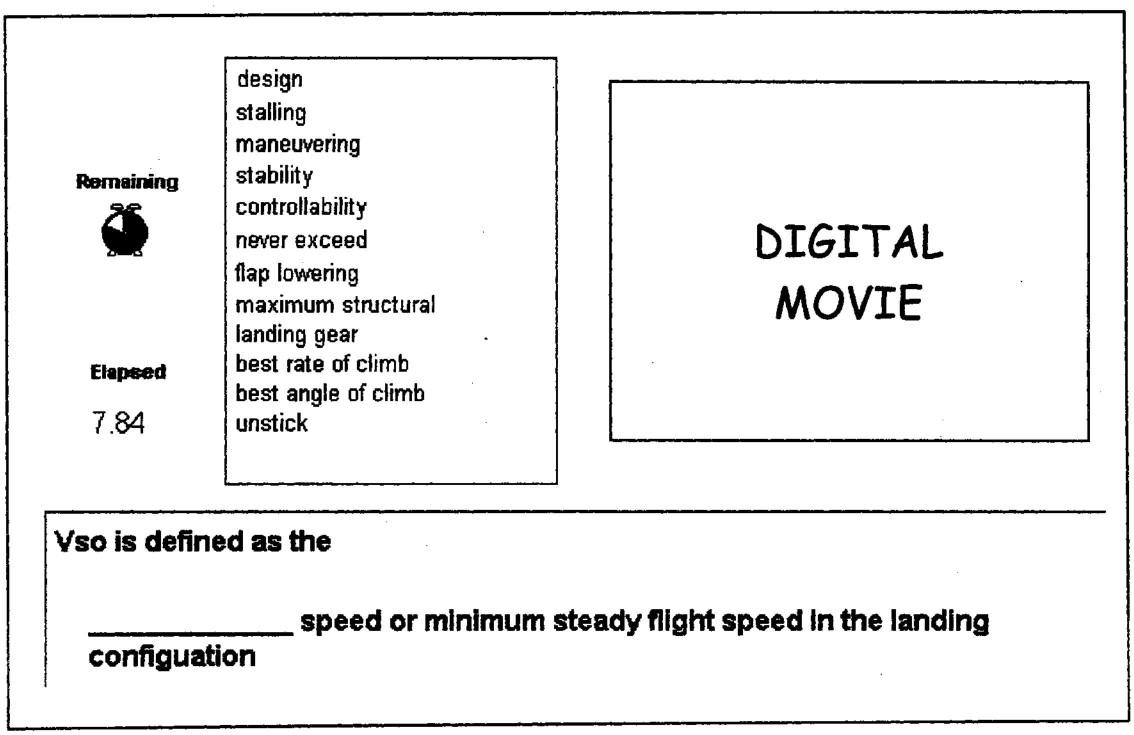

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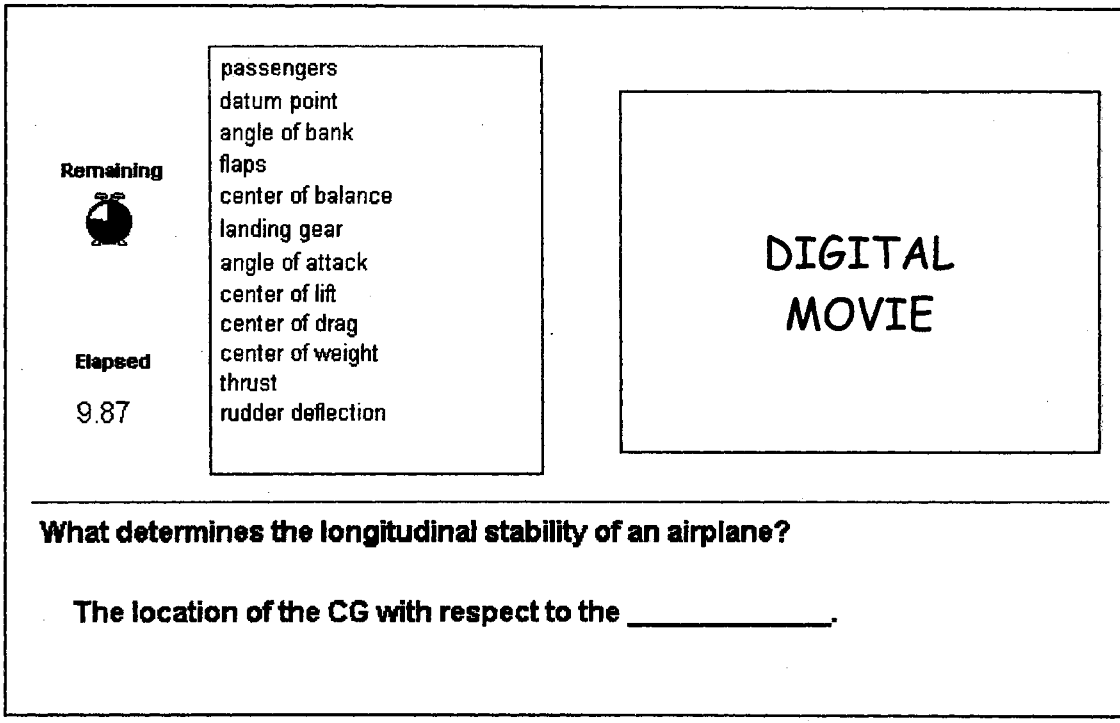


Figure B24. Question Twenty-Four.

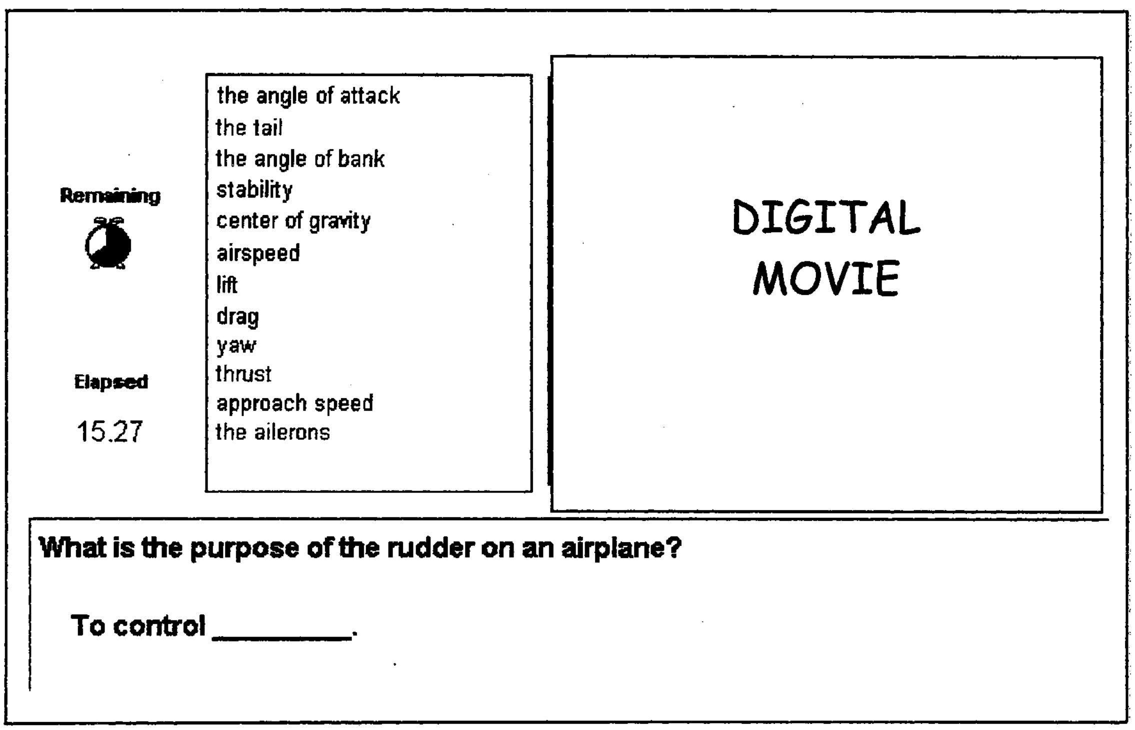


Figure B25. Question Twenty-Five.

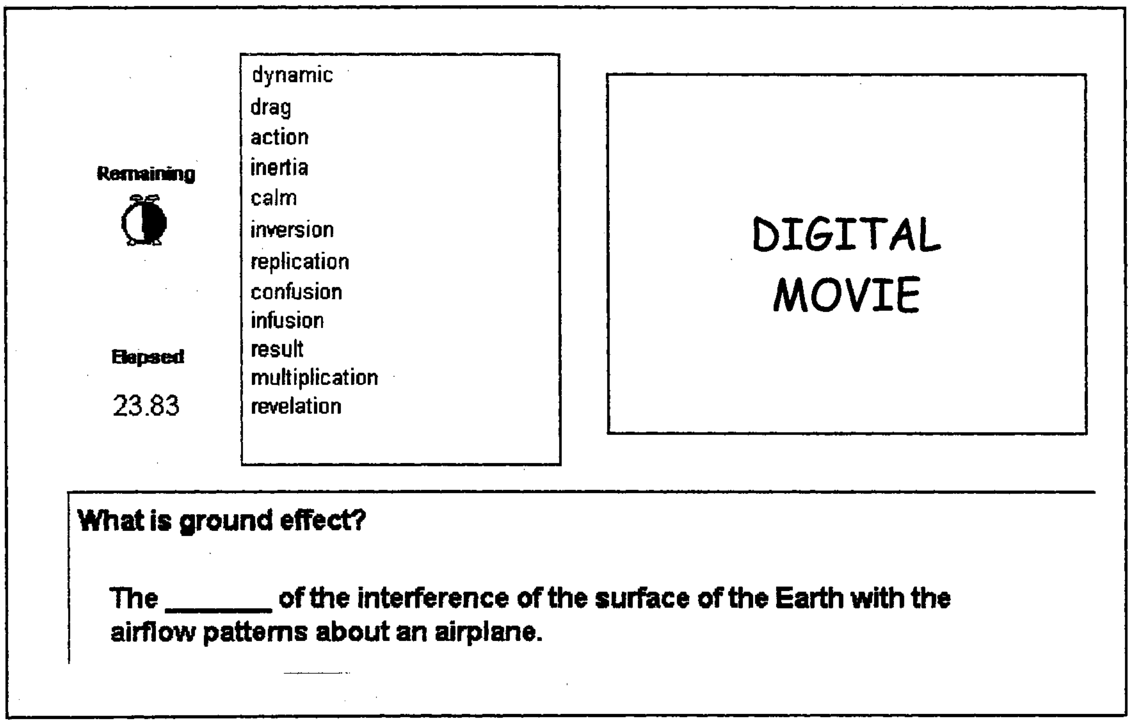
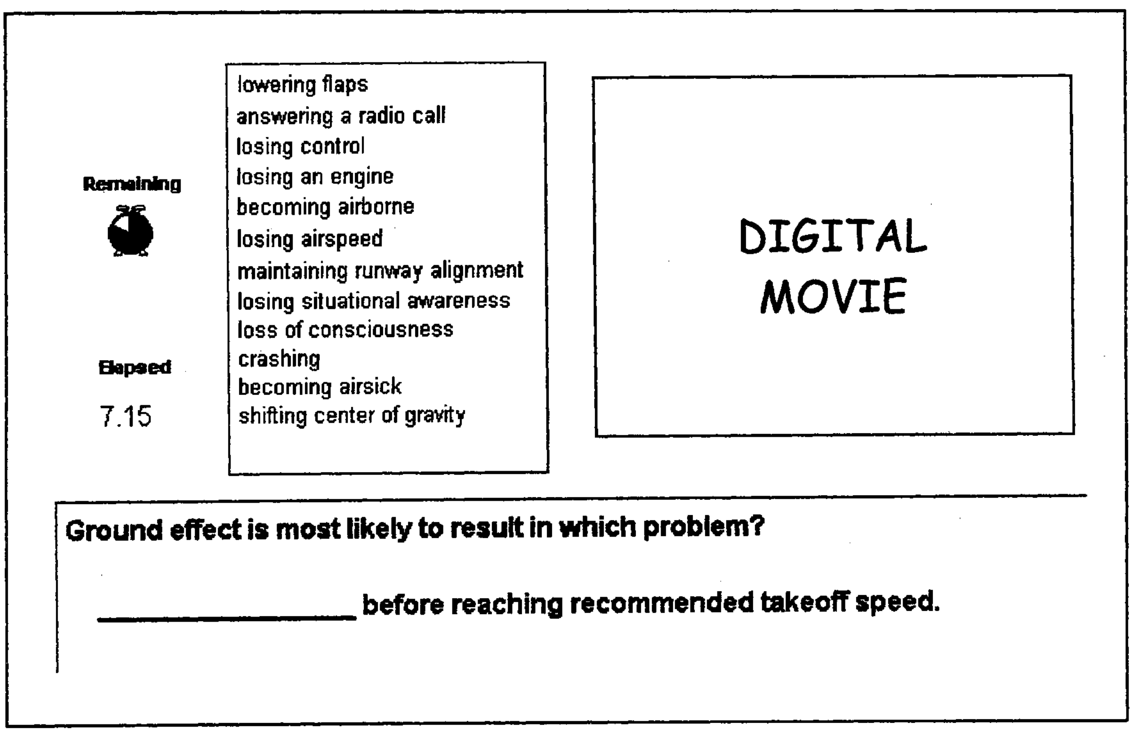


Figure B26. Question Twenty-Six.



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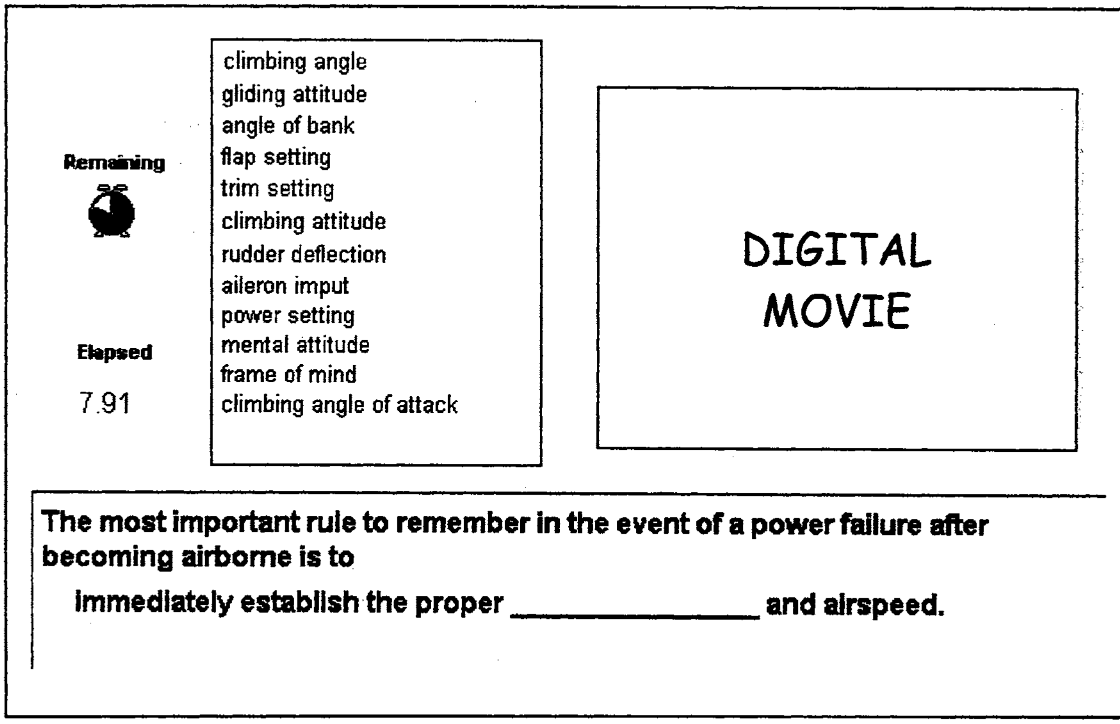

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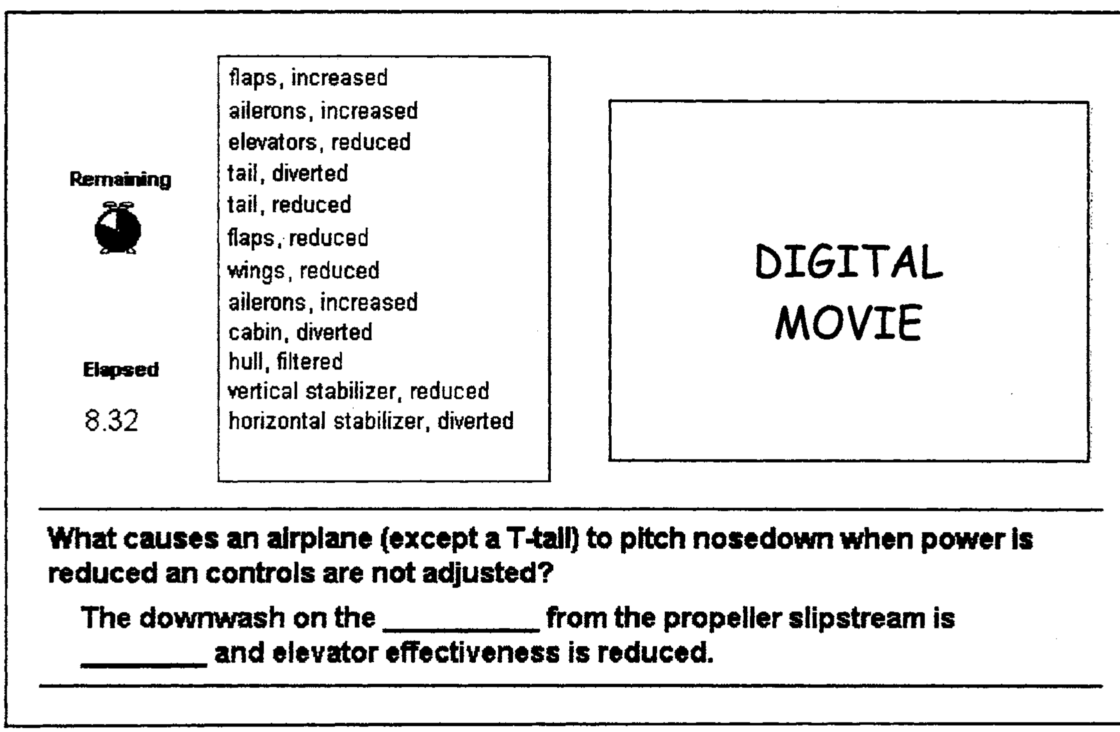


Figure B29. Question Twenty-Nine.

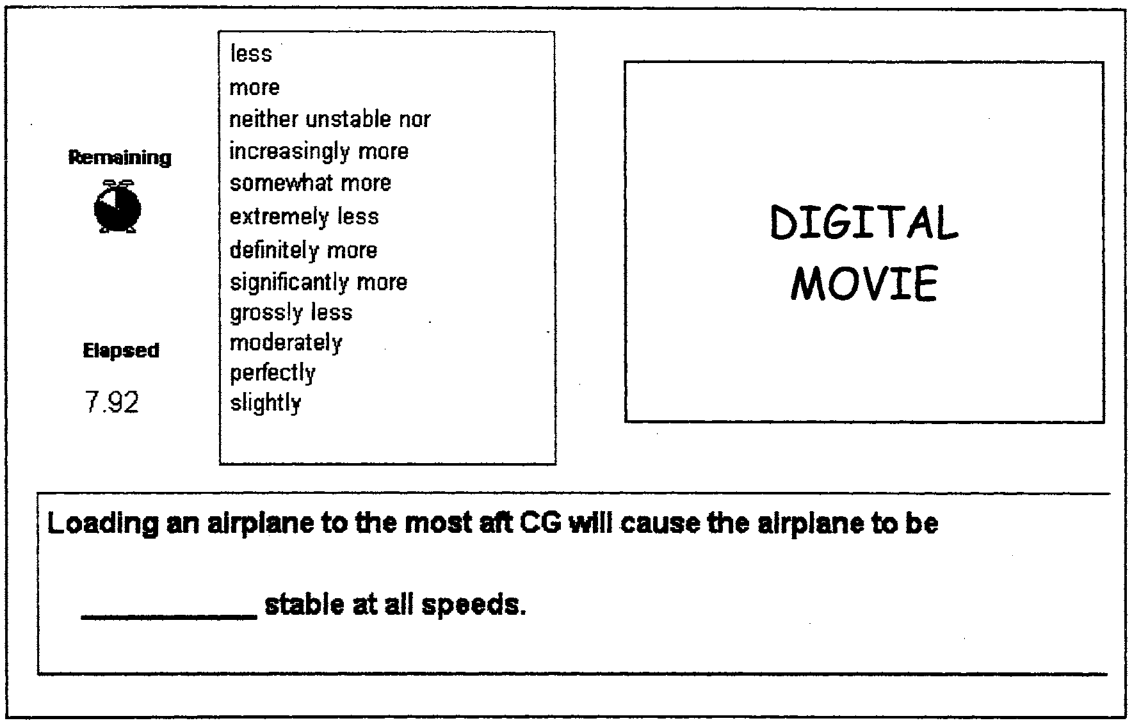


Figure B30. Question Thirty.

APPENDIX C

COURSE PLAN/CONTROL GROUP TEST

Slow Flight, Stalls, and General Aerodynamics

Objective: Given the symbol VSO and a number of statements select the statement that defines the symbol.

Instruction

CFAR Part 1 lists definitions for words, phrases, abbreviations, and symbols. The following symbols and definitions are important for future planning purposes.

V_F	design flap speed
V_{FC}/M_{FC}	maximum speed for stability characteristics
V_{FE}	maximum flap extended speed
V_H	maximum speed in level flight with maximum continuous power
V_{LE}	maximum landing gear extended speed
V_{LO}	maximum landing gear operating speed
V_{LOF}	lift-off speed
V_{MC}	minimum control speed with the critical engine inoperative
V_{MO}/M_{MO}	maximum operating limit speed
V_{MU}	minimum unstick speed
V_{NE}	never exceed speed
V_{NO}	maximum structural cruising speed
V_S	the stalling speed or the minimum steady flight speed at which the airplane is controllable

V_{SO}	the stalling speed or the minimum steady flight speed in the landing configuration
V_{S1}	the stalling speed or the minimum steady flight speed Obtained in a specified configuration
V_X	speed for best angle of climb
V_Y	speed for best rate of climb

Question One

VSO is defined as the

A. stalling speed or minimum steady flight speed in the landing configuration.

B. stalling speed or minimum takeoff safety speed.

C. stalling speed or minimum steady flight speed in a specified configuration.

Answer: A

Objective: Describe how frost on a wing's surface will change the performance of an airplane.

Instruction

Frost on a wing can change the wing's performance. The greatest performance degradation is due to disturbed airflow. A wing's lifting efficiency is at its peak when the airflow adheres to the wing's clean surface. Anything attached to the surface can decrease the wing's performance. The uneven distribution of frost on a wing causes airflow disturbances like eddies in a stream and reduces lift.

Frost does not change the camber of the wing, nor does it affect the angle of attack during takeoff.

Question Two

How will frost on the wings of an airplane affect takeoff performance?

A. Frost will change the camber of the wing, increasing its lifting capability.

B. Frost will disrupt the smooth flow of air over the wing, adversely affecting its lifting capability.

C. Frost will cause the airplane to become airborne with a higher angle of attack, decreasing the stall speed.

Answer: B

Objective: Describe the relationship between stability and control in an airplane.

Instruction

Stability is a characteristic of an airplane in flight that causes it to return to a condition of equilibrium, or steady flight, after it is disturbed. For example, if you are flying a stable airplane that is disturbed while in straight-and-level flight, it has a tendency to return to the same attitude. (Private Pilot Manual, 1-42) A stable airplane is easy to fly, however this does not mean that the pilot can depend entirely on stability to return the airplane to the original condition. (AC61-23C, 1-11).

Stability does not suggest that an airplane will not spin, nor does it suggest that an airplane is difficult to stall. Spins and stalls are not directly tied to stability.

Question Three

An airplane said to be inherently stable will

A. not spin.

B. be difficult to stall.

C. requires less effort to control.

Answer: C

Objective: Determine which basic flight maneuver increases the load factor of an airplane compared to straight-and-level flight.

Instruction

Straight-and-level flight is achieved when aerodynamic factors are at equilibrium. If an airplane transitions from level flight to a climb, the load factor increases until the angle of attack is set. However, once a climb is begun the load factor is neutralized. An unaccelerated stall is much the same as a climb. The aerodynamic factors are in equilibrium until the wing cannot maintain sufficient lift.

A turn cannot be sustained unless the airplane is kept in a curved path. The curved path can be achieved by increasing the load factor on the wings. As the angle of bank increases the load factor increases.

Question Four

Which basic flight maneuver increases the load factor on an airplane as compared to straight-and-level flight?

A. Turns.

B. Climbs.

C. Stalls.

Answer: A

Objective: Describe the relationship between indicated airspeed and altitude change, as it has to do with stall speed.

Instruction

Altitude does not affect indicated airspeed. Indicated airspeed is the direct instrument reading obtained from the airspeed indicator, uncorrected for variations in atmospheric density, installation error, or instrument error. For a given true airspeed, indicated airspeed decreases as altitude increases or for a given indicated airspeed, true airspeed increases with an increase in altitude.

Question Five

As altitude increases, the indicated airspeed at which a given airplane stalls in a particular configuration will

A. decrease as the true airspeed decreases.

B. decrease as the true airspeed increases.

C. remain the same regardless of altitude.

Answer: C

Objective: Locate the area and color of the airspeed indicator that identifies the range of power-off stalling speed in a specified configuration (VS1).

Instruction

The following is a description of the standard color-code markings on airspeed indicators used on single-engine light airplanes.

Table C1. Airspeed Descriptions

• Flap operating range	• White arc
• Power-off stalling speed with the wing flaps and landing gear in the landing position	• Lower limit of the white arc
• Maximum flaps extended speed	• Upper limit of the white arc
• Normal operating range	• Green arc
• Power-off stalling speed with the wing flaps and landing gear retracted	• Lower limit of the green arc
• Maximum structural cruising speed	• Upper limit of the green arc
• Caution range	• Yellow arc
• Never-exceed speed	• Red line

The lower limit of the green arc represents the power-off stall speed in a specified configuration (usually flaps up, gear retracted).

Question Six

Which color identifies the power-off stalling speed in a specified configuration?

A. Upper limit of the white arc.

B. Lower limit of the green arc.

C. Upper limit of the green arc.

Answer: A

Objective: Describe the relationship between aircraft weight and balance and flight characteristics.

Instruction

Loading in a tail-heavy condition has a most serious effect upon longitudinal stability, and can reduce the airplane's capability to recover from stalls and spins. With a CG aft of the rear CG limit, the airplane becomes tail heavy and unstable in pitch because the horizontal stabilizer is less effective. Another undesirable characteristic produced from tail-heavy loading is that it produces very light control forces. This makes it easy for the pilot to inadvertently overstress the airplane.

Question Seven

An airplane has been loaded in such a manner that the CG is located aft of the aft CG limit. One undesirable flight characteristic a pilot might experience with this airplane would be

A. a longer takeoff run.

B. stalling at higher-than-normal airspeed.

C. difficulty in recovering from a stalled condition.

Answer: C

Objective: Describe the relationship between a stall and a spin.

Instruction

The spin is the most complex of all flight maneuvers. There are actually hundreds of factors that contribute to the spinning of an airplane. In a light, training airplane a spin may be defined as an aggravated stall which results in autorotation. During the spin, the airplane descends in a helical, or corkscrew, path while the angle of attack is greater than the critical angle of attack. A stall must occur before a spin can develop. However, a stall is essentially a coordinated maneuver where both wings are equally or almost equally stalled. In contrast, a spin is an uncoordinated maneuver with the wings unequally stalled.

Question Eight

In what flight condition must an aircraft be placed in order to spin?

A. Stalled.

B. Partially stalled with one wing low.

C. In a steep diving spiral.

Answer: A

Objective: Describe the relationship between a turning stall and the stalled condition of each wing as it pertains to a spin.

Instruction

In a spin, both wings are stalled. The outside wing may be less fully stalled than the inside wing, but both wings must be stalled in order to enter a spin.

Question Nine

During a spin to the left, which wing(s) is/are stalled?

A. Only the left wing is stalled.

B. Both wings are stalled.

C. Neither wing is stalled.

Answer: B

Objective: Describe the relationship between angle of attack and a stall.

Instruction

The critical angle of attack (angle at which an airplane stalls) is determined by the lift coefficient of a particular wing configuration. An airplane will stall when the critical angle of attack is exceeded, regardless of weight or airspeed. Shifts in center of gravity or increases or decreases in gross weight will not affect the critical angle of attack.

Question Ten

The angle of attack at which an airplane wing stalls will

A. change with an increase in gross weight.

B. increase if the CG is moved forward.

C. remain the same regardless of gross weight.

Answer: C

Objective: Describe the relationship between ground effect and proximity of an aircraft to the ground.

Instruction

Ground effect becomes noticeable when the height of the airplane above the ground is less than the length of the wingspan. As an airplane approaches the surface of the ground, the ground interferes with the aerodynamic flow around the wing. This decreases the induced drag. The sensation is one of floating. An airplane can float well below the airspeed to sustain lift. If the airplane were to ascend out of ground effect with the same airspeed, it would most probably stall due to insufficient thrust and a higher angle of attack.

Question Eleven

Floating caused by the phenomenon of ground effect will be most realized during an approach to land when at

A. a higher-than-normal angle of attack.

B. less than the length of the wingspan above the surface.

C. twice the length of the wingspan above the surface.

Answer: B

Objective: Describe the aerodynamic characteristics that occur during ground effect and relate them to floating distance.

Instruction

Since ground effect decreases induced drag, the airplane tends to float while excess speed bleeds off. To decrease floating distance, fly at a lower speed. The floating distance increases greatly for each knot above approach speed. The airplane generates more lift in ground effect and would therefore require more up elevator displacement to fully stall the wing. Wing tip vortices also decrease in ground effect.

Question Twelve

What must a pilot be aware of as a result of ground effect?

A. Wingtip vortices increase creating wake turbulence problems for arriving and departing aircraft.

B. Induced drag decreases; therefore, any excess speed at the point of flare may cause considerable floating.

C. A full stall landing will require less up elevator deflection than would a full stall when done free of ground effect.

Answer: B

Objective: Describe the relationship between load factor and stall characteristics.

Instruction

Stall speed increases in proportion to load factor. Added G-forces cause an airplane to stall at an airspeed higher than the normal 1 G airspeed. Load factor does not increase an airplane's tendency to spin nor does it make the aircraft harder to control.

Question Thirteen

During an approach to a stall, an increased load factor will cause the airplane to

A. be more difficult to control.

B. stall at a higher airspeed.

C. have a tendency to spin.

Answer: B

Objective: Identify the four forces that act on an airplane.

Instruction

In normal (nonacrobatic) flight conditions, lift is the upward force created by airflow over and under the wings. Weight, caused by the downward pull of gravity, opposes lift. Thrust is the forward force which propels the airplane, and drag is the retarding force opposing thrust. Power affect thrust, but is not one of the aerodynamic forces acting on an airplane. Friction affects thrust, but is not one of the forces. Gravity acts on the airplane, but defines weight and is not one of the forces.

Question Fourteen

The four forces acting on an airplane in flight are

A. lift, gravity, power, and friction.

B. lift, weight, thrust, and drag.

C. lift, weight, gravity, and thrust.

Answer: B

Objective: Describe the relationship between aerodynamic forces acting on an airplane in straight-and-level flight.

Instruction

Assuming the airplane is not accelerating, thrust equals drag, and lift equals weight. Lift, weight, thrust, and drag do not have to be equal to achieve straight-and-level flight.

Question Fifteen

What is the relationship of lift, drag, thrust, and weight when the airplane is in straight-and-level flight?

A. Lift equals weight and thrust equals drag.

B. Lift, drag, and weight equal thrust.

C. Lift and weight equal thrust and drag.

Answer: A

Objective: Identify the purpose of the red line on an airspeed indicator.

Instruction

The red line is the never-exceed speed. Exceeding this speed may destroy the airplane. This speed has nothing to do with turbulence or rough air. This speed should not be confused with maneuvering speed. Flying at red line speed may have a negative effect on the airplane. Consult the manufacturer's manual for details.

Question Sixteen

What does the red line on an airspeed indicator represent?

A. Never-exceed speed.

B. Maneuvering speed.

C. Turbulent or rough-air speed.

Answer: A

Objective: Identify the airspeed that is not indicated on the airspeed indicator.

Instruction

The maneuvering speed of an airplane is not shown on the airspeed indicator. It can be found in the airplane manual or on placards.

Question Seventeen

What is an important airspeed limitation that is not color coded on airspeed indicators?

A. Never-exceed speed.

B. Maximum structural cruising speed.

C. Maneuvering speed.

Answer: C

Objective: Identify the V-speed symbol for maneuvering speed.

Instruction

V_A is defined as the design maneuvering speed. Other speeds are:

V_F	design flap speed
V_{FC}/M_{FC}	maximum speed for stability characteristics
V_{FE}	maximum flap extended speed
V_H	maximum speed in level flight with maximum continuous power
V_{LE}	maximum landing gear extended speed
V_{LO}	maximum landing gear operating speed
V_{LOF}	lift-off speed
VMC	minimum control speed with the critical engine inoperative
V_{MO}/M_{MO}	maximum operating limit speed
V_{MU}	minimum unstick speed
V_{NE}	never exceed speed
V_{NO}	maximum structural cruising speed

V_S	the stalling speed or the minimum steady flight speed at which the airplane is controllable
V_{SO}	the stalling speed or the minimum steady flight speed in the landing configuration
V_{S1}	the stalling speed or the minimum steady flight speed obtained in a specified configuration
V_X	speed for best angle of climb
V_Y	speed for best rate of climb

Question Eighteen

Which V-speed represents maneuvering speed?

A. V_{LO}.

B. V_{NE}.

C. V_{A}.

Answer: C

Objective: Describe the concept of equilibrium as it applies to the four aerodynamic forces acting on an airplane.

Instruction

In straight-and-level, unaccelerated flight, the four forces are in equilibrium. Lift equals weight, and thrust equals drag. If the airplane were to accelerate, then thrust would be greater than drag. An airplane at rest on the taxiway is acted upon by gravity, but there is not thrust, lift, or drag (assuming no wind).

Question Nineteen

When are the four forces that act on an airplane in equilibrium?

A. During unaccelerated flight.

B. When the aircraft is accelerating.

C. When the aircraft is at rest on the ground.

Answer: A

Objective: Identify, from a drawing, the angle of attack.

Instruction

The angle between the chord line and the relative wind is the angle of attack. The relative wind is parallel to, but opposite, the direction of flight of an airplane. The angle of incidence is the angle formed between the chord line and the longitudinal axis of the airplane. Dihedral is the term given the upward angle of a wing relative to the lateral axis of the airplane and does not have anything to do with angle of attack.

Question Twenty

(Refer to figure 1.) The acute angle A is the angle of

A. attack.

B. dihedral.

C. incidence.

Answer: A

Objective: Describe the purpose of wing flaps.

Instruction

Flaps increase both lift and induced drag, allowing a steeper descent without increasing airspeed. Flaps are not trim devices to make the airplane more controllable. In fact the pilot will need to adjust trim when flaps are extended or retracted. Some flaps increase lift because they increase wing area, but flaps never decrease the wing area.

Question Twenty-One

What is one purpose of wing flaps?

A. To enable the pilot to make steeper approaches to a landing without increasing the airspeed.

B. To decrease wing area to vary the lift.

C. To relieve the pilot of maintaining continuous pressure on the controls.

Answer: A

Objective: Describe the function of flaps during approach and landing.

Instruction

Because flaps increase lift, induced drag is also increased, thus allowing a steeper angle of descent without increasing airspeed. For an airplane to touch down using flaps, the airspeed must be decreased. Flying a higher airspeed with an increased flap setting may cause the airplane to land on the nose gear or cause the propeller to strike the surface first. If the pilot chose to not use flaps, the angle of descent would be much shallower than if flaps were selected.

Question Twenty-Two

One of the main functions of flaps during approach and landing is to

A. increase the angle of descent without increasing the airspeed.

B. permit a touchdown at a higher indicated airspeed.

C. decrease the angle of descent without increasing the airspeed.

Answer: A

Objective: Describe the relationship between torque effect, airspeed, power, and angle of attack.

Instruction

Torque effect is greatest at low airspeeds, high power settings, and high angles of attack much like a pilot would find during climb out. The least amount of torque effect occurs during low airspeed, low power, and low angle of attack maneuvering flight. High airspeed, high power, and high angle of attack will not cause a greater torque effect because of the higher airspeed.

Question Twenty-Three

In what flight condition is torque effect the greatest in a single-engine airplane?

A. High airspeed, high power, high angle of attack.

B. Low airspeed, low power, low angle of attack.

C. Low airspeed, high power, high angle of attack.

Answer: C

Objective: Describe longitudinal stability as it applies to an airplane.

Instruction

The longitudinal stability of an airplane is determined primarily by the location of the center of gravity (CG) in relation to the center of lift. This excludes any affect of the rudder, the horizontal stabilizer, or the rudder trim.

Question Twenty-Four

What determines the longitudinal stability of an airplane?

A. The location of the CG with respect to the center of lift.

B. The effectiveness of the horizontal stabilizer, rudder, and rudder trim tab.

C. The relationship of thrust and lift to weight and drag.

Answer: A

Objective: Describe the purpose of the rudder in relation to controlling an airplane.

Instruction

Since the rudder moves the airplane about its vertical axis, it is used to control yaw. Although the rudder is used to coordinate a turn, the tendency to overbank or roll the airplane is attributed to the ailerons. In some aircraft a roll can be achieved with rudder only (T-38). However, the T-38 is an exception.

Question Twenty-Five

What is the purpose of the rudder on an airplane?

A. To control roll.

B. To control overbanking tendency.

C. To control yaw.

Answer: C

Objective: Describe ground effect.

Instruction

When flying close to the ground, the airflow around an airplane is altered by interference with the surface of the earth. The resulting ground effect reduces the induced drag on the airplane.

Question Twenty-Six

What is ground effect?

A. The result of the disruption of the airflow patterns about the wings of an airplane to the point where the wings will no longer support the airplane in flight.

B. The result of an alteration in airflow patterns increasing induced drag about the wings of an airplane.

C. The result of the interference of the surface of the Earth with the airflow patterns about an airplane.

Answer: C

Objective: Describe ground effect in terms of maneuvering flight.

Instruction

The decreased induced drag while in ground effect allows the airplane to become airborne at a lower airspeed. This may fool you into thinking the airplane is capable of flying at the lower airspeed when you climb out of ground effect. Ground effect acts like a cushion of air. The floating sensation allows the airplane to stay airborne even when the airspeed is below the airspeed normally needed to sustain flight. Ground effect is of no effect when the airplane is on the ground. This is because lift is not sufficient to get the airplane off the ground.

Question Twenty-Seven

Ground effect is most likely to result in which problem?

A. Inability to get airborne even though airspeed is sufficient for normal takeoff needs.

B. Settling to the surface abruptly during landing.

C. Becoming airborne before reaching recommended takeoff speed.

Answer: C

Objective: Describe the procedure to take in the event of power failure after becoming airborne.

Instruction

Establishing the proper glide attitude and airspeed is critical to ensure the best possibility of reaching a suitable landing area. It also tends to reduce the possibility of a stall/spin accident. Checking to see if the fuel is feeding may be important, but should not be attempted until aircraft control is reestablished. Don't initiate maneuvers toward the landing pattern until aircraft is established.

Question Twenty-Eight

The most important rule to remember in the event of a power failure after becoming airborne is to

A. quickly check the fuel supply for possible fuel exhaustion.

B. determine the wind direction to plan for the forced landing.

C. immediately establish the proper gliding attitude and airspeed.

Answer: C

Objective: Describe the relationship between power reduction and pitch if the controls are not adjusted.

Instruction

At higher power settings, in airplanes other than T-tail designs, the propeller slipstream causes a greater downward force on the horizontal stabilizer. When power is reduced, this downward force on the tail is also reduced, and the nose pitches down. The CG of the airplane is not affected by a thrust reduction.

Question Twenty-Nine

What causes an airplane (except a T-tail) to pitch nosedown when power is reduced and controls are not adjusted?

A. The downwash on the elevators from the propeller slipstream is reduced and elevator effectiveness is reduced.

B. When thrust is reduced to less than weight, lift is also reduced and the wings can no longer support the weight.

C. The CG shifts forward when thrust and drag are reduced.

Answer: A

Objective: Describe how the position of load relative to CG can affect controllability.

Instruction

In an airplane loaded to the aft CG limit, the horizontal stabilizer is less effective, causing the airplane to be less stable at all speeds.

Question Thirty

Loading an airplane to the most aft CG will cause the airplane to be

A. less stable at slow speeds, but more stable at high speeds.

B. less stable at high speeds, but more stable at low speeds.

C. less stable at all speeds.

Answer: C

APPENDIX D

REFERENT PAIRS

TABLE D1

1997 PRACTICAL TEST, SLOW FLIGHT

Referent	#
Slow Flight	7
Control(s) (led)	5
Attitude	3
Airspeed	11
Altitude	14
Maneuvering	7
Power	12
Load Factor	4
Pitch	6
Turns	13
Maintain	18
Indications	3
Stabilized	3
Flight	8
Simulate(s)	1
Coordinated	6
Heading	9
Climb	12
Descent	9
Configuration	5

TABLE D2

PRIVATE PILOT MANUAL, SLOW FLIGHT

Referent	#
Slow Flight	0
Control(s) (led)	10
Attitude	6
Airspeed	29
Altitude	2
Maneuvering	7
Power	5
Load Factor	13
Pitch	6
Turns	17
Maintain	7
Indications	3
Stabilized	-
Flight	-
Simulate(s)	-
Coordinated	3
Heading	-
Climb	6
Descent	7

TABLE D3

AC 61-23C, PILOT'S HANDBOOK OF AERONAUTICAL KNOWLEDGE, SLOW FLIGHT

Referent	#
Slow Flight	0
Control(s) (led)	25
Attitude	2
Airspeed	37
Altitude	7
Maneuvering	-
Power	8
Load Factor	0
Pitch	-
Turns	14
Maintain	-
Indications	0
Stabilized	-
Flight	-
Simulate(s)	-
Coordinated	-
Heading	-
Climb	-
Descent	-

TABLE D4

1997 PRACTICAL TEST, POWER-OFF STALLS

Referent	#
Stall	45
Control(s)	10
Attitude	11
Airspeed	26
Power	3
Drag	37
Turns	5
Indications	6
AOA	13
Lift	23
Recognize	5
Recover	7
Altitude	8

TABLE D5

PRIVATE PILOT MANUAL, POWER-OFF STALLS

Referent	#
Stall	29
Control(s)	10
Attitude	6
Airspeed	29
Power	5
Drag	17
Turns	17
Indications	0
AOA	13
Lift	29
Recognize	3
Recover	3
Altitude	2

TABLE D6

AC 61-23C, PILOT'S HANDBOOK OF AERONAUTICAL KNOWLEDGE, POWER-OFF STALLS

Referent	#
Stall	21
Control(s)	25
Attitude	2
Airspeed	37
Power	8
Drag	51
Turns	14
Indications	0
AOA	37
Lift	71
Recognize	0
Recover	0
Altitude	7

TABLE D7

1997 PRACTICAL TEST, POWER-ON STALLS

Referent	#
Stall	40
Control(s)	3
Attitude	7
Airspeed	5
Power	7
Drag	0
Turns	7
Indications	2
AOA	1
Lift	0
Recognize	4
Recover	6
Altitude	4

TABLE D8

PRIVATE PILOT MANUAL, POWER-ON STALLS

Referent	#
Stall	29
Control(s)	10
Attitude	6
Airspeed	29
Power	5
Drag	17
Turns	17
Indications	0
AOA	13
Lift	29
Recognize	3
Recover	3
Altitude	2

TABLE D9

AC 61-23C, PILOT'S HANDBOOK OF AERONAUTICAL KNOWLEDGE, POWER-ON STALLS

Referent	#
Stall	21
Control(s)	25
Attitude	2
Airspeed	37
Power	8
Drag	51
Turns	14
Indications	0
AOA	37
Lift	71
Recognize	0
Recover	0
Altitude	7

TABLE D10

1997 PRACTICAL TEST, SPIN AWARENESS

Referent	#
Recognition	2
Awareness	4
Prevention	1
Recovery	10
Coordinated	4

TABLE D11

PRIVATE PILOT MANUAL, SPIN AWARENESS

Referent	#
Recognition	3
Awareness	0
Prevention	-
Recovery	3
Coordinated	3

TABLE D12

AC 61-23C, PILOT'S HANDBOOK OF AERONAUTICAL KNOWLEDGE, SPIN AWARENESS

Referent	#
Recognition	0
Awareness	0
Prevention	0
Recovery	0
Coordinated	-

TABLE D13

THREE-REFERENCE WORD LIST COMPARISON

Referent	Reference 1	Reference 2	Reference 3
Slow Flight	7	0	0
Control(s)	5	10	25
Attitude	3	6	2
Airspeed	11	29	37
Maneuvering	7	7	-
Power	12	5	8
Load Factor	4	13	56
Pitch	6	6	-
Turns	13	17	14
Maintain	18	7	-
Indications	3	3	0
Stabilized	3	-	-
Flight	8	-	-
Simulate	1	-	-
Coordinated	6	3	-
Heading	9	-	-
Climb	12	6	-
Descent	9	7	-
Configuration	5	-	-

TABLE D14

PRIME AND ASSOCIATIVE REFERENTS,
A THREE-WAY COMPARISON

Referent	Reference 1	Reference 2	Reference 3
Slow Flight	maneuvering	None	None
Control(s)	Flight	Wheel	None
Attitude	Pitch	Pitch	Pitch
Airspeed	Maintain	Maintain	Climb, constant
Maneuvering	Slow flight	Speed	As to place
Power	Apply	Add	Add
Load Factor	Loading	Lift	Lift
Pitch	Attitude	Power	Power
Turns	Coordinated	Coordinated	Load factor
Maintain	Pitch	Airspeed	Airspeed, pitch
Indications	Stall	Stall	Stall
Stabilized	Flight	Airspeed	None
Flight	Attitude	Coordinated	None
Simulate	Approach to land	None	None
Coordinated	Turns	Turns	Turns
Heading	Control	Control	None
Climb	Attitude	Angle	None
Descent	Rate	Rate	None
Configuration	Landing	Landing	None

TABLE D15

POWER-OFF STALLS, A THREE-WAY COMPARISON

Referent	Reference 1	Reference 2	Reference 3
Stall	-	-	-
Control(s)	Maneuver	Maneuver	Maneuver
Attitude	Pitch	Pitch	Pitch
Airspeed	Lift, AOA	Lift, AOA	Lift, AOA
Power	(engine)	(engine)	(engine)
Drag	(type)	(type)	(type)
Turns	(demo type)	(demo type)	Load factor
Indications	(of stall)	None	None
AOA	Lift, airspeed	Lift, airspeed	Lift, airspeed
Lift	AOA	AOA	AOA, load
Recognize	Stall (indications)	Stall (indications)	None
Recover	Stall	Stall	None
Altitude	Minimum loss of	Minimum loss of	Minimum loss of

TABLE D16

POWER-ON STALLS, A THREE-WAY COMPARISON

Referent	Reference 1	Reference 2	Reference 3
Stall	Approach to	-	-
Control(s)	Maneuver	Maneuver	Maneuver
Attitude	Stalling	Pitch	Pitch
Airspeed	Lift, AOA	Lift, AOA	Lift, AOA
Power	Climb	(engine)	(engine)
Drag	None	(type)	(type)
Turns	(demo type)	(demo type)	Load factor
Indications	(of stall)	None	None
AOA	Lift, airspeed	Lift, airspeed	Lift, airspeed
Lift	None	AOA	AOA, load
Recognize	Stall	Stall	None
Recover	Stall	Stall	None
Altitude	Minimum loss of	Minimum loss of	Minimum loss of

TABLE D17

SPINS, A THREE-WAY COMPARISON

Referent	Reference 1	Reference 2	Reference 3
Recognition	Recovery	Recovery	None
Awareness	Spin	None	None
Prevention	Spin	-	None
Recovery	Recognition, spin	Stall	None
Coordinated	Maneuver	Maneuver	-

TABLE D18

CONSOLIDATING THE LISTS

Referent	Reference 1	Reference 2	Reference 3
Slow Flight List			
Slow flight	Maneuvering	None	None
Control(s)	Flight	Wheel	None
Attitude	Pitch	Pitch	Pitch
Airspeed	Maintain	Maintain	Climb, constant
Altitude	Maintain	Maintain	Climb, constant
Maneuvering	Slow flight	Speed	As to place
Power	Apply	Add	Add
Load factor	Loading	Lift	Lift
Pitch	Attitude	Power	Power
Turns	Coordinated	Coordinated	Load factor
Maintain	Pitch	Airspeed	Airspeed
Indications	Stall	Stall	Stall
Stabilized	Flight	Airspeed	None
Flight	Attitude	Coordinated	None

TABLE D18 – continued

Referent	Reference 1	Reference 2	Reference 3
Power-Off Stalls Consolidation			
Stall	-	-	-
Control(s)	Maneuver	Maneuver	Maneuver
Attitude	Pitch	Pitch	Pitch
Power	(engine)	(engine)	(engine)
Drag	(type)	(type)	(type)
Turns	(demo type)	(demo type)	Load factor
Indications	(of stall)	None	None
AOA	Lift, airspeed	Lift, airspeed	Lift, airspeed
Lift	AOA	AOA	AOA, load
Recognize	Stall (indications)	Stall (indications)	None
Recover	Stall	Stall	None
Altitude	Minimum loss of	Minimum loss of	Minimum loss of
Power-On Stalls List			
Stall	Approach to	-	-
Control(s)	Maneuver	Maneuver	Maneuver
Attitude	Stalling	Pitch	Pitch
Airspeed	Lift, AOA	Lift, AOA	Lift, AOA
Power	Climb	(engine)	(engine)
Drag	None	(type)	(type)
Turns	(demo type)	(demo type)	Load factor
Indications	(of stall)	None	None
AOA	Lift, airspeed	Lift, airspeed	Lift, airspeed
Lift	None	AOA	AOA, load
Recognize	Stall	Stall	None

TABLE D18 – Continued

Referent	Reference 1	Reference 2	Reference 3
Stall	Approach to	-	-
Control(s)	Maneuver	Maneuver	Maneuver
Attitude	Stalling	Pitch	Pitch
Airspeed	Lift, AOA	Lift, AOA	Lift, AOA
Power	Climb	(engine)	(engine)
Drag	None	(type)	(type)
Turns	(demo type)	(demo type)	Load factor
Indications	(of stall)	None	None
AOA	Lift, airspeed	Lift, airspeed	Lift, airspeed
Lift	None	AOA	AOA, load
Recognize	Stall	Stall	None
Altitude	Minimum loss of	Minimum loss of	Minimum loss of
<u>Spin Awareness List</u>			
Recognition	Recovery	Recovery	None
Awareness	Spin	None	None
Prevention	Spin	-	None
Recovery	Recognition, spin	Stall	None
Coordinated	Maneuver	Maneuver	-

TABLE D19

A = C RELATIONSHIP BETWEEN PRIME REFERENTS

A = C		B
Airspeed	Altitude	Maintain
Attitude	Maintain	Pitch
Turns	Flight	Coordinated
Airspeed	Lift	Angle of Attack
Recognize	Recover	Stall or Spin
Airspeed	Angle of Attack	Lift
Turns	Load factor	Lift
Awareness	Prevention	Spin
Control	Coordinated	Maneuvering

APPENDIX E

SCORES

OU M001 24 17
Control Group Test 1 0 1 0 0 0 1 1 1 1 1 1 1 1 1
015.142 25.639 14.532 10.77 34.155 22.458 9.406 15.679 6.173 13.206 20.841 15.708 14.375 21.654 23.544

Distraction Test 3 1 0 1 1 0 1 1 0 0 0 0 0 1 1 1 0 1 0 1 1 1 0 1 1 1 0 1 3 0
44.956 22.437 33.994 17.931 16.813 17.759 25.345 17.96 43.052 33.087 23 36.58 15.269 29.329 16.36 8.341 13.964 8.496 32.873 5.263 19.855 26.243 22.324 21.144 20.982 15.292 43.986 22.09 44.906 42.917
****************EOF******************
OU M002 32 17
Experimental Group Test 1 0 1 1 0 1 1 1 1 0 1 1 1 1 1
016.844 7.871 22.018 10.169 23.153 28.168 13.842 7.101 8.269 17.682 14.02 23.885 13.486 7.22 10.995

Distraction Test 0 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 0 1 1 0 1 0 1 0 1 1 0 1
26.16 20.369 13.037 10.748 19.224 10.574 21.458 6.346 9.357 23.238 12.15 20.721 24.498 9.324 29.506 4.192 21.03 5.138 16.465 8.276 18.099 32.497 29.536 37.779 15.688 44.168 11.521 13.629 31.83 7.576
****************EOF******************
OU M003 24 17
Control Group Test 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1
050.557 20.814 19.595 10.584 18.327 54.424 8.446 4.282 6.177 10.083 17.933 26.811 19.012 34.01 11.463

Distraction Test 1 1 3 1 0 1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
28.889 21.213 44.896 17.538 20.939 9.602 20.305 7.316 10.636 13.445 18.83 19.973 14.055 20.087 13.016 8.407 8.906 5.994 18.028 4.044 12.823 20.235 18.69 8.355 4.06 14.244 13.414 10.094 18.47 15.016
****************EOF******************
OU M004 27 15
Experimental Group Test 1 1 1 1 0 1 1 1 0 1 1 1 1 1 0
013.99 11.69 12.364 6.323 34.686 11.564 10.452 3.807 12.333 9.743 12.809 22.209 21.343 6.78 29.656

Distraction Test 0 1 0 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 0 1 1 1
24.683 22.461 17.106 7.061 17.111 8.127 28.185 3.441 4.663 15.684 9.132 23.019 11.108 18.533 21.993 3.994 5.468 13.384 6.063 3.027 12.976 21.217 30.424 14.746 7.145 19.578 29.088 12.72 35.034 14.052
****************EOF******************

OU F005 22 15
Control Group Test 1 0 0 0 0 0 1 1 1 1 1 0 1 1 0
014.614 15.822 13.274 12.244 25.353 21.542 5.476 4.818 9.456 9.748 23.764 13.551 20.453 23.702 25.248

Distraction Test 0 0 0 0 0 0 1 1 0 1 0 0 0 1 1 1 1 1 0 1 0 1 1 0 0 1 1 1 0 1
16.26 10.661 9.456 9.089 15.323 7.918 15.565 10.202 20.801 29.898 31.109 22.212 18.796 7.674 9.31 8.332 7.504 8.024 16.741 5.51 22.26 30.498 30.538 28.749 37.086 17.154 19.669 8.745 33.249 30.984
****************EOF******************
OU F006 18 13
Experimental Group Test 1 0 0 1 1 1 1 1 1 0 1 1 1 1 1
020.293 29.424 18.485 34.683 19.339 38.735 24.428 6.435 15.447 14.43 26.93 25.601 19.651 22.396 32.458

Distraction Test 1 1 0 0 0 1 1 0 1 1 0 3 0 1 1 1 0 0 1 1 3 1 1 1 1 1 1 1 0 0
32.683 33.599 24.633 26.509 40.391 14.426 25.748 36.684 30.041 37.982 12.234 44.976 34.869 30.79 23.718 9.91 15.312 10.088 9.989 10.183 44.878 41.892 17.185 40.767 27.491 37.65 21.365 24.482 34.46 27.15
****************EOF******************
OU F007 18 13
Control Group Test 1 0 0 1 0 1 1 1 0 0 1 0 1 1 1
070.44 16.162 24.804 14.131 24.336 52.718 9.332 13.439 15.01 20.763 47.147 55.202 23.81 18.219 31.807

Distraction Test 0 1 1 0 1 1 0 1 0 1 1 0 0 1 1 0 0 0 0 0 1 1 0 0 1 1 1 1 0 0
44.647 19.138 20.726 24.696 24.098 9.433 38.189 5.231 21.392 18.905 38.462 26.007 16.016 11.124 32.935 7.522 23.809 8.675 30.108 5.116 20.141 23.405 24.912 32.769 16.046 12.6 26.165 20.926 36.252 17.035
****************EOF******************
OU M008 34 14
Experimental Group Test 1 0 1 1 1 0 1 1 1 0 1 1 1 1 1
018.46 14.454 14.045 9.321 17.73 17.048 18.252 10.356 7.267 12.214 22.543 16.99 13.698 11.675 14.492

Distraction Test 1 0 1 1 1 1 1 1 0 1 1 0 0 1 1 1 1 1 1 1 1 0 0 1 0 1 1 1 0 0
5.571 14.27 8.268 18.498 21.954 10.221 28.001 9.083 24.997 11.996 19.724 36.289 25.736 11.654 24.142 6.171 19.649 7.1 25.637 8.145 19.916 38.802 26.928 33.135 7.421 17.32 19.904 16.666 41.825 17.823
****************EOF******************

OU M009 19 13
Control Group Test 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
012.151 12.001 26.938 8.464 7.857 26.99 20.201 7.378 6.543 6.873 31.712 35.512 16.626 24.167 11.411

Distraction Test 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1 1
19.745 16.101 10.506 8.49 25.341 10.165 14.025 5.238 5.17 10.126 33.981 14.5 7.632 6.589 11.979 11.468 7.589 5.161 12.963 4.551 10.366 38.828 20.515 41.229 4.734 14.847 8.567 23.921 26.536 8.172
****************EOF******************
RS M010 37 17
Experimental Group Test 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
026.168 14.29 9.121 15.464 19.899 15.35 9.546 5.955 5.104 9.668 10.96 32.409 14.987 14.91 13.318

Distraction Test 1 3 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 1
26.898 45.121 15.74 9.552 31.148 10.115 33.204 9.159 16.803 7.165 21.672 17.438 35.99 10.291 20.479 6.487 12.481 5.801 20.534 6.015 15.525 20.695 15.345 18.246 7.725 18.089 14.984 12.757 45.076 16.591
****************EOF******************
RS M011 34 13
Control Group Test 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
046.697 9.656 27.366 7.204 29.636 53.937 9.266 5.48 8.509 24.454 22.826 18.549 20.78 20.959 19.017

Distraction Test 1 0 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 1
26.884 17.083 28.695 17.833 10.514 11.972 24.556 9.937 7.365 18.831 29.784 19.233 8.404 7.721 44.636 5.979 7.363 4.738 17.418 5.449 9.254 18.225 22.01 15.984 20.413 20.229 13.914 9.817 21.273 11.341
****************EOF******************
RS M012 23 13
Experimental Group Test 1 1 1 1 1 0 1 1 1 1 0 1 1 1 0
012.365 14.436 16.213 6.29 11.335 16.561 12.177 4.664 5.36 6.166 17.945 17.946 21.56 15.288 12.329

Distraction Test 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 0 1
8.948 8.315 7.951 8.787 12.818 7.748 12.408 4.928 14.284 7.16 13.836 13.266 36.531 6.213 17.591 8.094 11.433 5.158 24.168 4.196 10.16 32.404 18.154 9.42 13.75 16.534 12.37 18.798 29.385 12.016
****************EOF******************

RS M013 21 14
Control Group Test 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1
033.679 9.205 15.824 7.643 9.661 23.688 8.848 5.629 5.278 10.101 19.851 47.549 31.931 12.973 19.132

Distraction Test 3 0 1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1
45.127 21.333 11.879 11.665 12.512 17.709 20.005 6.816 30.208 7.18 19.219 14.077 23.08 5.733 10.254 5.4 11.029 4.847 38.655 4.955 8.83 20.941 39.571 16.192 5.755 16.055 16.741 10.898 29.012 7.56
****************EOF*****************
RS M014 20 15
Experimental Group Test 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
024.564 12.047 17.066 13.452 16.208 24.71 22.71 4.94 7.39 13.385 12.977 36.604 19.214 30.944 16.55

Distraction Test 1 1 0 1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
14.587 19.619 30.874 8.842 11.66 8.148 21.949 8.766 35.882 15.946 19.709 9.118 8.917 9.614 14.806 4.345 5.012 3.288 14.332 5.939 19.286 22.571 21.133 18.113 26.091 25.47 14.934 15.655 39.884 8.421
****************EOF*****************
RS M015 19 14
Control Group Test 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1
09.812 30.63 15.94 28.079 6.485 23.808 17.529 6.058 12.506 7.799 13.659 12.088 17.501 19.209 32.824

Distraction Test 0 0 1 1 1 1 1 1 0 0 1 1 1 0 1 1 1 1 1 0 1 0 1 1 0 0 1 0 1 3 0
21.274 39.745 27.278 37.193 14.138 17.898 18.365 17.615 22.264 13.213 18.753 25.681 17.477 7.767 13.396 6.151 6.697 7.672 17.233 6.712 16.371 32.879 21.555 20.231 32.305 9.948 32.756 28.517 45.051 18.356
****************EOF*****************
RS M016 38 14
Experimental Group Test 1 1 0 0 1 1 1 1 1 1 1 0 0 1 1 1
023.902 17.311 17.454 11.678 26.988 26.455 18.471 9.676 8.666 6.352 24.126 19.405 26.78 11.204 19.976

Distraction Test 1 0 0 1 1 0 1 0 0 1 1 1 1 1 1 1 1 1 1 1 3 1 1 0 1 0 1 1 0 1
34.936 18.809 29.937 16.498 25.471 13.529 20.679 27.67 18.736 9.392 33.246 44.056 21.21 40.764 21.8 8.058 20.396 16.212 36.131 14.655 45.136 31.031 18.527 33.246 14.865 25.123 33.813 19.993 30.431 19.247
****************EOF*****************

RS* M017 38 17
Control Group Test 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1
023.519 9.266 20.124 5.917 19.206 24.635 11.522 5.191 5.682 8.346 14.882 28.194 31.395 8.708 15.78

Distraction Test 1 0 0 1 0 0 3 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1
32.489 24.341 13.252 13.556 15.759 12.225 45.041 5.914 21.594 30.652 13.778 10.55 14.767 6.887 19.575 7.561 9.75 6.731 17.408 6.446 20.067 14.469 12.307 27.959 5.506 11.165 24.111 10.764 26.68 13.95
****************EOF******************
RS M018 43 16
Experimental Group Test 1 1 0 0 1 0 1 1 1 1 0 0 1 1 1
017.574 10.846 9.387 10.267 9.846 17.216 7.145 6.864 5.225 9.935 13.771 10.945 10.856 14.283 13.192

Distraction Test 0 0 0 1 0 1 1 0 0 1 0 0 0 0 0 1 1 1 0 1 0 1 1 0 1 0 1 1 0 0
3.695 12.365 13.766 7.275 15.963 13.404 26.118 18.107 16.861 17.325 29.589 28.943 7.951 19.502 16.063 7.442 7.565 8.026 18.323 2.908 14.496 15.269 11.145 12.886 11.83 16.831 30.458 16.919 28.752 17.342
****************EOF******************
RS M019 20 14
Control Group Test 1 0 0 1 1 0 1 1 1 1 1 1 1 1 0
036.618 12.206 8.024 28.067 10.979 32.709 7.534 4.682 5.048 7.436 16.444 15.5 18.998 15.304 17.532

Distraction Test 1 1 1 0 1 0 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
4.024 15.672 16.2 9.426 9.661 13.878 24.911 5.325 10.791 9.112 15.823 16.543 17.583 7.244 10.596 5.709 5.317 6.42 8.44 3.796 9.761 10.534 15.184 12.174 4.572 14.852 9.206 11.367 25.577 12.096
****************EOF******************
RS M020 34 13
Experimental Group Test 1 0 1 0 1 1 1 1 1 1 0 1 1 1 1
020.597 19.008 23.148 23.636 28.372 27.77 13.222 8.168 23.274 27.24 27.423 19.363 20.917 20.336 22.838

Distraction Test 0 1 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0 3 0 1 1 1 0 1 1 3 1
14.034 25.578 15.129 34.305 43.208 38.649 38.351 15.177 24.922 17.798 18.711 40.769 30.007 11.738 13.87 8.334 29.277 20.922 27.689 30.507 45.069 43.981 38.161 36.453 21.473 30.333 22.918 23.948 45.082 15.267
****************EOF******************

RS F021 54 17
Control Group Test 1 1 0 1 0 1 1 1 1 1 1 0 1 1 1
062.485 31.599 20.732 9.796 13.587 75.364 15.358 8.309 12.748 30.561 22.905 35.122 18.79 13.587 21.697

Distraction Test 1 0 1 1 0 0 1 1 0 0 1 1 1 1 1 1 0 1 1 1 3 3 0 1 0 1 1 1 3 1
41.252 35.671 26.071 21.955 44.388 11.52 33.035 9.881 43.826 44.775 17.193 25.639 22.286 13.479 36.315 11.413 34.504 11.888 15.554 15.473 44.92 45.049 31.795 28.396 44.305 42.531 43.631 32.925 45.023 13.832
****************EOF******************
RS M022 25 13
Experimental Group Test 3 1 0 1 1 0 1 1 1 1 0 1 1 1 1
045.081 37.872 15.712 17.696 13.88 23.119 17.599 11.142 17.875 14.531 39.956 39.665 27.6 20.998 38.021

Distraction Test 3 3 0 1 1 0 1 1 0 1 0 3 1 1 3 0 1 1 1 1 1 0 0 1 1 0 1 1 0 0
44.942 44.835 42.986 41.62 16.637 18.09 41.091 10.336 43.823 8.633 18.722 45.028 43.208 44.153 44.923 1.248 16.577 19.156 29.94 11.058 40.398 43.941 42.327 14.581 9.98 42.984 42.013 21.769 42.424 34.697
****************EOF******************
OSU M023 17 13
Control Group Test 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1
055.955 5.549 14.375 5.63 20.316 30.718 8.985 5.734 8.841 16.475 9.223 44.085 9.566 9.13 26.937

Distraction Test 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1
33.067 8.016 30.278 10.609 11.253 6.58 17.947 4.383 13.955 5.793 8.782 6.244 7.26 3.925 9.551 3.749 3.61 3.043 13.626 4.829 8.69 34.514 11.521 6.923 4.441 14.25 8.872 7.329 25.591 7.539
****************EOF******************
OSU M024 21 16
Experimental Group Test 1 1 1 0 1 1 1 1 1 0 1 0 1 1 0
014.428 7.331 10.346 10.673 6.242 16.257 7.991 6.92 2.676 4.212 12.229 14.209 11.61 12.383 10.22

Distraction Test 0 1 0 1 0 0 1 1 0 1 0 1 0 1 1 1 1 1 1 0 1 1 0 0 1 1 1 1 0 0
15.568 12.127 14.841 11.089 13.97 10.061 30.479 4.929 20.613 7.411 20.147 13.075 11.708 13.269 14.904 5.252 9.897 4.003 13.99 11.298 28.06 14.253 26.942 32.001 4.001 14.656 8.018 17.268 41.735 24.449
****************EOF******************

OSU M025 19 13
Control Group Test 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1
053.722 29.699 15.031 20.986 41.127 69.547 11.751 12.511 4.119 12.096 31.196 25.547
143.79 26.829 27.064

Distraction Test 0 0 3 1 1 1 1 0 0 1 0 1 1 1 1 1 1 1 1 1 1 1 1 3 1 1 0 1 3 0
29.057 34.914 44.959 32.731 40.875 15.191 38.406 27.744 34.981 20.697 25.338 43.463
32.051 7.975 15.419 17.399 9.589 8.364 17.658 16.859 18.191 42.005 20.663 44.989
15.579 37.347 44.261 26.614 46.226 31.488
****************EOF******************
OSU F026 18 13
Experimental Group Test 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
013.707 17.502 13.383 7.155 14.079 15.706 5.14 3.866 4.02 7.413 9.894 14.128 11.231
14.664 9.912

Distraction Test 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1 1 1 1 1 0 1
6.277 16.547 12.875 14.373 25.117 12.512 21.911 8.436 5.399 7.314 24.811 21.29
23.747 6.316 9.81 4.832 9.634 4.939 24.029 5.509 21.699 23.621 27.094 14.939 14.753
15.494 10.363 30.408 28.55 6.196
****************EOF******************
OSU M027 18 13
Control Group Test 1 1 1 0 0 1 1 1 0 1 1 0 1 1 1
016.428 17.158 60.199 14.393 26.238 42.347 7.909 7.808 11.117 9.32 25.457 20.423
44.036 34.856 11.305

Distraction Test 0 0 0 1 0 1 0 1 1 0 1 1 0 1 1 1 1 0 0 1 1 1 0 0 1 1 1 0 3 0
10.814 24.724 10.167 35.573 28.117 10.306 40.788 17.705 10.771 29.442 20.622 21.188
26.495 9.674 22.663 8.914 16.521 16.367 13.619 16.27 32.518 33.66 27.626 15.071
12.308 21.85 34.406 31.033 45.11 20.425
****************EOF******************
OSU M028 21 16
Experimental Group Test 1 1 0 1 1 1 1 1 1 1 0 1 1 1 0
011.144 6.023 7.017 4.55 13.404 17.974 7.283 5.961 6.087 7.038 9.841 11.43 16.174
11.41 9.423

Distraction Test 1 1 1 1 0 1 1 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1 1 0 0 1 0 1 1 0 1
14.24 12.578 7.181 12.599 18.71 7.765 15.755 5.805 8.693 14.788 17.656 10.986 7.371
6.215 14.598 5.383 6.11 3.634 13.697 5.426 13.383 10.379 13.232 12.231 13.704 25.268
11.862 8.888 26.372 12.925
****************EOF******************

OSU M029 19 14
Control Group Test 1 1 0 0 1 0 1 1 1 1 0 1 1 1 1
031.029 21.568 33.932 11.347 9.137 31.001 18.611 7.385 5.371 14.645 37.814 43.041 10.273 11.038 24.112

Distraction Test 1 1 1 1 0 0 1 0 0 1 1 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 3 1
14.811 17.873 32.962 25.11 31.466 12.924 28.055 24.227 24.733 19.502 13.673 41.872 35.389 19.008 17.51 7.351 9.542 5.992 15.61 6.013 18.21 22.122 32.136 20.306 9.149 19.234 22.665 21.91 45.094 10.981
****************EOF******************

OSU M030 18 13
Experimental Group Test 1 0 1 1 0 0 1 1 0 1 1 0 1 1 1
020.935 26.06 24.477 13.376 11.552 21.535 9.093 6.185 9.177 8.273 18.971 16.303 13.725 20.418 13.675

Distraction Test 1 0 1 0 0 1 1 1 0 0 0 1 0 1 1 1 0 1 0 1 0 0 0 0 1 0 0 1 0 1
33.604 19.233 28.782 7.735 10.09 13.158 21.694 5.899 17.936 38.374 32.018 23.202 12.055 13.429 15.874 12.34 21.003 6.498 25.487 3.421 26.293 36.165 33.702 16.068 15.83 38.077 21.662 20.132 36.884 21.584
****************EOF******************

OSU M031 20 14
Control Group Test 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1
042.33 11.212 26.651 4.227 31.892 38.794 16.99 9.32 4.299 18.969 29.369 42.563 18.753 14.342 13.339

Distraction Test 1 1 1 1 0 1 1 1 1 0 1 1 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 0 1
41.412 25.893 18.255 8.28 30.709 8.859 24.638 5.731 13.391 19.694 26.885 16.922 11.758 12.475 20.558 5.489 12.096 7.47 15.802 5.439 15.585 34.528 29.364 28.044 13.052 19.604 10.159 13.133 29.365 7.046
****************EOF******************

OSU M032 18 13
Experimental Group Test 1 1 1 1 0 0 0 1 1 1 1 1 1 1 1
016.532 12.778 17.911 6.956 15.717 32.627 18.173 6.407 7.987 8.457 29.299 34.414 22.24 21.016 21.68

Distraction Test 0 1 0 0 0 1 0 1 1 0 0 0 1 0 1 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1
18.262 22.431 20.317 25.965 34.455 17.067 43.387 4.814 9.11 39.108 14.678 38.338 12.031 20.261 22.172 9.657 30.659 6.978 36.288 5.678 21.111 14.677 23.08 36.169 28.462 19.212 24.698 10.003 31.065 16.525
****************EOF******************

OSU M033 20 13
Control Group Test 1 1 1 1 0 1 1 1 1 0 1 1 1 0 1
027.832 28.461 37.942 14.127 45.079 62.386 29.943 14.541 16.315 17.669 32.75 33.25 37.128 45.019 66.615

Distraction Test 1 1 1 1 1 1 1 0 0 1 0 0 1 1 1 1 0 1 1 0 1 1 1 0 1 0 3 0 0 1
31.885 17.761 33.372 31.609 21.208 11.135 31.839 22.25 32.405 36.841 21.538 22.82 22.953 19.175 21.491 11.102 19.737 17.769 16.916 8.756 14.53 13.553 14.097 27.879 14.27 21.55 44.854 33.492 15.811 20.39
****************EOF******************
OSU M034 18 13
Experimental Group Test 1 1 0 1 1 0 1 1 1 1 1 1 0 1 1
012.038 8.412 20.946 10.621 14.421 19.571 6.966 6.012 6.661 5.33 12.029 11.796 8.508 11.043 11.566

Distraction Test 0 0 0 1 1 0 0 1 1 1 1 0 0 1 0 1 0 1 0 1 1 1 0 0 1 1 0 1 0 1
28.216 28.944 18.877 32.974 12.003 9.308 33.281 9.243 10.792 11.174 28.096 21.755 16.21 7.586 20.892 16.968 18.719 4.999 12.392 3.188 21.276 22.679 31.793 35.192 7.074 37.452 22.644 27.744 43.318 9.5

APPENDIX F

INDIVIDUAL TESTING PATTERNS

OU Subject 001
Posttest 53/ Practice 73

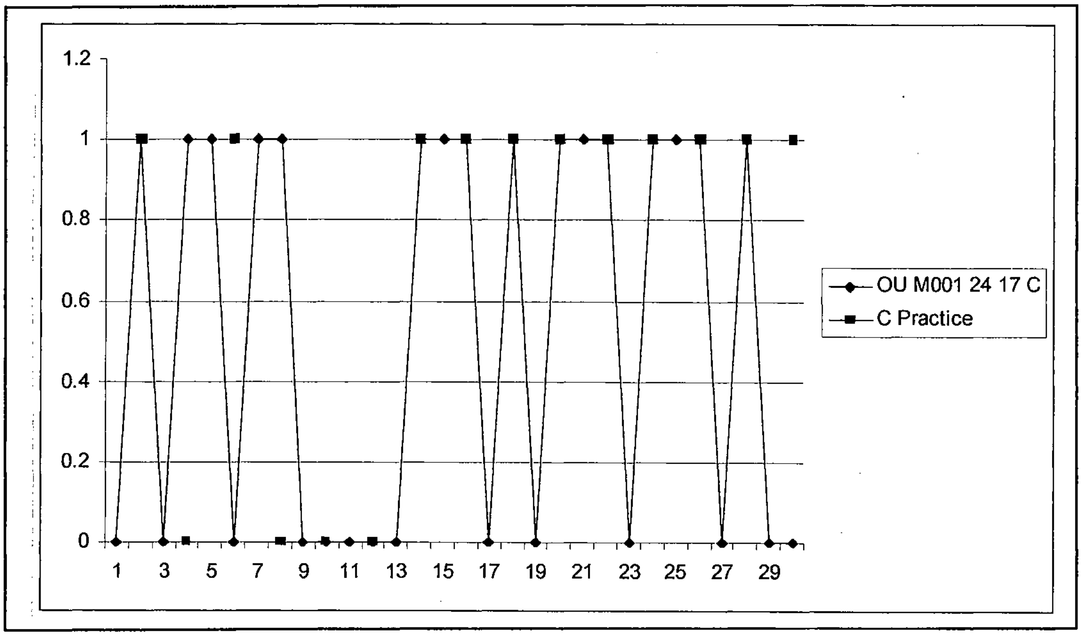


Figure F1. Subject 001.

OU Subject 002
Posttest 77/ Practice 80

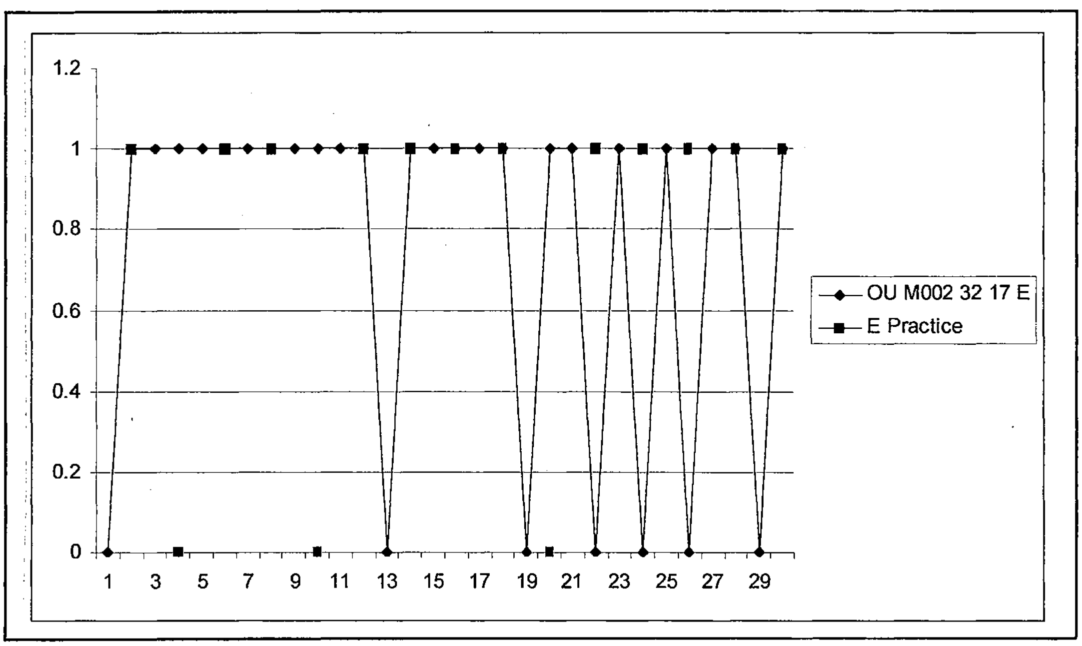


Figure F2. Subject 002.

OU Subject 003
Posttest 83/ Practice 87

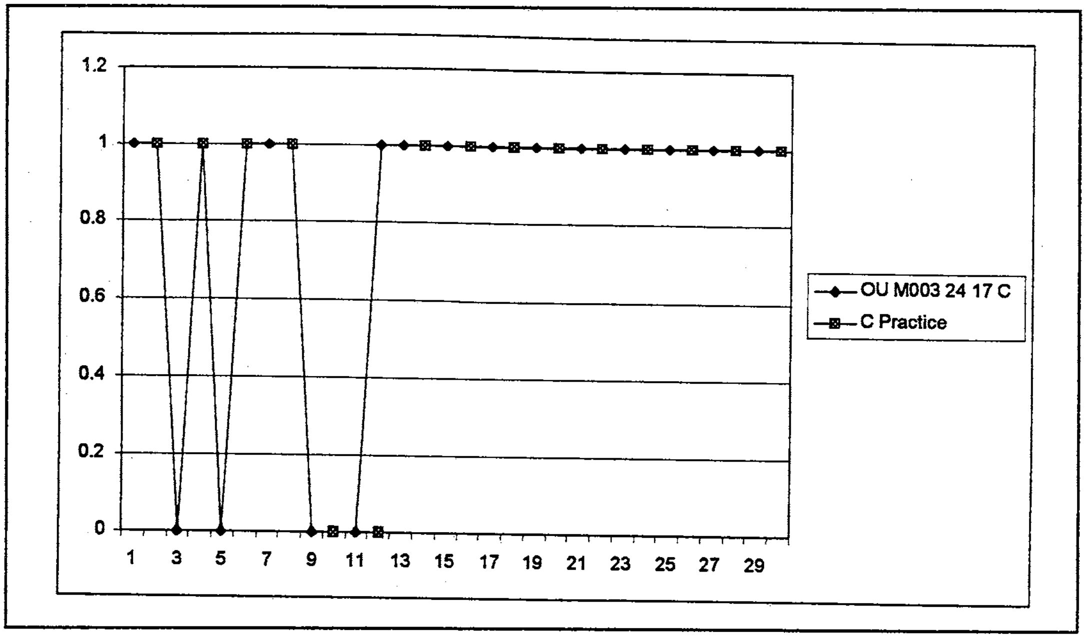


Figure F3. Subject 003.

OU Subject 004
Posttest 83/ Practice 80

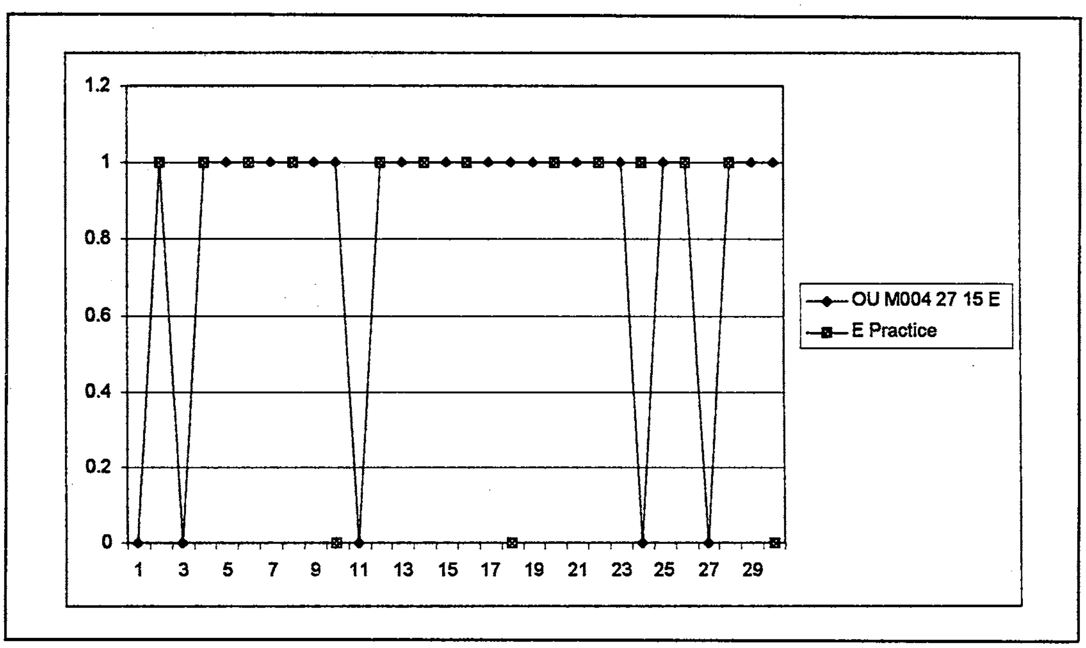


Figure F4. Subject 004.

OU Subject 005
Posttest 50/ Practice 53

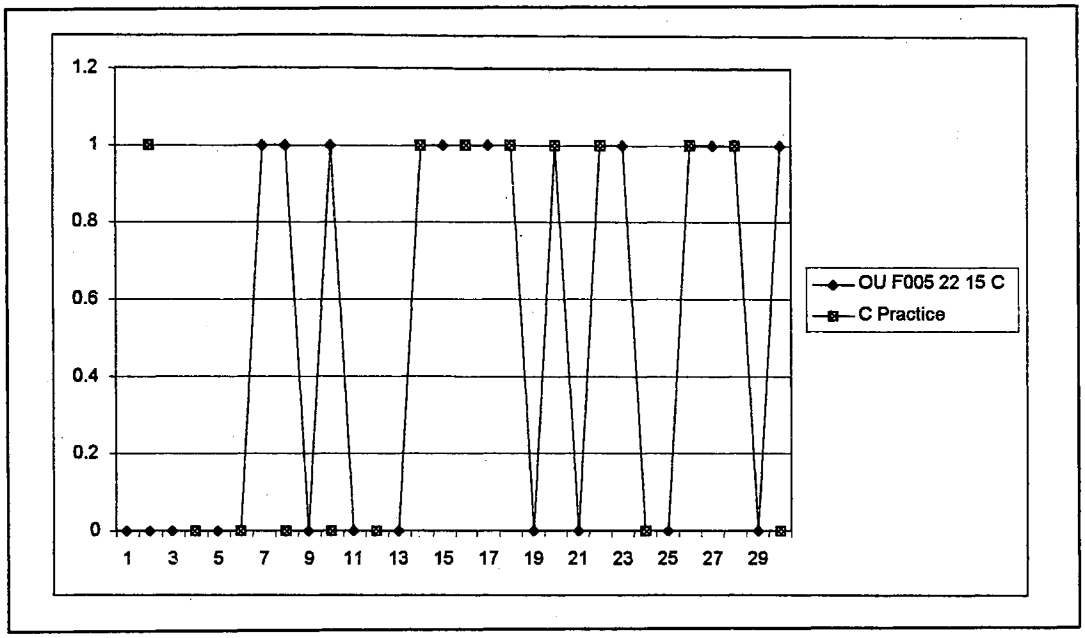


Figure F5. Subject 005.

OU Subject 006
Posttest 60/ Practice 80

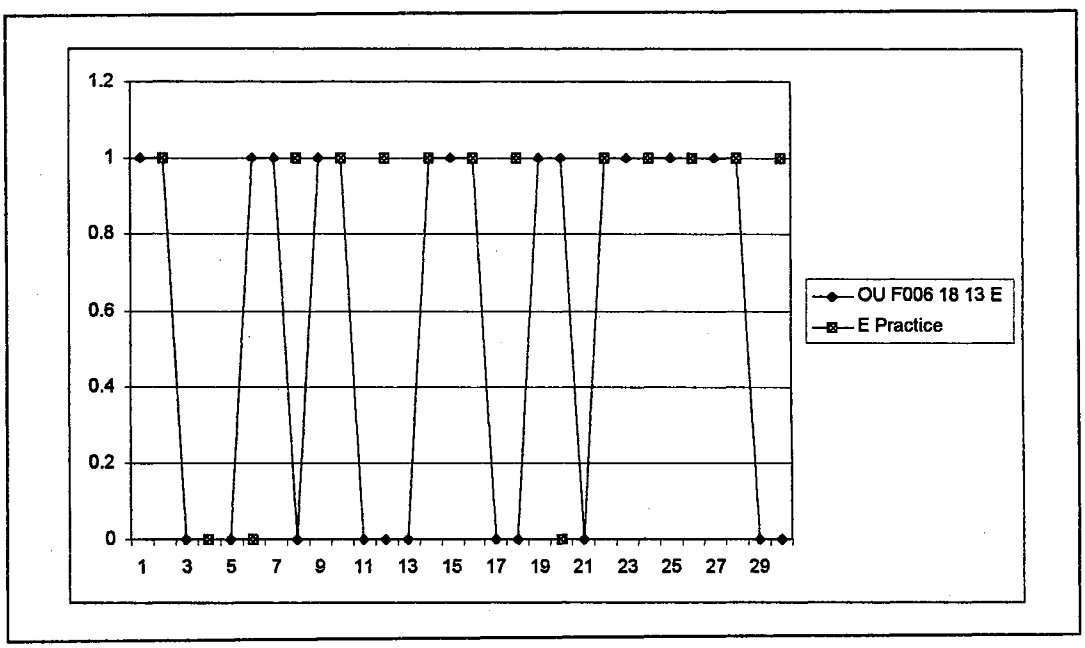


Figure F6. Subject 006.

OU Subject 007
Posttest 50/ Practice 60

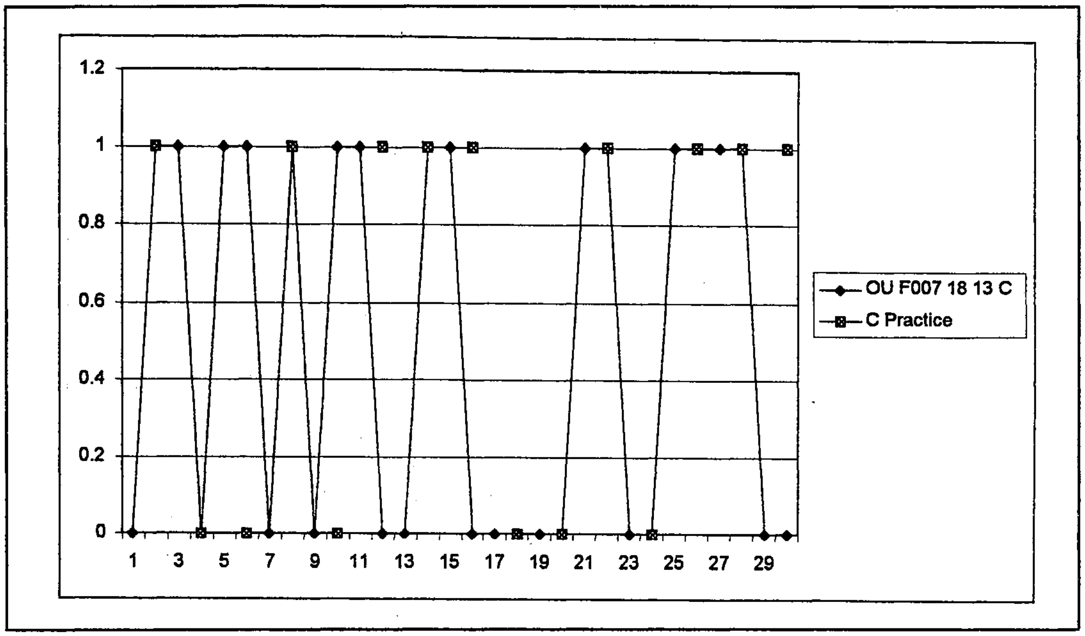


Figure F7. Subject 007.

OU Subject 008
Posttest 70/ Practice 80

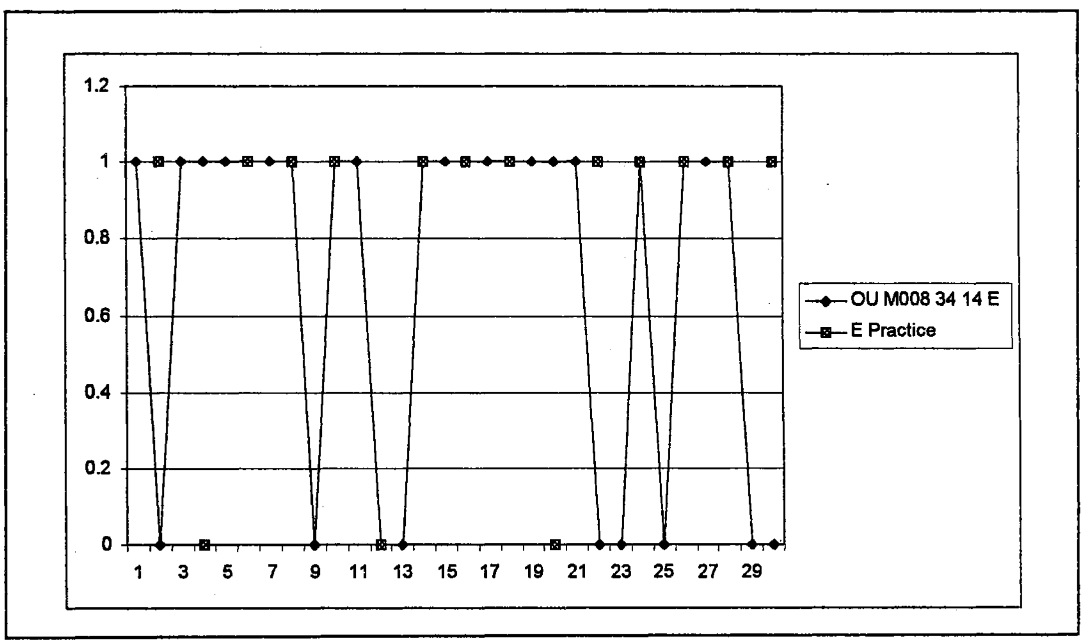


Figure F8. Subject 008.

OU Subject 009
Posttest 90/ Practice 100

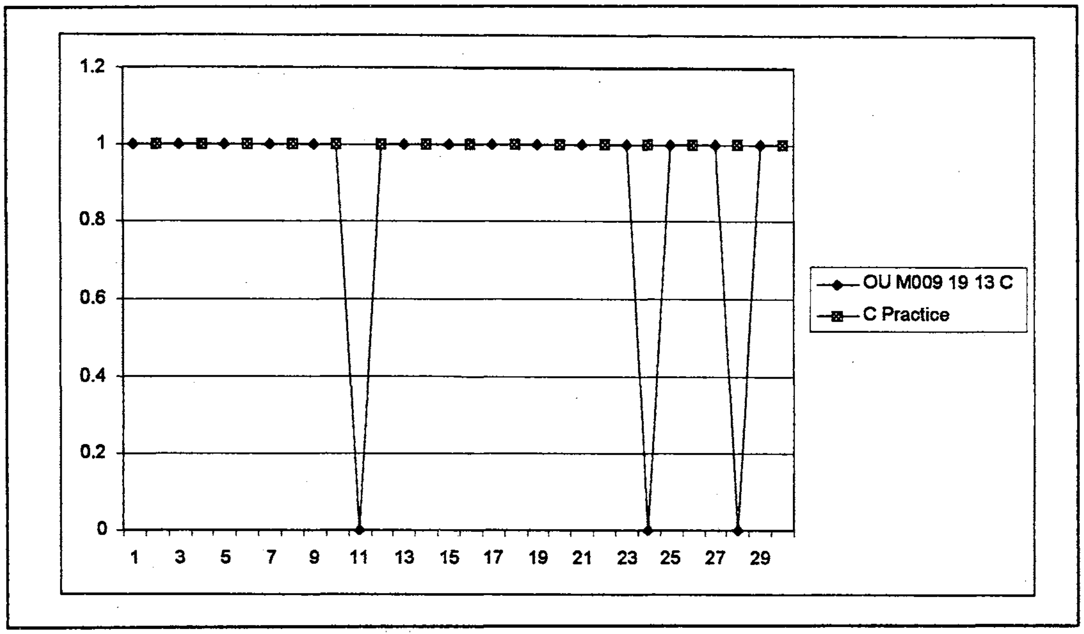


Figure F9. Subject 009.

OU Subject 010
Posttest 90/ Practice 100

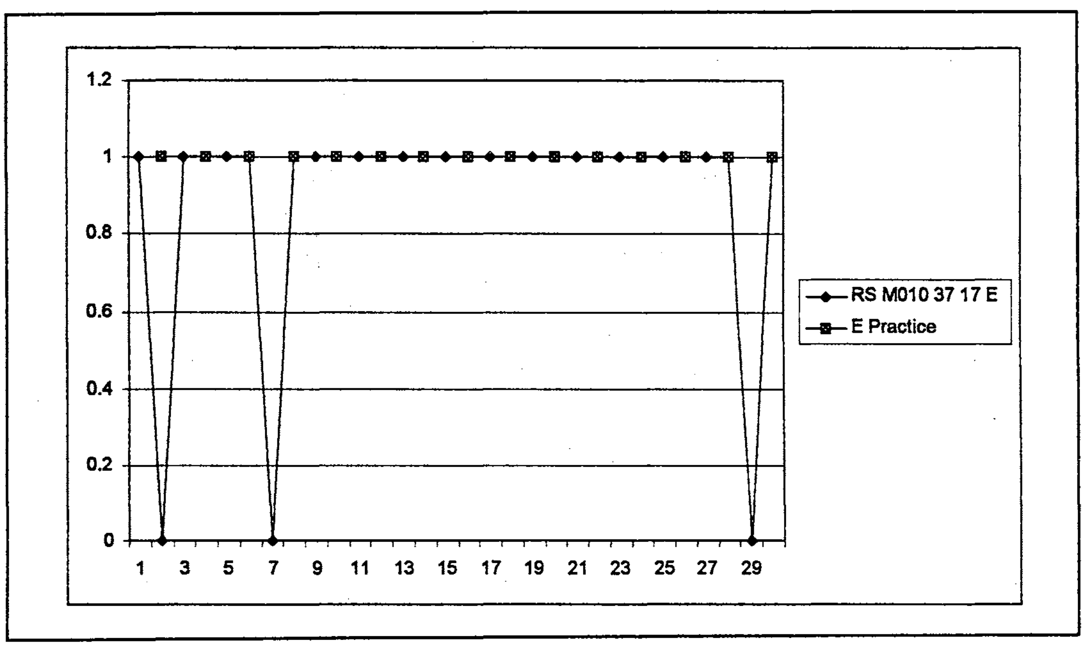


Figure F10. Subject 010.

Rose State Subject 011
Posttest 87/ Practice 100

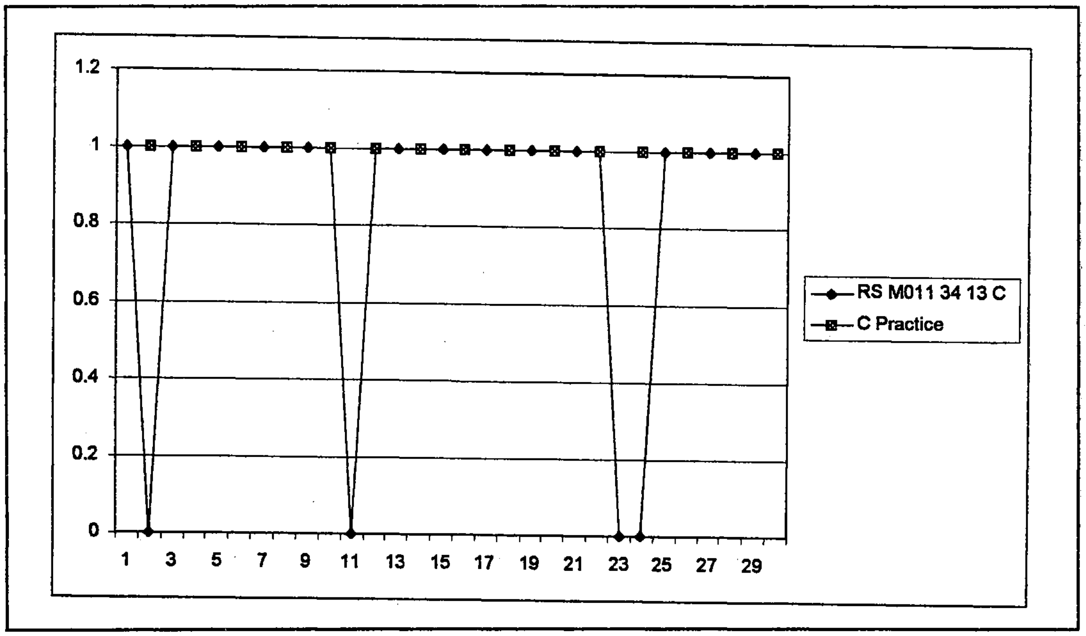


Figure F1. Subject 011.

Rose State Subject 012
Posttest 90/ Practice 80

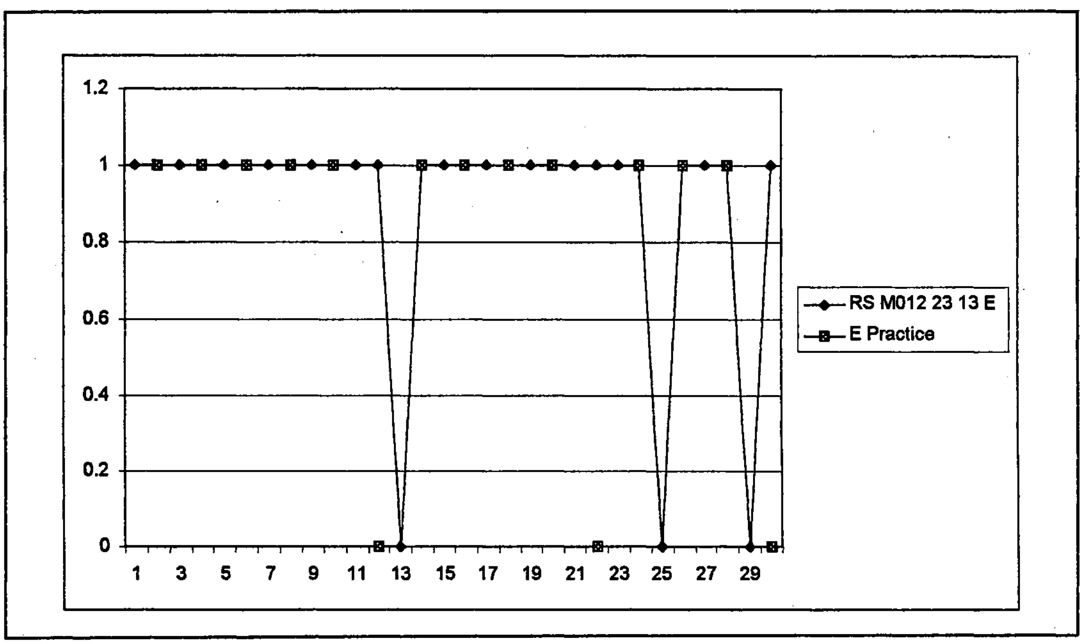


Figure F12. Subject 012.

Rose State Subject 013
Posttest 80/ Practice 93

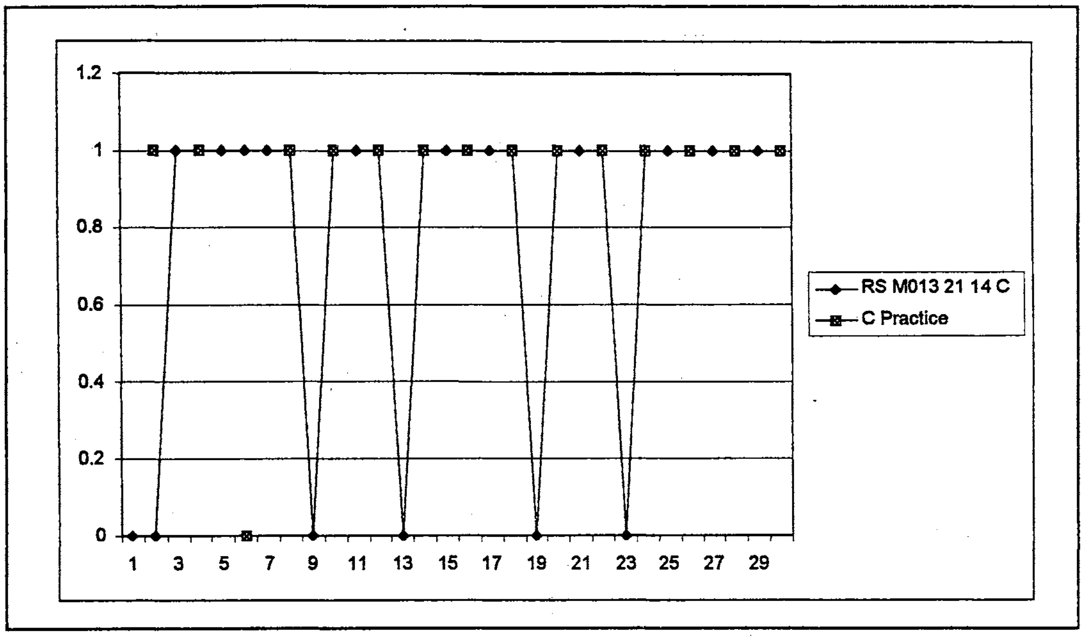


Figure F13. Subject 013.

Rose State Subject 014
Posttest 90/ Practice 100

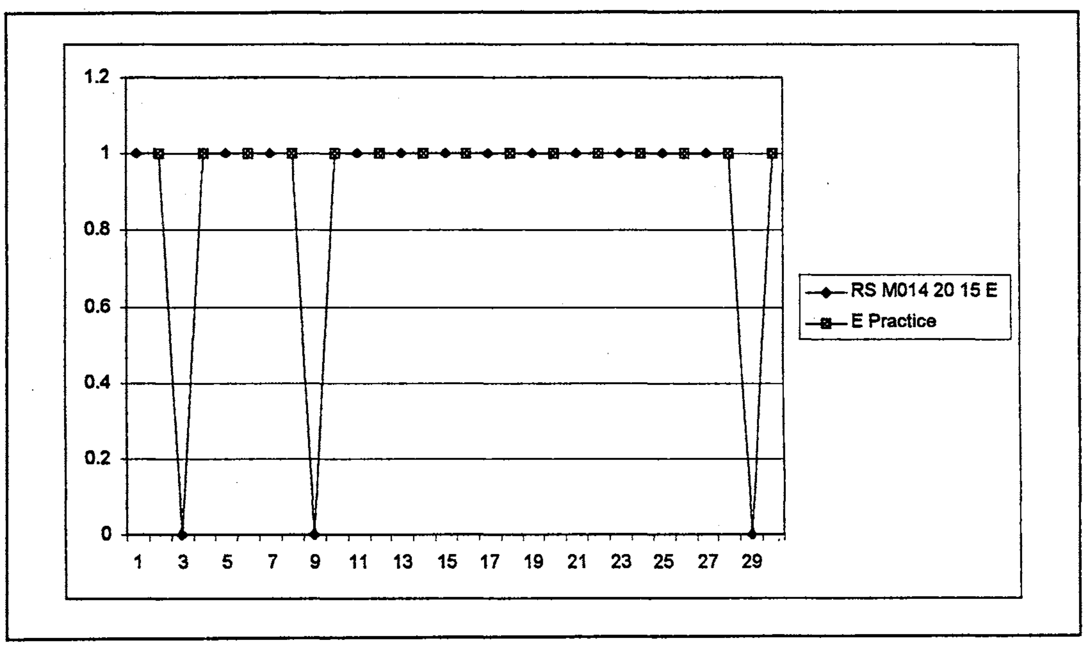


Figure F14. Subject 014.

Rose State Subject 015
Posttest 60/ Practice 80

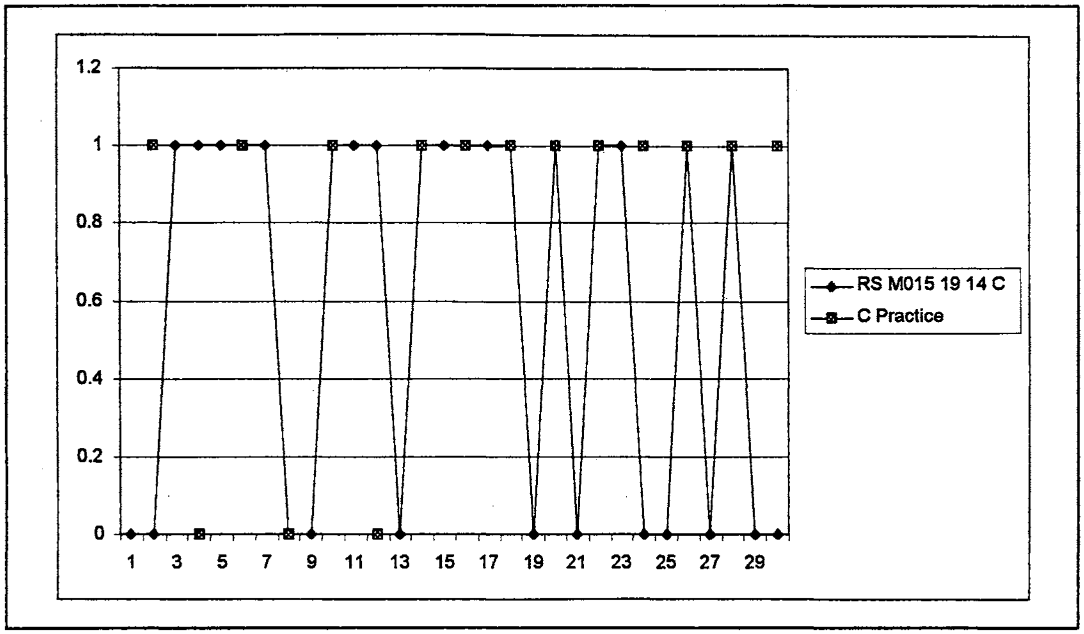


Figure F15. Subject 015.

Rose State Subject 016
Posttest 70/ Practice 73

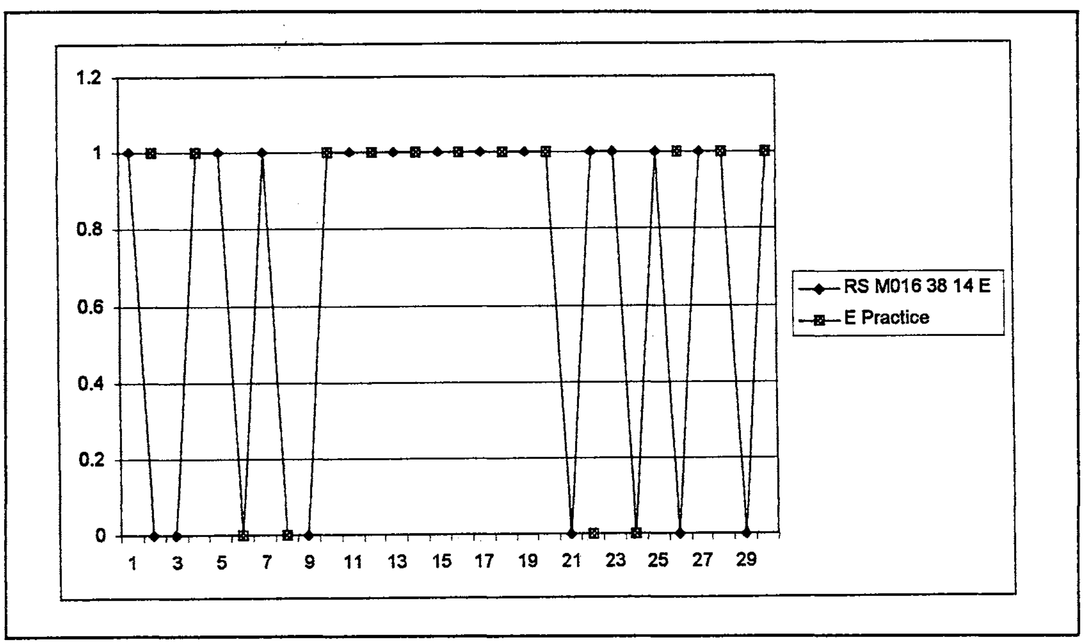


Figure F16. Subject 016.

Rose State Subject 017
Posttest 70/ Practice 93

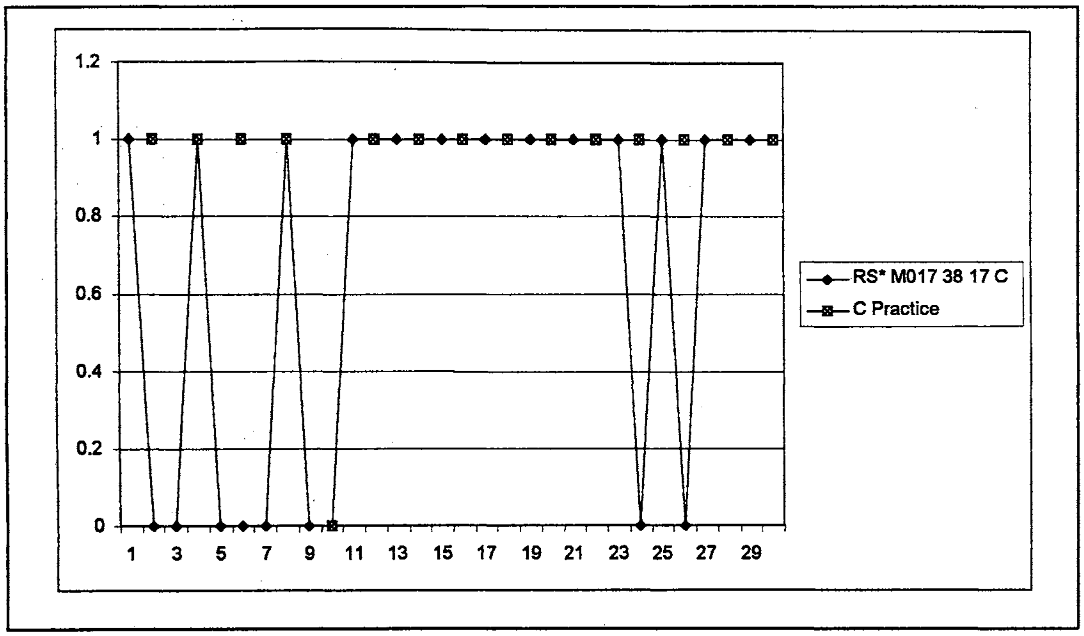


Figure F17. Subject 017.

Rose State Subject 018
Posttest 43/ Practice 67

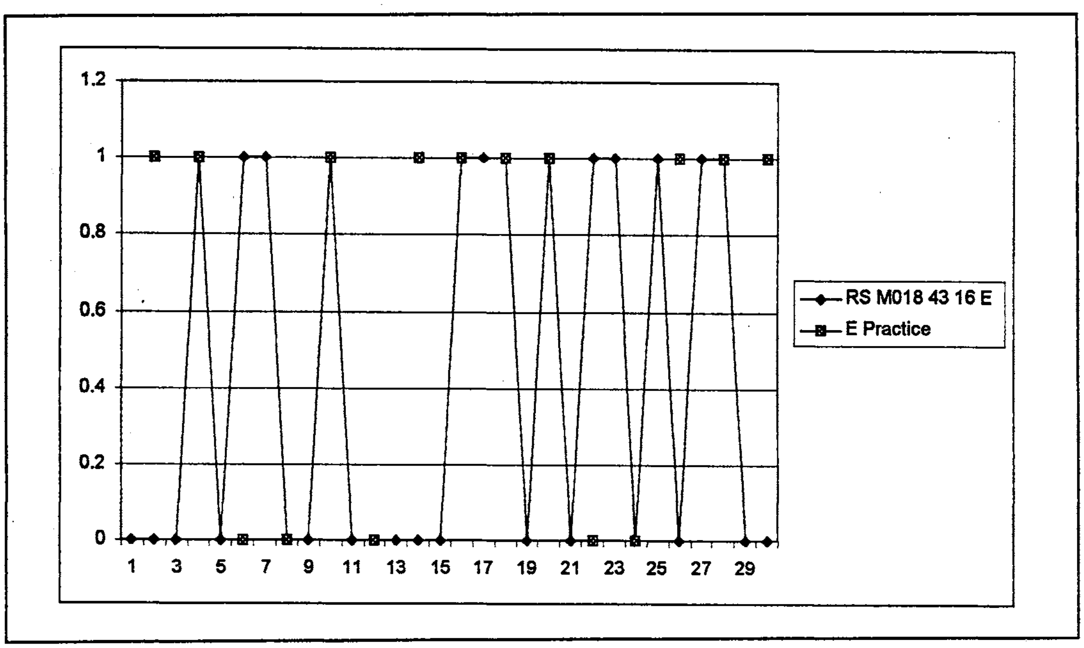


Figure F18. Subject 018.

Rose State Subject 019
Posttest 83/ Practice 73

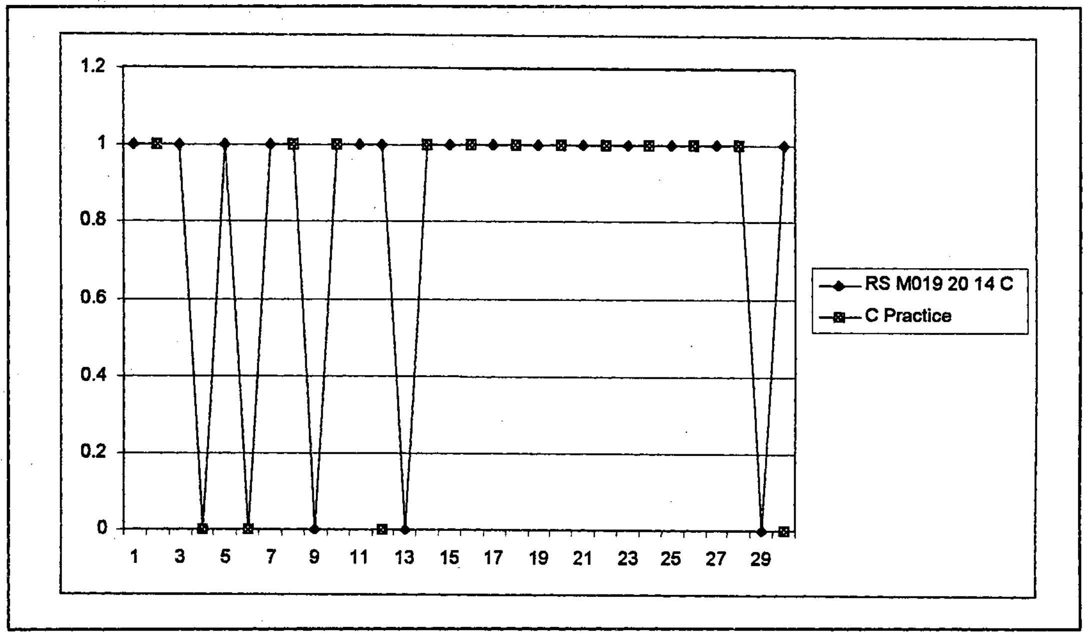


Figure F19. Subject 019.

Rose State Subject 020
Posttest 70/ Practice 80

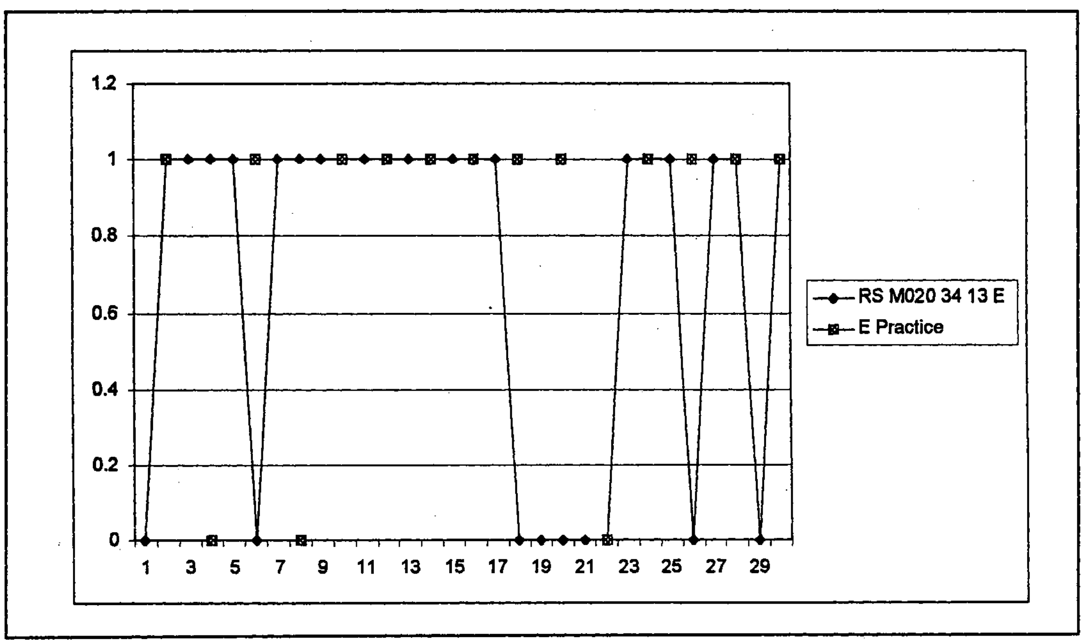


Figure F20. Subject 020.

Rose State Subject 021
Posttest 63/ Practice 80

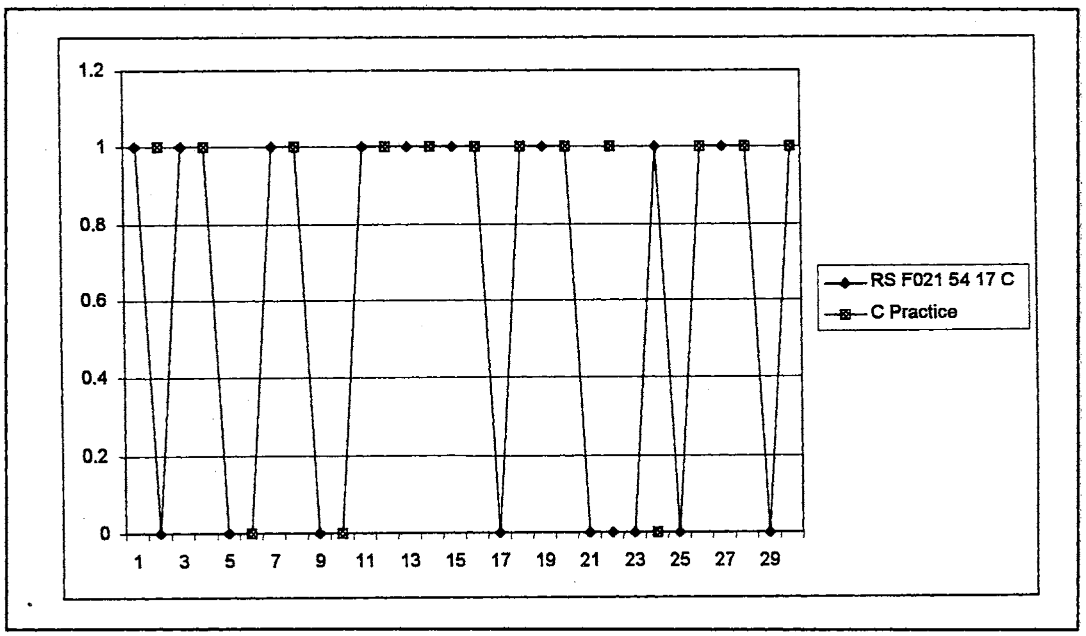


Figure F21. Subject 021.

Rose State Subject 022
Posttest 53/ Practice 73

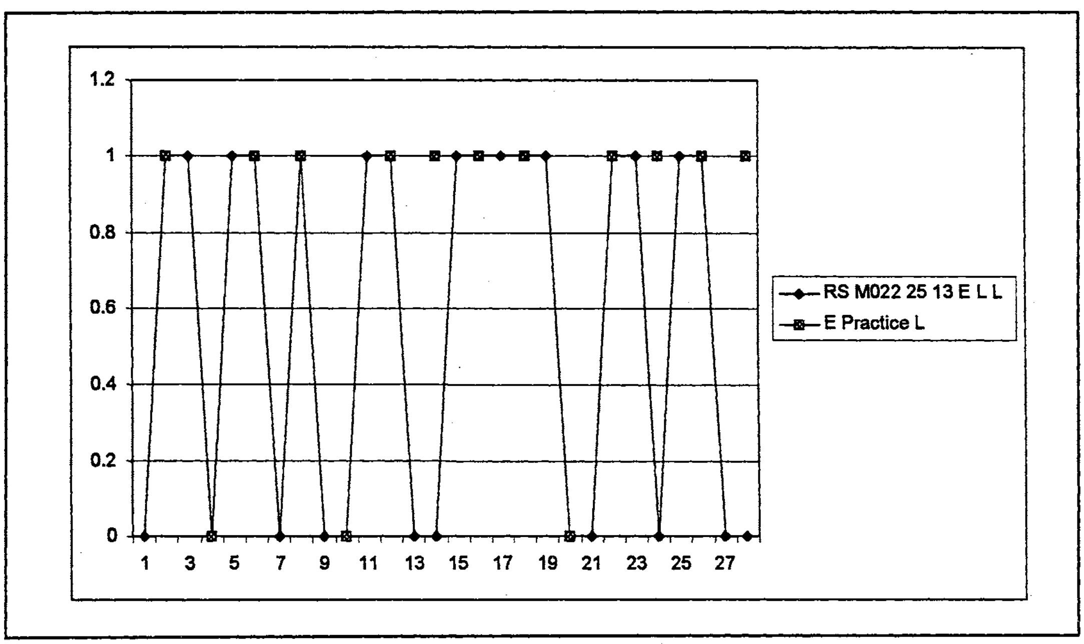


Figure F22. Subject 022.

OSU Subject 023
Posttest 93/ Practice 93

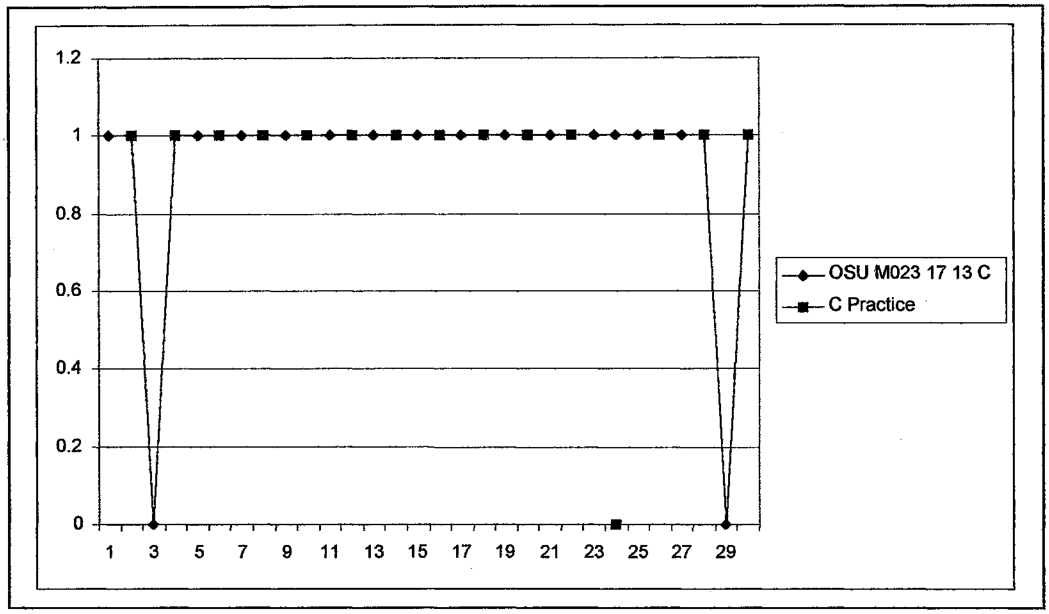


Figure F23. Subject 023.

OSU Subject 024
Posttest 60/ Practice 73

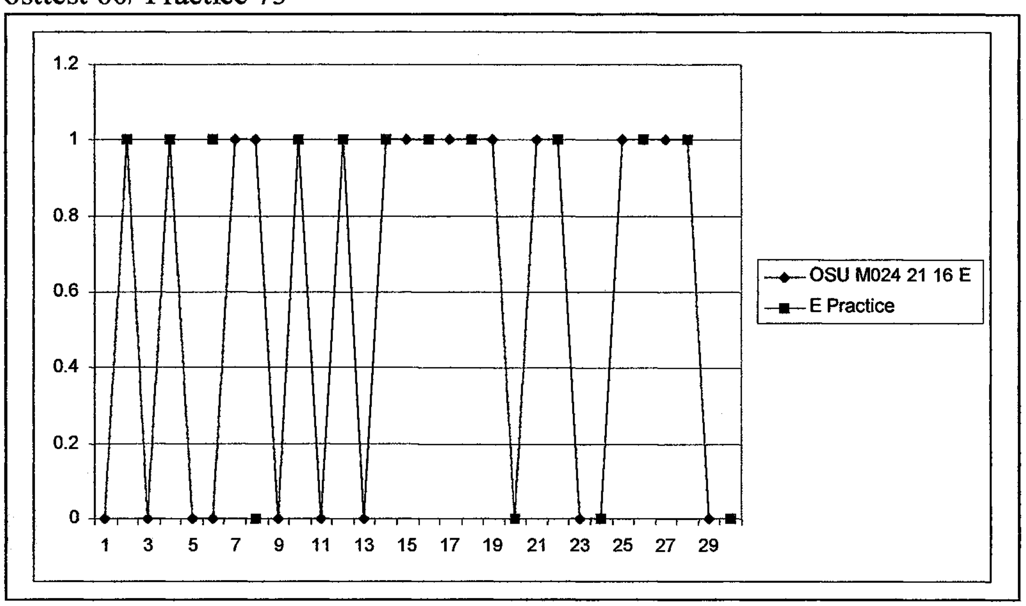


Figure F24. Subject 24.

OSU Subject 025
Posttest 67/ Practice 93

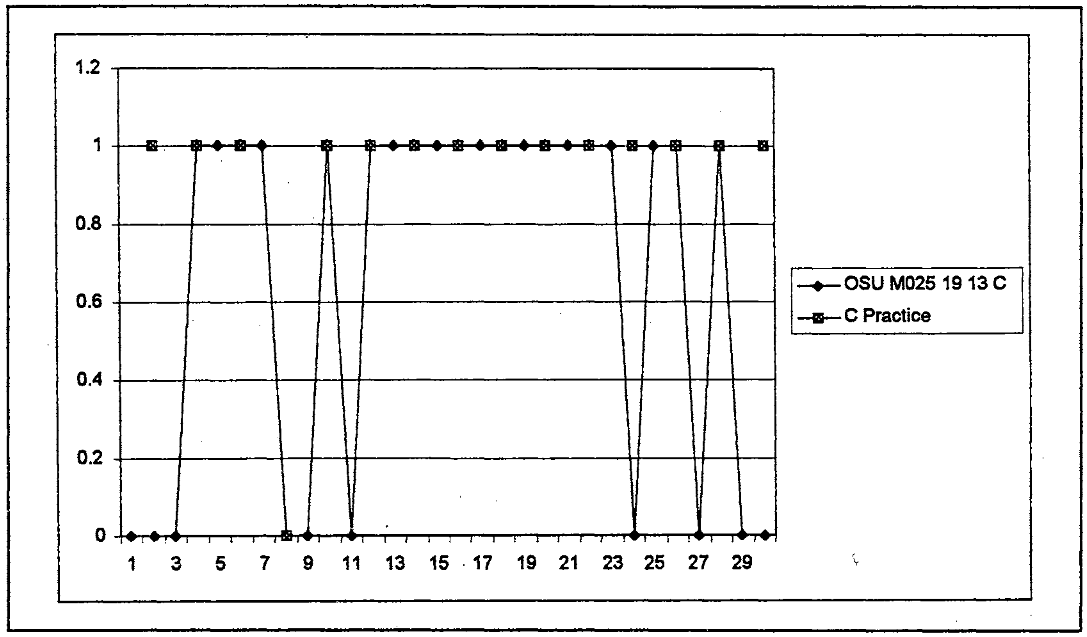


Figure F25. Subject 025.

OSU Subject 026
Posttest 87/ Practice 100

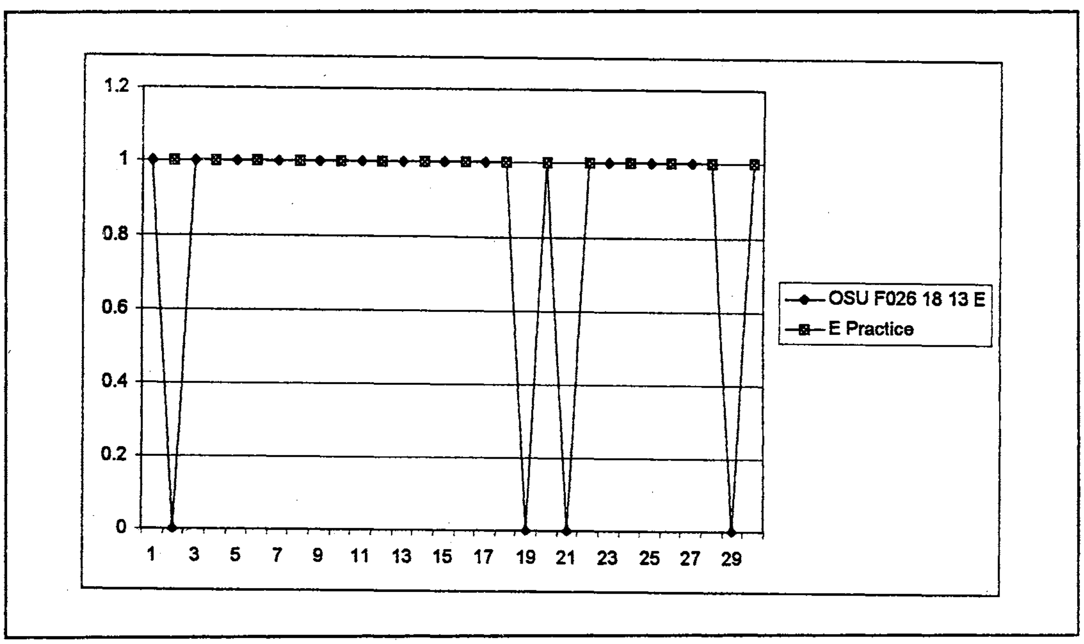


Figure F26. Subject 026.

OSU Subject 027
Posttest 53/Practice 73

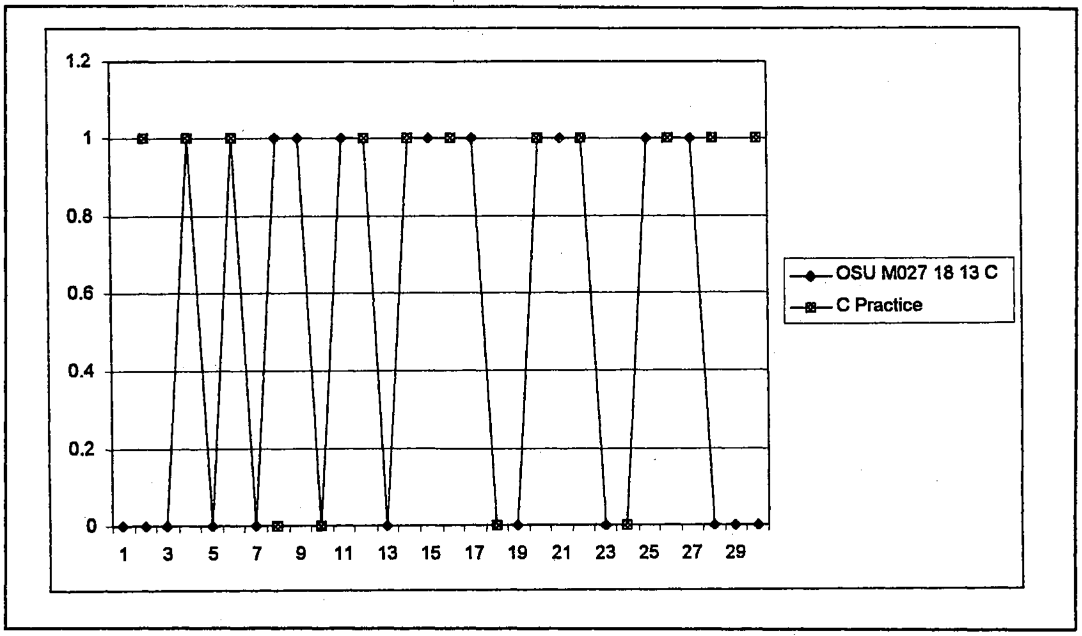


Figure F27. Subject 027.

OSU Subject 028
Posttest 73/ Practice 80

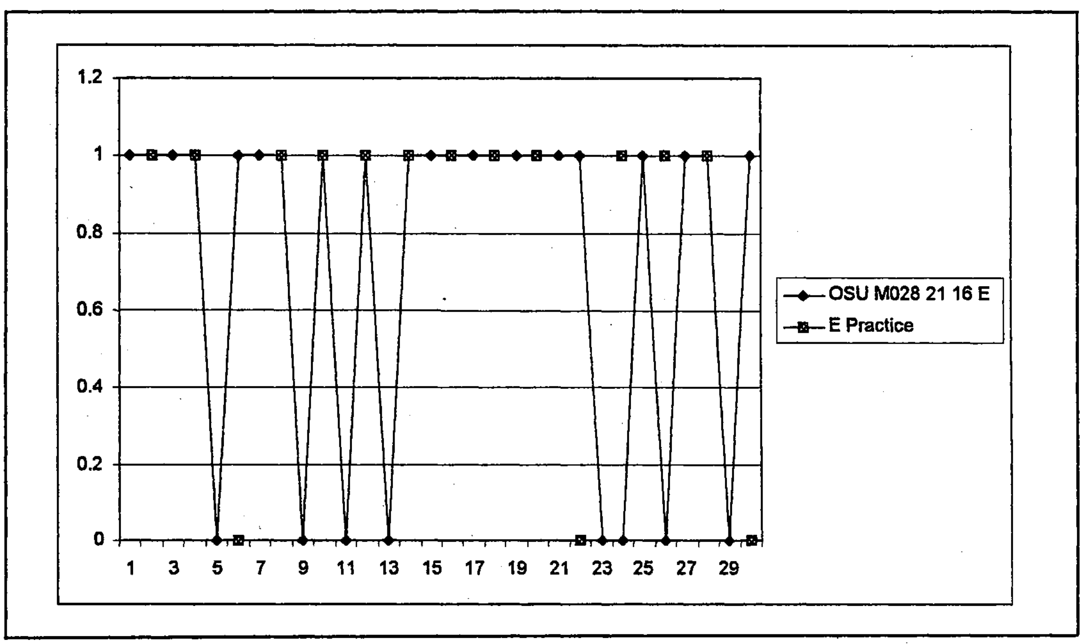


Figure F28. Subject 028.

OSU Subject 029
Posttest 70/Practice 73

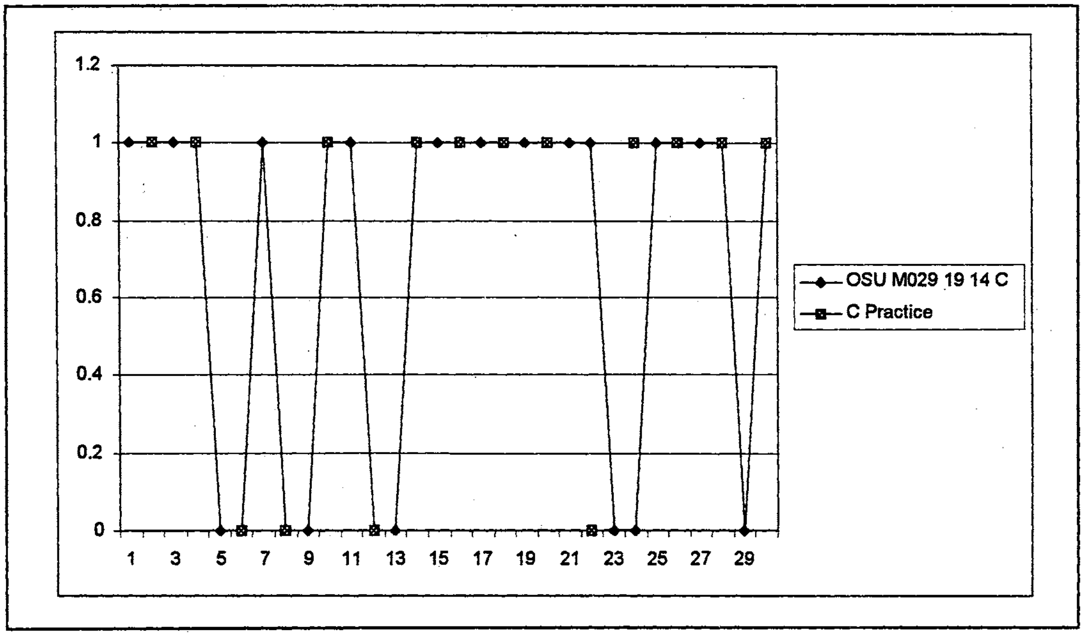


Figure F29. Subject 029.

OSU Subject 030
Posttest 47/ Practice 67

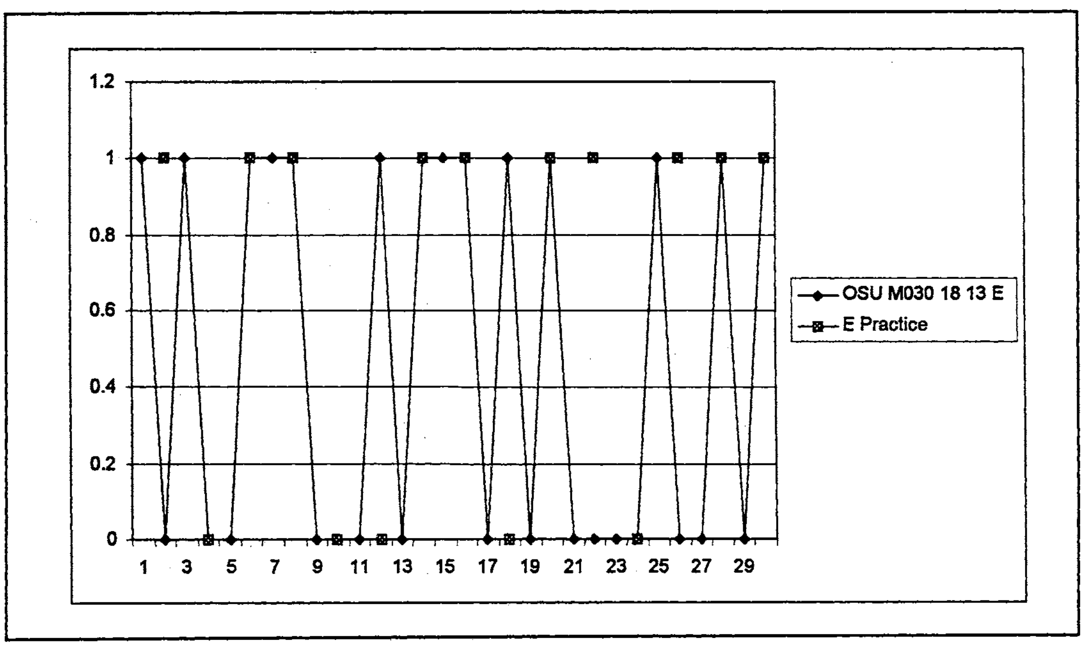


Figure F30. Subject 030.

OSU Subject 031
Posttest 80/Practice 87

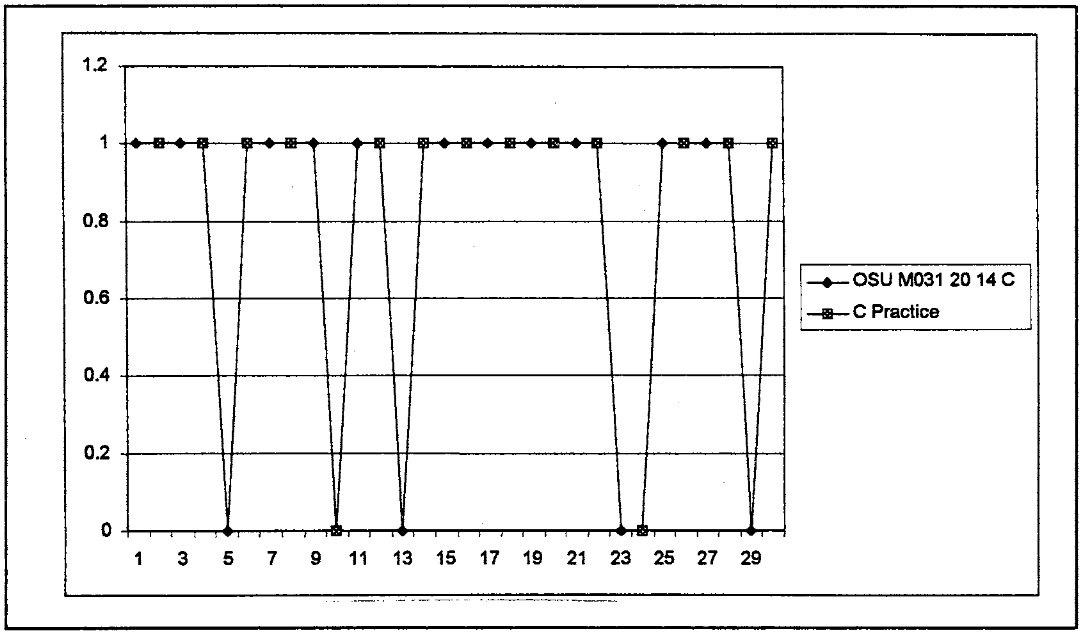


Figure F31. Subject 031.

OSU Subject 032
Posttest 60/ Practice 80

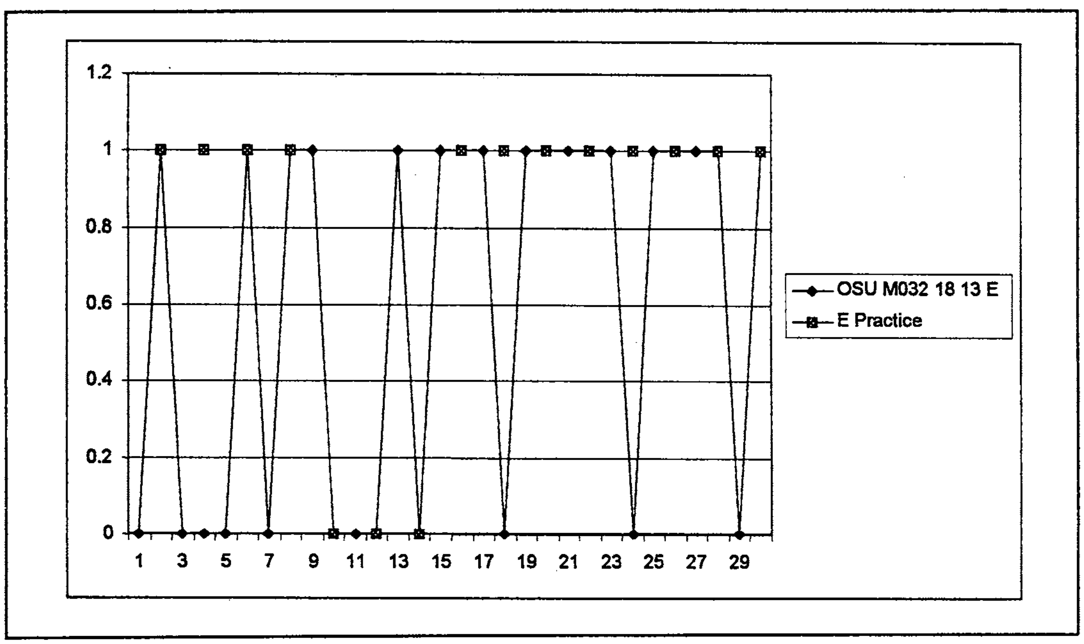


Figure F32. Subject 032.

OSU Subject 033
Posttest 63/Practice 80

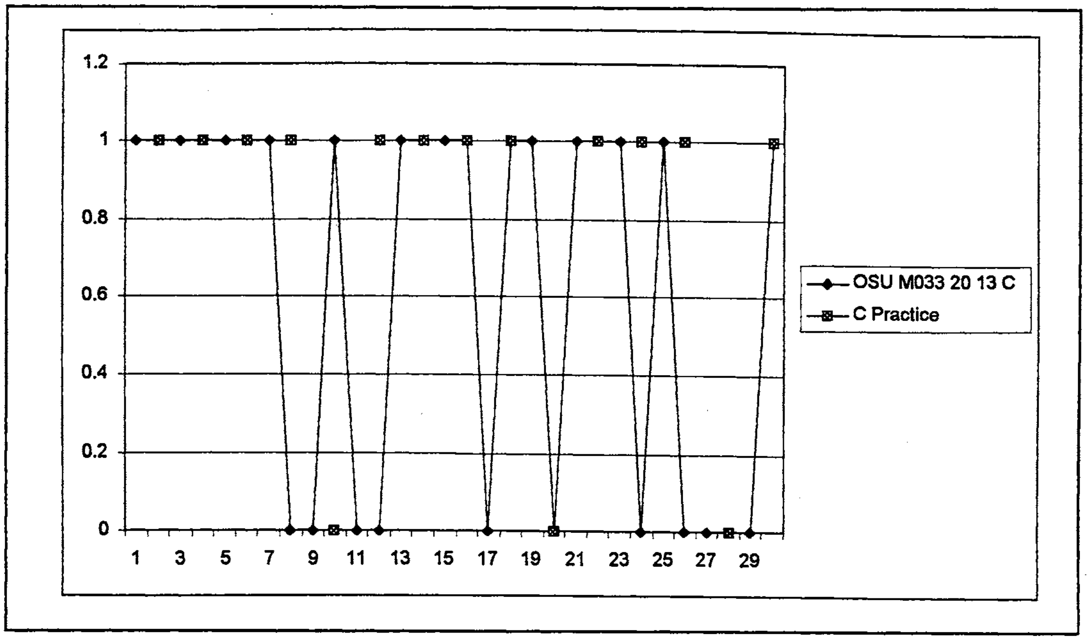


Figure F33. Subject 033.

OSU Subject 034
Posttest 53/ Practice 80

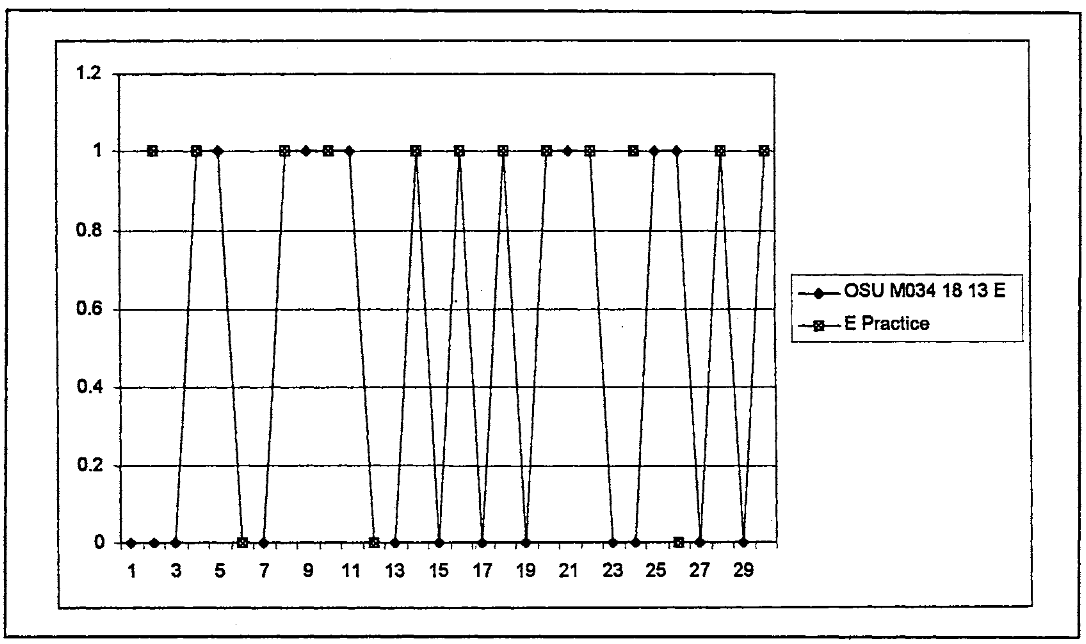
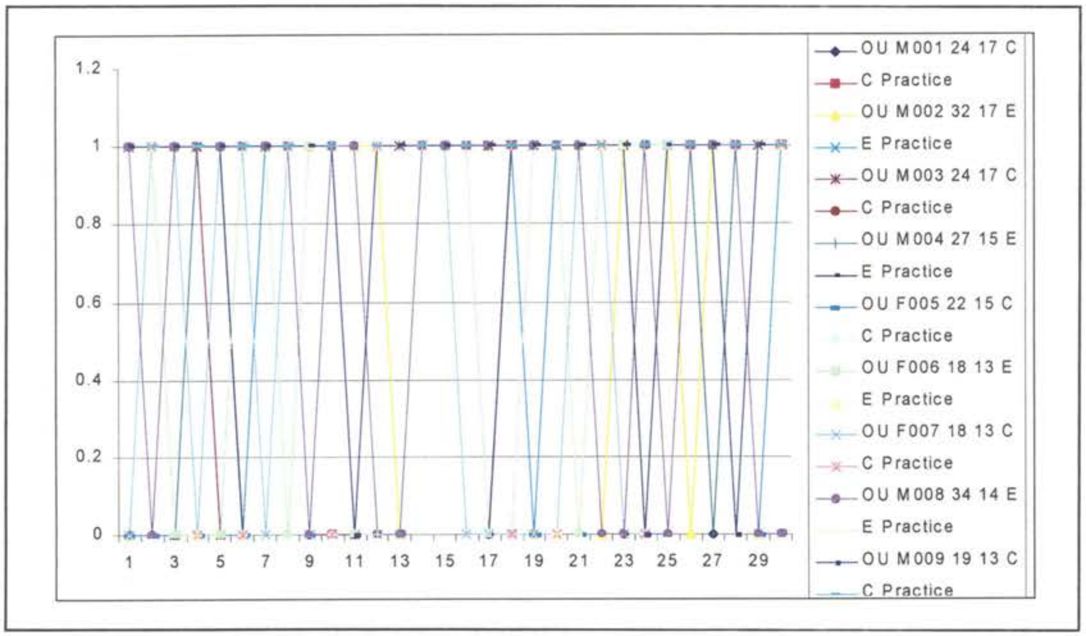
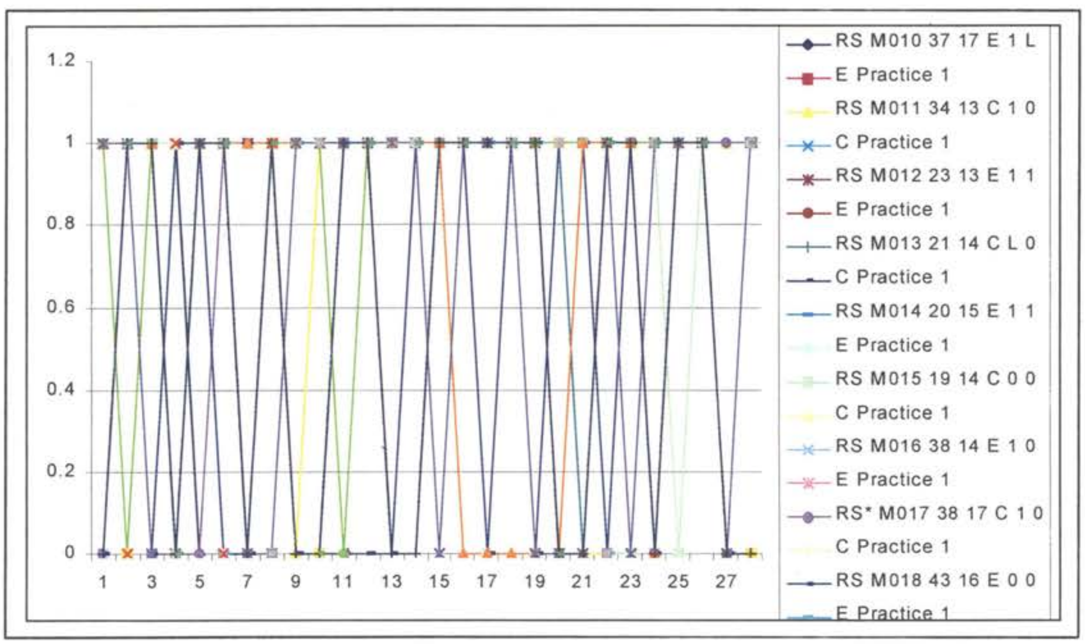


Figure F34. Subject 034.

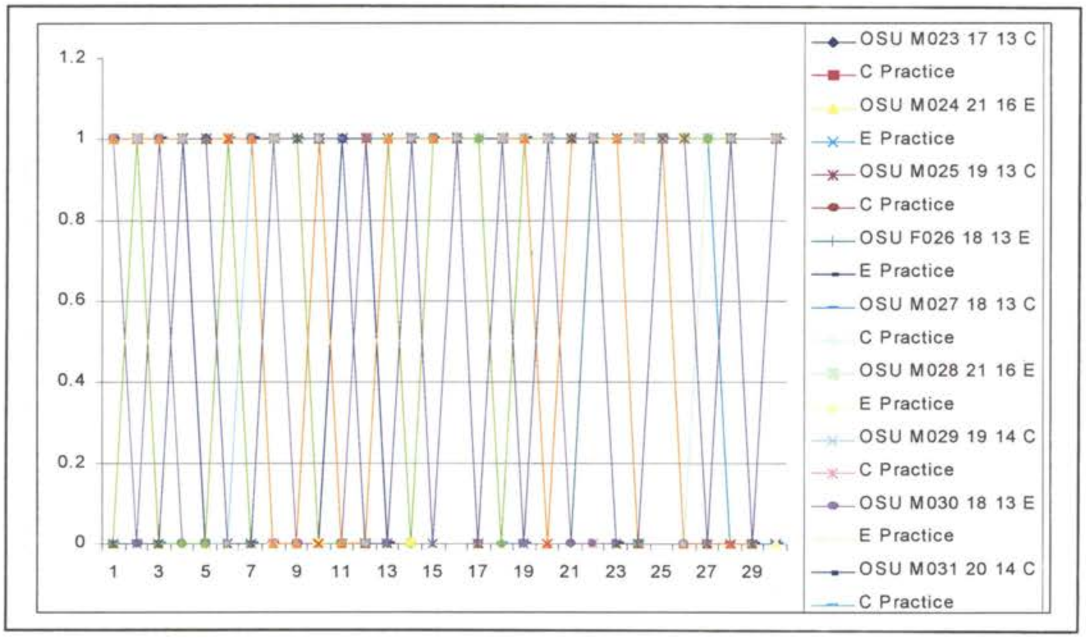
Composite Areas Missed (Posttest/Practice) for the University of Oklahoma
More than 50% of the subjects missed questions 1, 3, 9, 11, 13, 18,& 29.



Composite Areas Missed (Posttest/Practice) for Rose State College
More than 50% of the subjects missed question 29.



Composite Areas Missed (Posttest/Practice) for Oklahoma State University.
More than 50% of the subjects missed questions 5, 13, 23, 24, & 29.



APPENDIX G

TIME IN INTERACTION

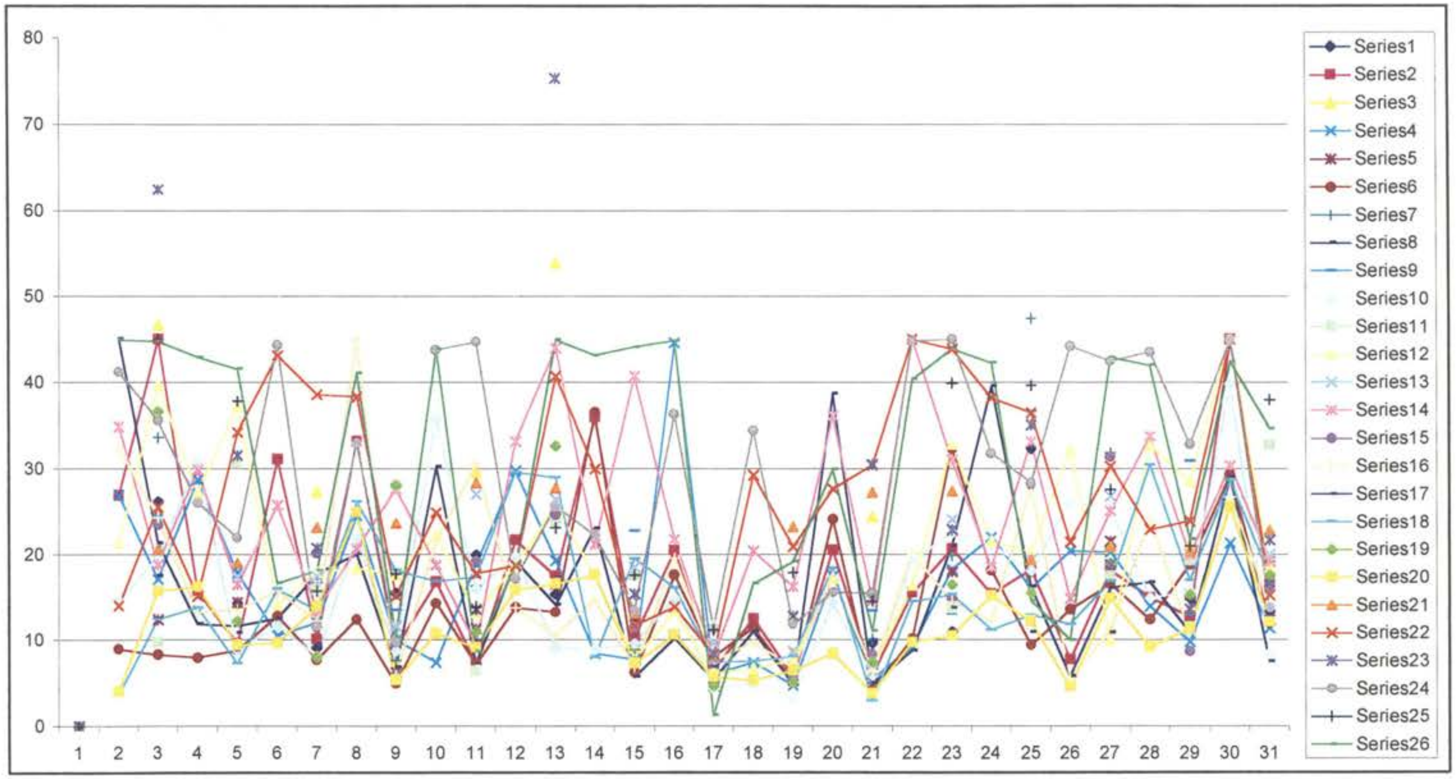


Figure G1. Rose State College Testing Times by Questions.

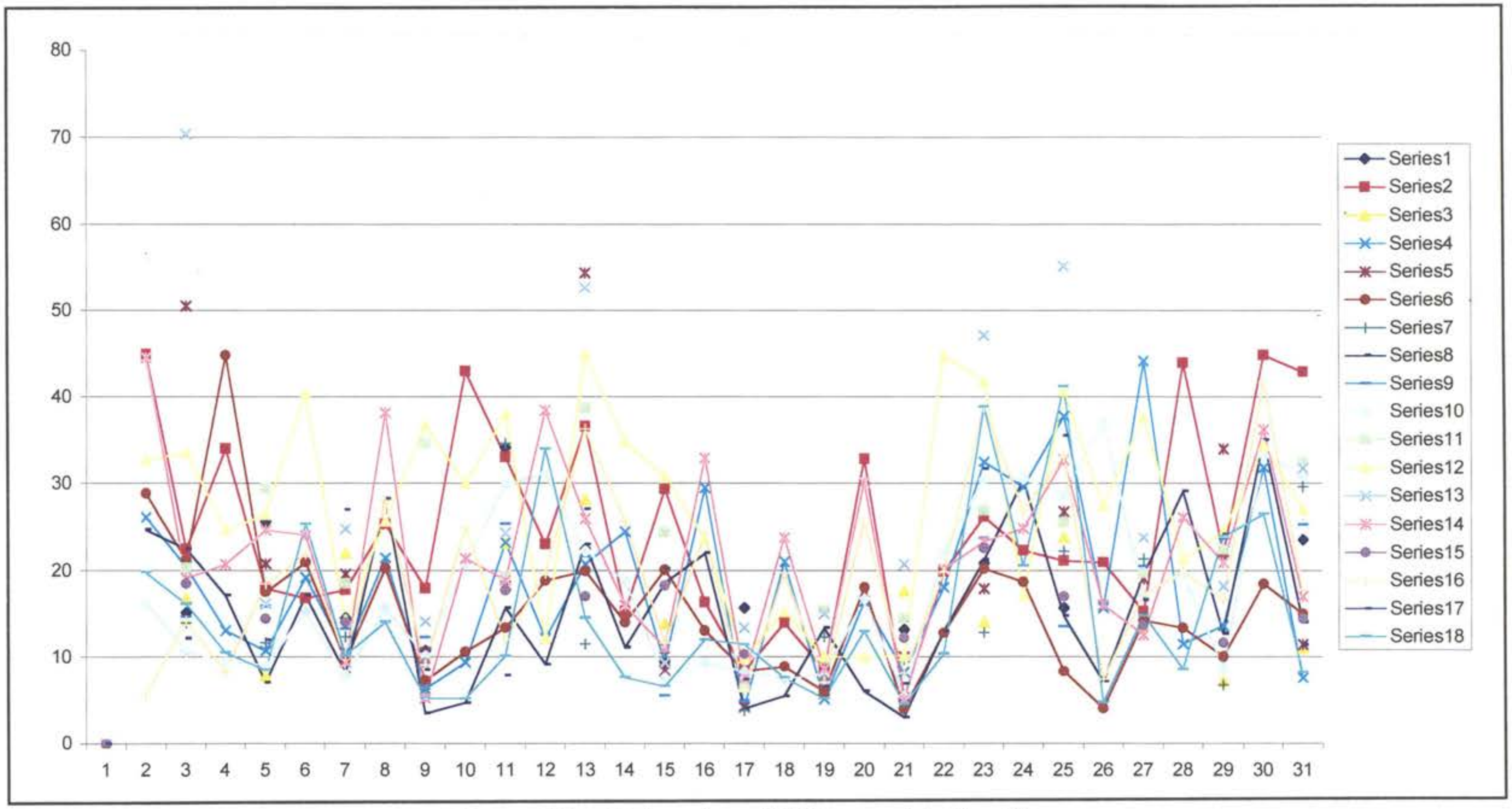


Figure G2. University of Oklahoma Testing Times by Questions.

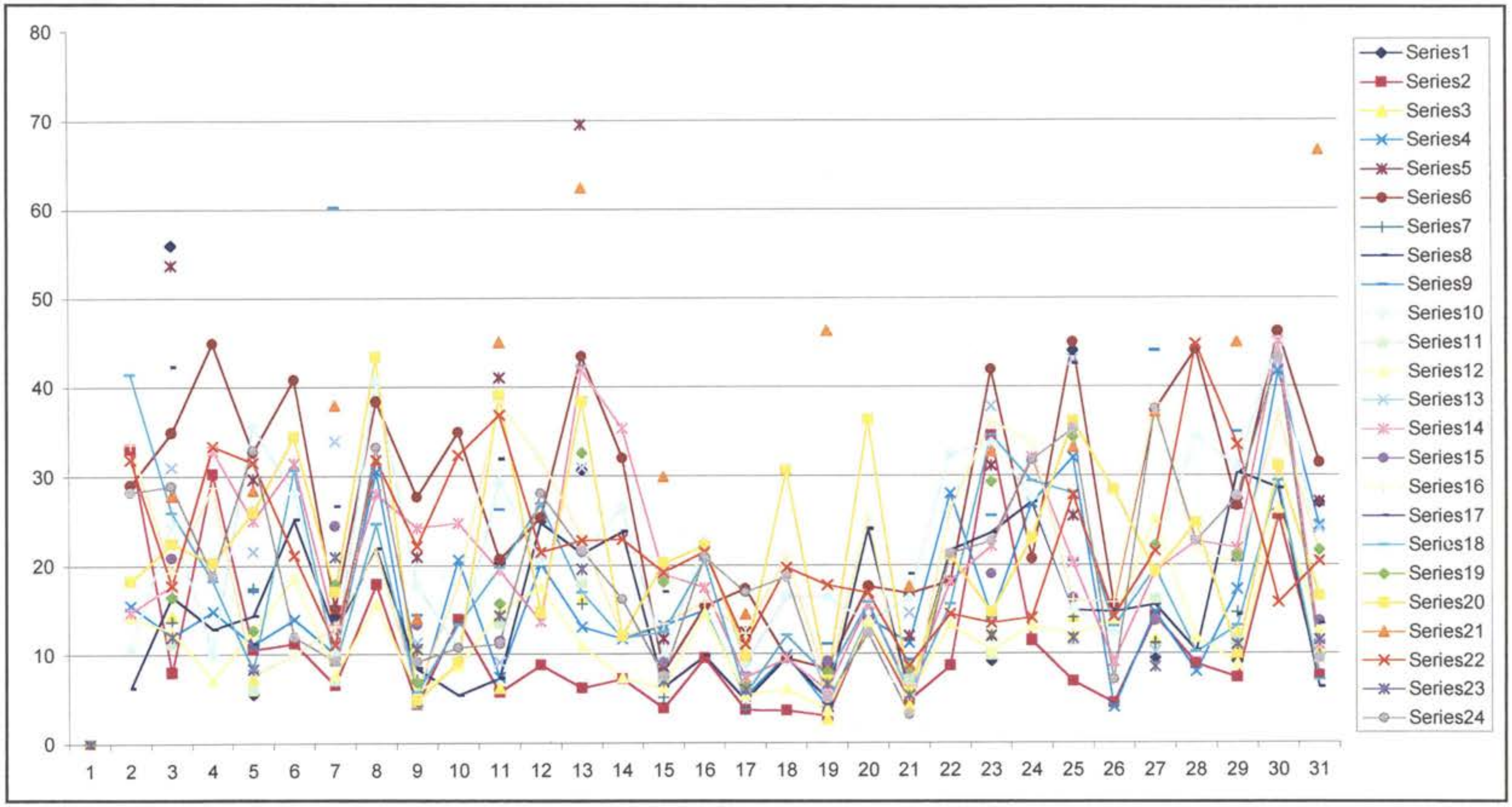


Figure G3. Oklahoma State University Testing Times by Questions.

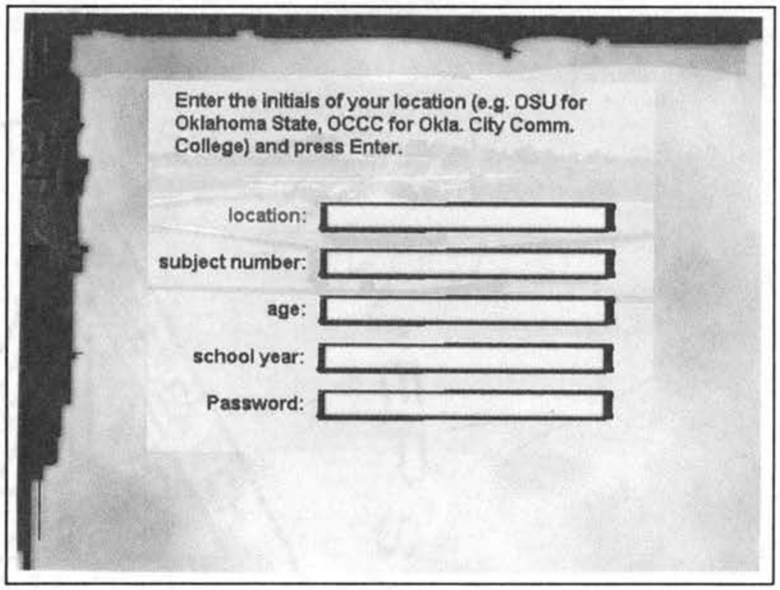
APPENDIX H

BRIEFING GUIDE

INSTRUCTIONS
For Subjects

LOGGING IN

The first screen you will see when logging in looks like the depiction below.



LOCATION

If you were enrolled in the ground school course at the University of Oklahoma, then your location would be "OU." If you are enrolled at Rose State, then type "RS", and so on.

SUBJECT NUMBER

The Research Administrator will assign your subject number. You will be asked to type either "F" for female or "M" for male at the beginning of the subject number. An example would be F001.

AGE

Type your chronological age. For example, type 18 if you are 18 years old.

SCHOOL YEAR

Type the number of years you have been in school. Use 17 for post grad.

PASSWORD

The password for all subjects is OSU. You will be asked to type the password twice. If you need assistance, ask the Research Administrator.

INSTRUCTIONAL MODULE

CLOCK TIME
The actual time of day is located in the upper left hand corner of the screen. This clock will appear throughout each module.

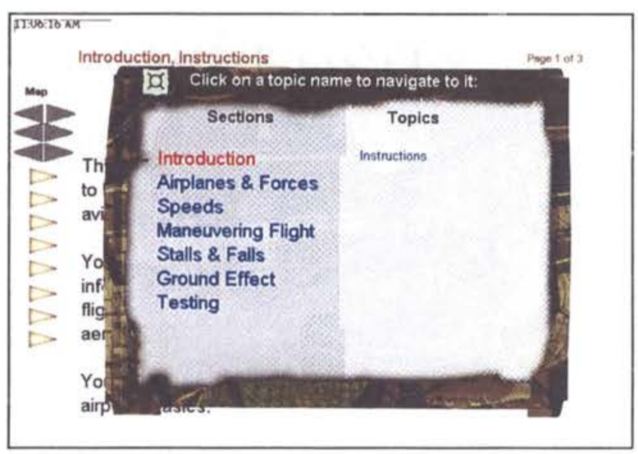
TEMPLATE USE
The triangular buttons on the left of the screen are used to navigate through the lesson. As you drag the mouse cursor over each button, a textual title appears to the left of the small airplane picture. Take some time to investigate this feature.

DIGITAL MOVIES
From time to time you will see a digital movie on the right of the screen. These movies are normally no longer than 2 minutes. Some of the movies are narrated and others are not. When they are narrated, the information may appear on the test.

SECTION TITLE
Notice that the title of the current section is "Introduction, Instructions." This title will change as you advance through each section. The page is recorded on the right of the screen.

MAP NAVIGATION

You may also move about the lesson by using the MAP feature on the template. When you click on the MAP button, a menu appears (see below). Just click on the section title on the left, followed by clicking on the topic title on the right. This will take you directly to that location—skipping the others.

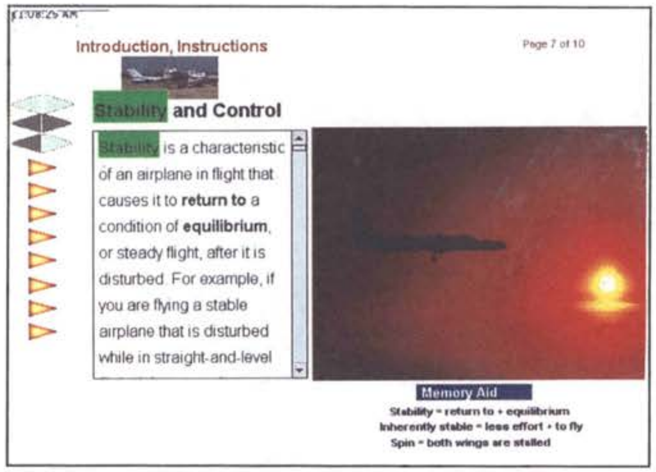


You may wish to use the MAP feature if you already have a good working knowledge of many of the subject areas, but need to review specific information.

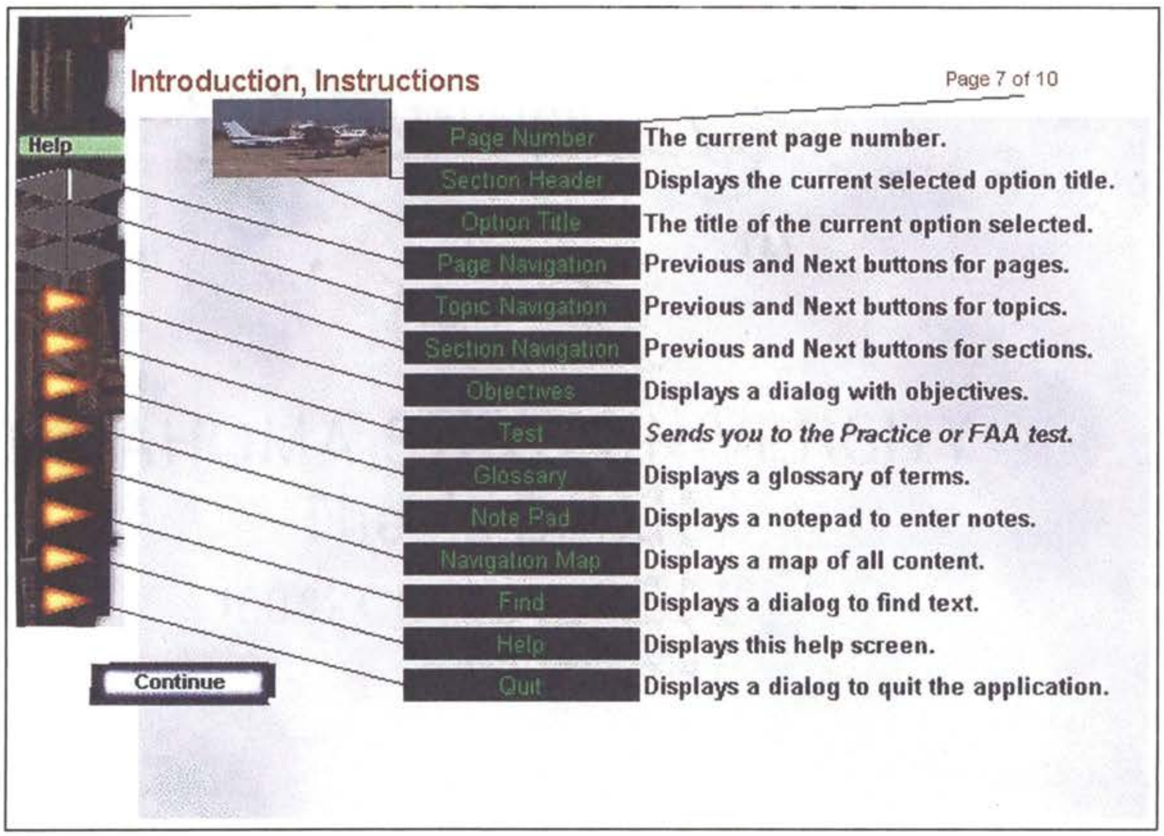
USING THE FIND FEATURE

The FIND feature is a powerful tool—letting you go directly to the location where a specific word appears. If you typed in the word "stability", then you may be sent to the location depicted below. Notice how the word is highlighted with a light green box.

When you click on the FIND button, a menu will appear in the upper right of the screen. Type in the word or words you wish to find, then click Find. All of the locations of your search will be listed. Use the Go To Page function to go directly to a page using the word you had chosen. There may be hidden words in the scrolling text box. You may need to scroll down the text to find other highlighted words.



NAVIGATION TEMPLATE NAMES AND IDENTIFICATION



Take a few moments to understand how the navigation template works. We have already discussed the functions of the Navigation MAP and FIND buttons.

GOING TO THE TEST

The Test button identification text is in Italics because this button will force you to leave the instructional module. The other buttons will help you to navigate within the instructional module.

BUTTONS THAT ADVANCE

Pay particular attention to the page and section navigation buttons. These two buttons will be the primary buttons for going forward and backward in the lesson.

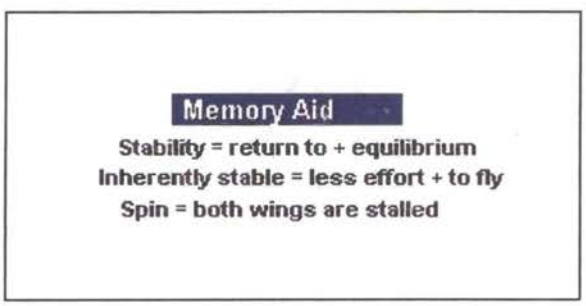
PAGE NAVIGATION

The Page navigation button can be used to advance within a section. The right button advances one frame forward. The left button revisits the previous frame. Continued use of the forward or backward button will advance the lesson or review the lesson.

SECTION NAVIGATION

The Section navigation button works much the same as the Page navigation button. The right arrow advances to the next section and the left arrow reviews the previous section.

MEMORY AID



A Memory Aid is a device to help the viewer remember important textual clues. In the example below, the word "Stability" can be defined as a return to equilibrium. Instead of using complete sentences, Memory Aid uses only the important words. In a test question the stem of the question may use the word "stability." You may expect that the phase or sentence answer would contain the word "equilibrium." You can see how this might also apply to "inherently stable" and "Spin."

TEST MODULE

When you click on the Test button, you will see a screen which asks you if you do indeed wish to go to the Test module. If you click yes, then you will see the screen depicted below.

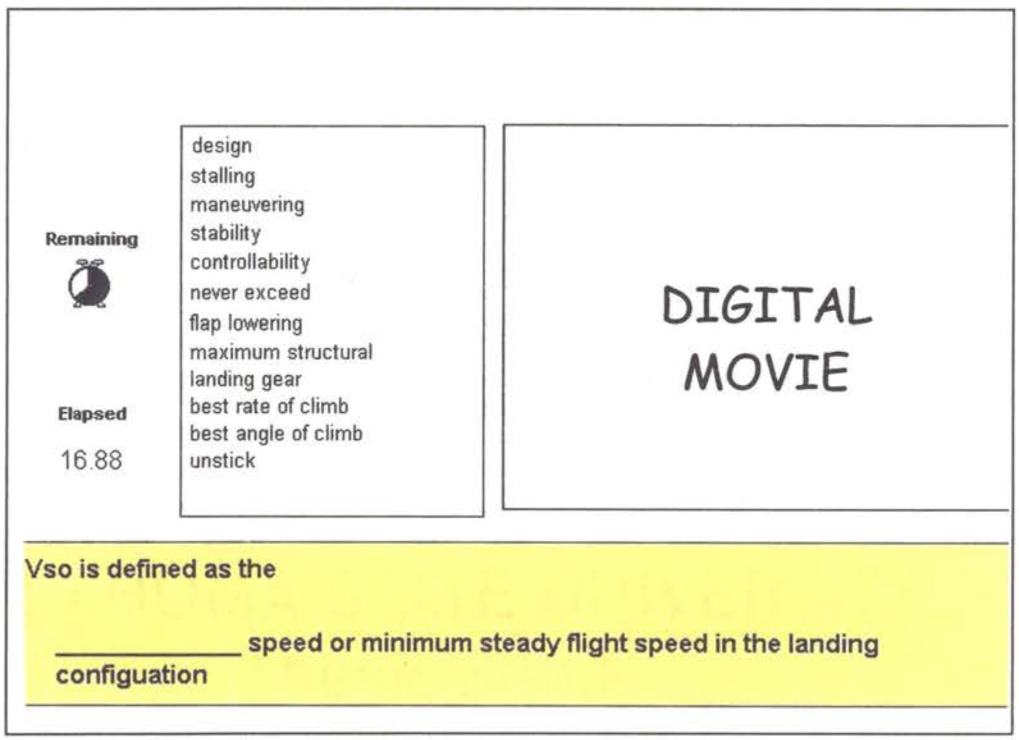
When you see this screen, contact the Research Administrator. You will receive specific instructions from the Research Administrator on how to navigate through the Test Module.

IF YOU HAVE NEVER PARTICIPATED IN A RESEARCH STUDY BEFORE NOW
The Research Administrator will ensure that each participant in this study has had the opportunity to complete a Consent Form. The Consent Form is the way the University ensures that no harm will come to anyone who participates in a research study.

Types of TESTS
There are two types of tests in this study. The first is the Inhibition Test Model and the second is a portion of the FAA Airmen Knowledge Test. Both tests have 30 questions. The Inhibition Test Model is a timed test and should not take more than 23 minutes. The FAA test is not timed, but should not take more than 23 minutes.

INHIBITION TEST MODEL

If you are to complete the Inhibition Test Model, the screen will appear as illustrated below.



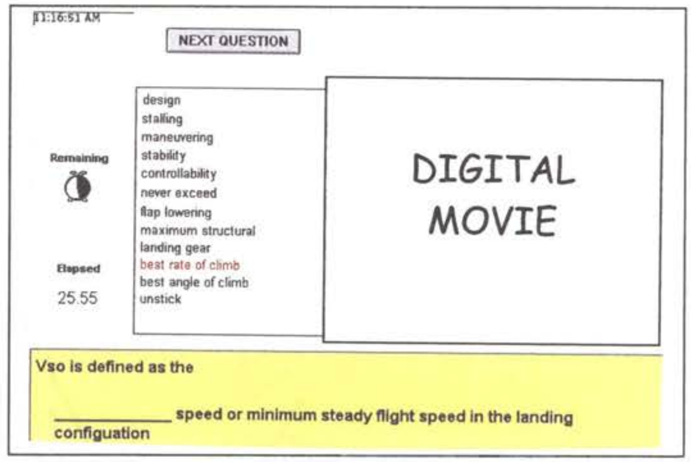
The question stem appears on the bottom of the screen. All 30 questions require you to fill in the blank. The possible answers are listed in a column in the center part of the screen.

Your task is to read the question, select an answer by clicking on the word or words, and then click the NEXT QUESTION button. You are to ignore all other distractions. Once you click on the NEXT QUESTION button, you will have 5 seconds to prepare for the next question. Failure to click the NEXT QUESTION button will result in a missed question.

DISTRACTERS

REMAINING TIME

A small clock, on the left of the screen will show remaining time. You have 45 seconds in which to answer the question. If you take too long, the test will automatically advance to the next question.

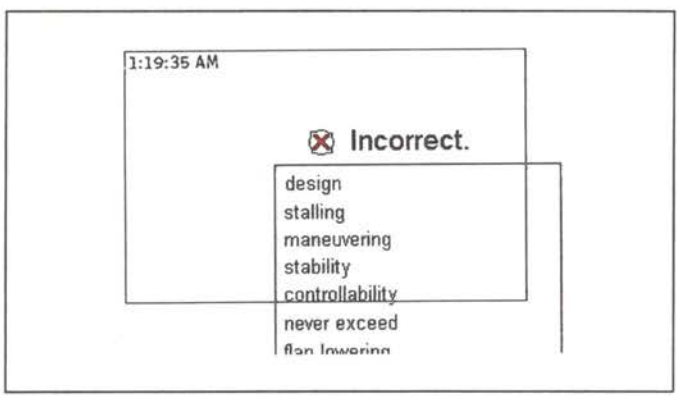


ELAPSED TIME

A digital elapsed time clock on the left of the screen shows how long it is taking to answer the question.

DIGITAL MOVIE

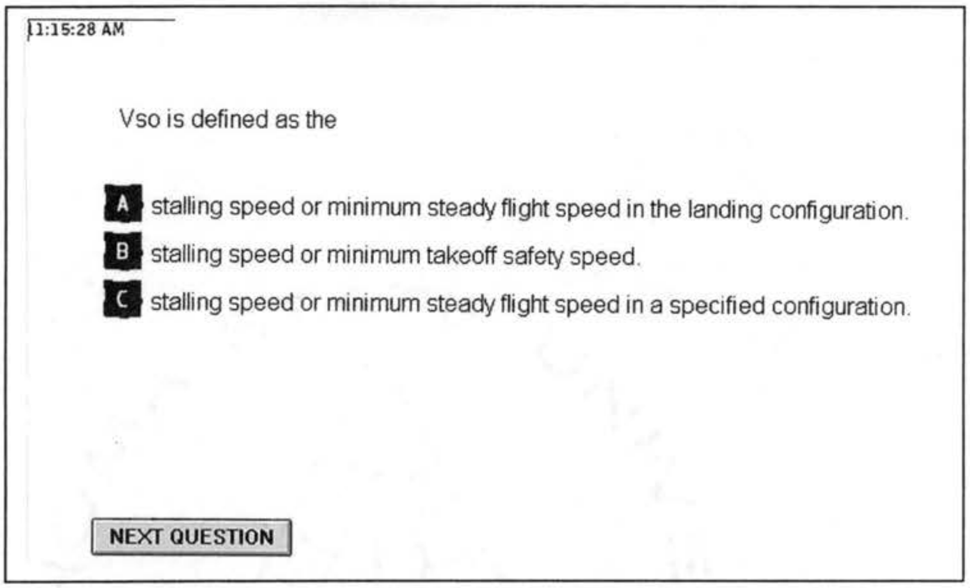
The movie shown on the right of the screen is not related to the question. It is a distraction.



GRADING YOUR RESPONSE

When you click on the NEXT QUESTION button, the timer counts down for 5 seconds and you see a Correct depiction or an Incorrect depiction. This will help you keep track of your success.

FAA TEST



The FAA test is 30 questions in length. This test is not timed. You may take all the time you wish to take.

Instructions

Read the question carefully, then select the best answer by clicking on the answer letter. Once you have made your selection, the NEXT QUESTION button will appear. You must click on the NEXT QUESTION button to advance to the next question. You will not receive any indication of whether your choice was correct or incorrect. Ask your Research Administrator for test feedback after the test is complete.

APPENDIX I

CONSENT FORM

CONSENT FORM
IRB # ED-00-140

"I, (student's name) ____, hereby authorize

______________________________ to perform the following treatment or procedure."

1. Procedure

- Each student participating in the experimental group will view a computer-based instructional module titled Slow Flight, Stalls, and Aerodynamic Effects, a practice module, and complete an end-of-course test
  - The practice module is an expanded multiple-choice instrument which introduces more audio, visual, and textual distracters than what are normally used in a simple four-distracter multiple-choice test
- Each student participating in the control group will view a computer-based instructional module titled Slow Flight, Stalls, and Aerodynamic Effects, complete multiple-choice practice questions, and complete an end-of-course test
  - The practice questions will use a typical four-distracter multiple-choice format

2. Duration
  - The instructional module viewing time will be no longer than 40 minutes (including practice module or practice questions)
  - The 30-question end-of-course test should take no more than 30 minutes to complete

3. Confidentiality
  - Students' names will not be used
  - Student participation will be tracked by number and location and will remain separate from the consent form
  - Once a student completes a consent form the student will be allowed to continue in the experiment
    - The computer-based instructional module will ask each student whether they completed a consent form. If the student answers "yes", then the lesson will continue. A "no" answer will automatically halt the lesson and direct the student to complete a consent form before continuing.
    - The computer will assign a sequential number to each student taking the lesson module. Student numbers, gender, age, and location will be written to an external file used for data collection. Student personal data and testing data will appear on the external file, but will contain the names of the students

4. There are no alternative methods of treatment.
5. There are no discomforts or risks to the student in this procedure.
6. If the procedure does not interfere with the FAA Airman Knowledge Test, then the procedure may be used to increase a person's ability to inhibit unwanted stimuli while attending to desirable stimuli. The application of this procedure may be useful to trainers who need to prepare there trainees for high concentration in excessively stimulated environments like FAA air traffic controllers.

This is done as part of an investigation entitled *EFFECT OF AN INHIBITION TESTING MODEL ON PRIVATE PILOT, AIRPLANE SINGLE-ENGINE LAND, GROUND SCHOOL STUDENTS.*

The purpose of the procedure is two-fold: (1) Establish the testing model as an interference-free instrument for future use and (2) Determine whether the instrument has value as a tool to increase one's ability to inhibit unwanted stimuli.

"I understand that participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty after notifying the project director." **(initial)**

I may contact Todd Hubbard at telephone number (405) 954-8200.

I may also contact Gay Clarkson, IRB Executive Secretary, 203 Whitehurst, Oklahoma State University, Stillwater, OK 74078, telephone number (405) 744-5700.

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

Date: ____________________________ Time: ____________________ (a.m./p.m.)

Signed: ____

Authorized signatory in place of subject (if required):

____

I certify that I have personally explained all elements of this form to the subject or his/her representative before requesting the subject or his/her representative to sign it.

Signed: ____
Project Director

APPENDIX J

INSTITUTIONAL REVIEW BOARD LETTER

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date: July 22, 1999 IRB #: ED-00-140

Proposal Title: "EFFECT OF AN INHIBITION TESTING MODEL ON PRIVATE PILOT, AIRPLANE SINGLE ENGINE LAND, GROUND SCHOOL STUDENTS"

Principal Investigator(s): H.C. McClure
Todd Hubbard

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

(Please change IRB contact person to Sharon Bacher, 203 Whitehurst, (405)744-5700)

Signature:

Carol Olson, Director of University Research Compliance

July 22, 1999
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

VITA

Todd P. Hubbard

Candidate for the Degree of

Doctor of Education

Thesis: EFFECT OF AN INHIBITION TESTING MODEL ON PRIVATE PILOT, AIRPLANE SINGLE-ENGINE LAND, GROUND SCHOOL STUDENTS

Major Field: Applied Educational Studies

Biographical:

Personal Data: Born on April 2, 1952, the son of Phil and Joyce Hubbard. Married to Deborah Hubbard, with children Matthew and Joshua.

Education: Graduated from Putnam City High School, Oklahoma City, Oklahoma, in May 1970; received Bachelor of Arts degree in History from Oklahoma State University in 1974; graduated from Squadron Officers School in 1980; graduated from Air Command and Staff College in 1982; received Master of Science degree in Aerospace Sciences from Embry-Riddle Aeronautical University in 1987; graduated from Air War College in 1992; completed requirements for the Doctor of Education degree at Oklahoma State University in May 2000.

Professional Experience: Commissioned as a Second Lieutenant in the United States Airforce in May 1974; graduated from undergraduate pilot training as Pilot in 1975; upgraded to Pilot in KC-135 aircraft in 1976; upgraded to Instructor Pilot in T-37 aircraft in 1979; upgraded to Pilot in U-2 aircraft in 1984; Commander, 4402nd Reconnaissance Squadron (Provisional), November 1992 – April 1993; Commander, 9th Services Squadron, December 1993 – September 1994; Commander 4402nd Reconnaissance Squadron (Provisional), September 1994 – January 1995; retired from the United States Air Force in 1995; Airplane Pilot Simulator for Boeing Aerospace Operations, October 1995 – May 1996; Instructional Designer for Boeing Aerospace Operations, 1996 – 1997; Instructional Design Consultant for NLX Corporation, 1996 – 1999; Instructional Systems

Designer for the University of Oklahoma at Mike Monroney Aeronautical Center, 1997 – 2000.

Professional Memberships: Daedalians, American Association of Aviation Psychology, Board of Directors for California Excellence Awards, Aviation Education Association.

Publications: Before you fly. Flying Safety, 1985; Dragonlady. Combat Crew, 1984; Modern technologies for reconnaissance: Surveillance and verification with regards to disarmament control, 1991, Air University Press; Operative aspects of central region air forces: In light of disarmament, International Symposium in co-operation with NATO's Sixteen Nation, Müch Publishing, 1990.