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General Aviation Pilots Transition to Advanced Cockpit Technologies and Adult Learning

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Pilots for many years have received training on the round instrument gauges. Can they now safely make the transfer to the new cockpit technologies? Studies show a cognitive deficit with pilots over the age of 40 making transitions to these advanced cockpits. Older pilots as well as older adult learners in general absorb and retain information differently than our younger counterparts. The training and instructional programs are now geared towards a one size fits all. According to the literature, problems seem to surface affecting older pilots. This article addresses these concerns.

Educational psychologists suggest that positive changes can be made for students in the area of adult education. This article will be looking specifically in the area of aviation and the transition of older pilots to technically advanced aircraft (TAA) and avionics. The learning process for these older pilots-- those over 40 and 50 years of age--should be approached in a different manor than present. Training and instructional programs are now geared towards a *one size fits all* and according to the literature, problems seem to surface that affect older pilots.

Pilots over 40 years and the Need for a Positive Change in Learning

Navigating an aircraft is a complex, time consuming and a highly-pressured activity and one that needs, to be explored in regard to new avionic technologies and aged pilots' abilities to safely transition to complex avionics. For "…older aviators, who typically experience age-related declines in cognitive abilities and visual acuity, these factors may play an even greater role during adverse weather conditions" (Kennedy, Taylor, Reade, & Yesavage, 2010, p. 489). O'Hare and Owen (2001) have stated that pilots equipped with more advanced avionics showed an increase in accident rates. "Comparing the numbers continuing on [in clouds] with those not continuing [visual conditions] shows a marginally significant difference between those using Global Positioning System (GPS) and those not" (O'Hare, & Owen, 2001, p. 80). O'Hare and Owen (2001, p. 81) also state "that as a result of the flight simulation study there is a tendency for pilots using a GPS navigation system [like the G-1000] in visual meteorological conditions (VMC) tend to behave differently from pilots using older methods of navigation, and at least two of these factors in decision making are age and recent flight experience."

Hamblin, Gilmore, and Chaparro (2006, p. 1979) state that "there can be a negative correlation with pilot's total flying time and their greater experience in traditional avionics may have more difficulty transitioning to Technically Advanced Aircraft i.e. computer screens (TAA)." He found that that pilots who accumulated a large amount of flight time in more traditional avionics setups had more trouble or even resisted transitioning to TAA. He also found that pilots who trained a flew using analog instruments acquired habits that were inadequate to learn and transfer to the new computer technology found on modern aircraft. However, research also showed that seasoned and experienced pilot's capacity and craving to learn are fundamentally the same as younger adult pilots under the age of 50 years when educators change the learning environment to address a slower learning rate and requirements for encouraging feedback (Broady et al., 2010). Difficulties with subjective learning because of age can be successfully neutralized by design and integration of positive encounters (Broady Chan, & Caputi, 2010). Broady et al. (2010) and Homko (2011) expressed that educators can enhance adult instruction in TAA for pilots over the age of 50 years by understanding their disposition toward technology.

There have been many studies of this using the quantitative methodologies. In setting the stage for a change in educational psychology and the need to understand learning for older adults this paper will present this prior research.

In the Kennedy et al. (2010) article looking at older pilots in particular, the sampling size used to conduct the testing of older pilots/younger pilot's verses moderate experience/high experience consisted of 72 pilots, 19 - 79 years of age, with two levels of IFR experience. The group with moderate experience was defined as having an IFR rating (instrument rated) or CFI (Certified Flight Instructor). The group considered with high experience was having a rating of CFII (Certified Flight Instructor-Instrument) or ATP (Air Transport Pilot). The study was modeled so that half the group were less than 40 years of age and the other half were 40 years and older. The two groups were further divided so that half of the *under 40* group were of moderate experience and the other half where considered high expertise. The *over 40* group was also divided the same way. Eligibility required a current FAA Medical Certificate.

Equipment used was a Frasca 141 flight simulator, "The simulator was linked to a computer specialized for graphics that generated a 'through-the-window' visual environment and continuously collected data concerning the aircraft's position and communication frequencies" (Kennedy et al., 2010, pp. 490-491)." The software was designed to collect flight data regarding accuracy of landings and holding pattern decisions. The project occurred from 0900 to 1600; and, pilots had the preference of choosing the time to participate in the simulation. The procedure was to fly three Instrument Landing System (ILS) approaches to Runway 30 at San Jose (SJC) airport with a 200-foot decision height. Three approaches were to be flown to a touch and go or a missed approach. IFR conditions were presented with fog down to minimums and another approach where the fog caused conditions below approach minimums. Each subject was to do two turns in the hold and then to be vectored to a six-mile final. In conclusion, the study showed that according to Kennedy et al. (2010):

> The negative correlation found between performance on the dual task cognitive measures and age suggests that age-related differences may be due to decrements in attention rather than decision making per se. However, the dual task cognitive measures did not significantly predict flight performance. Only speed of processing performance accounted for the age-related differences in aileron control. The results indicate that age-related declines in cognitive ability may affect certain aspects of flying an aircraft. (p. 495)

The results shown above as well as some of the solutions presented by Homko (2011) and Broady et al. (2010) may provide guidance on the cognitive learning that pilots, especially pilots over the age of 50 years whose experience is in conventional aircraft, can be utilized effectively in a different approach to learning. The Aircraft Owners and Pilots Association (AOPA) through the Air Safety Foundation stated that simulation should be used more extensively. TAA training should rely heavily on integrating various levels of simulation using scenario-based training integrating full TAA systems and instructors' stations to utilize different scenarios involving emergency and overload training. However, Computer Based Instruction (CBI) should be designed and implemented by taking into consideration the age and experience of the pilot. This will have an important effect on the transfer of learning from conventional to TAA. Kearns (2010) states "Clearly, the effectiveness of any e-learning [CBI] course will be directly linked to how the course is designed" (p. 28). How the course is designed and how effective it is in producing the desired results is the starting point for designing a course of study for the older, more experienced pilot. The focus of such a study would be pilots 50 years of age

and over, who had many years using conventional avionics and successfully transitioned to TAA aircraft through a properly designed and executed course. Ideally such a design could be used for those pilots looking into transitioning to TAA. Has the research been investigated for such a course design? What would it consist of? Kennedy et al. (2010) in their concluding remarks, states:

> Our findings suggest that providing older pilots with focused training in the flight simulator for situations that can carry a high degree of risk in real life, coupled with speed of processing training may be an ideal way to improve older aviators' flight safety. (p. 496)

Learning Theories to Improve Pilots Over 50 Years Old and Aviators Performance Constructivist Theories

McLeod (2018) in his article on Jean Piaget's Theory of Cognitive Development stated that *constructivism* is a learning theory by which a person comes to understand the information already possessed which has already been learned through that person's experiences. It has its foundation in cognitive psychology and its approach to education emphasizes that knowledge comes into fruition to adapt to the world in which the person is operating. Piaget's theory of constructivism impacts learning curriculum because teachers must make a curriculum plan which enhances their students' logical and conceptual growth.

Constructivist learning is just that--a constructive process where the learner is building internal knowledge from personal experiences. This knowledge does not deny the real world but contends to understand it within the context of the persons own understanding of it. A person grows from sharing these perspectives and by responding to new perspectives or experiences changing their internal understanding (Bednar, Cunnigham, Duffy & Perry, 1995). The challenge of constructivism occurs when a person changes by letting go of control from learning from the instructor to the student. The student is encouraged to achieve agreed upon objectives.

The objectives should be designed around the students' needs. This is based on their activities which emerge from the lives lived in context of their understanding and worldview. Hanckbarth (1996) states,

> The students should be working together with their peers in social construction of the meanings that are significant to them and the evaluation should not only be personalized but on going, it should be a shared analysis of their progress. (p. 11)

Bednar et al., (1995) in their article states that

> Agreeing with this view of knowledge, learning must be placed in a rich context, reflective of real-world context, for this constructive process to happen and transfer to environments beyond the school or training classroom. Learning through cognitive apprenticeship, mirroring the collaboration of real world problem solving, and using the tools available in problem solving situations, is

key. How effectual or instrumental the learner's knowledge structure is in facilitating thinking in the content field is the measure of learning. (pp. 103-110)

Strengths and Weakness of Constructivism Theory

One of the strengths of this theory is that students learn by experimenting--not by being told what to do, but discovering it for themselves (Mayer, 2004; Kirschner, Sweller, & Clark, 2006). This can enhance and strengthen a learner's knowledge and experience in an area of study. This leads to its weakness. While perhaps good for experienced students, it may not be so for the novice. The argument is that *learning by doing* strengthens learning, however, critics say that this strategy has little evidence for support with novice learners (Mayer, 2004; Kirschner, Sweller, & Clark, 2006). Sweller (1988) argues that novices do not have the experience of developed mental models that would be necessary for a *learn by doing* method. Mayer (2004) also reviewed the literature and found that the data over the last fifty years supports this and that situations with novices should be guided.

Applying Constructivism in Educational Practice

In this context, these older pilots are experienced in the aviation field, so constructivist ideas would work well in this area of adult education. *Pedagogy* deals in the area of instruction with children, however, instruction of adults has been referred to as *andragogy*. Andragogical methodology considers differences in learning with the understanding that adults have more experiences and existing schemas from life than children do (Knowles,1984). The theory of constructivism stresses that cooperative learning environment based on mutual planning and learning fit the needs of the student. The objectives are diagnosed needs and interest, which is foundational to the student's ultimately reaching their goal. This is relevant because of the involvement that the learner has in their progress to understand key concepts that are involved in the principle being applied using or emphasizing constructivism in adult education.

The study of cognition has many applications for educational psychology. Teachers need to help students learn by way of organizing information and thereby helping the student to relate one thing to another (Skinner, 1968). Information that is new will usually be acquired when a person associates one thing with another already learned. The teacher can then help a student understand new ideas by relating them to old ones; this would be positive transference (Skinner, 1968). Learning will be slowed, however, if that person is having trouble relating this new information to the old. It will become ineffective (Skinner, 1968).

From an operate conditioning perspective Skinner (1968) has stated that students should be actively responding if learning is to be achieved. Cognitivists emphasize mental activity as opposed to physical, believing that if students have control, the student would then decide what information is needed.

Scaffolding

The FAA (2003) states: "Pilot training will require emphasis and focus on higher order thinking skills to help pilots learn how to think instead of simply what to think" (p. 12). Higher

order thinking has been addressed using scaffolds as instructional procedures to provide temporary support for student's initial learning before they reach intended goals (Palincsar, 1986). Scaffolding is an important instructional concept because of the process it uses in guiding a learner from what they presently know to what is to be known. Vygotsky (1978) wrote that the notion of scaffolding was developed from "zone of proximal development" theory, which is, "the distinction between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (p. 86). Hogan and Pressley (1997) discuss scaffolding as modeling behaviors desired by offering explanations and having the students participate in their own verification of understanding the material.

Teaching Bloom's Taxonomy (Bloom, 1956) is a scaffolding device to improve higher order thinking (Hogan & Pressley, 1997). Through intellectual support scaffolding is used as an instructional device that provides the cutting edge of cognitive development to individual students (Hogan & Pressley, 1997).

Metacognitive skills, psychological type for heightened self-awareness, authentic learning, and cooperative learning - all cognitive processes and strategies used during problem solving are a part of scaffolding (Brown, 1987). The absence of such an integrated framework of scaffoldings can cause students to mindlessly and superficially attempt to problem solve without consideration of whether that idea makes sense on its own or how it integrates with other ideas (Pressley, Wood, Martin, King, & Menke, 1992).

Understanding Adult Learning

The field of adult education has grown since Knowles (1950) devised the term *andragogy,* which describes the way adults learn compared to pedagogy, or the way children learn (Henschke, 2009). Andragogy is based on certain assumptions and according to Knowles (1984) that as a person matures, learning becomes intrinsic and provides the motivation. Watkins and Marsick (2014) add five other factors to consider in adult education and learning:

- Their self-concept changes as it moves to being more independent.
- They accumulate knowledge from experience.
- Their readiness in relation to social roles.
- What is most relevant to them at the time.
- Their learning is centered on the problem at hand.

Educational theories have matured over time and andragogy may not be as widely accepted as it once was. Teaching of adults does have its challenges and the practice of adult education does have some exclusivities particular to it (Watkins & Marsick, 2014).

Adult education may have moved beyond andragogy, nevertheless, according to Merriam, Caffarella, and Baumgartner (2007) research has shown over the past decade for adults, learning from experience being self-directed are important for adult understanding. The discussion of adult educational development is a growing specialty in psychology that provides an understanding of an individual's learning preferences and capacity; similarly, cognitive science

has added to our understanding of how the brain functions in all developmental stages. Educational psychology may have advanced beyond the terms understood as andragogy as a field of study and moved beyond, however adult learning is still learning how one beyond school age develops their skills from higher education to the workplace or even professional development (Watkins & Marsick, 2014).

How Constructivism and Scaffolding Used in Unison can Affect Change with Pilots

Constructivism considers mutual planning important by taking into account the needs of the student. It is built on a cooperative learning environment with the objective of achieving and forming learning objectives that are based on the interest of the student.

Scaffolding on the other hand looks at the higher order of thinking skills that a pilot must use. It takes the learner from the known to the unknown. Scaffolding is designed to model the desired behavior or change in the student by offering explanations and engaging the student and verifying that the student understands the information presented to them. Its aim is the higher order of thinking as presented in Bloom's Taxonomy (Bloom, 1956) providing the necessary intellectual support the student needs. Bloom's Taxonomy is ideal in having students push the envelope of comfort and going a little beyond their personal comfort zones without being handheld by an instructor, building on the metacognitive skills along with cooperative learning for problem solving. It is these cognitive processes that allow the necessary strategies to develop for learning, especially in adults who are task oriented toward the goal that is set before them, such as learning a new avionics platform.

By combining constructivism, mutual planning, and understanding the specific needs of the student would have clear objectives. The goal is to develop the higher order of thinking skills to carry out the task by using the constructive blocks of Bloom's Taxonomy (Bloom, 1956). The development of Higher Order of Thinking Skills (HOTS), the older pilot can more easily transition to a very different type of avionics platform.

Analyzing the Evidence

Recent studies about age and learning have shown that even though some cognitive degradation occurs with age, older people's ability and desire to learn are not significantly different than younger people when the learning is specifically changed to address their slower learning rate and need for positive reinforcement (Broady et al., 2010). Broady et al. (2010) showed that recent training and positive experiences could effectively counteract the challenges of cognitive losses due to age.

Constructivism has its roots in cognitive and biological sciences. Its emphasis is the different ways for example that knowledge is created to help one adapt to their environment. Learning is a constructive process, one block building on another. It comes from cumulative experiences and sharing of different ideas and then changing one's internalized response to those ideas or views (Bednar et al., 1995). A pilot with years of flying experience has the background in aviation that an instructor can use in guided constructivism to provide the need in transitioning to TAA. This can have a positive effect in their learning and adaption to the new avionics

platforms (Loyens, Rikers & Schmidt, 2008). This however cannot be self-regulated instruction but guided positive reinforcement coupled by a scaffolding methodology (Loyens et al., 2008; Brown, 1987). Homko (2011) stated:

> What can be taken from this observation is an understanding that older people could well be taught to use technology in much the same way as younger people are taught. However, the literature also suggests that at least two additional considerations are necessary in designing computer and technology education for older learners. First, consideration must be given to allow ample time for older people to master new skills. Second, care must be taken to treat any person learning to use technology in a positive manner that makes them feel like they are valued and that success is the expected outcome. While it is true that these two points ought to be considered for all learners, they nonetheless particularly pertain to older users. (p. 15)

Looking at the two suggestions that Homko makes, constructivism guided by way of scaffolding under a properly trained facilitator would help to fill this need. In constructivism with the student and facilitator, together they plan and diagnose the learner's needs and interests, which then can be properly designed. Using scaffolding with the constructivism designed earlier, the facilitator can develop the proper guidelines with the student for developing the supportive strategies needed to reach that higher order of thinking skills these aging pilots will need to use computerized avionics platforms. Together it will help bridge the learning gaps older pilots are having with the new systems by changing the way the curriculums are taught today.

Conclusion

In the literature review, it was shown that age and pilot effectiveness in cognitive abilities do deteriorate and that in advanced TAA aircraft, the effect is even more pronounced. It was also shown in the data analysis of the NTSB reports that pilots above the age of 40 in both glass and conventional flight decks are having more problems in aircraft accidents and incidents in comparison to their younger peers. The training industry as a whole needs to look at the recommended training programs suggested by AOPA regarding TAA aircraft.

Glass flight deck training requires system knowledge and cognitive training on regular and systematic bases. In other words, the old idea of training to pass a test was perhaps useful in its time, but with advanced aircraft avionics and the complications of the National Airspace System and the coming implementation of NextGen (Next Generation Air Traffic Control) this is proving not to be enough. Ground based training must also pull away from just the generic to aircraft specific in the realm of the glass flight deck classrooms. Pilots need to demonstrate that they possess at least the minimum knowledge of aircraft instrumentation and displays in order to safely operate aircraft that are equipped with these more advanced avionics platforms.

The literature review and the data has also shown that through a properly designed program and instruction, any pilot regardless of age can improve performance to acceptable levels to perform safe and successful flights when transitioning to TAA aircraft.

Scenario based training (SBT) can also be used to address learning problems with older pilots. According to Summers, Ayers, Connolly & Robertson (2007):

> …where the instructor introduces real life situations for the development of the pilot. This training is a scenario-based approach to training pilots. It emphasizes the development of critical thinking and flight management skills, rather than solely on traditional maneuver-based skills. The goal of this training philosophy is the accelerated acquisition of higher-level decision-making skills. Such skills are necessary to prevent pilot-induced accidents. (p.4)

This statement from Summers et al. (2007) suggests that SBT would adapt well to the pairing of constructivism and scaffolding.

With pilots transitioning to more advanced flight deck designs and higher performance aircraft, SBT provides a means of teaching pilots how to stay ahead of their aircraft. With the advances of avionics in today's fligtdecks, the needs for increased technical skills are apparent. If these skills are lacking the potential for accidents will be compounded. A new way of instructing and teaching is required to have pilots, especially older pilots, transition to these new platforms (Summers et al., 2007).

Scenario based training, similar to what 14 CFR Parts 121 and 135 use in their training programs known as Line Oriented Flight Training (LOFT). This exposes pilots to real world scenarios under the guidance of a flight instructor in a controlled environment to experience situations a pilot alone may not be able to handle. These advanced flight deck avionics platforms require the pilot to be properly trained and motivated under new learning theories in understanding the cognitive development of aging pilots in order to safely operate in the world of TAA. Coupling the learning theories of constructivist theory with scaffolding theory fits very well with scenario-based training and can have the positive effect especially on older pilots transitioning to these more complicated avionics platforms. Proper facilitator training in these concepts used with scenario-based training will help to develop the higher order of thinking skills and reaction for these older pilots that may ultimately produce the desired outcome of effective learning.

References

Aircraft Owners & Pilots Association [AOPA] (2007). Technically advanced aircraft safety and training. *Air Safety Foundation.* Retrieved from http://www.aopa.org/asf/publications/topics/TAA2007.pdf

Bednar, A. K., Cunningham, D., Duffy T. M. & Perry J. D. (1995). *Theory into Practice: How do we Link?* In G. J. Anglin (Ed), Instructional Technology: Past, present and future. Englewood, Co: Libraries Unlimited, pp 100-112.

Bloom, B. (1956). Taxonomy of educational objectives. New York: David McKay Co. Inc

Broady, T., Chan, A., & Caputi, P. (2010). Comparison of older and younger adults' attitudes towards and abilities with computers: Implications for training and learning. *British Journal of Educational Technology , 41* (3), 473-485.

Brown, A. L. (1987). *Metacognition, executive control, self-regulation, and other more mysterious mechanisms*. In F. Weinhart & R. Kluwe (Eds.), Metacognition, motivation, and understanding (pp. 65-116). Hillsdale, NJ: Lawrence Erlbaum Associates.

Federal Aviation Association [FAA]. (2003). *FAA-Industry Training Standards (FITS) Program Plan*. Oklahoma City, OK: Department of Transportation. Washington, D.C.: U.S. Government Printing Office

Hackbarth, S. (1996).*The Educational Technology Handbook*. New Jersey: Englewood cliffs.

Hamblin, C. J., Gilmore, C., & Chaparro, A. (2006). *Learning to fly glass flightdecks requires a new cognitive model.* Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting, 1977-1981.

Henschke, J. A. (2009). *Beginnings of the history and philosophy of andragogy 1833-2000.* In V. Wang (Ed.), Integrating adult learning and technology for effective education: Strategic approaches. Hersey, PA: IGI Global.

Hogan, K., & Pressley, M. (1997). *Scaffolding student learning: Instructional approaches and issues.* Cambridge, MA: Brookline Books.

Homko, C. J. (2011). *The effects of age and recency of experience on the completion of complex tasks in a Technically advanced aircraft*.(Master's thesis, Purdue University), Available from ProQuest. (1501836).

Kearns, S. K. (2010). *E-learning in aviation*. Burlington, VT: Ashgate.

Kennedy, Q., Taylor, J. L., Reade, G., & Yesavage, J. A. (2010). Age and expertise effects in aviation decision making and flight control in a flight simulator. *Aviation, Space, and Environmental Medicine, 81*(5), 489-497.

Kirschner, P. A.; Sweller, J.; Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist 41* (2): 75–86. doi: 10.1207/s15326985ep4102.

Knowles, M. S. (1950). *Informal adult education: A guide for administrators, leaders, and teachers.* New York: Association Press.

Knowles, M. S. (1984). *Andragogy in action: Applying modern principles of adult education*. San Francisco: Jossey-Bass.

Loyens, S. M., M., Rikers, R. M., J., P., & Schmidt, H. G. (2008). Relationships between students' conceptions of constructivist learning and their regulation and processing strategies. *Instructional Science, 36*(5-6), 445-462. doi: 10.1007/s11251-008-9065-6

Mayer, R. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist 59* (1): 14–19. doi: 10.1037/0003-066X.59.1.14.

McLeod, S. A. (2018). *Jean Piaget's theory of cognitive development*. Retrieved from https://www.simplypsychology.org/piaget.html

Merriam, S.B., Caffarella, R. S., & Baumgartner, L M. (2007). *Learning in adulthood: A comprehensive guide*. (3rd ed.) San Francisco: Jossey-Bass.

O'Hare, D., Owen, D. (2001). "*The 'where' and the 'why' of cross-country vfr crashes: database and simulation analyses"*. Proceedings of the Human Factors and Ergonomics Society 45th Annual Meeting-2001, 78-81.

Palincsar, A. S. (1986). Metacognitive strategy instruction. *Exceptional Children, 53*(2), 118-124.

Pressley, M., Wood, E., Martin, V. E., King, A., & Menke, D. (1992). Encouraging mindful use of prior knowledge: Attempting to construct explanatory answers facilitates learning. *Educational Psychologist, 27*(1), 91-109.

Skinner, B.F., (1968). *The Design of Experimental Communities*. International Encyclopedia of the Social Sciences (Volume 16). New York: Macmillan, 1968, pages 271-275.

Summers, M., Ayers, F., Connolly, T., & Robertson, C. (2007). *Managing risk through scenario based training, single pilot resource management, and learner centered grading.* Retrieved from http://www.faa.gov/training_testing/training/fits/guidance/media/ RM_thorugh_SBT.pdf

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science 12* (1): 257–285. doi: 10.1016/0364-0213(88)90023-7.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge: Harvard University Press.

Watkins, K. E., & Marsick, V. J. (2014). Adult education & human resource development: Overlapping and disparate fields. *New Horizons in Adult Education & Human Resource Development, 26*(1), 42-54. Retrieved from http://search.proquest.com.library. capella.edu/docview/1500818471?accountid=27965