A COMPARISON OF FIXED BASE/PC-BASED SIMULATORS WITH TRADITIONAL MOVEABLE PLATFORM FLIGHT SIMULATORS AS A TOOL FOR TEACHING PRIVATE PILOTS RADIO NAVIGATION AND BASIC ATTITUDE INSTRUMENT FLYING SKILLS

Steven Hampton, Ed.D.
Associate Professor
Embry-Riddle Aeronautical University

ABSTRACT

In flight training, attention has been focused on the useability of flight training devices. In the past such devices as the GAT-1 trainer were used. The recent development of small, inexpensive computers has resulted in the creation of smaller fixed-based devices. Further, the development of the personal computer has made it possible for all pilots and flight students to own their own computers. Software is available for the training of flight students using these devices. Unfortunately the use of PC-based devices by pilots for flight training has been restricted by the Federal Aviation Administration because of their concern about the type of software that is available and its training value. However, the use of PC-based training devices may well be a means of reducing the cost of flight training. Can these fixed-base and personal computer-based training devices be used as effectively as the GAT-1 trainer?

The intent of the study was to evaluate the capabilities of three types of flight training devices. The study compared the ability of the three trainers to teach the skills required for Private Pilot operations. The results indicated that their were no significant differences in the means. The results also showed that the PC-XT-based Novel Twist and the Frasca had a higher absolute mean than the GAT-1 Trainer and that the Novel Twist had the highest mean.

Results from the study show that the new generation of general aviation flight training devices can provide the BAI/Radio Navigation training required for Private Pilot applicants. Further, the analysis of the results suggest that additional studies should be completed to (1) verify the tabulated results, (2) determine why the computer-driven simulators rated higher than the traditional GAT-1 trainer, and (3) determine the full capabilities of PC-based desktop simulators.

INTRODUCTION

An integral part of any Private Pilot flight curriculum includes a segment that teaches a student how to fly by reference to instruments, and also how to utilize basic radio navigation techniques. Traditionally this segment of the course has been taught in either the airplane used for training or a flight simulator such as the GAT-1 Link trainer. These devices are no longer mechanically suitable or desirable. Can computer-based devices such as those utilized by the airlines be used instead? Unfortunately, these are rather expensive. Some simulator builders such as Frasca offer generic training devices in the $50-60,000 price range, also somewhat price prohibitive. Other possibilities include PC-based devices, which are inexpensive and have multiple application possibilities. If the PC-based training devices can be used, they may reduce the cost of flight training considerably.

Simulators have been present in flight training since before WW II. A concerted effort to use simulators for flight training was made by the major airlines and military in the 1940s and 50s to help reduce training costs. General aviation operators which have utilized some form of flight simulator since the 1950s unfortunately do not have the resources to afford the kind of simulators developed for military and airline operations. These devices often cost $3-18 million. Instead, a small segment of the simulator industry has developed generic flight training devices that typically range in price from $4,000 to $60,000.

The introduction of personal computers within the past ten years has accelerated the applications of microprocessor technology to the point where it is now possible for a personal computer to have the processing power of a minicomputer. The result has been the development of several successful generic training devices. While the FAA has seen fit to condone the introduction and development of microcomputer fixed-base training devices, they have not yet approved PC-based systems.

Background

Numerous previous studies have shown that simulators are effective as instrument trainers and that the transfer of training from simulators to aircraft is high. These studies have proved the concept and ability of trainers such as the GAT-1 trainer to replicate and reduce flight training time. Examples of research using these devices can be found in the proceedings of numerous aviation symposiums (Jensen 1987). Further evidence to support the concept and value of simulation training can be found in the FAA's recent authorization to allow airlines to train and check out air crews solely in a simulator. These simulators, however, are very costly, typically in the $3-18 million range, well beyond the capabilities of any primary flight training institution. In general, simulators are used to reduce training costs and to provide total control while providing an inherently safe learning environment (Gebhard 1983).

Some simulator developers, including Frasca, have developed affordable generic general aviation trainers. These trainers are fixed base and capable of simulating flight situations and conditions without motion through the use of microprocessor technology. Such simulators have control panels and radios that come as close as possible to those found in aircraft. Based on studies conducted by their own researchers, Frasca claims that if properly used the "transfer of training can result in 100 per cent transfer in many tasks, cutting total flying time by as much as 50 per cent" (Lombardo 1985:23-24).

Most simulators in use today use some form of computer technology to replicate flight situations. The recent development of personal computers that are within the budget of general aviation suggests that PCs, if properly used, could be utilized to supplement and replace some of the training currently being done in the mid-range flight simulators. There is some empirical evidence to suggest and support the training effectiveness of microcomputer-based technology in task simulation contexts. This was demonstrated by Poleman and Edwards (1983) who showed that a computer-aided, two-dimensional graphics simulator can be superior to material presented in illustrated textual material in the transfer of cockpit procedural skills.

Unfortunately few if any studies have been conducted to evaluate the capabilities of personal computers as flight training devices. Searches of numerous databases unfortunately were unable to provide any meaningful literature.

Purpose

The intent of the study was (1) to determine whether the current generation of microcomputer fixed-base simulators can replicate and provide a level of transfer of training comparable to trainers developed and used in the 1960s and 70s, and (2) to evaluate the capabilities of personal computers to provide the same level of training.

The study was limited to evaluating the capabilities of the training devices. No attempt was made to determine the various reasons for the differences, if any, in the outcomes. The study was further limited to the skills taught to Private Pilot applicants

The hypotheses for the study are as follows:

1) There are no differences among the outcomes of students taught in the GAT-1, Frasca, and Novel Twist.

2) The Frasca and Novel Twist can provide the BAI/Radio Navigation training that is required for Private Pilot applicants to the same standard as the GAT-1.

METHOD

Subjects and Instructors

Thirty subjects were randomly selected from among Aeronautical Science students enrolled in FA 105-2 . FA 105-2 is the second in a series of five courses leading to Commercial Pilot certification. Successful completion of FA 105-2 means that the student is eligible for Private Pilot certification. All of the thirty subjects held student pilot certificates.

The subjects all had completed FA 104 (the pre-solo flight course), and Lesson 3 of FA 105-2. Each student had approximately the same amount of flight experience. The subjects were randomly assigned in groups of ten to either the control Group A, or one of two experimental groups, Group B and Group C.

All of the flight instructors who volunteered to participate in the research project had approximately the same amount of training experience, between six to twelve months. The students were randomly assigned to the instructors with an attempt to ensure that each instructor taught the same number of students in each simulator.

Procedure

The experimental design compared the effectiveness of two types of low-cost simulators with a control group utilizing a standard General Aviation Trainer. The subjects were evaluated prior to and after completion of the training.

To ensure that the subjects had achieved the same standard and training experience prior to being accepted for the experiment, each student was required to have successfully completed Lesson 3 of FA 105-2, the Private Pilot Certification course at E-RAU. The study required that each group received the same instruction in Basic Attitude Instrument Flying and Basic Radio Navigation. Each subject received the same amount of flight instruction and evaluation time. The two experimental groups (A and B) received an additional .5 hr of instruction in the GAT-1 prior to evaluation for orientation purposes prior to testing. The post-test performance evaluation of all three groups was conducted in a GAT-1 trainer.

The control group, Group A, was taught in a Singer-Link General Aviation (GAT-1) Trainer. The GAT is a two-axis simulator with a movable pedestal. The flight panel replicates a generic aviation trainer, with movable controls and flight instruments. Navigation is provided by two nav/com radios. The simulator provided no visual depiction.

Experimental Group B was taught in a Frasca 141. The Frasca 141 is a fixed-axis, computer-based simulator. Input to the computer and flight instruments uses digital electronics. The flight panel of the simulator replicates a generic general aviation aircraft. Navigation is provided by two nav/com radios. No visual simulation was provided.

Experimental Group C was taught utilizing an IBM PC-XT computer with an RGB color monitor. The PC-XT was integrated with a Novel Twist Cockpit Procedure Trainer (CPT). Software was provided by the Instrument Flight Trainer, a program from Flight Deck Software. The face of the CPT controls radio frequencies, position of flaps, gear, trim, and cockpit view by touch pads. Pushing the pads results in changes seen on the computer monitor. A manual yoke and throttle control are used to change attitude and power. The PC receives its information from the cockpit procedure trainer, which in turn displays it on the monitor. Visual depiction was provided.

All three groups were required to perform maneuvers in ten areas. They were as follows: (1) Four Fundamentals, (2) VOR Orientation, (3) VOR Tracking, (4) VOR Station Passage, (5) NDB Orientation, (6) NDB Homing, (7) NDB Station Passage, (8) Signal Loss, (9) Recovery from Unusual Attitudes, and (10) Emergency Climbs and Descents.

The students were graded using a standard alphabetical system, "A"-"F", with the grade "A" representing the highest possible grade and "F" the lowest. The grades were then transferred to a numbering scale: an "A" equals a value of 4; a "B", 3; a "C", 2; a "D" 1; and an "F", 0.

To determine the effectiveness of each of the flight training devices, an ANOVA was used to evaluate the combined means of the three groups for all ten skill areas at the .05 level of confidence. An IBM-compatible statistical package was used to obtain the results (Doane: 1985).

RESULTS

The results indicate that the two experimental groups did as well as or surpassed the level of training of the control group in the GAT-1 trainer. The hypotheses, therefore, cannot be rejected. The results are presented in the following tables.

Presentation of results

The sample sizes in all of the groups remain the same at 10. The first two tables represent the overall result of all ten combined skills. The mean represents the total combined mean average of a particular group, "A", "B", or "C" in all ten areas (see Table 1).

TABLE 1

Mean Overall Standard Deviation and the Sample Size for Groups A, B, and C

Group	Mean	Standard Deviation	N
A	27.7	3.400982	10
B	29.9	5.152134	10
C	32.5	3.922868	10
Overall:	30.03	4.537077	30

The mean average was 27.7 for group "A", 29.9 for group "B", and 32.5 for group "C". The second table shows the results of an ANOVA evaluating the means of the three groups.

TABLE 2

ANOVA Table Indicating the Overall Degrees of Freedom and the Computed Value of F

Source	Sum of Squares	Degrees of Freedom	Variance
Between:	115.4668	2	57.7334
Within:	481.5	27	17.83333
Total:	596.9668	29	20.58506
Compute F = 3.237 with d.f. = 2 and 27			

Based on the results from the sample, the null hypothesis cannot be rejected since the calculated F value is 3.237, which is less than the critical F value of 3.49.

DISCUSSION

Interpretation and Conclusions

Overall there are no significant differences between the combined means of the three groups in the ten skill areas evaluated. Further investigation was suggested, however, because of the closeness of the computed F value 3.237 to the critical F value of 3.49. Therefore, an additional ANOVA was conducted between the combined means in each group for each of the ten skills being investigated.

The results showed that in one area the critical F value was exceeded: NDB Homing, which had an F value of 5.771. Further investigation using a Tukey (TSD) test into the reasons for the significant difference was therefore warranted. The investigation indicated that the mean for the level of training for NDB Homing in the GAT-1 was significantly lower than that in the Frasca or Novel Twist. However, because of the repeated use of the same data, the chances for a type 1 error had increased to 10% at the .01 significance level. Therefore, I am reluctant to report any firm results or conclusions.

There are several possible reasons for the results which indicate that the Frasca and Novel Twist are capable of providing equal or better training than the Singer Link GAT-1 in the areas evaluated. These are discussed below. It is possible that the level and standard of training are dependent more on the quality of instruction than on the machine. This is exemplified by the results of the Novel Twist, a machine costing considerably less than either of the other two. Another is the apparent ease of use: both the Frasca and Novel Twist were reported to be more versatile than the GAT-1. Further, the instructors indicated that it was easier to evaluate and debrief the students using the additional functions that use of a computer afforded them. Other reported advantages included the observation that both the Frasca and Novel Twist were able to replicate the airspace with which the students were familiar. The instructors were particularly impressed by the ease with which the computer-based machines were able to repeat a phase of flight in which the students were having trouble.

One area of concern that the instructors reported was the apparently slow speed at which the PC-XT machine was able to show changes in flight attitudes. Several instructors indicated that the "jerky movement" of the monitor picture made the simulation quality less than desirable. Use of a faster processor with an EGA or VGA monitor may resolve this problem.

Following the investigation and evaluation of the results, it is apparent that the new generation of fixed-base computer-driven flight training devices can provide a high level of instrument flight training at the Private Pilot level. Further, the results indicate that desk top simulators using a personal computer can also replicate the training required for a Private Pilot flight student and may also be suitable for training Instrument Pilot applicants.

The use of a PC-based simulator such as the Novel Twist would result in considerably lower costs per flight simulator hour. A possible result of the reduction in student training costs may well be an increase in the numbers of students taking flight training. Further, for those students with PCs at home, the device would allow them the opportunity to better prepare for activities in the simulator or aircraft and to replay flights completed. The training operator's PCs could also be used for purposes other than flight training, such as bookkeeping, FAA computerized testing, and maintenance of flight training records. Unfortunately one drawback to the use of the PC-based systems is that the FAA does not currently approve the use of these flight training devices; therefore, students cannot log the training time towards their Private or Commercial Certificate, and Instrument rating.

Recommendations

Based on the interpretation and conclusions five specific recommendations are made:

1) That an additional enlarged study should be conducted to verify the results.

2) That a study should be conducted to determine the reasons for the superiority of the Frasca and Novel Twist.

3) That a study be conducted to evaluate the effect of the role that the quality of flight instruction has on simulator training.

Because the use of a PC-based flight training device for flight training is not approved by the FAA, it is suggested that the following course of action may be appropriate:

4) That a study be conducted to evaluate the full capabilities of the PC-based flight training device both for Instrument Training and for maintaining Instrument currency by Instrument pilots.

5) That an additional study be conducted to determine the level of the transfer of training from the PC-based training device to an aircraft.

6) That the above studies be done using a 286- or 386-based PC, with at least an EGA monitor to enhance the speed, and the quality of resolution on the PC monitor.

7) That the FAA should fund the necessary research to establish the appropriate criteria needed to certify the use of PC-based flight training devices.

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