THE COMPARATIVE EFFECTIVENESS OF A PROLONGED FLARE AND NORMAL FLARE ON STUDENT PILOT ACHIEVEMENT IN THE LANDING MANEUVER AND ON TIME TO SOLO

By

WAYNE ROBERT MATSON

Bachelor of Science
University of Minnesota
Duluth, Minnesota
1963

Master of Arts
Northern Arizona University
Flagstaff, Arizona
1966

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
May, 1973

THE COMPARATIVE EFFECTIVENESS OF A PROLONGED FLARE AND NORMAL FLARE ON STUDENT PILOT ACHIEVEMENT IN THE LANDING MANEUVER AND ON TIME TO SOLO

Thesis Approved:

Kenneth E. Wiggins
Thesis Adviser

L. Herbert Bruneau

Kenneth St. Clair

Bill F. Elsom

N. N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

I was unaware that a doctoral program and dissertation could be such an enjoyable experience. And for this experience I wish to express my sincere appreciation to those who guided my educational efforts and made this study possible. I wish especially to thank:

Dr. Kenneth E. Wiggins, my advisor and doctoral committee chairman, for his understanding and personal concern toward my total educational effort and for his direction of this study. My doctoral studies would not have been possible without his support.

Dr. Bill F. Elsom for "turning-me-on" to research.

Dr. L. Herbert Bruneau, Dr. Bill F. Elsom, and Dr. Kenneth St. Clair, of my doctoral committee, for their special interest and counseling from the beginning of my studies to the completion of this dissertation.

Mr. Orrin R. Tatchio, Mr. Phil E. Hale and Mr. Rick L. Gladden, of the OSU Aviation Education Department, for their special interest, patience, and assistance during the study.

Mr. A. Howard Hasbrook and Mr. Paul G. Rasmussen, of the FAA Civil Aeromedical Institute, for their expertise and guidance and for their interest in me and my work.

My wife Merridee and daughter Ann Marie for their sacrifices and smiles. I now know what it means to say--Without their support this study would not have been possible.

To paraphrase Dr. Bruneau--Now that I've completed this "pilot" study I can get on with my research.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table		Page
XII.	Summary of the Averages and Ranges of Criterion Values for Normal and Prolonged Flare Groups and for the Study as a Whole	53
XIII.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Attempts-to-Land in the Instructional Environment X	58
XIV.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Time-to-Land in the Instructional Environment X	58
XV.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Time-to-Solo in the Instructional Environment X	58
XVI.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Attempts-to-Land in the Instructional Environment Y	59
XVII.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Time-to-Land in the Instructional Environment Y	59
XVIII.	Comparison of the Normal Flare vs Prolonged Flare Groups on the Time-to-Solo in the Instructional Environment Y	59

CHAPTER I

INTRODUCTION

Students in pilot training must learn a variety of flight maneuvers before they become competent pilots. Some maneuvers appear to be more difficult than others. During the pre-solo phase of learning to fly, the landing maneuver appears to be the maneuver that is the most difficult to learn.

The comment is often heard: "Early in their training many students can do everything but land the plane." (39:36) Barnhart (4:337), in discussing basic flight techniques in light aircraft states: "Without reservation, the roundout [one phase of the landing maneuver] requires keener judgment and more practice than any other single part of basic flying."

The Federal Aviation Administration's (FAA) Flight Training Handbook (20:56) describes some of the difficulties a student might encounter while learning the landing maneuver. It states that although "not all students will experience all the . . . difficulties . . . most will experience one or more." It also states: "Landings require much time and patience as well as painstaking analysis on the part of the instructor." (20:61) In the Flight Instructor's Handbook the FAA states:

> Making the most effective use of time available is a basic problem in instruction. This is particularly true in flight instruction, where the time available is often limited

> by financial considerations. The instructor must arrange his instruction so that the student pilot achieves the most perceptions in the least total time. (18:5)

It, therefore, seems reasonable for those in flight instruction to study the landing maneuver in an attempt to answer at least two questions: (1) Why does the landing maneuver appear to be difficult? (2) How can the landing maneuver be made easier? The purpose of this study is to analyze some of the theoretical difficulties and to determine whether the employment of an experimental teaching strategy, based on the theoretical difficulties, can significantly reduce flight training time.

Nature of the Problem

From the viewpoint of student achievement, the landing maneuver appears to have at least two major components: (1) learning to make the first acceptable landing and (2) learning to make the variations in the maneuver that are required for passing successive stages of training. For the purposes of this study, learning the landing maneuver is synonymous with learning to make the first acceptable landing.

In making his first landing the student appears to gain for himself a feeling of great personal satisfaction. This feeling is probably second in intensity to the feeling associated with making the first solo. If, on the other hand, the first landing is delayed it can be quite frustrating for the student. This feeling is probably similar to that associated with the first solo being delayed.

When the student makes his first landing, he seems to know he is successful. Kershner (34:86) believes that if the student makes or doesn't make it, he won't have to take the instructor's word for it.

He can see and feel it for himself.

It is possible that after the student has made his first landing he has learned the landing maneuver; i.e., he can then continue to land without assistance. He then can begin to learn the variations in the landing maneuver; i.e., crosswind, short field, soft field, slips-to-a-landing, etc.

There are no standard criteria for judging good, bad, proficient, or acceptable landings. Because of the lack of standardization and objective criteria associated with landings or any other flight maneuver, evaluating the quality of landings is, at best, a very subjective affair. The situation, however, is somewhat different with that first landing because the instructor is primarily concerned with the student simply getting the plane down--somewhere on the runway. The Flight Training Handbook states: "He should not be required to solve any accuracy problems during this early landing practice other than to land somewhere on the desired runway." (20:54) Although the decision is subjective as to how much leeway to allow the student in his attempt at making a landing, it can be reasonably assumed that a particular instructor will apply the same limits to all his students, and that the success or lack of success, becomes somewhat more objective. That is, the student either makes it, or he doesn't.

The present study focused on efforts (attempts-to-land) related to making the first landing and the first solo. If a student could prolong his practice in the flare during each attempt at landing, it seemed reasonable to suspect that he could learn the cues associated with the maneuver sooner than he normally would. Although the additional time in the flare could significantly affect student time in the landing maneuver, this time (measured in seconds) should not significantly affect student time in the other phases of training, e.g., time to solo (measured in hours). Experience indicates that additional practice can mean additional achievement. Experience also indicates that when the type of practice is slightly different, the results can also be slightly different, i.e., unexpected.

The study also sought to determine whether the time required for making the first landing was related to the time required for making the first solo. If a student had a great deal of trouble making the first landing, he quite naturally could not begin to practice the variations necessary for solo until later in his training. Would this delay be reflected in his time to solo? If each maneuver were objectively evaluated, it is reasonable to suspect that the time required to make the first landing would be related to the time required to solo. The highly subjective criteria used to evaluate student readiness for solo might, however, distort any possible relationship between time-to-land and time-to-solo.

In addition, the study sought a deeper analysis of the prolonged flare technique, as well as evidence to indicate whether the student, with his first landing, had learned the maneuver, i.e., in the sense that it was described above.

Statement of the Problem

From the literature the landing maneuver appeared to be the most difficult and therefore the most time consuming maneuver in pre-solo flight training. The purpose of this study was to determine whether an experimental teaching strategy that provides for prolonged practice in the landing maneuver would significantly improve student achievement, thereby reducing student pilot practice time in the landing maneuver and in pre-solo flight training. This study investigated the comparative effectiveness of a prolonged flare and a normal flare on student pilot achievement.

Significance of the Study

The landing maneuver is difficult and time consuming for some students. Any instructional method that would make the maneuver easier to learn and would allow the student to learn the maneuver in less time would be of great benefit to the student both attitudinally and financially. In reference to the landing maneuver, the Flight Training Handbook states: "If the student shows no progress at first, he may become discouraged and a severe mental handicap may develop." (20:61). The Flight Instructor's Handbook states: "Making the most effective use of the time available is a basic problem . . . in flight instruction, where the time available is often limited by financial considerations." (18:5).

Since many student pilots drop out of flight training before they qualify for their pilot's license, improved instructional techniques would appear to be an important area of research. The Flight Instructor's Handbook (18:34) states: "Recent surveys have revealed that of the total number of students who start flight training, less than half go on to receive their pilot certificates." Jason (29:32), in a recent article stated:

> Each year, about half of the roughly 150,000 new flight students become dropouts. . . . every student who discontinues represents a serious loss. The individual who is denied

> the rewards of flying loses; the instructors, the FBOs and the aircraft and equipment manufacturers lose. Everyone loses. And that is a disaster.

The importance of improving instructional techniques seems even more critical when one examines large scale military flight training programs.

> In a keynote address to a conference on engineering systems for education and training, the Honorable Thomas D. Morris, Assistant Secretary for Defense (Manpower), asserted that pilot training is the most costly and time-consuming in-house training effort within the military establishment. Excluding depreciation of facilities and investment in aircraft, the training of a jet pilot costs about $250,000, while $110,000 and $45,000 are needed respectively to train a propellor aircraft pilot and a helicopter pilot. The annual cost for this training approached one billion dollars. It is clear that even small gains in pilot training efficiency would result in substantial savings in dollars per year (44:5)

Limitations of the Study

This study was limited to those students who lacked formal flight training. All students received their basic flight training from the flight instructors in the Aviation Education Department of the Oklahoma State University during the fall semester, 1972. The students were assigned to one of two 1971 Cessna 150 Commuter airplanes and to one of two flight instructors for the period of the study.

Assumptions of the Study

The study assumed that the flight instructors were consistent in the instruction of their students.

The study also assumed that the effects of weather were evenly distributed among the students.

The study further assumed that the students were not aware they were participating in an experimental study and that the instructors were not aware the time-to-solo criterion was to be analyzed.

The study assumed that the variations in aircraft configuration, i.e., the flap settings and the tachometer (RPM) settings, were randomly distributed about the designated settings.

Definitions of Terms

The Treatment was "flare time" and was defined as follows: Students taught with the prolonged flare were instructed the same as the students taught with the normal flare with one exception. On final, before the transition for flare, when the student was sure of making the runway, he set his RPM at 1500. Students using either technique could use whatever power was necessary to adjust their flight path prior to the transition. The difference between the levels of the treatment was that with the extra power a student would experience a longer flare, thus providing prolonged practice in the landing maneuver.

Treatment Paradigm:

Normal Flare	Prolonged Flare
1. 10° Flap	1. Same
2. IAS: 70 mph on final	2. Same
3. Power-Off during flare	3. Power-On (1500 RPM)

Normal Flare was defined as that flare which results from the conditions specified in the treatment.

Prolonged Flare was defined as that flare which results from the conditions specified in the treatment.

Attempts-to-land was defined as the number of landing attempts made by a student prior to his first acceptable landing. This number includes the attempt of the acceptable landing.

Time-to-Land was defined as the amount of time flown by a student prior to his first acceptable landing. This includes the time of the acceptable landing.

Time-to-Solo was defined as the amount of time flown by a student prior to his first solo flight.

An Acceptable Landing was defined as any landing in which a student has handled all of the controls after turning on to the final leg of the approach to the landing. It was not an acceptable landing if the instructor touched any of the controls once on the final approach to the landing. The instructor was free to make any comments he felt appropriate at any time.

Instructional Environments (X and Y) were defined as the set of stimulus variables, excluding the treatment variable, to which the students were exposed.

Instructional Environment Paradigm:

Environment X	Environment Y
1. Instructor X	1. Instructor Y
2. The airplane assigned to Instructor X	2. The airplane assigned to Instructor Y
3. The Sequence of Maneuvers taught by Instructor X	3. The Sequence of Maneuvers taught by Instructor Y
4. Flight Group X	4. Flight Group Y

Instructor was defined as a Certified Flight Instructor employed by the Aviation Department of the Oklahoma State University.

Airplane was defined as a 1971 Cessna 150 Commuter.

Sequence of Maneuvers was defined as the sequence in which the maneuvers were taught by the two instructors. Each instructor used a slightly different sequence. Each instructor, however, used the same sequence for all of his students. The maneuvers were those suggested for pre-solo flight in the FAA Private Pilot Flight Training Guide (41).

Flight Groups (X and Y) were defined by the selection procedures described in Chapter III.

Learning the Landing Maneuver was synonymous with learning to make the first acceptable landing.

Learned the Landing Maneuver was defined as the ability to continue to make acceptable landings once the student had made his first acceptable landing.

CHAPTER II

REVIEW OF THE LITERATURE

Flight research is plagued by many of the same problems encountered in other areas of behavioral research. Smode, Hall, and Meyer (44), in what may be considered one of the most comprehensive reviews of the literature relevant to pilot training stated:

> The general conclusion from the analysis and interpretation of the literature . . . is that very little of the results is directly applicable to pilot training. . . .
>
> There is . . . substantial ambiguity surrounding the research that deals specifically with pilot performance. . . .
>
> Additional variance is contributed by the difficulty of relating research tasks to the pilot's task in flying an airplane. This is part of the more general and traditional problem of correlating laboratory and simulation conditions with real world conditions. . . .
>
> . . . much of the research is unorganized and unsystematic by any standards.

The present study reviewed the development of (1) *flight research*, focusing on the results relevant to (2) *flight training*, (3) *inflight measurement* of pilot performance and (4) the *landing maneuver*.

Flight Research

An Historical Introduction to Aviation Psychology (50), provides a review of flight research for the period beginning with World War I and continuing up to the preliminary stages of World War II.

> Aviation psychology had its origin in the first World War and was concerned primarily and almost exclusively with the selection of aircraft pilots. Emphasis was at first upon reaction time and emotion. . . .

> Tests of intellectual processes covered attention, memory, perception, judgment, and general intelligence. Combinations of psychomotor, emotional, and intellectual tests were found to be better predictors of rated flight performance than were any single tests. However, the criteria of performance during the first World War were themselves of doubtful value. . . .
>
> Personality observations were carried out by interview and questionnaire methods, but the reliability of the procedures used is highly questionable. There were no standardized personality tests. . . .
>
> The chief contributions of psychologists to sensory aspects of selection were their criticisms of existing sensory requirements. They emphasized the need of establishing requirements through adequate job analysis and of providing objective, reliable and proven instruments for measuring sensory capacity. . . .
>
> The chief values of early aviation psychology are (1) that it broke the ground for later investigators and (2) that it showed some avenues which are fruitful and others which are unfruitful. On the positive side, for example, are the Italian studies of reaction time which suggested the value of complex choice reactions in a simulated cockpit. . . .
>
> The chief criticisms of early work in aviation psychology are: (1) its <u>preoccupation with selection</u> to the exclusion of the learning process and other functions affecting flight performance; (2) the <u>neglect of job analysis</u> as a means of determining the exact value of the task performance by pilots; (3) <u>failure to conduct research in the air</u>; (4) <u>absence of trustworthy methods for rating or measuring flight performance</u> so that the value of tests in selecting aviators could be determined; and (5) <u>absence, in most instances, of adequate research aimed at determining how well the tests actually differentiated good and poor prospects for flight training</u>. In so far as tests are concerned, there was too much dependence upon the 'reasonableness' of a test, upon what is sometimes called 'face validity,' and a parallel failure to determine experimentally its actual value in selecting flyers. . . .
>
> It is to be regretted that psychological [flight] research virtually stopped with the end of [World War I] . . . to be renewed only as [World War II] . . . approached.

Strickland (45), in <u>The Putt-Putt Air Force</u>, commented on the progress in flight research preceding World War II.

> Over the years aviation research had been concentrated upon the product. Millions had gone into improvement of the aircraft, its design, engines, propellors, instruments and other components, but hardly anything on the man at the controls. True, the Army and Navy had their departments of aviation medicine and certain criteria for pilot selection that were generally accepted as authoritative until evidence

> indicated the need for more explicit standards.
>
> By the mid-thirties, several airlines, notably United and Northwest, were deep into flight research on their own; and Harvard University had a laboratory devoted exclusively to the study of pilot fatigue, but for the most part all this related to transport and military flying. With the enactment of the Civilian Pilot Training Program, the Civil Aeronautics Authority felt that the time had come to find out more about the average man in the sky, the non-professional pilot. . . .
>
> CAA felt that some of the answers could be given by the 10,000 [later expanded to 50,000] young CPTP participants, coming as they did from every part of the United States, from every kind of background, and with an almost infinite range of physiological and psychological makeup. . . .

Dr. Viteles (50), who served as chairman of the Committee on Selection and Training of Aircraft Pilots, stated that:

> The program of research sponsored by the Civil Aeronautics Administration, through the N.R.C. which began in 1939, was the first comprehensive and systematic approach to problems of aviation psychology. Among other things, this program broadened the scope of aviation psychology to embrace the training and maintenance of flyers as well as their selection.

Using existing facilities at approximately 40 universities throughout the nation and grants totaling approximately $900,000, the CAA sponsored flight research for over five years. <u>The Aircraft Pilot: 5 Years of Research</u> (51) is a summary of outcomes.

When Committee research was initiated little or nothing was known about the nature of inflight instruction. The instructor and student in the airplane could not be observed, making analysis of the instructional process difficult. To make observable for study what had previously been unobservable, a short-wave transmitter and electrical interphone suitable for use in a light plane were developed. Then, <u>for the first time in history</u>, elementary flight instruction could be observed and evaluated in light of modern scientific and educational principles.

Two immediate outcomes were apparent from this preliminary research: (1) much of the instruction given in the air could be given better on the ground, and (2) "good" pilots are not necessarily "good" instructors.

Following an analysis of 10 hours of recorded flight instruction by each of 4 instructors, it was found that no two used the same terminology or even the same basic facts in explaining what they were teaching. A total of 500 technical or specialized terms were used, many of which were unique to an individual instructor.

These findings led to the development of two popular training aids of fundamental importance for elementary instruction: (1) Patter For Elementary Flight Maneuvers (40) provided the flight instructor with appropriate "Patter" for each of the maneuvers, and (2) Fundamentals of Elementary Flight Maneuvers (22) outlined the basic facts which could be understood by the student pilot.

The work of the Committee was impressive and monumental in scope, especially when compared to what has taken place since. Although some important research has occurred since these early efforts, such as the research related to integrated contact-instrument flight training, the research represents, for the most part "a sporadic 'chipping away' at portions of the defined issues with no overall concepts of guidance enunciated by users, buyers or researchers." (44)

It is interesting to note that the current Flight Training Handbook and Flight Instructor's Handbook are not essentially different from the early publications of the CAA and the Committee. Several sections in the current FAA handbook have been reproduced verbatim from the earlier efforts of the CAA.

An Assessment of Research Relevant to Pilot Training points up the fact that:

> . . . 'surges in published research [have been] related to the existence of groups that conducted research specifically on pilot training. . . . The number of . . . studies in the literature corresponds with the peak time periods these units were actively conducting this type of research. (44)

Flight Training

> The body of the findings [relevant to flight training] . . . simply does not contain the substance needed for resolving major problems in pilot training. Perhaps the basic reason for this has been the absence of systematic or programmatic assults on the prevalent issues to be solved. (44)

In the review of the literature related to the manipulation of instructional variables Smode, Hall and Meyer (44) concluded that:

> Only a limited number of studies specifically concerned with variations in the methods and techniques of training pilots were discovered in the literature. Manipulation of instructional variables such as sequence of instructional units; size, composition, and complexity of these units; course content and length; scheduling of training conditions; amount of instruction, etc., can be expected to have significant effects on skill acquisition, but we were unable to locate any such researches in the aviation environment. . . . It is also clear that answers are not available for many questions relating to the manipulation of instructions. . . . course specification is based on judgment plus experience and expertise with previous systems as modified by the availability of time, money, and training aircraft. . . .
>
> Data from educational research dealing with the effects of manipulation of instructional variables are vague and sketchy and contribute little to what is already employed in the training of pilots.

Studies related to an assessment of the variables associated with the flight instructor indicate that despite his importance in flight training, little has been done to control the quality or maximize the effectiveness of flight instructor personnel. A study by Williams and Flexman (55) demonstrated that instructors differed significantly in judgment as to when pilot trainees were ready to solo.

> The quality of pilot training is in a large part dependent upon individual instructor pilots. . . . A viewpoint that has prevailed is that since instructors are easily defined as expert pilots, their activities and procedures in instructing students are satisfactory to the objectives of the training program. Yet significant variability among instructor personnel in techniques, philosophy of instruction, and performance assessment has been demonstrated repeatedly. One result has been a significant lack of control of their outputs in a training program. (44)

Although one might have reasonably suspected the existence of inter-instructor variability, studies (7, 23, 30) of the effects of inter-instructor "experience" support the generalization that there is no basis for the notion that experienced pilots make better instructors than relatively inexperienced pilots.

There appears to be no data to indicate that more experienced pilots make better instructors than less experienced pilots. In fact, the evidence suggests that experienced pilots are no better instructors than relatively inexperienced pilots. Evidence (30) also indicates that there are no differences in student attitudes toward inexperienced and experienced flight instructors.

> The . . . studies indicate that a high level of pilot experience is not necessary for a pilot to be effective as an instructor. How much the experienced pilot may enrich the training program by his experiences or contribute to the proficiency of his students for later operational flying is, however, unknown and data bearing on this point should be collected. (44)

Jenkins and Williams developed ways of investigating "tension" during flight and presented evidence that instructors who are themselves tense turn out tense students. "There is this characteristic variation between the students trained by different instructors." (52)

Inflight Measurement

Because of the problems inherent in extrapolating from laboratory, e.g., simulator, studies to real world situations, the review focused on the research relevant to inflight measurement of pilot performance.

> The efforts of research personnel to reduce the effects of differences in check pilot standards and to otherwise increase the reliability and diagnostic capacity of flight proficiency evaluation [have been] . . . directed primarily toward making the evaluation more objective. (25)

Following his recent review of the literature relevant to inflight measurement of pilot performance, Forrest (21) concluded:

> The history of pilot performance evaluation is not without many studies and designs of objective measurement, and statements of reasons for adopting objective flight tests. Yet, we find outselves today conducting flight checks in the same manner as they have been accomplished for as many years as pilot certification has existed. This situation may be attributed to our inability to provide a practical method of implementing objective flight testing.

Forrest was of the opinion that computer methodology and utilization could help make objective flight testing a viable phase of pilot education and training.

Following their review of the literature, Smode, Hall, and Meyer (44) concluded:

> The research on flight check development has shown a consistent trend toward increasing objectivity in scoring performance. Yet, with perhaps the exception of the research accomplished for Army Aviation (helicopter flight checks) and a conglomorate of inputs to the Air Force Standardization/Evaluation program, none of the evaluation instruments is in use today. The obvious question is: 'What are the reasons for not using these research results?' There are several. The systematic flight checks require special training of the instructors. Also, flight instructors resist these techniques because they require more 'head in the cockpit' time than they are willing to allot. Finally, there is a certain natural resentment against the regimentation of setting up

> and observing this event at this time. Flight instructors intuitively feel they know best how to assess training progress and outcome.

After reviewing the research on the use of objective measures in flight performance evaluation Greer, Smith, and Hatfield (25) concluded:

> In the various research efforts, increasing objectivity and requiring subjective judgments to be more specific have usually resulted in higher reliability and almost always have produced greater analytic capacity in comparison with the traditional method. But the increases in reliability of check grades have not been as great as is desired, and the fluctuating reliability of the objective check has plagued researchers. Apparently, the requirement for check pilots to attend to and describe, or judge (where description is not possible), specific aspects of student performance is, of itself, no guarantee of high reliability. Check pilot biases seem to be manifested in 'relatively objective' measures as well as in subjective measures, and this probably accounts for low or fluctuating reliability. Thus, primary attention should be accorded the problem of reducing differences in check pilot standards so that the more objective measures can be used reliably and for detailed diagnosis of training programs.

Forrest (25), included the following major points in his summary of the history of inflight evaluation of pilot performance.

1. The general principles by Gordon (24) constitute a valuable guide for researchers investigating inflight evaluation of pilot proficiency.

2. In general, the trend has been toward objective measurement, and this is justified by findings of greater reliability. The finding of increased reliability, however, is not universal.

3. Most systems in recent use have not attempted completely objective measurement but have combined objective and subjective items.

4. While complex scoring methods have shown advantages in rotary wing measurement simple scoring methods have done as well in fixed wing studies.

5. Complexity of objective grading forms has led to resistance from instructor pilots on grounds of safety. This resistance emphasizes the requirements for simplicity of

recording, if the form is to be perceived as safe. It further implies the need for training instructors in techniques of observation and recording.

6. Inherent complexity of the psychomotor learning involved, in interaction with variability of response among supposedly identical aircraft and the highly variable nature of the flight environment (including wind, temperature, illumination, etc.) serves to render the achievement of precise inflight measurement very unlikely.

Smode, Hall and Meyer (44) included the following points in their outline of the various shortcomings identified in the experimental procedures and tasks related to the measurement of pilot performance.

1. Noncomparability of measures across studies (e.g., different measures of proficiency used, such as accidents, attrition rates, nonstandard flight checks, ratings on different inflight events).

2. Differences in skill level of pilots/trainees, making for noncomparability among subjects.

3. Heavy reliance on subjective opinions. Instructor ratings on "goodness" of performance are the most available and center on what the individual instructor considers important. It is difficult to know what constitutes the elements of criterion performance. Thus, differing bases for comparisons exist and the results of a study become highly specific to that study.

4. Check pilot biases. Evaluation is wholly based on the judgment of the examiner, and various biases at one time or another influence the results.

5. Differing tolerance limits for describing adequacy of performance during inflight measurement (e.g., differences in out-of-tolerance envelope).

6. Use of imprecise criterion measures of the event being examined. The criterion is sometimes irrelevant or confounded in assessing the effects of the independent variable.

7. Precise measures. An adequate number of effective measures for describing performance is not available.

8. Procedural changes within a study as it progresses; for example, subjects may be transferred, equipment modified or changed during the study, scheduling and administrative problems may occur, and more rarely, changes may be dictated because of safety considerations. The result is a severely unbalanced design.

9. Validity of the checks. The validity of a proficiency test is due in large part to the accuracy with which the job has been analyzed and to the selection of the critical events to be measured. No indication of validity of the flight checks was discernible in the studies cited. Nor can validity be easily expressed. At present, pilot training research has been unable to define precisely the pilot's job and, hence, unable to specify the critical behaviors to be assessed. Validity, although indeterminate, is assumed to be adequate based on subject matter expertise about flying.

10. Flight environment. It is difficult to measure and evaluate performance in the air. Pilot performance is affected by a variety of interactions involving contingencies in flight and changes in individual reactivity (intra- and interday fluctuations in trainee performance), to which may be added hazard and safety features as well as interpersonal aspects between the examiner and the trainee.

11. Differing ways of interpreting transfer-of-training data. In some cases, transfer assessments may be based on performance in initial trials; in other cases it may be based on performance across larger blocks of the transfer task.

12. Reporting of the same studies in several different documents, making it difficult to determine exactly what was done.

In summarizing their findings relevant to inflight measurement, Smode, Hall, and Meyer (44) stated:

> . . . the evaluation of inflight performance is a long way from being effectively achieved, and less than complete information is provided by present measures and methods. . . . In many instances, measurement is sufficiently difficult that the practice is to obtain what is measurable rather than what is desired. Another serious difficulty with flight measurement is the frequent inability to detect and assess differences in performances when they, in fact exist. . . . The overwhelming problem continues to be the inability to structure the inflight environment so that accuracy, reliability, and validity of measurement are within tolerances.

The Landing Maneuver

The comment is often heard: "Early in their training many students can do everything but land the plane." (39:36) Barnhart

(4:337), is discussing basic flight techniques in light aircraft, states: "Without reservation, the roundout [one phase of the landing maneuver] requires keener judgment and more practice than any other single part of basic flying."

It is interesting to note that the section devoted to the landing maneuver in the Flight Training Handbook (20:56-61), which is currently in use, is taken virtually verbatim from the 1941 Flight Instructor's Manual (19:73-77). One might well wonder what research supports the suggestions presented in the current Flight Training Handbook. The Handbook (20:61) further states: "It will be found in many cases that the technique of landing will come to the student seemingly all at once after several periods during which no apparent progress was made." This statement seems to imply that the landing maneuver difficulties are not well understood.

Langewiesche (35:289), commenting on the landing maneuver, stated: "For the beginner, it is no simple task to fly the airplane onto the ground," and "The more experienced pilot, too frequently misjudges his height slightly or misjudges his rate of descent or . . . misjudges the height of his landing gear." Kershner (34:82) also noted: "This disease of sweating landings even strikes old pilots who should know better."

A recent study by Eggspuehler, Weislogel, et al., (12:6) reported that the top five most threatening experiences of private pilots without instrument ratings were "low visibility (reported by 28%), crosswind (24%), low ceiling (23%), malfunctions (21%), and landings (21%)." Excluding weather conditions, malfunctions and landings appeared as the most threatening experiences of the typical private pilot.

In an exploratory study sponsored by the Division of Research of the Civil Aeronautics Administration and the National Research Council, Tiffin and Bromer (46:v) noted: "It is commonly recognized that landing is one of the critical maneuvers in the safe operation of a plane." Hurt (28:200) reminds us ". . . the landing phase of flight instruction accounts for more pilot caused aircraft accidents than any other single phase of flight."

Why does the landing maneuver appear to be difficult? Theoretically there are several probable answers.

One answer is couched in terms of performance criteria. With most flight maneuvers performance is subjectively judged by the flight instructor. His judgment, however, is not nearly as objective as the ground itself. Langewiesche (35:287) analyzes this "difficulty" as follows:

> In other maneuvers, the pilot can continuously correct his mistakes as they become apparent to him. . . . In the landing, the error becomes apparent often only upon contact with the ground, at the instant when it is too late for correction.

Kershner (34:82, 85) agrees with this analysis when he states:

> . . . the landing is a maneuver done close to the ground where the smallest mistakes may look like near crashes. . . . You won't have to take the instructor's word for it if you foul up, you can see and feel it for yourself.

If the other required flight maneuvers had performance criteria as "objective" as those of the landing maneuver, landings may not appear to be difficult for the student. In any case, we would still be concerned with obtaining methods to improve student achievement.

Associated with the more stringent performance references of the landing maneuver is student anxiety. Langewiesche (35:297) focuses on this probable difficulty in stating: "When you get tense you will almost certainly stare: approaching the ground, most students do get tense: that is largely why the landing is so difficult for most beginners."

To improve the student's judgment in the landing maneuver, the normal procedure is to allow him to continue to make normal landings until he learns how to make acceptable landings. One wonders if there might not be a more effective method.

The Flight Training Handbook describes a normal landing as follows:

> A landing is nothing more than a very slow transition from a normal glide attitude to the landing attitude. This transition is generally referred to as a round-out or flare, and is started approximately 10 to 15 feet above the ground. . . . The final flare and touchdown should be made with the engine idling [power-off] at minimum controllable airspeed, and the airplane should be allowed to touch down on the main gear at approximately stalling speed. . . . Many students will try to put the airplane on the ground. It is paradoxical that the way to make a perfect landing is to try to keep the plane off the ground with the elevators. (20:56-60)

Current flight training theory suggests that landings, i.e., concentrated practice on landings, should not be started too soon. The student should instead learn the basic maneuvers suggested by the FAA prior to his concentrated efforts on the landings. The rationale supporting this theory maintains that practice in the basic maneuvers benefit the student in the landing maneuver. "The practice time which has been devoted to stalls, as well as the instruction received in glides, will prove of great benefit to the student in the practice of landings." (20:56)

Many flight instructors believe that if the basic maneuvers are properly taught:

> The landing will be only another maneuver, the logical result of all the preparation that has gone before, and one of a long series of extensions of principles by which the student has progressed, and will continue to progress toward his goal of becoming a competent pilot. (20:56)

If one accepts this theory, there still remain certain aspects of the landing maneuver that apparently cannot be practiced except while actually in the landing maneuver.

> Although in glides and stalls attempts have been made to build up the student's kinesthetic sensitivity, few will have developed it . . . to a degree where it is of primary assistance in landings, although it will be a factor. . . . Vision is therefore the most important sense used, and the controls are operated in accordance with it. (20:57)

> 'Floating' [the flare] on landings is in part a result of ground effect. The student is puzzled because his airplane continues to remain airborne just off the surface at a speed which would have resulted in an immediate stall at a higher altitude. (18:51)

There are, therefore, at least three major sensations that are unique to the landing maneuver. These sensations are represented by the special (1) vision cues, (2) kinesthetic cues, and (3) ground effect cues. The proper responses to these sensations must be learned by the student so that he can make acceptable landings. The <u>Flight Training Handbook</u> summarizes some of the difficulties in stating: "The landing requires fine timing, technique, and judgment of distance and altitude, as well as feel of the plane." (20:59)

Learning the landing maneuver would appear to be synonymous with learning the landing cues. Over the years there have been numerous suggestions for teaching the student to land, i.e., how to recognize and respond to the cues. Langewiesche (35) stated the following:

> Like so many other things in the supposedly elusive art of flying, the judgment of the height in landing can be broken down into teachable learnable detail. . . . As you approach the ground you must keep your vision relaxed and look all

around; you must take in the whole scenery, . . . There is the horizon , . . There is the perspective of familiar things. . . . there is the way things appear 'above' or behind each other. . . . depth perception has nothing to do with landing. . . you can prove this to yourself by landing with one eye closed. And it is proved also by the whole career of one of the greatest pilots of all time--Wiley Post.

Kershner (34) believes:

The best place to look is about 20 degrees to the left of the nose and far enough ahead so that the ground is not blurred. Don't stare at one spot. Scan the ground; your depth perception depends on a lot of eye movement. If you look only straight down the relative movement of the ground is great and you may have a tendency to stall the airplane while it's still a fair distance off the ground. . . . If you look too far ahead the error in your depth perception may cause you to fly the plane into the ground.

The Flight Training Handbook states:

Ordinarily at the time of landing, the vision should be focused ahead of the airplane approximately the same distance as it would be in a car traveling at the same speed. (20:57)

Hasbrook (26) in a recent article describing the landing maneuver "cue by cue" stated:

. . . consistently good landings require constancy in flight path angle and airspeed. To obtain this consistency, keep alert to the visual cues [explained in the article] that are necessary to the task. . . . if a pilot's having trouble with his landings, it's a sure bet he's not looking in the right place at the right time.

Barnhart (4) states:

Many persistent cases of difficulty in landing have been overcome by improvement in visual habits. You must rely on certain definable visual cues to detect: a) Alignment with the runway, b) Pitch attitude, and c) Height above runway. One source of visual cues is in details such as tufts of grass, texture of runway surface, and--at night--local illumination around runway lights. Another source is the overall perspective of the runway and surrounding terrain as it appears to flatten from the lower viewing angle, . . . perspective is highly important for height. . . . Depth perception, the ability to separate near objects from far objects, is an important adjunct to perspective, although research has established that binocular or 'stereo' depth perception is not essential as once was thought. Most of our ability to

> perceive depth is based on known or assumed size of adjoining objects, viewing angle, obscurement of far objects by near objects, and differences in illumination. . . . As a general rule, looking too far ahead will cause a high level-off; and looking too close will cause a late level-off.

Tiffin and Bromer (46) made an analysis of eye fixations and patterns of eye movement in landing a Piper Cub J-3 airplane. In spite of the fact that this was an exploratory investigation, certain general trends were observed. For example, while individual pilots exhibited a fair degree of consistency in visual habits, no single pattern was discovered which invariably differentiated experienced and inexperienced pilots. The authors also noted that "experienced pilots who insisted that there was a proper place to look in the landings were likely to deviate from this suggested pattern in their own landings." It was recommended that "instructors do not insist that students learn to look at a certain specific place, and nowhere else, while the airplane is being landed."

To date the evidence suggests that although there are some common beliefs relative to learning the landing cues, no method has been shown to be more effective or superior to any other method. At present the only conclusion that can be reached is that given enough time and practice the student will learn the cues.

A Study of the Effect of Training in Slow Flight on Landing Performance (3:1) stated what might probably be a significant factor in landing maneuver difficulties.

> In the usual power-off landing [the normal landing] the period of leveling off and landing [the flare] is relatively short, i.e., a matter of a few seconds. Therefore, in normal landing instruction the period of time during which the student pilot is exposed to, and must learn to recognize, the sensory cues important to proper execution of this critical part of the maneuver is brief.

Some instructors have drawn attention to this fact in stating that by the time the student solos (after approximately 8 to 10 hours of flight time), he has had only one or two minutes of landing time. As an example, if the flare lasts for only six seconds--a probable situation with power-off in a light airplane--and you have made 20 landings prior to solo, your total landing time would have amounted to only two minutes.

One method of providing the student with additional practice time in the landing maneuver was reported in: Evaluation of Instructional Techniques Described as Effective by Flight Instructors (15:95, 96) and in its shorter version, The Tricks of the Trade: A Handbook for Flight Instructors. (39:36-8).

> THE PROBLEM: Student has difficulty in leveling off and landing.
>
> WHAT CAN BE DONE ABOUT IT? Tell the student you are going to take up the maneuver 'skimming the runway.' Instruct him that you will go out farther on the approach and come in under part throttle. State that you will handle the throttle and that he will handle the other controls. Direct him to fly at a constant altitude 5 feet above the runway, and caution him not to let the wheels touch.
>
> After skimming the runway a number of times until the student is proficient, on the next trial slowly inch the throttle back, at the same time directing the student to 'hold her off, don't let the wheels touch.' The student will gradually pull the stick back, and by the time it is all the way back, the throttle should have been closed and the plane will settle in on three points.
>
> Then point out that the secret of good landings has been demonstrated--hold the plane off as long as possible and when it is ready it will land. Then proceed with the usual landing instruction, repeating this skim-the-runway procedure when necessary. (The contributing instructor points out that this technique gives the student prolonged practice in leveling off, whereas in ordinary landings, this part of the maneuver is over in a few seconds.) He stated that he first used this technique only on students who were having difficulty, but now uses the method to introduce landings to all students.

The effectiveness of this technique was reported by a number of flight instructors who responded to a survey of effective techniques employed by flight instructors. The consensus of a group of experts who evaluated the techniques was that this technique had merit. The report (15) of the compilation and evaluation of the techniques presented several techniques as being effective in improving student achievement in the landing maneuver, including techniques providing for prolonged practice. These techniques, however, were not rated as being effective on the basis of experimental research, but rather by expert opinion.

At least one experimental research study (3) employed this technique in an effort to improve landing performance. The researchers stated that:

> It seemed reasonable that an instructional procedure which increased the length of the pre-stall [flare] period would allow greater opportunity for the student pilot to learn to recognize the sensory cues which indicate that the plane is about to stall. Furthermore, extension of this period prior to an actual landing would, it was felt, provide greater opportunities for the development of judgment as to correct altitude at which the plane should be leveled off.

This study, however, was not concerned with students making their first acceptable landing, but rather with the quality of the landings. The landings were evaluated following the seventh, fifteenth, twenty-fifth and thirty-fifth hours of training. The study employed experimental-control group comparisons with the experimental group receiving: (1) preliminary training in stalls from slow flight, and (2) landing instruction with the "skimming the runway" technique. Because these two techniques were combined in one method it was impossible to ascertain the individual effectiveness of either. The study, however, reported no systematic differences between the methods when measured by several subjective, e.g., instructor grades on the maneuver, and objective, e.g., "g" forces read from an accelerometer, measures. The study also reported that there was no record available of the actual number of landings executed by members of the control and experimental groups.

Techniques similar to "skimming the runway" would not be acceptable to those flight instructors who adhere to the following suggestion from the Flight Training Handbook. "At the very outset, the student should be required to form the habit of keeping one hand on the throttle throughout the landing." (20:58) One might also object to this technique on the grounds that it does not allow the student to touch down during several passes over the runway, thus delaying possible student achievement and adding another dimension of subjectiveness to the performance criteria.

Langewiesche (35:294) comments on the advantages of a prolonged flare in his discussion on landings. "We shall discuss the floating landings [as opposed to a stall-down landing] first because it is easier to do and much easier to understand."

> The pilot approaches in a normal glide and levels out only when quite near the ground; so that he finds himself shooting along level, a foot or two off the ground, still with plenty of excess speed. The process of landing then consists simply of holding the ship off the ground as long as possible.

The method described above relies on the student approaching at a higher than normal airspeed, transitioning to the flare, and simply "holding her off." One criticism of this technique is that in order to obtain a significantly longer flare, the airspeed required would be considered by some instructors as being excessive, and unnatural.

Another method relies on the student approaching at a higher than normal power setting, transitioning to the flare, and simply "holding her off." This method had been employed and was believed to be effective by some of the flight instructors at O.S.U. A criticism of this technique is that in order to obtain a significantly longer flare, the power required would be considered by some instructors as being excessive and unnatural.

How can the landing maneuver be made easier? Or, for the purposes of the study, how can students learn the landing maneuver in a shorter period of training? Methods that provide students with prolonged practice in the landing maneuver appear promising. These methods, (1) seem reasonable, and (2) have been advocated by others, as being effective in improving student achievement in the landing maneuver.

To prolong the student's practice time in the landing maneuver, one must keep the airplane flying for a longer period of time in the flare, i.e., one must obtain a prolonged flare in contrast to a normal flare. This can be accomplished in two basic ways: (1) approach at a higher airspeed, or (2) approach at a higher power setting. A third way of obtaining prolonged practice is to have the student fly just above the runway without touching down, e.g., skimming the runway. This method, however, is somewhat different than the other two in that the student is not allowed to actually land during some of his attempts.

Although several variations of these techniques have been used by flight instructors, a search of the literature and personal communication revealed no experimental evidence to indicate that any of these techniques do in fact significantly save time or improve any other criteria. Because of the apparent difficulty of the landing maneuver and the apparent potential of prolonged flare practice being of benefit to the student pilot, this study researched the effectiveness of one variation of this concept.

The experimental method selected satisfied several important criteria. (1) It was based on the theoretical concept that prolonged practice would aid in student pilot achievement in the landing maneuver. (2) It caused the least disturbance to a basic flight training program. (3) It was reasonably uncomplicated and inexpensive to implement, and (4) it was considered safe (by the flight instructors at the Oklahoma State University).

The experimental method that was chosen provided for a prolonged flare in contrast to a normal flare. This was accomplished by entering the flare with a power-on setting in contrast to a power-off setting. The choice of using power rather than airspeed to prolong the flare was a decision of the OSU Aviation Department personnel after a consideration and some flight testing of the two techniques.

Summary

The study investigated the problem implied in the following statement. "Early in their training many students can do everything but land the plane." (39) A search of the literature and personal communications revealed that the current method of teaching the landing maneuver is essentially the same as it has been for more than thirty years. Also, the method is a result of tradition rather than experimentation. The general conclusion from an analysis and interpretation of the literature is that very little of the results is directly applicable to pilot training, and that there is substantial ambiguity surrounding the research that deals specifically with pilot performance.

Following an analysis of some of the possible landing maneuver difficulties it was concluded that, in the normal power-off landing, the period of the flare was relatively short. This meant that the period of time during which the student pilot is exposed to, and must learn to recognize, the sensory cues important to proper execution of this critical part of the maneuver was brief. It therefore seemed reasonable to conclude that if an instructional method could increase the length of the flare period it could increase the opportunity for the student to learn the landing maneuver cues.

An experimental teaching strategy, employing a prolonged flare, was developed and its relative effectiveness was compared to a teaching strategy employing a normal flare.

CHAPTER III

DESIGN AND METHODOLOGY

The investigation is concerned with an experimental evaluation of an instructional technique thought to aid student pilot achievement in the landing maneuver. The experiment was conducted during the fall semester, 1972, at the Oklahoma State University (OSU).

Description of the Sample

The participants in the study were those students who had not received any formal flight training and who were enrolled for basic flight training from the Aviation Education Department at OSU (Aviation Education 1222). Formal flight training was defined for the purposes of the study as (1) any flight training received from a certified flight instructor and/or (2) any flight training that has prepared the student to make "acceptable landings." Flight orientation time of less than three hours was not considered as formal flight training.

Forty-three students registered for and began flight training in the fall semester, 1972, and forty-two students reached at least the solo stage of flight training. Of the original forty-three students, eighteen were in the Air Force R.O.T.C. Flight Program and were excluded from the study population. (This was an AFROTC decision.) Of the twenty-five remaining students, twelve were selected for the study and were divided into two flight groups (X and Y) of six students each.

The students and groups were determined as follows. At the beginning of the school year, the students filled out class schedules, noting the hours they would have free for flight instruction. The flight instructors (X and Y) also filled out class schedules, noting the hours they would have free for flight instruction. From the students' and instructors' class schedules the flight instructors (X and Y) made up two flight groups (X and Y) by selecting students that:

1. Had free periods not in conflict with the instructors' free periods.
2. Could fly four periods per week.
    a. All flight periods were scheduled Monday through Friday, between 8:30 a.m. and 5:30 p.m.
    b. Flight periods were scheduled in one hour blocks of time. Students averaged between 0.7 and 0.8 of an hour of actual flight time per period. The remaining time was devoted to pre- and post-flight discussions.
    c. It was suggested that each student should have two flight periods in the morning and two flight periods in the afternoon.

The instructors searched the student class schedules until they had each obtained six students who would fit into their schedules and meet the above requirements. The instructors did not meet the students until after the flight groups had been determined.

After the groups had been determined, the students within the groups were randomly assigned to the levels of the treatment, i.e., normal flare or prolonged flare. The random assignment was by the simple flip of a coin. There were three students at each level within each flight group.

Student and Instructor Characteristics

The student and instructor characteristics presented in Tables I and II are presented for descriptive purposes only. No comparisons were attempted.

TABLE I

STUDENT CHARACTERISTICS

Student Number	Sex	Age	College*	Class**	Ground School
1	M	20	ED	3	All students had taken or were taking ground school or had passed the written private pilot examination
2	M	20	BU	3	
3	M	20	BU	2	
4	M	22	AG	3	
5	M	21	AG	4	
6	M	22	BU	4	
7	M	19	AG	2	
8	M	22	AG	4	
9	F	19	AG	2	
10	F	19	AS	2	
11	M	19	AS	2	
12	M	28	EN	4	

*Abbreviations for Colleges are: AS, Arts and Sciences; BU, Business; EN, Engineering; AG, Agriculture.

**Classes are (1) Freshman, (2) Sophomore, (3) Junior, (4) Senior, (5) Special Student, (6) Graduate Student.

TABLE II

INSTRUCTOR CHARACTERISTICS

Instructor	Sex	Age	College*	Class**	Licenses	Hours	Students
X	M	33	EN	2	Commercial (Instrument) Instructor (Airplanes) (Instruments)	2300	Instructor has taught approximately 150 previous students
Y	M	25	ED	6	Commercial (Instrument) Instructor (Airplanes) (Instruments)	1300	Instructor has taught approximately 100 previous students

*Abbreviations for Colleges are: EN, Engineering; ED, Education.

**Classes are (1) Freshman, (2) Sophomore, (3) Junior, (4) Senior, (5) Special Student, (6) Graduate Student.

Design of the Study

The study employed a randomized block design (levels-by-treatment design) with "flare time" serving as the one treatment variable and "instructional environments" serving as the two classification variables. Flare times were determined by the two methods of practicing the landing maneuver: the normal flare and the prolonged flare. Instructional environment X consisted of instructor X, the airplane assigned to instructor X, the sequence of maneuvers taught by instructor X, and flight group X. Instructional environment Y was defined in a similar manner.

The design was selected because it controls for (1) possible differential effects of the assignment to the two flight groups; (2) possible differential effects of the two instructors; (3) possible differential effects of the two airplanes; and (4) possible differential effects of the two sequences of maneuvers.

Design paradigm:

Classifications	Treatment Normal	Treatment Prolonged
Environment X		
Environment Y		

There were three students per cell in the design of the experiment.

The design allows one to check for the effects of the treatment (normal flare vs prolonged flare) and for any interactive effect between the treatment and the classification (Environment X vs Environment Y). A review of the literature and situational factors indicates that the classifications are in effect different. These differences, however, do not prevent one from making a comparison of the effects of the treatment and of the effects of interaction.

Procedures of the Study

Determination of the Flare Times

The flare times were determined by the two methods of learning the landing maneuver, i.e., the normal flare and the prolonged flare. The actual times for each method were unknown. A search of the literature and personal communications, e.g., interviews with the flight research personnel at Cessna Aircraft Co., Wichita, Kansas--manufacturers of the aircraft used in the study, revealed that no empirical or mathematical data existed to give the actual times involved. Performance data on flare times, like other aircraft performance data, would, if it existed, be in the nature of averaged or idealized results. It is unrealistic to believe that any pilot could consistently fly the performance figures. An average of a pilot's results can, however, be expected to conform to the performance data.

It was decided to obtain performance times for the two flares by flight testing the methods according to the operationalized procedures of the study. After four flights by four instructors, the times appeared to range as follows. The normal flare time ranged between 6 and 8 seconds; and the prolonged flare time ranged between 24 and 32 seconds. These times indicated that the prolonged flare provided three to four times as much time in which to learn the landing maneuver as the normal flare. These figures, however, can only be considered as approximations. The results were obtained by flight instructors "flying the flare." Whether students would significantly differ from these times is not known. Student flare times were not determined in the study because the observations would have been a distraction to the instructors monitoring the students' attempts-to-land.

Standardization of the Flight Instructors

To check whether the flight instructors understood the operationalized flare methods, this investigator flew with each instructor. This investigator checked flap settings, airspeed settings and power settings during the flight instructor's attempts-to-land. The landing approach and flare transition were also observed and standardized.

The standardization flights occurred during the determination of the flare times. The investigator was satisfied that both instructors understood both of the operationalized flare methods.

Comments of the Flight Instructors

In a study of this nature, i.e., where professional instructors are involved, professional opinion can be of value in analyzing the present study and in planning future research. It was decided, therefore, to plan two interview sessions with the instructors to obtain their opinions on the procedures, the treatment, and potential intervening variables. One session was planned to follow the fourth period of instruction. The other session was planned for the end of the experiment, i.e., after all the students had made an acceptable landing. The instructors were interviewed separately on both occasions.

Schedule of Attempts

At the beginning of the study the number of attempts and the amount of time normally required for students to make their first acceptable landing was unknown. This type of information is normally not recorded in student pilot log books. No data was found giving the desired information.

In developing a possible schedule, three factors were considered.

1. There should be no more than one landing per period for at least the first two periods.
2. For experimental purposes a schedule of attempts was needed that would, hopefully, allow the student to make his first landing before the end of the seventh period. With 0.7 to 0.8 of an hour of flight time per period each student would

have flown approximately 5 hours at the end of the seventh period--an amount of time equal to one half the time (10 hours) normally needed for the student to make his first solo.

3. Undue emphasis should not be placed on the landing maneuver. Following a discussion of the possibilities, the following schedule was agreed upon by the instructors and the investigator.

During flight training only one landing was to be attempted in the first two periods. The attempt was to occur at the end of the instructional period. During the following four periods the students attempted two landings at the end of the periods. The seventh period was planned for "concentrated" take offs and landings. During this period the student would attempt six landings.

If the student had not made an acceptable landing at the end of the seventh period, the flight instructor was to adjust the student's flight training as per the student's needs. From the eighth period on, flight time and landing time was to be adjusted to the needs of the individual student as perceived by the instructor. The landings, however, would continue to be flown as per their operationalized definitions until the student had made his first acceptable landing. After the students had made their first acceptable landings, the instructors were to consider the experiment to be over and continue with the optimum program of flight training for their students.

The First Landing: A Validity Check

The decision to use only <u>one</u> acceptable landing was based on the belief that once the student had learned to make his first acceptable landing, he had learned the landing maneuver, i.e., he could continue to make acceptable landings. This belief is analogous to the idea associated with certain psychomotor tasks. Once you learn, e.g., to ride a bike, you never forget. You may still fall down from time to time, but you haven't forgotten how to, e.g., ride.

It was possible, however, that the first acceptable landing could have been a matter of "luck." To check for this possibility it was decided to note whether or not the students could make an acceptable landing on their next attempt. This check would add some validity to the use of one acceptable landing as a measurement of success in learning the landing maneuver. In flight group X, all of the students attempted another landing immediately, while in flight group Y, the students were to wait until the next flight period before attempting another landing.

The First Landing and the First Solo

The study sought to determine whether or not the time required for making the first landing was related to the time required for making the first solo. If a student had a great deal of trouble making his first landing, he quite naturally could not begin to practice the variations necessary for solo until later in his training. Would this delay be reflected in his time to solo? If each maneuver were objectively evaluated, it is reasonable to suspect that the time required to make the first landing would be related to the time required to solo. The highly subjective criteria used to evaluate student readiness for solo might, however, distort any possible relationship between time-to-land and time-to-solo.

Ecological Validity

The subjects were not told that they were in an experimental study because student performances can be affected when they are aware that they are being studied. There was no reason to believe that the students noticed any differences in their flight training, nor that they were subjects in an experimental study.

The instructors were not told that the time-to-solo criterion was to be analyzed. As far as they were concerned the experiment was over when the student had made his next attempt following his first acceptable landing. The rationale supporting this procedure is of extreme importance in regard to flight training. Current flight training theory suggests that it is unwise to rush a student to solo. A student should solo when it is felt that he has achieved the proper level of competence. It could have added an extreme bias to the experiment if flight instructors were aware that time-to-solo was to be analyzed. There was no reason to believe that the instructors were aware that the time-to-solo criterion would be analyzed.

Hypotheses

Although prolonged flare practice appears promising as an approach to reducing landing practice time, the differences in configuration of the airplane in executing normal and prolonged flares could have produced some unexpected effects. This study, therefore employed nondirectional alternative hypotheses.

The following null hypotheses were tested with each of the criteria of concern in this study. Each hypothesis was tested at the 0.05 level of confidence for significance.

Attempts-to-Land Criterion

1. There was no significant difference in student achievement for the normal flare and prolonged flare methods as measured by attempts-to-land.

2. There was no significant interaction between the normal flare and prolonged flare methods of instruction and the instructional environment classifications as measured by attempts-to-land.

Time-to-Land Criterion

3. There was no significant difference in student achievement for the normal flare and the prolonged flare methods as measured by time-to-land.

4. There was no significant interaction between the normal flare and prolonged flare methods of instruction and the instructional environment classifications as measured by time-to-land.

Time-to-Solo Criterion

5. There was no significant difference in student achievement for the normal flare and the prolonged flare methods as measured by time-to-solo.

6. There was no significant interaction between the normal flare and prolonged flare methods of instruction and the instructional environment classifications as measured by time-to-solo.

Independent Variable

The independent variable in this study was the flare time associated with the method of learning the landing maneuver. Two methods were used. They were the normal flare and the prolonged flare methods of landing.

Dependent Variable

The following dependent variables were measured in this study:

1. The attempts-to-land.

2. The time-to-land.

3. The time-to-solo.

Research Questions

In addition to the above hypotheses, the following research questions were also under investigation:

1. Is the student's first acceptable landing a valid measure of the fact that he has learned the landing maneuver?

2. Is time-to-land related to time-to-solo?

Data Collection

The attempts-to-land were recorded in the students' official flight training log books. The time-to-land (determined from the logged time and the attempts-to-land) and the time-to-solo were also recorded in the students' logs.

The data were collected from the log books after all students had made their first landing and after they had made their first solo. The validity checks and instructor comments were obtained during the two planned interviews.

Data Analysis

The hypotheses were tested, using analysis of variance (AOV). The rationale for the employment of AOV to the design, method, and type of data in this study has been presented in several publications.

The validity check data were reported to the investigator during the second planned interview. The results are reported in Chapter IV and are discussed in Chapter V.

The relationship under investigation was computed using a Spearman rank correlation. This technique was used due to the size of the sample and the assumptions of the Pearson product-moment correlation.

The instructors' comments were recorded during the interviews. Their opinions are presented in Chapter IV and are discussed in Chapter V.

CHAPTER IV

RESULTS OF THE STUDY

The major goal of this study was to investigate the comparative effectiveness of a prolonged flare and a normal flare on student pilot achievement in learning the landing maneuver. Achievement was measured both by the number of attempts (attempts-to-land) and the amount of time (time-to-land) required for the student to make his first acceptable landing. A check was made to determine the validity of using a student's first acceptable landing as an indication that the student had learned how to land without assistance. A check of the possible effects of the methods on learning to solo and of the relationship between the time-to-land and the time-to-solo were also goals. In an attempt to gain additional insight into the problem and the experiment, the flight instructors were asked for their comments. The results of the study are reported in this chapter.

A Validity Check

To check the validity of using a student's first acceptable landing as an indication that the student had learned how to land without assistance, it was decided to note whether or not the students could make acceptable landings on their next attempt, following their first acceptable landing. The results showed that all the students in the experiment, regardless of environment or method, were successful in making an acceptable landing on their next attempt.

In every case all of the attempts made by the students, following their first acceptable landing were normal flare attempts. The students in Environment X made their next attempt immediately, i.e., in the same flight period. The students in Environment Y, except for number 7, made their next attempt in their next flight period. Student number 7 made his immediately. Table III presents a summary of student success on their "next attempt."

TABLE III

SUMMARY OF STUDENT SUCCESS IN MAKING AN ACCEPTABLE LANDING ON THEIR NEXT ATTEMPT FOLLOWING THEIR FIRST ACCEPTABLE LANDING

Success in "Next Attempt"	Environment X Normal	Environment X Prolonged	Environment Y Normal	Environment Y Prolonged
YES	3	3	3	3
NO	0	0	0	0

Learning to Land Comparisons

Student achievement in learning the landing maneuver, as measured by attempts-to-land and time-to-land, is presented in Table IV. These data were used to test the first four hypotheses. For completeness and comparative purposes time-to-solo is included in Table IV. These data were used to test hypotheses five and six. Also presented in Table IV

TABLE IV

SUMMARY OF ATTEMPTS-PER-PERIOD, ATTEMPTS-TO-LAND, TIME-TO-LAND, AND TIME-TO-SOLO FOR STUDENTS, METHODS, AND ENVIRONMENTS

Instructional Environment	Flare Methods	Student Number	Number of Attempts per Flight Period 1 2 3 4 5 6 7 8 9 10	Attempts to Land	Time* to Land	Time* to Solo
X	Normal	1	1 1 1 1 2 2	8	4.9	8.0
		2	1 1 1 1 1 1	6	4.6	---**
		3	1 1 1 1 1 1	6	5.4	9.0
	Prolonged	4	1 1 2 2 2 2	10	5.2	8.4
		5	1 1 2 2 2 2 4	14	6.4	9.1
		6	1 1 1 1 2 2	8	5.7	9.1
Y	Normal	7	1 1 1 2 1	6	3.5	8.0
		8	1 1 2 2 2 6 5 2	21	5.7	8.7
		9	1 1 2 2 1 1 2 2 1 2	15	6.8	10.0
	Prolonged	10	1 1 2 2 2 2 3	13	5.2	10.1
		11	1 1 2 2 2 6 4 1 2	21	6.2	8.1
		12	1 1 2 2 2	8	3.6	9.8

*Times are in hours and tenths of hours.

**Student dropped out of flight training before soloing.

TABLE V

FLIGHT SCHEDULE OF PERIODS SHOWING STUDENTS,* DAYS, AND TIMES

	Instructor X					Instructor Y					
	Day					Day					
Time	M	T	W	T	F	M	T	W	T	F	Time
8:30		3	3	3	3	7	9		9	7	8:30
9:30		2	1	1		12	11		8	8	9:30
10:30	2		2		2	8	7	8	7	9	10:30
11:30	4	6	6	6	6				11		11:30
12:30											12:30
1:30						10	10	10	12	10	1:30
2:30	1	5	4	5				12		12	2:30
3:30			5	4	5	11				11	3:30
4:30		1			4	9					4:30

*Student numbers are the same in Tables IV and V.

is the actual number of attempts made by each student in each flight period. Table V presents the schedule of periods showing the times, days, and instructor for each student.

The first and second hypotheses were:

H_o1: There was no significant difference (0.05 level of confidence) in student achievement for the normal flare and prolonged flare methods as measured by attempts-to-land.

H_o2: There was no significant interaction (0.05 level of confidence) between the normal flare and prolonged flare methods of instruction and the instructional environment classifications as measured by attempts-to-land.

The results shown in Tables VI and VII indicate that hypotheses 1 and 2 will not be rejected. No significant differences were found between the students taught by the prolonged flare and those taught by the normal flare when measured by attempts-to-land. The analysis also indicated that there was no significant interaction between flare methods and instructional environments.

The third and fourth hypotheses were:

H_o3: There was no significant difference (0.05 level of confidence) in student achievement for the normal flare and the prolonged flare methods as measured by time-to-land.

H_o4: There was no significant interaction (0.05 level of confidence) between the normal flare and prolonged flare methods of instruction and the instructional environment classifications as measured by time-to-land.

The results shown in Tables VIII and IX indicate that hypotheses 3 and 4 will not be rejected. No significant differences were found

TABLE VI

GROUP AND SUB-GROUP MEANS OF ATTEMPTS-TO-LAND FOR NORMAL FLARE AND PROLONGED FLARE GROUPS WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

	Normal	Prolonged	---	Group
Environment X	6.67	10.67	---	8.67
Environment Y	14.00	14.00	---	14.00
Group	10.34	12.34		

TABLE VII

COMPARISON OF NORMAL FLARE AND PROLONGED FLARE ATTEMPTS-TO-LAND WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

Randomized Blocks Analysis of Variance					
Source	SS	df	ms	F	P
Total	331	11			
Flare Methods	12	1	12.00	.43	N.S.
Environments	85	1	85.33	3.08	N.S.
Methods x Environments	12	1	12.00	.43	N.S.
Error	221	8	27.67		

TABLE VIII

GROUP AND SUB-GROUP MEANS OF TIME-TO-LAND FOR NORMAL FLARE AND PROLONGED FLARE GROUPS WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

	Normal	Prolonged	---	Group
Environment X	4.97	5.77	---	5.37
Environment Y	5.33	5.00	---	5.17
Group	5.15	5.39		

TABLE IX

COMPARISON OF NORMAL FLARE AND PROLONGED FLARE TIME-TO-LAND WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

Randomized Blocks Analysis of Variance					
Source	SS	df	ms	F	P
Total	11	11			
Flare Methods	0	1	.16	.13	N.S.
Environments	0	1	.12	.09	N.S.
Methods x Environments	1	1	.96	.75	N.S.
Error	10	8	1.27		

between students taught by the prolonged flare and those taught by the normal flare when measured by time-to-land. The analysis also indicated that there was no significant interaction between flare methods and instructional environments.

Learning to Solo Comparisons

Student achievement in learning to solo, as measured by time-to-solo is presented in Table IV. These data were used to test the last two hypotheses.

The fifth and sixth hypotheses were:

H_o5: There was no significant differences in student achievement for the normal flare and the prolonged flare methods as measured by time-to-solo.

H_o6: There was no significant interaction between the normal flare and the prolonged flare methods of instruction and the instructional environment classifications as measured by time-to-solo.

The results shown in Tables X and XI indicate that hypotheses 5 and 6 will not be rejected. No significant differences were found between the students taught by the prolonged flare and those taught by the normal flare when measured by time-to-solo. The analysis also indicated that there was no significant interaction between flare methods and instructional environments.

Landing/Soloing Relationship

The correlation coefficient between time-to-land and time-to-solo was determined to be +.35 (Spearman Rho). This correlation was shown to be not significant. Therefore, no relationship was shown to exist.

TABLE X

GROUP AND SUB-GROUP MEANS OF TIME-TO-SOLO FOR NORMAL FLARE AND PROLONGED FLARE GROUPS WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

		Normal	Prolonged	---	Group
Environment X		8.50	8.87	---	8.69
Environment Y		8.90	9.33	---	9.12
	Group	8.70	9.10		

TABLE XI

COMPARISON OF NORMAL FLARE AND PROLONGED FLARE TIME-TO-SOLO WHEN CLASSIFIED BY INSTRUCTIONAL ENVIRONMENTS

Randomized Blocks Analysis of Variance					
Source	SS	df	ms	F	P
Total	6	10*			
Flare Methods	0	1	.43	.58	N.S.
Environments	0	1	.48	.65	N.S.
Methods x Environments	0	1	.00	.00	N.S.
Error	5	7	.74		

*Due to the unequal cell sizes, as a result of the one student dropping out before soloing, a method of unweighted means (The harmonic mean) was employed in the analysis of variance.

Criterion Values

The values presented in Table XII are the averages and ranges of the criterion variables employed in the study. These data, although specific to the experiment, provide information that was unknown prior to the study. It is interesting to note that the time required to learn to land was more than half the time required to learn to solo.

TABLE XII

SUMMARY OF THE AVERAGES AND RANGES OF CRITERION VALUES FOR NORMAL AND PROLONGED FLARE GROUPS AND FOR THE STUDY AS A WHOLE

Criterion Values	Normal Mean	Study Mean	Pro-longed Mean	Normal Median	Study Median	Pro-longed Median	Range of Values
Attempts-to-Land	10.34	11.35	12.34	7	9	11.5	6 to 21
Time-to-Land	5.15	5.27	5.39	5.15	5.30	5.45	3.5 to 6.8
Time-to-Solo	8.70	8.90	9.10	8.70	9.00	9.10	8 to 10.1

Instructor Comments

The two flight instructors were asked for their opinions on the experimental problem and procedures during the study and at its completion. Their comments are presented below.

Instructor X

1. "The instructor should have more say." He believed the experimental procedures were too rigid.

2. "The 1500 RPM was working out ok."

3. "I don't like the restrictions on having to make two landings per period. It cuts the period too short. You have to return to the airport too soon--to get in both landings."

4. "After they [the prolonged flare students] get into the flare [the prolonged flare] and 'recognize it' then they should be able to cut power and land. Holding the power on [keeping the setting at 1500 RPM] seems to be detrimental to the student after he's learned how to flare. If they could have cut it [the power] they could have landed sooner."

5. "It's [the prolonged flare is] eating up too much of the runway."

6. "Let the instructor use the prolonged flare as long as he believes it is necessary--then change [to normal flare]."

7. "Instructors should use a schedule they believe best."

Instructor Y

1. "The two landings per period were introduced too soon."

2. "Prolonged landing ok at first, but should drop off after a certain point."

3. "The normal landing is ok."

4. "Wind gusts usually fouled things up in the prolonged flare."

5. "One student made his first acceptable landing in a crosswind."

6. "One student made his first acceptable landing after switching to another runway."

Confounding Variables

An inspection of the data at the conclusion of the experiment revealed two variables acting to confound the results. The exact effects of these two factors and/or the effects of their interaction are unknown.

Schedule of Attempts

A review of the data in Table IV indicates that the schedule of attempts was not a constant, as was planned. Instructor X misunderstood the directions and thought that the schedule of attempts was for the prolonged group only. Instructor Y also misunderstood the directions and thought the concentrated landings, i.e., the six landings, were scheduled for the sixth period instead of the seventh period. Additional discrepancies from the planned schedule of attempts are noticeable in Table IV. The instructors commented that, in a couple of cases, they had been involved in the teaching of their students and simply forgot about the schedule of attempts. In the case of student number 9, the instructor stated that a second landing in the period was a complete waste of time. "The student wasn't ready for a landing attempt let alone two landing attempts." The schedule was altered for the student beginning with period number 5.

A comparison of the data in Table IV indicates that the students [1, 2, 3, 6, 7, 12] with the fewest attempts-to-land, with the exception of number 12, had fewer attempts-per-period. Students 2 and 3 had only one landing per period. Students 1 and 6 had only one landing per period until the fifth period, and student 7 had only one landing period until the fourth period.

Due to the variation in schedules of attempts it was thought to be worthwhile, for exploratory purposes, to analyze the one experiment as two experiments. The effects of the methods in Environment X were analyzed as Experiment X. Environment Y was analyzed in a similar manner.

A t-test comparison of the differences in the means between the normal flare and the prolonged flare groups in the Instructional Environment X, as measured by attempts-to-land, time-to-land and time-to-solo, is presented in Tables XIII, XIV and XV. Similar comparisons for Instructional Environment Y are presented in Tables XVI, XVII and XVIII. The results show that in Environment Y the mean score differences were not significant [by any standard] as measured by any of the dependent variables. In Environment X the mean score of the normal group was 4 attempts lower than the mean score of the prolonged group (Table XIII), and this difference was significant beyond the 0.10 level of confidence. The tabulated t-value was $t_{0.10}(5) = 2.015$ compared with the calculated $t\ (5) = 2.12$.

The schedule of attempts was biased in the Environment X in that the attempts were not evenly distributed among the flare groups. The normal group had fewer attempts-per-period than the prolonged group.

Schedule of Periods

A review and comparison of the data in Tables III and IV indicates that the flight periods were not evenly distributed between mornings and afternoons, as had been suggested. Of interest here is the fact that the students [1, 2, 3, 6, 7, 12] with the fewest attempts-to-land flew during the morning hours. Students 2, 3, 6, and 7 flew entirely in the morning. Student number 1 flew half his time in the morning; and although student number 12 flew for the most part in the afternoon, he made his first acceptable landing during the one period in which he flew in the morning. The fact that should not be overlooked, however, is that students 8 and 9 also flew in the morning; student 11 flew half of his time in the morning, and these three were the students with the most attempts-to-land.

The schedule of periods was biased in that the periods were not evenly distributed among the flare groups. The normal group spent 88% of its possible time flying in the morning. The prolonged group spent 33% of its time flying in the morning.

The "biased" Schedules

In all of the cases except one the students with the fewest attempts-to-land were those students who flew in the morning and had fewer attempts-per-period. Although a relationship appears to exist between these two factors and attempts-to-land their actual effects and/or the effects of their interaction cannot be determined from the study.

TABLE XIII

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE ATTEMPTS-TO-LAND IN THE INSTRUCTIONAL ENVIRONMENT X

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	6.67	1.15	1.33			
Prolonged	10.67	3.05	9.33	7.01	5	2.12

TABLE XIV

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE TIME-TO-LAND IN THE INSTRUCTIONAL ENVIRONMENT X

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	4.97	.4041	.16			
Prolonged	5.77	.6028	.36	2.25	5	1.91

TABLE XV

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE TIME-TO-SOLO IN THE INSTRUCTIONAL ENVIRONMENT X

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	8.50	.7071	.50			
Prolonged	8.87	.4041	.16	3.12	4	.7652

TABLE XVI

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE ATTEMPTS-TO-LAND IN THE INSTRUCTIONAL ENVIRONMENT Y

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	14.00	7.55	57.00			
Prolonged	14.00	6.56	43.03	1.32	5	0

TABLE XVII

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE TIME-TO-LAND IN THE INSTRUCTIONAL ENVIRONMENT Y

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	5.33	1.68	2.82			
Prolonged	5.00	1.31	1.72	1.64	5	.2709

TABLE XVIII

COMPARISON OF THE NORMAL FLARE VS PROLONGED FLARE GROUPS ON THE TIME-TO-SOLO IN THE INSTRUCTIONAL ENVIRONMENT Y

Group	Mean Score	Standard Deviation	Variance	F Ratio	Degrees of Freedom	T Score
Normal	8.90	1.01	1.02			
Prolonged	9.33	1.08	1.17	1.14	5	.5068

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The study investigated the problem implied in the following statement. "Early in their training many students can do everything but land the plane." (39) A search of the literature and personal communications revealed that the current method of teaching the landing maneuver is essentially the same as it has been for more than thirty years. Also, the method is a result of tradition rather than experimentation. The general conclusion from an analysis and interpretation of the literature is that very little of the results is directly applicable to pilot training, and that there is substantial ambiguity surrounding the research that deals specifically with pilot performance.

Following an analysis of some of the possible landing maneuver difficulties it was concluded that in the normal power-off landing the period of the flare was relatively short. This meant that the period of time during which the student pilot is exposed to, and must learn to recognize the sensory cues important to proper execution of this critical part of the maneuver was brief. It therefore seemed reasonable to conclude that if an instructional method could increase the length of the flare period, it could increase the opportunity for the student to learn the landing maneuver cues.

An experimental teaching strategy employing a prolonged flare was developed, and its relative effectiveness was compared to a teaching strategy employing a normal flare. The study focused on the two methods and their effects on the time and attempts required for the students to make their first landing and on the time required for the students to make their first solo.

The study also sought to determine whether the time required for making the first landing was related to the time required for making the first solo.

In addition, the study sought a deeper analysis of the prolonged flare technique as well as evidence to indicate whether the student, with his first landing, had learned the maneuver.

Conclusions

Due to the sampling selection procedures, generalizations beyond the sample are not appropriate. Comparisons between instructors or instructional environments are also not appropriate. The size of the sample dictates a cautious interpretation of the conclusions reported below. Any interpretation of the data should recognize the variations in the two factors: (1) schedule of attempts, and (2) schedule of periods, as confounding variations. The study should be considered exploratory in nature.

A Validity Check

The study demonstrated the validity of the procedure to use the student's first acceptable landing as a measure of the concept that the student had learned the landing maneuver, i.e., learned how to land without assistance. All of the students, regardless of flare method, instructional environment, or time to the next attempt, were able to make an acceptable landing on the attempt following their first acceptable landing. Once they had made their first landing, students were able to continue to land without assistance. The check also indicated that prolonged flare practice does not interfere with the student's capability to make normal flare landings.

Learning to Land Comparisons

From an analysis of variance on student achievement, no significant differences were observed between those students taught by the prolonged flare method and those taught by the normal flare method as measured by their attempts-to-land and their time-to-land. The study also indicated that there were no significant interactions between flare methods and instructional environments when measured by these two dependent variables. One might conclude that the methods appeared to be equally effective.

Discussion

If the methods are equally effective, and if prolonged practice is not detrimental to a student's ability to make normal landings, then the prolonged flare may have an advantage. The student, in addition to being able to make an acceptable landing and a normal landing, would know how to "handle" a prolonged flare should he happen to find himself in one. Although the study showed that students taught with the prolonged flare could make normal landings, it did not check to see whether students who had been taught normal landings could make prolonged landings. An example of a pilot having to make a type of prolonged flare, follows. While approaching a busy airport the tower may request a pilot to keep his airspeed up on final due to the other traffic. With the extra airspeed the pilot may find himself in a position where would have to "bleed off" his excess airspeed over the runway--he would find himself in a prolonged flare.

Discussion

Two factors may have acted to the disadvantage of the prolonged flare method: (1) restricting the students to 1500 RPM throughout the flare, and (2) the schedule of periods. Both of these factors can be related to the weather. The prolonged flare is more susceptable than the normal flare to the effects of the weather, i.e., the weather has a longer time to act on the airplane in a prolonged flare. Barnhart (4:339) reminds us that in "a long float. . . the aircraft is highly vulnerable to gusts of wind."

Restricting the student to 1500 RPM once they had learned how to flare seemed to be detrimental. The instructors observed that "the student would be doing just fine [in the prolonged flare] and then a gust of wind would foul them up." They believed that the 1500 RPM should be used only as long as it takes the student to learn to make a smooth flare: The instructors also thought the student should then be able to either (1) reduce the power (to some setting between 1500 and power-off) prior to the flare, (2) reduce the power while in the flare, or (3) transition to the normal flare landing.

The schedule of periods favored the normal flare group in that the normal group spent 88% of their possible time flying in the morning--when the air is generally smoother. The prolonged group spent only 33% of their possible time flying in the morning.

A Significant (?) Difference

The difference (significant beyond the 0.10 level of confidence, two tailed t-test) favoring the normal group over the prolonged group in Environment X cannot be attributed to a difference in the methods, but rather to a difference that could be a result of (1) the methods, (2) the methods interacting with the Instructional Environment X, (3) the possible effects of different schedules of attempts, (4) the possible effects of the different schedules of periods, and/or (5) the interaction of any combination of these variables. Only one general conclusion can be made. That is, the possible effects of all these variables must be controlled in any future experiments if one wishes to place any confidence in his conclusions concerning the comparative effectiveness of the normal flare and the prolonged flare on student achievement in the landing maneuver.

Discussion

If one can assume that the instructional environments are not biased toward either method, then a likely reason for the difference, noted above, is the difference in the schedule of attempts. The reasoning is as follows. If, (1) the methods are shown not to be different in their effects, as was the indication in Instructional Environment Y where the schedule of attempts were essentially the same, and if (2) the schedule of periods did not favor the normal group, as was the indication in Environment Y (i.e., the normal group flew for the most part in the morning--the time of day related to fewest attempts-to-land--whereas the prolonged group flew for the most part in the afternoon, yet no difference was indicated in the performance of the groups taught by the two methods), then it could be concluded that the difference was a likely result of the differences in the schedule of attempts.

If the difference was due to the schedule of attempts, then one could conclude that one landing per period is more effective than two landings per period in this phase of flight training. The instructors' comments support this conclusion. They believe that one landing per period is to be preferred at least for the first few periods. The optimum schedule is unknown.

The foregoing was hypothetical, and no conclusions are drawn. The implication was presented to show that the biased schedule of attempts is at least as likely a reason for the difference as the biased schedule of periods.

Learning to Solo Comparisons

From an analysis of variance on student achievement no significant difference was observed between those students taught by the normal flare method and those taught by the prolonged flare method as measured by their time-to-solo. The study also indicated that there was no significant interaction between the flare methods and the instructional environments when measured by this dependent variable.

Discussion

If the methods do not differentially affect the time required to learn to land, it might be reasoned that they would not differentially affect the time required to solo. However, the nature of the problem suggests that even if the flare methods do not differentially affect student achievement in learning to make the first landing, they could differentially affect student achievement in learning the variations to make the first solo. The methods, however, appeared to be no different in their effects on student achievement in learning to solo. Also to be noted was the indication that prolonged practice was not detrimental to normal landings. Students who had learned to land by making prolonged landings appeared to be equally capable of making normal landings.

Landing/Soloing Relationship

The correlation between time-to-land and time-to-solo was determined to be +.35 (Spearman rank-order correlation). This correlation was shown to be not significant. We can conclude therefore that the time-to-solo was not related to the time-to-land. Is this reasonable, considering that the time-to-land represented more than one-half the time-to-solo? If a student takes longer to learn how to land, isn't it reasonable to assume that it would take him longer to learn how to solo?

Discussion

Although there is no way of determining from the present study why the time-to-land is not related to the time-to-solo, one answer may lie in the nature of the criteria. Whereas the criterion for success in learning to land was relatively objective, i.e., the first acceptable landing, the criterion for success in learning to solo was extremely subjective, i.e., the instructors' opinion. Becuase so many students in pilot training solo between 8 and 10 hours, "that fact" may have become the determining criterion. That is, solo the student somewhere between 8 and 10 hours. It is interesting to note that all of the students in the present study soloed between 8 and 10.1 hours.

The Instructors' Conclusions

The flight instructors concluded that:

1. The two landings per period were started too soon.

2. The instructor should be allowed to adjust the amount of prolonged flare to the needs of the particular student.

3. The prolonged flare had merit and they would use it from time to time with adjustments in the number of attempts and in the type of attempts (i.e., the amount of flare).

Discussion

When the instructors believed that the experimental procedures were interfering with the progress of their students, they deviated from the procedures. "Flight instructors intuitively feel they know best how to assess training progress and outcome." (44) This factor represents a potential intervening variable, and should be considered in planning research on pilot performance.

Confounding Variables

With one exception, the students obtaining the fewest attempts-to-land had two potentially important factors in common: (1) they flew in the morning, and (2) they had fewer attempts-per-period. The action of these two factors and/or their interaction prevents one from drawing any conclusions relative to either. Further, the results of the study are confounded by the actions of these two variables.

It should be noted that the study assumption of an even distribution of the effects of weather on student achievement was not demonstrated to be in error. Although it was noted that the schedule of periods was biased, the effects of the weather were not shown to be biased.

Discussion

If the biased schedule of attempts caused a difference, then one could conclude that the extra attempts, e.g., two per period, in the early stages, e.g., first six periods, are ineffective and a waste of time. If the biased schedule of periods caused a difference, then one could conclude that the morning is the most effective time of day to learn the landing maneuver.

Why might a morning schedule of periods favor students learning to land an airplane? There are any number of possibilities. Two potentially important possibilities include (1) the weather--it is generally smoother in the morning, and (2) student fatigue--the student is generally fresher in the morning.

Why might fewer attempts per period favor students learning to land an airplane? Here again, there are any number of possibilities. Two potentially important possibilities include (1) student readiness--the student may have to develop certain skills before he can profit from his attempts-to-land, and (2) student fatigue--if the landing comes at the end of a period the student may be too tired to profit from any extra attempts-to-land.

Future Studies

In planning a similar experiment, one might wish to consider variations on the prolonged flare technique defined in the present study. Variations may be derived from the results of the study.

1. Schedule of Attempts
   a. The schedule should be controlled.
   b. One possibile schedule would allow one landing per period up to the seventh period. (Assuming a flight period of 0.7 to 0.8 on an hour.)
2. Schedule of Periods
   a. The schedule should be controlled.
   b. If scheduling procedures allow, one possible schedule would provide for two flight periods in the morning and two flight periods in the afternoon per student.
3. Instructor Deviations
   a. The deviations should be controlled.
   b. The deviations could be investigated.
4. Prolonged Flare
   a. Begin with a flare similar to the one described in this study. Then, when the student has learned (instructor's

opinion) how to make a smooth flare, begin to reduce the amount of power on each attempt.

b. After the student has learned how to make a smooth flare, transition to the normal flare landing may be advantagous.

c. The method employed in the present study was a "power" prolonged flare. How effective is an "airspeed" prolonged flare?

d. If they exist, what is the optimum,

i. Schedule of attempts,

ii. Number of attempts.

iii. Type of attempts.

The following conclusions result from this study:

1. A Validity Check: The study indicated that once a student had made his first acceptable landing, he could continue to land without assistance.

2. Prolonged Practice: The study indicated that prolonged flare practice did not interfere with a student's ability to make normal flare landings.

3. Learning to Land: The study indicated that the two methods of flare were equally effective for students learning how to land an airplane.

4. Learning to Solo: The study indicated that the two methods of flare were equally effective for the students learning to solo an airplane.

5. Interaction: The study indicated that the two methods and the two environments did not interact in any significant way in any of the comparisons.

6. Landing and Soloing Relationship: The study indicated that the time required to learn to solo an airplane was not related to the time required to learn to land an airplane. The criteria employed in judging a student's ability to land and to solo may account for this finding.

7. Criterion Values: The study indicated that the average time required to learn to land was more than half the average time required to learn to solo.

8. Instructor Comments: The instructors believed that for a method to be effective, the number of attempts and the type of attempts should depend on the individual student.

9. Confounding Variables: The study indicated that the schedule of attempts and the schedule of periods acted to confound the results. In the final analysis, the value of this study will be determined by the extent to which the constructs and the findings stimulate further research in the area.

Recommendations

1. On the basis of the findings of this study, in particular the findings that the prolonged flare method is not detrimental to the student and is at least as effective as the normal flare method, it is recommended that further study of the relative merits of methods providing for prolonged practice in the landing maneuver be carried out.

2. Although the study demonstrated the validity of using the student's first acceptable landing as a measure of the fact that the student had learned the maneuver, additional checks on this measure are recommended.

3. It is recommended that in future experimental studies of this nature, that both the schedule of attempts and the schedule of periods be controlled.

4. It is recommended that additional experimental studies be carried out, not only on the landing maneuver, but in all aspects of pilot training.

5. It is recommended that the following be considered. After summarizing the shortcomings in research support for pilot training, Smode, Hall and Meyer (44) presented an interesting answer to

> . . . an interesting question: 'what is an effective way out of the dilemma?' Probably the most obvious answer is the need for a research effort having as its minimum requirements the following: a group made up of scientific and operational personnel (research teams) to initiate and monitor needed programs; an emphasis on'on-site' research and application; a capability for longitudinal studies, as required; and an emphasis on obtaining validity data in a training program. Such an 'organization for training,' responsive to changing field requirements, would also provide documentation procedures and media to take advantage of previous [work].

It seems reasonable to suggest that with a group such as the one proposed above, flight research efforts could be planned and coordinated using existing facilities and equipment throughout the nation. As long as flight training is taking place in many locations, including institutions of higher education, why should attempts not be made to integrate research efforts into existing programs?

SELECTED BIBLIOGRAPHY

(1) Aircraft Landings. (Volume I, A DDC Bibliography, April, 1959-December, 1968). Alexandria, Virginia: Defense Documentation Center, 1969.

(2) Ambler, Rosalie K., and J. R. Berkshire. The Effects of Four Instructional Flights During Pre-flight Indoctrination. Special Report No. 60-5, U. S. Naval School of Aviation Medicine, U. S. Naval Aviation Medical Center, Pensacola, Florida, 1960.

(3) Bakan, David, R. Y. Walker, and Seymour Wapner. A Study of the Effect of Training in Slow Flight on Landing Performance, Washington, D. C.: CAA Division of Research Report No. 71, April, 1947.

(4) Barnhart, Harley E. "Basic Flight Techniques in Light Aircraft," Modern Airmanship. 3rd ed. Ed. Neil D. Van Sickle. Princeton, New Jersey: D. Van Nostrand Company, 1966.

(5) Billings, C. E., J. J. Eggspuehler, and R. Gerke. Studies of Pilot Performance in the Flight Environment. Report No. RF-1857-2, Ohio State Research Foundation, contract DA 49-193-MD-2615, U. S. Army Research and Development Command, Washington, D. C., May, 1966.

(6) Bowen, H. M. et al. Study, Assessment of Pilot Proficiency. NAVTRADEVCEN 1614-1, U. S. Naval Training Device Center, Port Washington, N. Y., August, 1966.

(7) Bowers, N. D. Factors Related to Achievement in an Instructor's Training Syllabus. Special Report No. 58-4, U. S. Naval School of Aviation Medicine, Pensacola, Florida, 1958.

(8) Boyle, D. J., and W. V. Hagin. The Light Plane as a Pre-primary Selection and Training Device: I. Analysis of Operational Data. HRRC-TR 53-33, Human Resources Research Center, Air Research and Development Command, Goodfellow AFB, Texas, 1956.

(9) Caro, P. W., Jr. Flight Evaluation Procedures and Quality Control of Training. HumRRO Technical Report 68-3, March, 1968.

(10) Crawford, Meredith P. and John T. Daily. "An Analysis of Elementary Pilot Performance From Instructor's Comments," American Psychologist, Vol. 1, 1946, p. 292.

(11) Dommasch, Daniel O., Sydney S. Sherby, and Thomas F. Connolly. Airplane Aerodynamics. 4th ed. New York: Pitman Publishing Corporation, 1967.

(12) Eggspuehler, J. J., G. S. Weislogel, et al. Study to Determine the Flight Profile and Mission of the Certified Private Pilot. Washington, D. C.: Federal Aviation Administration, 1968.

(13) Eliasson, A. H. "The Sequence of Flight Instruction." Army Aviation, Vol. 10, No. 6, 1961, pp. 341-344.

(14) Erickson, Stanford C. A Review of the Literature on Methods of Measuring Pilot Proficiency. Research Bulletin 52-25, Human Resources Research Center, Air Training Command, Lackland Air Force Base, San Antonio, Texas, August, 1952.

(15) Ewart, Edwin S., Albert S. Thompson, and Morris S. Viteles. Evaluation of Instructional Techniques Described as Effective by Flight Instructors. Washington, D. C.: CAA Division of Research Report No. 63, June, 1946.

(16) Fleishman, E. A., and G. N Ornstein. "An Analysis of Pilot Flying Performance in Terms of Component Abilities." Journal of Applied Psychology, Vol. 44, 1960, pp. 146-155.

(17) Flexman, R. E., W. G. Matheny, and E. L. Brown. Evaluation of the School Link and Special Methods of Instruction in a Ten-Hour Private Pilot Flight-Training Program. Aeronautics Bulletin, No. 8, Urbana, Illinois: University of Illinois Institute of Aviation, 1950.

(18) Flight Instructor's Handbook (AC 61-16A). Washington, D. C.: Federal Aviation Administration, 1969.

(19) Flight Instructor's Manual. 3rd ed. Washington, D. C.: CAA Bulletin No. 5, September, 1941.

(20) Flight Training Handbook (AC 61-21). Washington, D. C.: Federal Aviation Administration, 1965.

(21) Forrest, Frank G. Develop an Objective Flight Test for the Certification of a Private Pilot. Washington, D. C.: Federal Aviation Administration, 1970.

(22) Fundamentals of Elementary Flight Maneuvers. Washington, D. C.: Civil Aeronautics Bulletin No. 32, February, 1943.

(23) Gallagher, T. J., and B. H. Lowi. The Proficiency of First Tour Pilots as Instructors. Special Report No. 58-5, U. S. Naval School of Aviation Medicine, Pensacola, Florida, 1958.

(24) Gordon, T. Some Principles of Developing Proficiency Measures Derived from Research on Pilot Proficiency. Unpublished manuscript, University of Chicago, 1951.

(25) Greer, G. D., W. D. Smith, and J. L. Hatfield. Improving Flight Proficiency Evaluation in Army Helicopter Pilot Training. HumRRO Technical Report No. 77, U. S. Army Aviation Human Research Unit, Fort Rucker, Alabama, May, 1962.

(26) Hasbrook, Howard A. "Anatomy of a Landing." Business and Commercial Aviation, August, 1971.

(27) Houston, Robert C., James F. Smith, and Ralph E. Flexman. Performance of Student Pilots Flying the T-6 Aircraft in Primary Pilot Training. AFPTRC-TR-54-109, Air Force Personnel and Training Research Center, Air Research and Development Command, Lackland Air Force Base, San Antonio, Texas, 1954.

(28) Hurt, H. H., Jr. Aerodyanmics for Naval Aviators (NAVIR 00-80T-80). Washington, D. C.: Superintendent of Documents, U. S. Government Printing Office, 1965.

(29) Jason, Hilliard. "Student Pilot: Less is More." Flying. Vol. 91, No. 1, July, 1972, p. 32.

(30) Johnson, J. H., and J. R. Berkshire. The Use of Newly Designated Aviators as Instructors. Special Report No. 60-6, U. S. Naval School of Aviation Medicine, Pensacola, Florida, 1960.

(31) Kelly, E. Lowell. The Flight Instructor's Vocabulary. Washington, D. C.: CAA Division of Research Report No. 22, October, 1943.

(32) Kelly, E. Lowell, and E. Ewart. The Effectiveness of "Patter" and of "Fundamentals of Basic Flight Maneuvers" as Training Aids. Washington, D. C.: CAA Division of Research, Report No. 6, December, 1942.

(33) Kershner, William K. The Advanced Pilot's Flight Manual. 3rd ed. Ames, Iowa: Iowa State University Press, 1970.

(34) Kershner, William K. The Student Pilot's Flight Manual. 3rd ed. Ames, Iowa: Iowa State University Press, 1968.

(35) Langewiesche, Wolfgang. Stick and Rudder. New York: McGraw-Hill, 1944.

(36) Miller, N. (Ed.) Psychological Research on Pilot Training. Army Air Force Aviation Psychology Program Research Report No. 8, Washington, D. C.: U. S. Government Printing Office, 1947.

(37) Mohler, S. R. Fatigue in Aviation Activities. AM 65-13, Federal Aviation Agency, Civil Aeromedical Research Institute, Oklahoma City, Oklahoma, 1965.

(38) Mullins, C. J., and J. A. Cox. Evaluation of the AFROTC Flight Instruction Program. WALD-TN 60-44, Wright Air Development Division, Personnel Laboratory, Lackland AFB, Texas, 1960.

(39) National Research Council Committee on Selection and Training of Aircraft Pilots. The Tricks of the Trade: A Handbook for Flight Instructors. Washington, D. C.: CAA, 1947.

(40) Patter for Elementary Flight Maneuvers. Washington, D. C.: Civil Aeronautics Bulletin No. 31, February, 1943.

(41) Private Pilot Flight Training Guide (AC 61-2A). Washington, D. C.: Federal Aviation Administration, 1964.

(42) Smith, R. G., Jr. The Development of Training Objectives. Research Bulletin No. 11, Human Resources Research Office, George Washington University, Alexandria, Virginia, June, 1964.

(43) Smith, R. G., Jr. Controlling the Quality of Training. Technical Report 65-6, Human Resources Research Office, George Washington University, Alexandria, Virginia, June, 1965.

(44) Smode, Alfred F., Eugene R. Hall, and Donald E. Meyer. An Assessment of Research Relevant to Pilot Training. (AD-804-600) Arlington, Virginia: BioTechnology, Inc., 1966.

(45) Strickland, Patricia. The Putt-Putt Air Force. (GA-20-84). Washington, D. C.: Federal Aviation Administration, 1971.

(46) Tiffin, Joseph, And John Bromer. Analysis of Eye Fixations and Patterns of Eye Movement in Landing a Piper Cub J-3 Airplane. Washington, D. C.: CAA Division of Research Report No. 10, February, 1943.

(47) Tinker, Miles A., and William S. Carlson. Sensitivity of Peripheral Vision in Relation to Skill in Landing an Airplane. Washington, D. C.: CAA Division of Research Report No. 14, April, 1943.

(48) Townsend, J. C., and R. Flexman. Suggested Ways of Improving Instruction in the Primary Pilot Training Program. Air Force Personnel and Training Research Center Report AFPTRC-TR-54-126, Lackland Air Force Base, Texas, 1954.

(49) Viteles, M. S., et al. A Course in Training Methods for Pilot Instructors. Washington, D. C.: CAA Division of Research Report No. 20, June, 1943.

(50) Viteles, M. S. An Historical Introduction to Aviation Psychology. Washington, D. C.: CAA Division of Research Report No. 4, October, 1942.

(51) Viteles, M. S. The Aircraft Pilot: 5 Years of Research (A Summary of Outcomes). Washington, D. C.: CAA Division of Research Report No. 46, June, 1945.

(52) Viteles, M. S. The Psychology of Learning in Relation to Flight. Washington, D. C.: CAA Division of Research Report No. 16, June, 1943.

(53) Walker, R. Y., S. V. Bennett, and E. S. Ewart. A Study of Individual Differences Among Flight Instructors in Making Spot Landings. Washington, D. C.: CAA Division of Research Report No. 56, February, 1946.

(54) Wapner, S., H. Odbert, and L. Festinger. Comparison of Student Pilot Performance in Successive Check Flights as Measured by Photographic Records. Washington, D. C.: CAA Division of Research Report No. 59, 1946.

(55) Williams, A. C., Jr., and R. E. Flexman. Evaluation of the School Link as an Aid in Primary Flight Instruction. University of Illinois Institute of Aviation Aeronautics Bulletin No. 5, 1949.

VITA

Wayne Robert Matson

Candidate for the Degree of

Doctor of Education

Thesis: THE COMPARATIVE EFFECTIVENESS OF A PROLONGED FLARE AND A NORMAL FLARE ON STUDENT PILOT ACHIEVEMENT IN THE LANDING MANEUVER AND ON TIME TO SOLO

Major Field: Higher Education

Biographical:

Personal Data: Born in Duluth, Minnesota, August 21, 1941, the son of Charles A. and Vera A. Matson.

Education: Graduated from Central High School, Duluth, Minnesota, in June, 1959; received Bachelor of Science degree in Mathematics from University of Minnesota, Duluth, in 1963; received Master of Arts degree in Mathematics from Northern Arizona University in 1966; completed requirements for the Doctor of Education degree at Oklahoma State University in May, 1973.

Professional Experience: Teacher of Aerospace Science, Mathematics, and Physical Education, Flagstaff High School, Flagstaff, Arizona, 1963-1967; Lecturer in Space Science, under NASA contract, University of Redlands, Redlands, California, 1967; Director of Educational Programs, Centuri Engineering, Inc., Phoenix, Arizona, 1968; Assistant Professor of Aerospace Studies, Chief Ground and Flight School Instructor, Director of the National Air Tour Workshops, Central Washington State College, Ellensburg, Washington, 1969-1971; Space Science Education Specialist under NASA contract, Graduate Research Assistant with the Space Science Education Project, Oklahoma State University, Stillwater, Oklahoma, 1971-1973.