

## TRANSFER OF TRAINING EFFECTIVENESS OF A FLIGHT TRAINING DEVICE (FTD)

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A transfer of training research design was used to measure the effectiveness of a flight training device (FTD) and to determine the point at which additional training in a FTD was no longer effective. The dependent measures were number of trials to specific completion standards, time to complete a flight lesson, and time to a successful evaluation flight. Percent transfer and transfer effectiveness ratios (TERs) were computed for each instrument task and for the time to complete a flight lesson. The data from the current study indicates that the FTD and the PCATD appear effective in teaching basic and advanced instrument tasks to private pilots but the limited number of subjects prevented this effectiveness from being convincingly demonstrated. As a result of prior training in an FTD and a PCATD time to a stage check or an instrument rating flight check flight was less when compared to an airplane control group.

### Introduction

In an earlier study by Taylor et al., (1996), a commercially available Personal Computer Aviation Training Device (PCATD) was evaluated in a transfer of training experiment to determine its effectiveness for teaching instrument tasks. The data indicated that transfer savings for both the number of trials to reach a performance criterion for instrument tasks and time to complete a flight lesson were positive and substantial for new instrument tasks. A comparison of instrument rating course completion times resulted in a saving of about four hours in the airplane as a result of prior training in the PCATD. As a result of the Taylor et al. (1996) study, a Federal Aviation Administration (FAA) advisory circular published in 1997 permits 10 hours of instrument training to be completed in an approved PCATD.

To evaluate transfer of training effectiveness of a flight training device (FTD), the performance of subjects trained on instrument tasks in an FTD and later trained to criterion in an airplane must be compared to the performance of subjects trained to criterion only in the airplane. Roscoe (1971) demonstrated that the transfer effectiveness ratio (TER) accounts for the amount of prior training in ground trainers by specifying the trials/time saved in the airplane as a function of the prior trials/time in the ground training. Because diminishing transfer effectiveness ratios as the number of trials or hours in ground trainer increases, additional ground-based training will at some point cease to be cost effective. The law of diminishing returns adequately describes this relationship between extra training and resultant benefit. The purpose of the present study was to use an incremental transfer of training research design to measure the effectiveness of an FTD and a PCATD to determine the point at which additional training in a FTD or a PCATD is no longer effective.

### Method

#### Participants

Participants were assigned to four FTD (Frasca) groups, one PCATD group, and a control (airplane) group. In the initial proposal a total of 180 pilots (30 in each of the 6 groups) were scheduled to participate in the study. Due to funding reductions in the second and third years, the number of pilots in the study was first reduced to a total of 120 pilots (20 subjects in each group) and due to the elimination of FY 2005 funding the eventual number of participants for each group who successfully completed the instrument program ranged between 15 and 20. The participants were University of Illinois, Institute of Aviation private pilot students, who were enrolled in the Institute's instrument flight program. This program consists of two semester courses: AVI 130, Basic Instruments and AVI140, Advanced Instruments. All students in the instrument program were involved in the study. A total of 106 students completed the study. Each semester the students were assigned equally to the six groups while maintaining a balanced number of subjects across all groups to account for students who did not complete the course prior to completion.

#### Equipment

Training in the FTD was conducted in four Frasca 141 FTDs with generic single-engine, fixed-gear, and fixed-pitch propeller performance models. The PCATD training was conducted using FAA approved PCATDs from Aviation Teachware Technologies (ELITE) v. 6.0.2, with flight controls by Precision Flight Controls. These PCATDs simulated the flight characteristics of the Piper Archer III aircraft. Airplane training was carried out in the Piper Archer III

aircraft, which is a single-engine, fixed-pitch propeller, fixed undercarriage aircraft.

### Procedure

The Frasca groups received 5, 10, 15, and 20 hours of prior instrument training in a FTD, respectively, and the PACTD group received 5 hours of prior training in the ELITE PCATD. With the exception of the cross country training for Frasca groups 15 and 20 the prior training was distributed equally between AVI 130 and AVI 140. A Control group received all training in the airplane. Training on selected instrument tasks using the FTD and PCATD was administered to the four FTD groups and the PCATD group during four flight lessons for each semester. In addition, FTD training was given during certain x-country lessons in both AVI 130 and AVI 140 for the 15 and 20 hour FTD groups.

Prior to the start of each semester, all flight instructors were standardized on the use of the FTD and PCATD, changes in the training course outlines (TCOs), and experimental procedures. Flight instructors served as both instructors and data collectors. They rated student performances on designated flight tasks in the aircraft. For performance assessment in the aircraft, each instructor recorded if the student met the completion standards during the execution of the designated flight tasks. They also recorded the number of trials to criterion for specific tasks and flight time to complete a flight lesson (Phillips et al., 1995). Four check pilots, blind to the allocation of students to training conditions, were used to conduct the AVI 130 stage check and the AVI 140 instrument rating flight check.

Each flight instructor was instructed to schedule a stage check after Flight Lesson 40 in AVI 130, and an instrument rating flight check after Flight Lesson 55 in AVI 140 when the student was judged to be able to meet the proficiency standards for the stage check and the instrument proficiency check, respectively. These check flights permitted the assessment of the differential time to complete the flight course as a function of the amount of prior training in the FTD and the PCATD. Those students who failed the evaluation flight or failed to meet the proficiency standards by Flight Lesson 45 (stage check) and Flight Lesson 60 (instrument rating check flight) were provided additional flight time to reach proficiency. Dependent measures were trials in the airplane to proficiency, time to complete the flight lessons in the airplane, and total course completion time in the airplane for both courses.

Mean number of trials to reach criterion in the airplane for selected instrument tasks, and mean time to complete the flight lesson in the airplane were computed for all groups for both courses. Analyses of Variance (ANOVA) were performed to analyze the differences between the six groups. ANOVA were used to determine the significance of the trial variable and flight lesson completion time variable as a function of experimental treatment for both AVI 130 and AVI 140. Finally, ANOVA were used to determine the significance of the differences of the time to a successful check flight for the AVI 130 and AVI 140 courses as a function of the experimental treatment for the three groups (PCATD, FTD 5 and 10 groups) that received only prior training only on instrument tasks compared to the control group. To further identify the locus of any significant effects, post-hoc tests were used to make specific pairwise comparisons using Tukey's test of significance.

### Results

A total of 124 subjects successfully completed the AVI 130 Basic Instruments course and took the final check ride. Table 1 shows the results of the check ride for the six groups. A total of 75 students passed the check ride on the first attempt and 49 students passed on the second attempt. Nine students were recommended for a remedial course, AVI 102. The total dual flight time to completion for the six groups is shown in Table 1 and in Figure 1. The average dual flight time to course completion for the airplane group was greater than the average time for each of the five experimental groups who had prior training in the PCATD or the FTD. The airplane group required 22.35 hours of dual to complete the course while the five experimental groups, after prior training in the PCATD or the FTD, required between 18.31 and 20.87 hours of dual flight time in the airplane to complete the course.

For AVI 130, ANOVAs were computed to determine effect of the experimental treatment (assignment to groups) for mean trials to criterion in the airplane for selected instrument tasks for the four flight lessons for the three groups (PCATD, FTD 5 and 10 groups), that received prior training only on instrument tasks, and the control group. For Flight Lesson 37, there was a significant difference for both ILS and VOR ( $F(3,81)=2.78$ ;  $p < .05$  and  $F(3,81)=5.12$ ;  $p < .05$  respectively) and for Flight Lesson 38 there was a significant difference for VOR and DME ARC ( $F(3,81)=2.84$ ;  $p < .05$  and  $F(3,81)=2.70$ ;  $p < .05$  respectively). No other instrument tasks were significant. For Flight Lesson 37, pairwise comparisons using Tukey's test of significance indicated a sig-

nificant difference between the airplane and the Frasca 5 and 10 groups ( $p < .05$ ). ANOVA were computed to determine effect of the experimental treatment for mean time to complete the flight lesson for the four flight lessons for the PCATD, FTD 5 and 10 groups and the control group. A significant treatment effect was found for Flight Lessons 34/35, 36, and 37 (all  $p < .05$ ). Pairwise comparisons indicated a significant difference between the airplane and all three groups for Flight Lesson 34/35 and between the Airplane and the Frasca 5 and 10 groups for Flight Lesson 37 (both  $p < .05$ ). An ANOVA to determine effect of the experimental treatment for total course completion time in the airplane was computed. A significance difference was found ( $F(3,80)=3.67$ ;  $p < .05$ ). Pairwise comparisons using indicated a significant difference between the airplane and the Frasca 5 group ( $p < .05$ ).

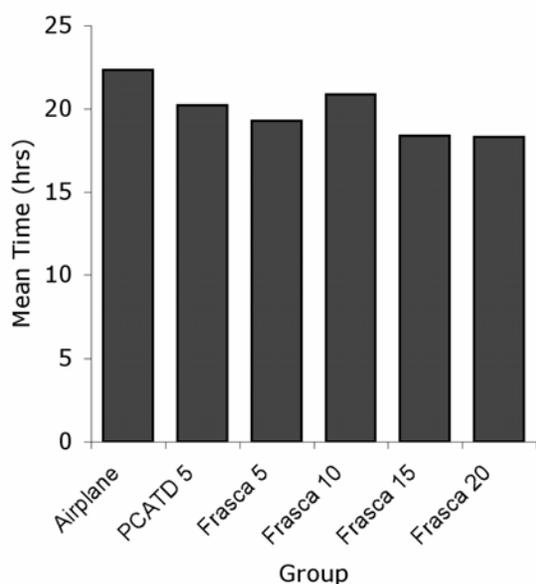


Figure 1. Total time to successful completion of flight lesson 45, showing incremental transfer effectiveness of the experimental groups.

A total of 106 subjects successfully completed the AVI 140, Advanced Instruments course and took the final check ride (the instrument rating flight check). Table 2 shows the results of the check ride. A total of 51 students passed the check ride on the first attempt and 46 students passed on the second attempt. The total dual flight time to completion for the six groups for the advance instrument course (AVI 140) is shown in Table 2 and in Figure 2. The average course completion time for the airplane group is greater for each of the five experimental groups who had prior training in the PCATD or the FTD. The airplane group required 26.38 hours of dual to complete the

course while the total dual hours in the airplane to completion for the five experimental groups ranged from 25.78 to 20.79 hours after prior training in the PCATD or the FTD.

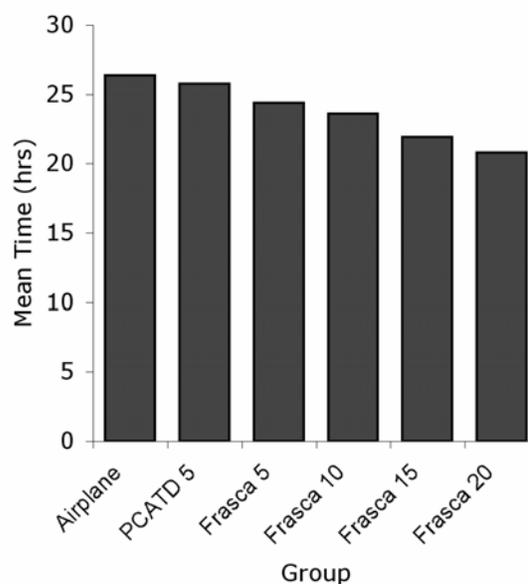


Figure 2. Total time to successful completion of flight lesson 60, showing incremental transfer effectiveness of the experimental groups.

For AVI 140, ANOVAs were computed to determine effect of the experimental treatment (assignment to groups) for mean trials to criterion in the airplane for selected instrument tasks for the four flight lessons for the three groups (PCATD, FTD 5 and 10 groups), that received prior training only on instrument tasks, and the control group. For Flight Lesson 48, there was a significant difference for ILS approach ( $F(3,77)=2.90$ ;  $p < .05$ ). Pairwise comparisons indicated a significant difference between the PCATD 5 and the Frasca 5 group ( $p < .05$ ). For Flight Lesson 50, there was a significant difference for NDB approach ( $F(3,77)=3.90$ ;  $p < .05$ ). Pairwise comparisons indicated a significant difference between the Airplane and the PCATD 5 and the Frasca 5 groups ( $p < .05$ ). For Flight Lesson 52, there was a significant difference for NDB Hold and GPS approach ( $F(3,76)=3.34$ ;  $p < .05$  and  $F(3,75)=3.14$ ;  $p < .05$  respectively). Pairwise comparisons indicated a significant difference between the PCATD 5 and the Frasca 5 groups for NDB Hold ( $p < .05$ ). ANOVA were computed to determine effect of the experimental treatment for mean time to complete the flight lesson for the four scored flight lessons for each of the three groups (PCATD, FTD 5 and 10 groups) that received only prior training on instrument tasks and the Control group. A significant treatment effect was

found for Flight Lesson 52 ( $F(3,76)=5.79; p < .05$ ). Pairwise comparisons indicated a significant difference between the PCATD 5 and the Frasca 5 and 10 groups ( $p < .05$ ). An ANOVA was computed to determine effect of the experimental treatment for total course completion time in the airplane for AVI 140. A significance difference was found ( $F(3,65)=2.77; p < .05$ ). Pairwise comparisons indicated no significant difference between any groups.

The effect of allocating 5 and 10 hours in the Frasca for cross-country flight was evaluated. For AVI 140, the airplane group required 26.38 hours of dual to completion while the Frasca 10, 15 and 20 groups required 23.60, 21.93 and 20.79 hours respectively. This represents a savings of 2.78 hours, 4.45 hours and 5.59 hours respectively. Since the Frasca 15 and 20 groups received the same treatment as the Frasca 10 group regarding training only on instrument tasks and an additional 5 and 10 hours respectively for cross country training, the computed savings for the 5 and 10 hours cross country time was 1.67 and 2.81 hours respectively.

#### Discussion

The data from the current study indicates that the FTD and the PCATD appear effective in teaching basic and advanced instrument tasks to private pilots but the limited number of subjects prevented this effectiveness from being convincingly demonstrated. With the limited number of subjects and the current variability among subjects, the power of the ANOVA is low. The current data fail to replicate the findings of Taylor et al. (1996, 1999) that PCATDs are useful to teach instrument tasks to private pilots. As a result of prior training in an FTD and a PCATD, time to the stage check in AVI 130 and to the instrument rating flight check was less for three groups (PCATD, FTD 5 and 10 groups) that received prior training only on instrument tasks as compared to the control group. For AVI 130, pairwise comparisons indicated a significant difference between the airplane and the Frasca 5 group and for AVI 140, pairwise comparisons indicated no significant difference between any groups. One purpose for conducting an incremental transfer of training study is to determine at what point additional training in the FTD and the PCATD is no longer effective. The data collect does not permit this to be determined convincingly. A study by Taylor et al., (2002) clearly indicated that the use of 5 hours of PCATD time was cost-effective based on the allocation of PCATD time for these tasks for the PCATD 5 group. The current study shows that the PCATD is only effective for the NDB task. We attribute the

difference between the two studies to be the result of the lack of power in the current study.

Time to complete the flight lesson was significant for three flight lessons out of four for AVI 130 when comparing the PCATD, FRASCA 5 and 10 groups with the Control group, but for only one flight lesson out of four for AVI 140. Taylor, et al (2002), which tested the incremental effectiveness of the PCATD, found two of four flight lessons significant for AVI 130 and one for AVI 140.

We do not believe that data generated in the current study provides convincing evidence for flight schools to use in determining how to best implement PCATDs or FTDs in their training programs. There is the possibility that FTDs can be used effectively for teaching cross-country procedures in addition to using them to teach instrument tasks, but the current study has failed to demonstrate significant savings through their use.

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Table 1.  
*Flight Lesson 45 Statistics (Fall, 2002, Spring, Summer, Fall 2003 and Spring 2004)*

	Airplane Only	PCATD 5.00	Frasca 5.00	Frasca 10.00	Frasca 15.00	Frasca 20.00
Number of Students	22	20	22	20	21	19
% First Flight Pass Rate	59.00 (N=13)	65.00 (N=13)	45.45 (N=10)	75.00 (N=15)	76.19 (N=16)	42.11 (N=8)
% Second Flight Pass Rate	100.00 (N=9)	100.00 (N=7)	100.00 (N=12)	100.00 (N=5)	80.00 (N=5)	100.00 (N=11)
Students Recommended 102	0	0	1	1	4	3
Total Dual to Completion	22.35 (N=22)	20.20 (N=20)	19.27 (N=22)	20.87 (N=20)	18.36 (N=21)	18.31 (N=19)
Variance Tot. Dual to Completion	9.39	6.40	10.03	14.17	9.87	9.48

Note: This lesson is the final check ride for AVI 130.

Table 2.  
*Flight Lesson 60 Statistics (Spring, Summer, Fall, 2003, Spring, Summer, Fall 2004)*

	Airplane Only	PCATD 5.00	Frasca 5.00	Frasca 10.00	Frasca 15.00	Frasca 20.00
Number of Students	18	18	20	16	15	19
% First Flight Pass Rate	44.44 (N=8)	55.56 (N=10)	45.00 (N=9)	43.75 (N=7)	40.00 (N=6)	57.89 (N=11)
% Second Flight Pass Rate	100.00 (N=10)	75.00 (N=6)	88.89 (N=8)	88.89 (N=8)	100.00 (N=9)	62.50 (N=5)
Students Recommended 102	2	3	4	3	5	2
Total Dual to Completion	26.38 (N=18)	25.78 (N=17)	24.40 (N=18)	23.60 (N=16)	21.93 (N=15)	20.79 (N=18)
Variance Tot, Dual to Completion	16.55	6.03	7.92	8.80	10.20	17.89