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FORUM***THE PCATD's ROLE IN THE COGNITIVE PROCESSES
OF FLIGHT TRAINING***

Amy Combs

It has been proven that performance on one task, such as flight in an aircraft simulator, may aid or facilitate performance on a second task (flying the actual aircraft). This concept is known as positive transfer, or learning to make the same response to new but similar stimuli. Positive transfer is an important issue in the area of aviation simulation and has been the basis for a variety of research experiments conducted by the FAA, NASA, the US military, and academia.

In previous years, it was presumed that simulators with high fidelity, or realism, would produce the greatest amount of transfer. However, recent studies of the cognitive processes have led to the questioning of that presumption. It would be much more efficient and economical to use part-task, low fidelity trainers in flight school programs. Because of the idea that higher fidelity produces greater transfer, the effectiveness of a low fidelity training device has not been widely accepted in the industry. However, in 1997, despite criticism, the Federal Aviation Administration (FAA) approved a Personal Computer Aided Training Device (PCATD) as a substitute for ten hours of actual aircraft time in instrument training. The PCATD is PC based and utilizes a Microsoft Windows type Technology. Several Universities have completed studies concerning the transfer of training from the PCATD to the actual aircraft in an attempt to verify its effectiveness as a training device and its economic feasibility to the school's flight training program.

University Studies of the PCATD

Many universities have researched the use of the PCATD in a flight training program and have found a wide range of results varying from a 42.8% positive transfer to the aircraft to a -25% transfer (Roscoe). However, only the results found by Andrews University, Middle Tennessee State University, and the University of Illinois are presented in this report.

Andrews University conducted a study involving sixty subjects with no previous flight experience. Thirty subjects

participated as a control group which completed training in the aircraft only. The thirty remaining students formed the experimental group; these students practiced a pre-determined maneuver on a computer based training device before attempting the same maneuver in the aircraft. The software used was AzureSoft's Electronic IFR Training Environment and the hardware consisted of a monitor, flight stick, and rudder pedals. The simulation was set to model the performance capabilities of a Cessna 150/152. The experimental group was required to complete the maneuver on the computer training device within the following limits:

Altitude	+/- 100 ft
Heading	+/- 10 degrees

Bank Angle	+/- 10 degrees
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The maneuver consisted of flying a squared pattern involving flying North, East, South, and West headings for 1.5 minutes each with right turns at the end of every leg and a 450 degree turn to the right after the West leg ending on a North heading.

The Andrews study found that the experimental group, after performing the maneuver on the training device, took an average of twelve minutes and twenty three seconds in the airplane to meet performance criteria as compared to an average of twenty minutes and twenty three seconds for the control group. Andrews University published a report of the study claiming a 48% transfer rate (Ortiz, 1993)

Middle Tennessee State University conducted an

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experiment similar to that of Andrews University; however the MTSU study was conducted with a very small number of participants. Again, students with no previous flight experience were divided into experimental and control groups. A second experimental group was formed in the MTSU experiment but its purpose is irrelevant to this report and will be ignored. This experiment required the students to complete a 90 degree left turn followed by a 360 degree right turn. Both groups were to perform the task within the same limits as the Andrews University study. MTSU found an 8% transfer rate between the PCATD and the aircraft. The average number of attempts to meet criteria in the aircraft for the experimental group equaled 1.3 with an average time of 3.8 minutes. The control group took an average of 1.75 tries to perform the maneuver within limits with the average time of 5.04 minutes. The transfer effectiveness ratio was found to be .12 (Ferrara, 1999).

The FAA based its approval of the PCATD on the study conducted by the University of Illinois. Once again, this study was performed under the same basic methodology; however, the University of Illinois selected students who had already obtained their private pilot's license. This study was designed to test the PCATD as a device for instrument flight procedures and required subjects who already possessed knowledge of visual flight. The experiment required the 47 subjects in the experimental group to practice various instrument maneuvers and approaches (series of maneuvers to line the aircraft up with the runway for final approach when weather conditions obscure the runway from the pilot's view) before performing them in the aircraft. The study revealed an average Transfer Effective Ratio of .15 which is almost identical to that of the MTSU study. The University of Illinois also reported that the PCATD was far more effective for introduction to maneuvers than for their review (University of Illinois, 1996).

There has been a wide range of research conducted on the use of the PCATD with varying results and all results showing under 50% transfer rates. These results make the validity of the PCATD as a substitute for logged instrument training time questionable. However, the remainder of this report focuses on the reasons behind the low transfer rates and why the PCATD should be used as a substitute for ten hours of aircraft training time.

Low Transfer Rates

In response to the University of Illinois study and the

FAA approval of the PCATD, Rudy Frasca, owner of the well known flight simulation company Frasca International, Inc., wrote an article entitled PCATDs Counterpoint. In this article, Frasca claims:

Approved simulators are quite complex. The proponents of the PCATD only see the tip of the iceberg. Simulator manufacturers like myself have to be aware of the whole iceberg, the big picture, when it comes to simulation..... We therefore conclude that PCATD's should only be used as a supplement to an instrument course- outside of the instrument hour requirements. (1998)

Frasca is correct in stating that the PCATD is only the tip of the iceberg in regards to its fidelity. In all fairness the PCATD is a crude attempt at producing a realistic flight environment. It is commonly thought that the greater the stimuli similarity, in this case the PCATD and the aircraft, the higher the transfer rate. The Encoding Specificity Principle supports this idea by claiming that the amount of overlap between the conditions at the time of encoding (practice in PCATD) and the conditions at the time of test (performing maneuver in aircraft) affect the amount of transfer (Reed, p.63). The greater the overlap the better the test results. Obviously there is a low encoding specificity between the PCATD and the aircraft; the environmental conditions of sitting in front of a computer screen versus being in an airplane are very different. The PCATD does not provide a realistic visual field nor does it produce any non-visual physiological cues of motion that are continuously present in the cockpit.

In addition to the absence of physiological indications of motion, there is also another factor that may influence the results of the study of transfer between the PCATD and the aircraft. It has been proven that stress affects performance. Paul Fitts, author of Human Performance, defines stress "not as a condition that feels stressful to the individual but by a specification of the demands that the environment places on the individual"(p.33). Stress has the same way of testing man as it does machine and materials. "Stress on a system is varied by changing the load, temperature, vibrations, etc.." (Fitts, p.33). Different environmental stresses present in the airplane combine in complex ways and affect human performance. The failure to perform a specified maneuver within limitations in the airplane, after having practiced it on the PCATD, may not be the result of a failure of transfer. When a student is practicing instrument approaches on a PCATD, he/she is not subject

to noise from the propeller, turbulence, hazardous weather cells, or extreme temperatures. It is apparent that the demands of the environment are capable of decreasing performance in the cockpit.

Again, the PCATD's poor fidelity may cause it to be regarded as the "tip of the iceberg" as it is in Frasca's opinion. However, when examining the role of the PCATD in the "big picture" the device's training capabilities are apparent.

The Learning Process

Richard Jensen, author of *Aviation Psychology*, acknowledges that there is a growing trend away from "total reliance on simulator realism" (p.126). Perhaps this is due to the advancing research in cognitive psychology which is providing more information about the learning process. There is a growing recognition that learning efficiency can frequently be enhanced by part-task training. "Virtually all tasks can be considered to be comprised of subtasks or task elements which, while not unrelated to the overall task, can be practiced and learned independently, up to a point, in limited and much less complex and costly task settings" (Jensen, p.126). In opposition to the PCATD, Rudy Frasca commented:

Most of us took typewriting courses in school. If our schools had decided to save money by using typewriter simulators that had only half the keys, we'd have had a problem. After becoming proficient on the part-task typewriter, we would have had to unlearn then relearn, using the real thing. (1998)

However, research conducted by Paul M. Fitts along with supporting evidence from various experiments studying the transfer of learning contradict Frasca's opinion. In fact, the experiments reveal that learning in parts is more efficient than learning a whole concept at once. Fitts discovered that learning of complex tasks takes place in three distinct phases. "Each of these phases involves a distinct set of psychological processes, and a considerable amount of research indicates that these processes can be supported by practice settings having limited but task relevant information processing capabilities" (Jensen, p.126). Fitts' three phases of learning include the cognitive phase, the associative phase, and the autonomous phase.

During the cognitive phase, the student develops knowledge about the system and its characteristics and functions. It is during this phase that instructions and

demonstrations are most effective. The early stage of learning is characterized by the transfer of very general modes of attack (Fitts, p.12). It is apparent that the use of the PCATD can support this stage of learning. "It is commonly observed that individuals improve in their ability to learn new tasks when they have practiced a series of related or similar tasks" (Ellis, p.32). This improvement in performance is defined as "learning to learn". In the process of learning to learn, a student appears to be learning general approaches or modes of attack, becoming familiar with the situation and learning related classes of materials (Ellis, p.33). The PCATD is an excellent tool to aid the learning to learn process because fidelity does not affect this nonspecific transfer. "Nonspecific transfer is a general concept that refers to transfer not dependent upon any specific features of the task, but dependent upon more general characteristics such as modes of attack and general principles" (Ellis, p.35).

In addition to, or perhaps in parallel to, the learning to learn process, stimulus predifferentiation also takes place in the cognitive stage of learning. "Stimulus predifferentiation refers to the facilitation in learning a new stimulus response task as a result of some type of preliminary experience or practice with the stimuli themselves" (Ellis, p.49). It may not be necessary to pair the stimulus and response in order to obtain positive transfer; exposure to the stimulus and the chance to discriminate between stimuli will aid in transfer. For example, regardless of the student's flight performance on the PCATD, simply exposing the student to the different types of instrument approaches (NDB, VOR, ILS, etc), holding patterns, and entries to holding patterns will help the student when attempting the instrument procedure in the aircraft. As the amount of generalization among stimuli is reduced the amount of positive transfer will increase.

Stimulus predifferentiation is a contributing factor to the next element of the cognitive phase which is referred to as mediation processing. The PCATD is responsible for creating mediating responses; these responses are mechanisms for producing transfer. The ease or difficulty of learning depends on the availability of mediation responses which are based upon previous learning experiences (Ellis, p.36). Training in the PCATD increases the availability of mediating responses which provide for an easier learning of maneuvers in the aircraft. The responses serve to bridge the gap between being told to perform a

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maneuver and actually implementing the maneuver. The mediation process is an acquisition of pieces of knowledge which come together to allow the pilot to know the correct process for performing a maneuver.

In the associative phase of learning, "old habits which have been learned as individual units during the early phase of skill learning are tried out and new patterns emerge" (Fitts, p.12). During this stage, more specific stimulus-response relations are transferred to the new activity. Mistakes such as incorrect procedures or responses to wrong cues are gradually eliminated. "The [associative stage] lasts for varying periods of time depending on the complexity of the skill and the extent to which it calls for new subroutines and new integrations" (Fitts, p.12). It is vital to the student in this stage to practice extensively. It has been proven that a small amount of practice will lead to negative transfer, while a greater amount will approach zero transfer, with a substantial amount of practice leading to positive transfer. The findings of the study of practice on transfer rates produce a U shaped curve, or parabola (Ellis, p.42). During this stage, learning to learn, stimulus predifferentiation, and mediation processing are integrated into knowledge that allows the student to implement his/her method of attack to a particular task or series of synchronized tasks.

The autonomous stage is recognized as the phase where skills require less cognitive processing and can be carried on while learning other activities. This stage relates more to flight in the aircraft. The PCATD affects the first two stages of learning far more than the autonomous stage; therefore, the focus of its use should be limited to the cognitive and associative phases.

Teaching for Transfer

In Henry Ellis'(1965) *Transfer of Learning*, the author emphasizes five steps of teaching that lead to transfer.

1) "Maximize similarity between teaching and the ultimate testing situation"(p.70):

As stated earlier, the PCATD does not have the fidelity required for maximum transfer; however, it is possible to produce similarity between the procedures to complete a maneuver on the PCATD and the procedures to complete the maneuver in the aircraft. The flight instructor plays a crucial role in maintaining that the student follow the same steps on the ground as in the air.

2) "Provide adequate experience with the original task" (p.71):

Since extensive practice increases transfer, it is

important that the student has the opportunity to practice a maneuver until he/she has solid knowledge of it. An advantage of the PCATD is shown in this step. Sometimes aircraft scheduling, weather, maintenance, or the schedule of the flight instructor or student cause lessons to be rushed and often leave the student without adequate practice on a particular maneuver. The PCATD is not subject to these constraints and it provides the student with more practice time prior to a training flight or even following an inadequate flight.

3) "Provide for a variety of examples when teaching concepts and principles"(p.71):

Again, due to the constraints mentioned previously, flight instructors often have a hard time providing variety in lessons. A student may only have the opportunity to fly approaches at a limited number of airports. Because instrument approaches have numerous variables depending on what type of approach is being executed and at which airport the approach is being made into, it would be more advantageous to the student to use the PCATD since it is capable of providing a variety of stimuli (approaches, airports, weather conditions, etc).

4) "Label or identify important features of a task" (p.72):

This step relates to stimulus predifferentiation. The PCATD offers exposure to various stimuli and allows the student to make distinctions between them.

5) "Make sure that general principles are understood" (p.72):

The cognitive stage of learning is a process of transferring very general modes of attack and strategies appropriate to previously learned skills which are also related to the new task. The PCATD gives the student the opportunity to grasp the general principles involved in the task and to "call upon" previously acquired knowledge which will aid in the determination of the mode of attack.

Conclusion

Upon observation of all the elements that contribute to learning, it is apparent that the studies mentioned in the first section of the report merely scratched the surface of the transfer capabilities of the PCATD. In spite of low fidelity, the PCATD has numerous features that contribute to the learning process. This training device supports the student through two vital stages of learning and enhances the elements that make up the stages. The PCATD may not produce a 100% transfer value from performance on the ground to performance in the air; however, it does yield a transfer of knowledge about the process required to perform

the maneuvers in the aircraft. The PCATD is a platform for understanding and recognizing various stimuli in the flight environment. Perhaps one of the most important functions of learning is the comprehension of an idea. PCATD provides a means for students to grasp a given concept and then practice performing it. Paul Fitts tells of a flight instructor who implemented the stages of learning in his flight lessons:

Alex Williams was highly successful in bringing novice aircraft pilots quickly to the level of proficiency in order for them to solo. His techniques emphasized the "intellectualization" of the pilots task. Williams conducted detailed discussions of each maneuver to be practiced, of the exact sequence of responses to be made, and of the exact perceptual cues to be observed at each step. Each lesson was followed by a short flight and then another discussion. (p.11)

In this experiment, Williams reduced the hours taken to solo by 6.5.

In Rudy Frasca's opinion, the PCATD should not be a substitute for ten hours of actual aircraft time due to the fact that the transfer value is not 100%. However, in this case, it is Frasca himself who is not looking at the big picture. Learning requires the elements of "learning to learn", stimulus predifferentiation, mediation processes, and skill integration which are present in the cognitive and associative stages of learning. Without the PCATD, these processes must take place in the aircraft, which most likely constitutes ten hours of flight time. When looking at the big picture, the PCATD is not substituting ten hours of flight time; it is simply supporting the student's acquisition of knowledge which in turn reduces the amount of flight time required to fully comprehend a particular maneuver or procedure.□

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