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MICROCOMPUTER-BASED INSTRUMENT FLIGHT SIMULATION: UNDERGRADUATE PILOT TRAINING STUDENT ATTITUDE ASSESSMENT

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The purpose of this investigation was to assess United States Air Force (USAF) Undergradate Pilot Training (UPT) student attitudes toward using a T-37 tailored personal computer (PC) or microcomputer-based simulation as an addition to the formal training syllabus. Eight student classes were surveyed in Phases I and II of the three phases of UPT. As hypothesized the UPT students were most receptive to using a microcomputer simulation for instrument training after having completed both instrument academics and the initial instrument simulator missions. Only 36% of the students starting UPT were likely to use a microcomputer simulation to replace 75% or more of their "chair-flying," compared to 51.4% of the students who had completed an instrument simulator sortie. On the average, UPT students having completed I2106 (two sorties prior to the instrument check ride) said they would use a microcomputer simulation on a daily basis to enhance their training. After attempting to learn the instrument procedures, students indicated they were eager to use a microcomputer simulation. It was demonstrated that, in general, UPT students are sensitive to their difficulties in learning instrument procedures and are willing to replace chair-flying with a microcomputer simulation.

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PREFACE

This research supports the current Research and Technology Plan, whose general objective is to increase combat readiness by developing and demonstrating more cost-effective ways of acquiring and maintaining new skills. The work was conducted under Work Unit 1123-25-13, Microsimulator Development, whose principal investigator is Capt Stuart Bishop.

Special thanks to Aircrew Training Research Division research psychologists, Dr Dee Andrews, Dr Richard Thurman, Dr Peter Crane, and Joseph Mattoon, for their guidance in the literature search and support in reviewing and suggesting changes. Schedule coordination for time to administer the survey was accomplished entirely by Ms Alice Beard, 82nd FTW Academic Scheduler. Her efforts in arranging time with the classes, allowing the survey to be completed in only three days, is greatly appreciated.

MICROCOMPUTER-BASED INSTRUMENT FLIGHT SIMULATION:

UNDERGRADUATE PILOT TRAINING STUDENT ATTITUDE ASSESSMENT

SUMMARY

This work was performed to assess the interest level undergraduate pilot training (UPT) students have toward using personal computer or microcomputer-based simulation to aid their training. Eight UPT classes at Williams Air Force Base, Arizona, were surveyed using a descriptive questionnaire to assess their opinions toward using a microcomputer to aid learning of instrument and navigation procedures for the T-37 aircraft. The survey was conducted over a three-day period on a non-interference basis with the students' flying and academic schedule. A cross-sectional sampling of the students' opinions was obtained through their responses to the questionnaire. Each student's responses were correlated to their position in instrument training. As hypothesized, UPT students were most receptive to using a microcomputer simulation for instrument training after having completed instrument academics and the initial instrument simulator missions. The overall purpose of this investigation was to determine those times when UPT students are the most motivated to use a microcomputer simulation. Follow-on research could be tailored around these times and thereby ensure an excellent chance for realizing training transfer benefits.

INTRODUCTION

Student pilots spend an extensive amount of time using cardboard or paper representations of aircraft instruments when initially learning instrument procedures. This process is generally referred to as "chair-flying" and is the primary method by which instrument procedures are first attempted. Despite the popularity of chair-flying, mental visualization of aircraft responses to pilot actions is not always effective. Relying on students to initially teach themselves often places a considerable workload on the instructor pilot (IP) to correct chair-flying-induced misconceptions and errors.

If students had a device which allowed practice with aircraft instruments and navigation aids and if the device could give appropriate responses based on student input, a significant portion of the IP's workload in instrument training might be eliminated. Allowing students to use a device which behaves like the aircraft, to learn basic instrument maneuvers, would eliminate many of the problems which result from the use of mental visualization. If the basics of instrument flight could be more easily mastered, students could be able to progress to higher proficiency levels in basic tasks or to more complex maneuvers at an earlier stage.

The United States Air Force (USAF) Air Training Command (ATC), in conjunction with the Armstrong Laboratory's Aircrew Training Research Division (AL/HRA), is in the process of developing, exploring, determining, and evaluating new training tools for use within existing training programs. One example of a new training tool is a microcomputer-based simulation for the T-37 UPT aircraft. This simulation would be used primarily for instrument and navigation training.

Researchers at AL/HRA have proposed a device which allows practice as often as desired and which may increase student pilot proficiency in instrument procedures. This increased proficiency could result in UPT graduates with greater instrument skills under the current training syllabus. It might also allow increasing instrument proficiency standards in the UPT syllabus in the future.

Statement of the Problem

The purpose of the present study was as follows: (a) determine the interest level of UPT students toward the concept of using a microcomputer simulation for learning instrument and navigation procedures for T-37 aircraft, and (b) to find the point during their training when students are most likely to favor using such a simulation.

Acquisition of knowledge in UPT is generally accomplished via classroom lecture, computer-aided instruction (CAI), and individual instruction during aircraft sorties or simulator missions. In the UPT setting, all students are exposed to the same classroom and CAI lessons. Flight instructors, however, will tailor individual instruction to their students. This tailoring is predicated upon an IP's experiences with previous students and upon each particular student's receptiveness to the IP's instruction. If a student is not receptive to a particular style, IPs may modify their approach to the student. If the student still does not respond to an IP's instruction, the IP requests that another IP fly the next sortie. This is done to preclude any lack of communication or any miscommunication from affecting the student's performance.

Each academic class requires the student to have completed a reading and workbook assignment prior to class. The classes include lecture, film, video, slide, and/or a demonstration system mockup (i.e., hydraulic, engine, electrical, etc.). Courses usually consist of a series of lessons with an examination at the end. Students can then fly simulated missions or actual aircraft sorties which require the academic classes as prerequisites for specific sorties. Students within a UPT class will become slightly spread throughout the syllabus for a variety of reasons--illness, failing tests/boldface (emergency procedures), or lack of IP availability. For those students who are farthest behind in the syllabus, a delay of a week or more can occur between academic training and the next instrument mission related to the academic course. This leads to a break, for the average student, between acquiring knowledge and being able to apply the knowledge. This break results in a less-than-ideal situation. A self-directed microcomputer simulation immediately available to students would allow them to apply instrument procedures without delay. Another benefit of microcomputer simulation would be the ability to accomplish repeated practice in a short period of time. This practice might lead to automatization of the students' skills.

Review of Related Literature

In the literature search, no other studies were found relating to UPT student attitudes (or attitudes of any prospective group of pilots) toward using a microcomputer simulation for training. The review was then focused on the UPT learning process, considerations for using a microcomputer simulation for initial student learning, and current uses of microcomputers in educational settings.

Reigeluth and Schwartz (1989) hypothesized the learning process consists of three phases: acquisition, application, and assessment. During acquisition, the student learns basic principles, procedures, and cause-effect relationships. During application, the student applies these principles, procedures, and relationships to problems. Application allows mastering a procedure through repeated practice. Repeated practice may lead to automatization of some types of skills; that is, the ability to perform certain tasks and/or decisions without conscious awareness. Assessment determines if the learner has achieved mastery. When learners correctly analyze their own performance and make timely corrections with only minor deviations, mastery has been achieved.

By allowing repeated practice on a task, automatization can occur. Task automatization is distinguished by automatic cognitive processing (Schneider, 1985). Automatic processing is a fast, parallel process, not limited by short-term memory. Automatic processing requires little effort or attention on the part of the individual. However, development of automatic processing does require extensive training. If a student can internalize or form a working model of the system, training transfer and schema formation (cognitive process) will be enhanced (Ryder, Beckchi, Redding, & Edwards, 1988). Developing a schema of linked behaviors through repeated performance or deliberate training leads to task's becoming internal and automatic (Nagel, 1988). Achieving automaticity in a task can increase processing speed by a factor of 100 and reduce mental workload by 95% (Fisk, Ackerman, & Schneider, 1985). Automaticity develops slowly and only after repeated, and often massive, amounts of practice over a relatively compressed time period (Myers & Fisk, 1985).

There are various implications of using microcomputer simulation for initial student learning. High-fidelity simulation, like the aircraft, may not be the most appropriate medium for initial student learning. In some cases, low-fidelity simulation can teach more efficiently than actual aircraft flights for novice students (Povenmire & Roscoe, 1973; Roscoe, 1971). Novice learners tend to be confused by high-fidelity representations due to the rapid presentation of complex sequences (Miller, 1974). Aircraft flights or high-fidelity simulation sorties can overwhelm novice students during initial missions. Too much realism in a computer simulation has been found to reduce a student's motivation level to the point where no transfer to similar real-world situations is possible (Malone, 1980).

One explanation for this effect is that high fidelity means higher complexity and a higher cognitive load on the learner. Also instructional techniques shown to improve initial learning tend to be of lower fidelity (Alessi, 1988). According to Edwards (1986), preserving the perceptual and cognitive aspects of a task allows a low-physical-fidelity microcomputer simulation to provide cognitive training transfer comparable to that achieved through training in the actual aircraft.

Microcomputer-based simulation applications in educational situations are relatively recent developments (Mattoon & Thurman, 1990). Training applications first appeared as tutorial programs, drill-and-practice assignments, diagnostic simulations, pre-lab simulations, laboratory data collection and analysis, lecture demonstrations, class management, and for controlling videotapes and videodiscs (Gredler, 1986; Smith, 1984). Advances in microcomputers over the last decade have opened the door to tailoring instruction to take advantage of microcomputer applications. As the cost of microcomputers has decreased, more systems have been acquired, providing wider acceptance and increased opportunities for training.

The benefits to be gained from the application of microcomputer technology are sizable. For example, in a survey of eight studies introducing computer-based instruction (CBI) in college courses, Kulik, Kulik, and Cohen (1980) found CBI to substantially save instructional time. They determined conventional classes required an average of 3.5 hours per week but with CBI the total time was reduced to 2.25 hours, a 36% reduction. A more extensive comparison of 32 studies showed an average of 30% reduction in required class time (Kulik & Kulik, 1989).

As computers have become more capable, more advanced interactive programming applications have become available for use in learning situations. For instance, microcomputer-based simulation has been incorporated into the conversion training program at American Airlines (Shifrin, 1988). Pilots transitioning from one aircraft type to another are provided a program which covers the differences between currently assigned aircraft and the one to which they are changing. Pilots owning microcomputers are allowed to take the course programs home for their use to further augment the formalized instruction.

Enhanced graphics displays, touch screens, reactive/interactive programming, digital generation of audio tones, and programming using tutorial languages yield virtually unlimited applications of microcomputers in learning situations. Microcomputer simulation has the potential to become the fastest-growing segment of flight simulation (Nordwall, 1988). Unfortunately, the technological developments in microcomputer-based simulation have far outpaced research into determining how to best apply them to the learning process.

Statement of the Hypothesis

A review of the literature indicated a dearth of previous research to validate the effectiveness or ineffectiveness of microcomputer-based simulation in pilot training applications. Benefits of using a microcomputer simulation to increase task automatization are unproven in pilot training applications. Additionally, it is unknown whether students have an interest in using such a simulation. This should be known before any research regarding its effectiveness can be planned. The author believes UPT students will have a basic interest in using a microcomputer simulation to aid their training, as most aspiring pilots will try anything to help themselves learn when they begin UPT. It was hypothesized that UPT students will have the greatest interest in using a microcomputer simulation to aid their learning after beginning flying the T-37 and receiving the T-37 academic instrument courses. This corresponds with the point when the students will have completed the first four instrument simulator sorties and advanced instrument academics. At this point a student will have tried traditional chair-flying methods and experienced the lack of feedback associated with mental visualization of instrument procedures.

METHOD

Overview

A survey questionnaire was developed to determine how familiar UPT students are with computers in general and whether they would be willing to use a microcomputer simulation in their training. The survey questionnaire was administered to obtain a cross-section of UPT students' responses. The survey was conducted as quickly as the 82nd Flying Training Wing (FTW) Academic Scheduling Office could arrange time. Using a cross-section of students throughout training allowed a more rapid data collection than following classes through training and minimized the disruption associated with periodically administering the survey for a longitudinal investigation.

Subjects

The sample group was the eight UPT classes at Williams AFB, Arizona in Phase I (Preflight) and Phase II (T-37) of UPT during January 1991. The survey was administered to 199 UPT students over a three-day period.

Instrument

The survey questionnaire was developed with the assistance of AL/HRA research psychologists. It was pretested using five volunteers at AL/HRA who had not been involved in its development and four UPT students eliminated from T-37 flying training. The former UPT students were particularly helpful in pointing out areas of confusion.

Questions were kept as direct as possible, and no future efforts were mentioned on the survey questionnaire. Each student's status regarding the UPT syllabus was determined by asking for the most recently completed instrument aircraft and simulator sortie, contact sortie, and academic course. Their status with regard to the training syllabus was important to interpretation of their responses regarding the use of a microcomputer simulation to aid their training.

The survey instrument is contained in the Appendix.

Study Design

This investigation employed a descriptive research method. Due to the large number of respondents, the results were assumed to be generalizable to the entire population of UPT students. One of the major concerns of using the already-formed UPT classes was the cluster bias which particular classes may have toward microcomputers. To avoid having students voice their opinions and thus bias the class while the survey was administered, the students were asked not to discuss the questions as they completed the survey.

Procedure

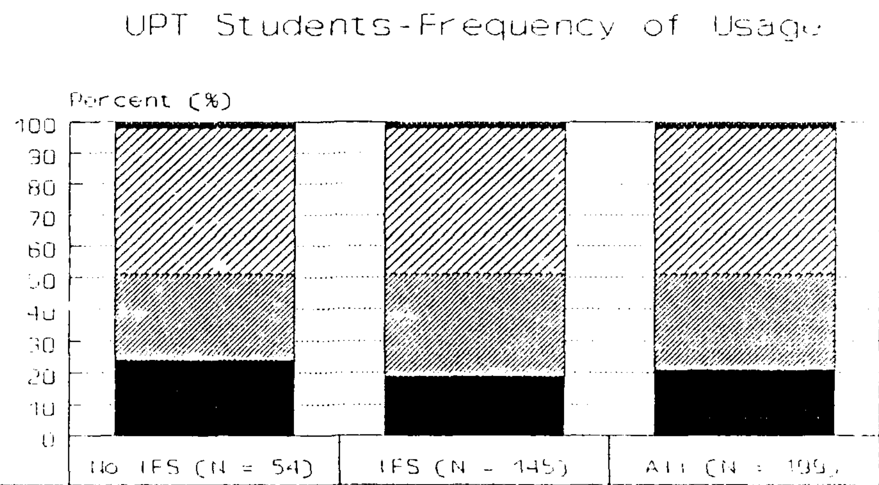
Approval to conduct this research was granted by the 82nd FTW, Director of Operations. Survey questionnaires were distributed to each student at the beginning of a scheduled academic class. The students took the survey at individual desks, rather than at group tables in a flight room, to improve the chances of obtaining independent opinions.

All of the classes in Phase I and Phase II of UPT at Williams AFB, AZ, were surveyed within a three-day period in January 1991. Eight classes were available due to the timing, with one class finishing Phase II and one class starting Phase I during the three-day period. Scheduling time to administer the survey was coordinated through the 82nd FTW Academic Scheduling Office. Surveys were collected immediately upon completion. UPT classes surveyed included 91-12, 91-13, 91-14, 91-15, 92-01, 92-02, 92-03, and 92-04. The average time for a class tc complete the survey questionnaire was seven minutes.

RESULTS

UPT students were almost unanimously in favor of using a microcomputer simulation to learn instrument and navigation procedures. For the initial analysis of the responses, they are grouped as follows: all students; students with no instrument flight simulator (IFS), T-50, missions completed; and students who had completed at least one IFS mission. An IFS mission is an instructional mission with an IP instructing and evaluating student performance. Student response groupings were then further broken down to single IFS missions and aircraft sorties to help determine changes in motivation levels throughout T-37 instrument training and to pinpoint exact interest peaks.

As shown in Figure 1, most UPT students (98%) indicated a willingness to use microcomputer simulation. A majority (47%) indicated they would use it weekly; 30% said they would use it daily; and 21% favored "every possibility" usage (i.e., more than once a day)

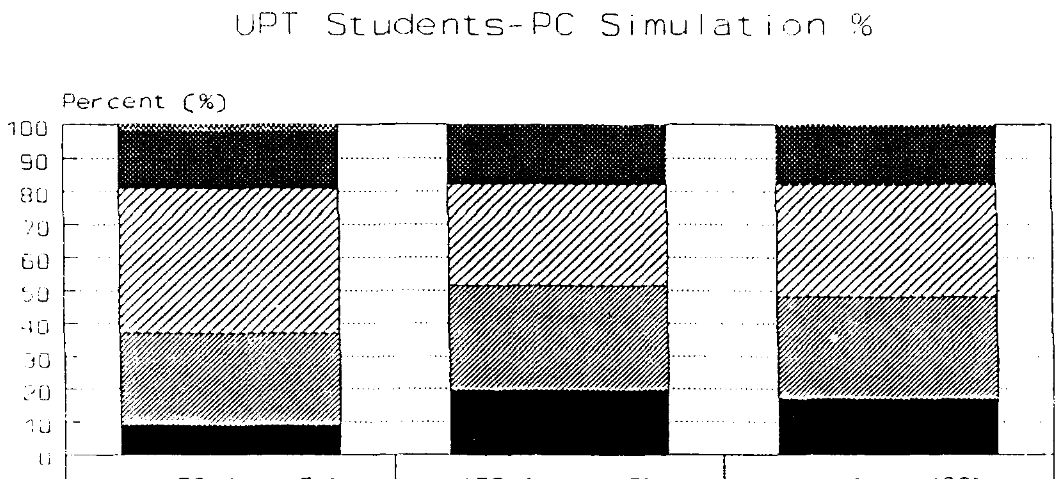


	No IFS (N = 54)	IFS (N = 145)	All (N = 199)
Never	2	2	2
Weekly	47	47	47
Daily	27	32	30
Every Possibility	24	19	21

Figure 1.
UPT Student Responses to Probable Frequency of Usage.

Those students who had completed at least one IFS mission (N=145) and those with no IFS training (N=54) favored weekly use equally (47%). However, more IFS students (32%) preferred daily use compared to the no-IFS students (27%). Comments made by the IFS students indicated that demands on their spare time would preclude more frequent use. Two percent of each group said they would never use the simulation.

Eighty-two percent of all UPT students surveyed indicated they would use microcomputer simulation to replace 50% or more of their chair-flying to learn instrument-navigation procedures, as shown in Figure 2. The differences between the IFS students and the no-IFS students are noticeable. Whereas 51.4% of the IFS students indicated they would use a microcomputer simulation to replace 75% or more of their chair-flying, only 37% of the no-IFS students did so. Also, IFS students were 10.6% more likely to use microcomputer simulation to entirely replace (100%) chair-flying.



	No IFS (N = 54)	IFS (N = 145)	All (N = 199)
0 %	2	0	0.5
25 %	17	17.8	17.5
50 %	44	30.8	34
75 %	28	31.8	31
100 %	9	19.6	17

100 % 75 % 50 % 25 % 0 %

Figure 2.
UPT Student Responses to Probable Percentage of Chair-Flying Replaced by PC Simulation.

Responses based on the number of IFS missions completed (0 to 15) were compared to determine if responses varied based on experience in the IFS. Mean responses as to probable frequency of usage are shown in Figure 3 for each number of IFS completions. Numeric values were assigned as Never-1, Weekly-2, Daily-3, and Every Possibility-4 for this comparison. As shown, two distinct peaks in the frequency of usage occur at two and ten IFS missions completed. At these experience levels, probable frequency of use was greater than daily.

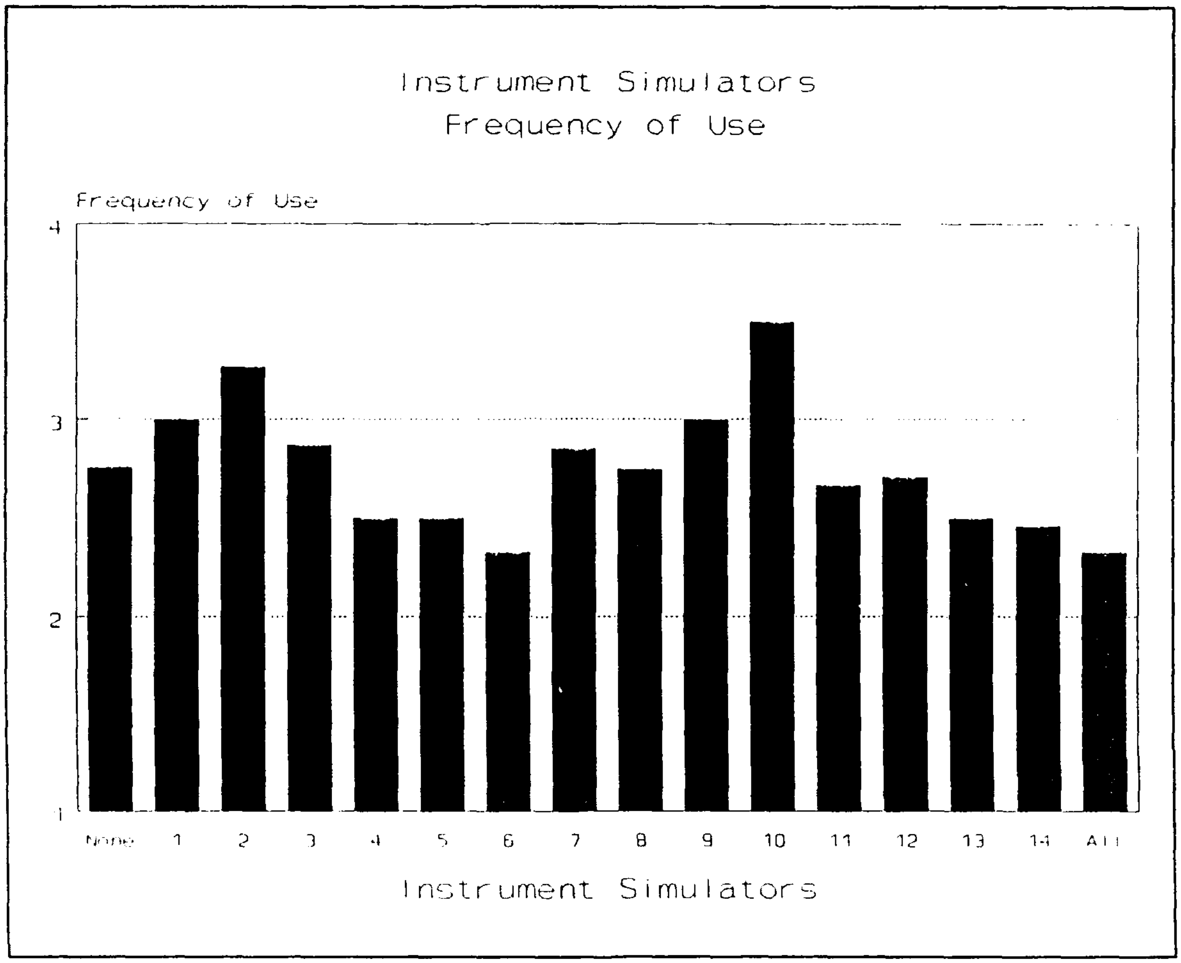


Figure 3.
UPT Student Responses Based on IFS Missions Completed to Probable Frequency of Usage.

Similarly, mean responses to the percentage of chair-flying IFS students would replace with microcomputer simulation are shown in Figure 4 for each number of IFS missions completed. As shown, there is a peak at one and two IFS missions (77.17%) and at seven and eight missions (75%). Chair-flying replacement percentages for students with no IFS missions completed and those with all IFS missions completed are 56.48% and 50.93%, respectively.

Having compared responses in terms of IFS missions completed, the author looked at how they relate to the number of instrument aircraft sorties completed (0 to 7). Mean responses to probable frequency of usage versus number of instrument sorties completed are shown in Figure 5. Again numeric values were assigned as Never-1, Weekly-2, Daily-3, and Every Possibility-4. Unlike the simulator plot, the sortie plot lacks the distinct peaks for more frequent usage. Two peaks in frequency of usage appear at I2102 and I2106. However, the most frequent usage from the sortie comparison occurs at I2106, the next-to-last sortie prior to the instrument check ride. This sortie indicates "daily" usage to be the preferred response.

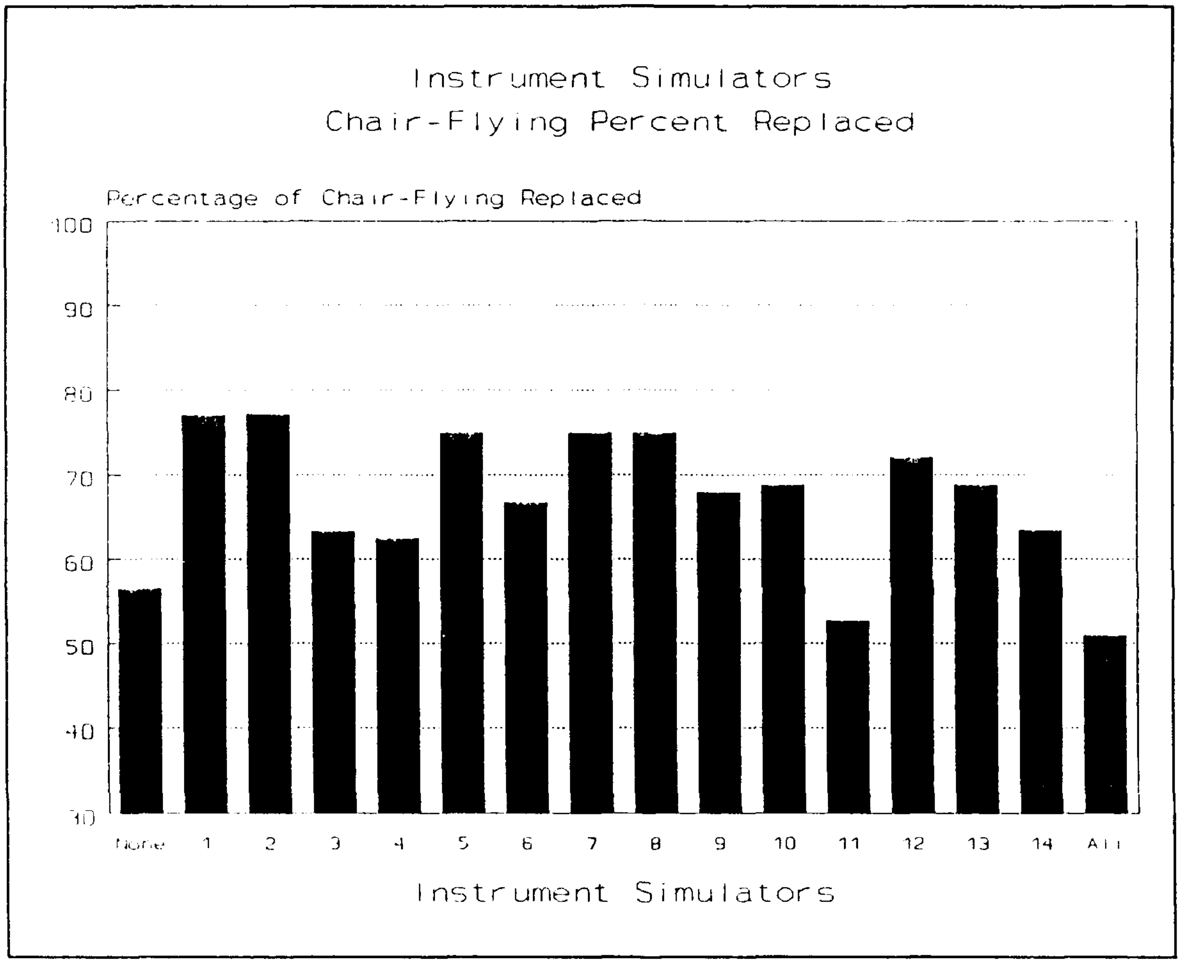


Figure 4.
UPT Student Responses Based on IFS Missions Completed to Probable Percentage of Chair-Flying Replaced by PC Simulation.

A comparison of responses to probable percentage of chair-flying replaced by microcomputer simulation, based on instrument sorties completed, is shown in Figure 6. Results are similar to those shown in Figure 5. These percentages resemble those shown in Figures 3 and 4 for IFS missions completed.

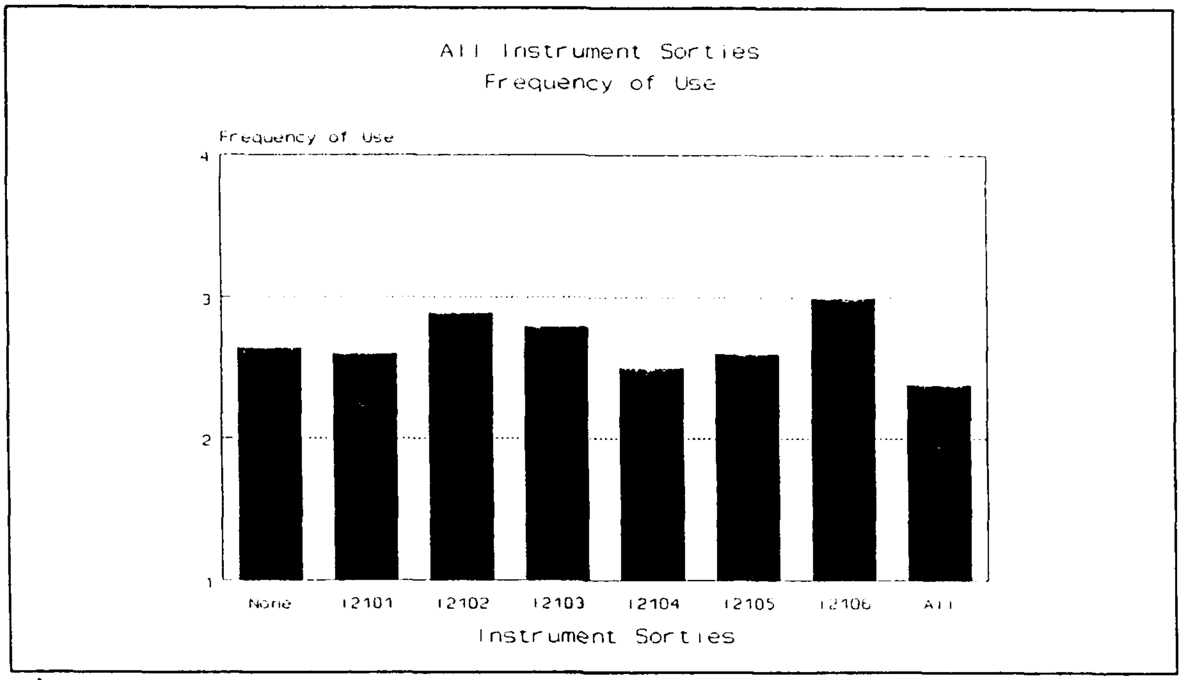


Figure 5.
UPT Student Responses Based on Instrument Sorties Completed to Probable Frequency of Usage.

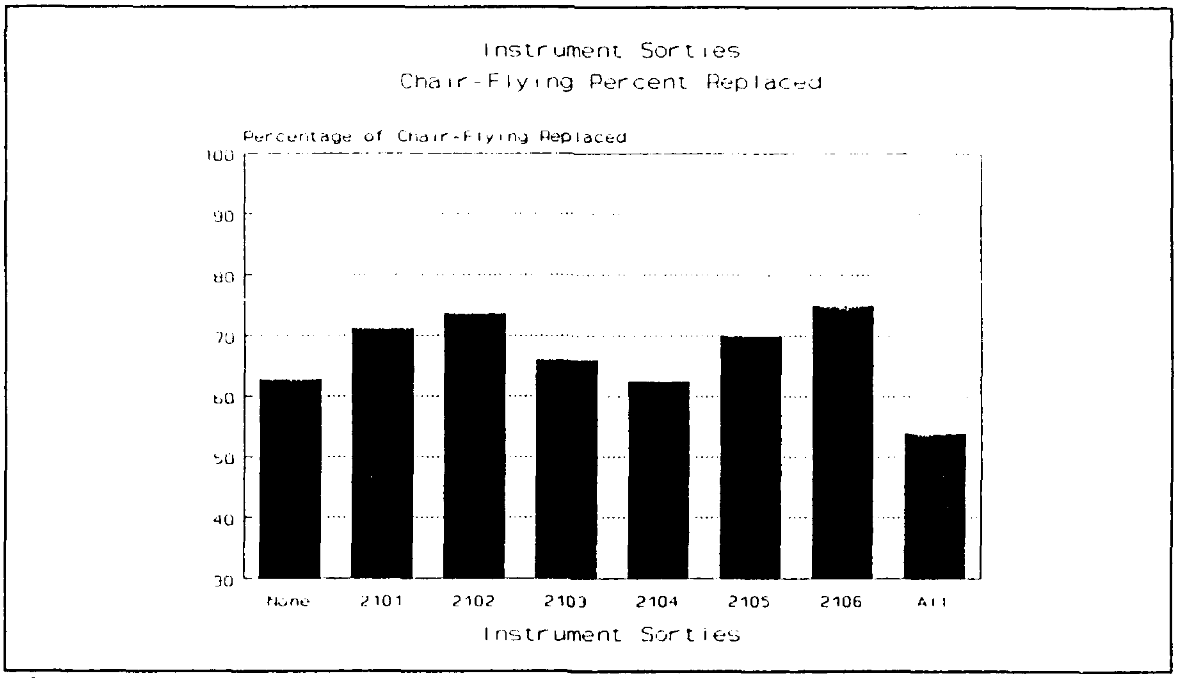


Figure 6.
UPT Student Responses Based on Instrument Sorties Completed to Probable Percentage of Chair-flying Replaced by PC Simulation.

Students' comments were not very informative. Most students were simply restating their answers to the survey questions. The notable exception came from students already finished with instrument training. A number of those students seemed to echo these sentiments, "It's a good idea, but I was able to finish instrument training without a micro-based simulation; so should anyone else."

DISCUSSION

It appears there is a higher interest level in using microcomputer simulation in those students entering UPT than in those who have completed instrument training using traditional chair-flying methods. This suggests that students are willing to use such a program early in training and are willing at certain crunch points--IFS missions 1 and 2, IFS missions 7 and 10, and sorties I2102 and I2106. The lower overall interest at the completion of T-37 instrument training may reflect the belief that they could finish without it and so could anyone else.

The lower frequency of usage at IFS mission five may be attributed to the forthcoming mid-phase contact check ride, and the feeling no extra time would be available until after the check ride is completed. The first peak at IFS mission 2 is probably due to the novelty of flying on instruments with no outside references available. The peak at IFS mission 10 is probably attributable to the difficulty of the tasks being performed. The tenth IFS mission is the point at which the student combines instrument procedures and begins flying missions in real-time--from takeoff, through the mission, and through the first instrument approach--with very limited use of freeze and reset functions.

The lack of distinct peaks on the instrument sortie comparisons is the result of having a greater number-range of IFS missions completed for each aircraft sortie completed. That is, IFS comparisons provide a much finer-grained method of pinpointing student interest. For specific instrument aircraft sorties, students could have completed several different IFS missions. The sortie comparison does yield an interest peak later in training than the simulator mission comparisons though. Interest peaking at I2106 may be the result of feeling inadequately prepared for the upcoming check ride two sorties later.

A microcomputer simulation could be used with highly motivated students after two distinct IFS missions, #2, I1302 or #7, I1403. After I1302, students could gain extra practice in applying basic instrument cross-check procedures. This practice could improve the fundamentals of the instrument cross-check early in training. Having a good background in basic skills would allow students to concentrate on learning more demanding tasks in subsequent IFS missions rather than continuing to work on the basics. Having had two IFS missions with an instructor should allow students to have at least a basic understanding of the instrument cross-check and the concept of performance and control instruments.

Upon completion of I1403, the students again become motivated to use a microcomputer simulation to enhance their training. This mission is also a point where the instrument training is expanding greatly. Students are beginning to be required to fly multiple instrument procedures in a real-time mode. For instance, students are being required to fly a fix-to-fix, enter a holding pattern, and then commence an instrument approach procedure--all in real-time.

This scenario easily task-saturates most UPT students. This overtasking is reflected in the increased interest UPT students have between simulator missions 7 and 10 toward the use of microcomputer simulation to aid their training. Students could begin flying actual instrument profiles after I1403; this would ensure they have had seven IFS missions with IPs, three of those flying more advanced procedures/profiles. This experience is the minimum necessary to ensure the students have a basic understanding of the more advanced instrument procedures/profiles.

Another possible use a microcomputer simulation could fill is for students experiencing difficulty applying certain procedures. An IP could direct the student to fly certain procedures or profiles in a reactive microcomputer simulation rather than simply instructing the student to review the procedures and chair-fly them. This type of simulation would offer UPT students the capability to practice an entire mission prior to doing it in the IFS with an IP. The additional practice students could receive might allow them more time to master the advanced procedures rather than barely meeting the minimum requirements.

CONCLUSIONS AND RECOMMENDATIONS

While attempting to learn instrument procedures, UPT students indicated they were eager to use a microcomputer simulation. It would appear students are motivated enough to use a microcomputer simulation to learn T-37 instrument/navigation procedures provided the simulation responds appropriately. This interest should allow a thorough test using T-37 UPT students to determine actual benefits and the potential training transfer of such a simulation.

My recommendation, based on the level of interest UPT students have shown toward using a T-37 microcomputer simulation, is to develop a research plan in coordination with the 82 FTW and Air

Training Command Headquarters to investigate training transfer effects of a microcomputer simulation tailored for T-37 instrument/navigation procedures. As a follow-on, this survey questionnaire could be incorporated to see whether motivation to use the simulation increases after use. If a positive training transfer is demonstrated, then a wider application throughout UPT would be justified.

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Appendix
Survey Instrument
UPT Student
Micro-Computer(PC) Based Simulation Survey

Name (optional):________________________ Rank:___________
UPT Class:__________

Previous experience-prior to UPT (hours, aircraft, & ratings):
____
____

Please mark the most recently completed UPT activities:

In Phase I____ Phase I(preflight)____ Instrument Sortie I____
Instrument Sim I____ Contact Sortie C____ Acad. Course______

Please circle the appropriate response.

1. Have you ever used a computer? (any type) Yes No

2. Have you ever played a game on a computer? Yes No

3. Have you ever used any of the following:
   Microsoft Flight Simulator Yes No
   Yeager's Advanced Flight Trainer (AFT) Yes No
   Other Flight Trainers Yes No

4. If a T-37 PC instrument flight simulator program were available, how likely would you be to use it? Circle one.

   Never Weekly Daily Every Possibility

   Why? ____

5. How much would you use a T-37 flight simulator program to replace traditional "chair-flying" to increase instrurent/navigation skills? (percentage) Circle one.

Won't Use		Half-n-Half		Replace Chair-flying
0	25	50	75	100

6. If you would use it, when would it be most beneficial? Circle one.

   Phase I During T-37 Basic sims
   T-37 Basic Inst. Academics Before First Inst. Sim
   T-37 Adv. Inst. Academics I14xx Sims I15xx

   Why?____
   ____

For additional comments, please use the reverse side.