EMBRY-RIDDLE Aeronautical University
SCHOLARLY COMMONS

Journal of Aviation/Aerospace Education & Research

Volume 30
Number 2 *JAAER 2021*

Article 3

2021

Interactive Modules for Flight Training: A Review

Stephanie G. Fussell Ph.D.
Kent State University - Kent Campus, sfussel2@kent.edu

Robert Thomas Ph.D.
Embry-Riddle Aeronautical University, thomasr7@erau.edu

Scholarly Commons Citation

Fussell, S. G., & Thomas, R. (2021). Interactive Modules for Flight Training: A Review. *Journal of Aviation/Aerospace Education & Research, 30*(2). https://doi.org/10.15394/jaaer.2021.1901

Introduction

The COVID-19 pandemic forced an abrupt shift in training and teaching nationwide in early 2020. Although web-based instruction and learning management systems (LMS) have been implemented in higher education environments for many years, the sudden closure of schools across the country in early 2020 prompted many face-to-face (F2F) courses to transition to a blended or fully online learning environment. Across the globe, curricula were adapted, and activities were revamped, replaced, or removed; in-person training requirements were also adapted for socially distanced instruction policies (Eades, 2021; Lederman, 2020; Martinez, 2020; Mishra et al., 2020). This shift has highlighted the fact that teaching alternatives to F2F instruction are a necessary component to provide a well-rounded education for students in the current climate.

The change in the learning environment also accentuated the need for dynamic and interactive learning materials for flight students. The Federal Aviation Administration (FAA) provided Special Guidance on April 6, 2020 (FAA, 2020b) to address interruptions in training due to COVID-19 and allowed 14 CFR 141 Pilot Schools to request deviations from training course outlines (TCO). Approved deviations from the TCOs included the ability to waive F2F instruction and the implementation of asynchronous and synchronous online delivery of course content. Generally speaking, 14 CFR 141 pilot training can incorporate ground school administered via traditional course work, one-on-one with a Certificated Flight Instructor, and computer-based training programs to train flight students to FAA standards (FAA, 2020c). Lessons can also be augmented with interactive content for learning modules with assessments built-in, as appropriate, to ensure learning occurs via the interactive learning modules. These interactive learning modules would be accessed by the student outside of their ground school lesson. The goals of creating and implementing interactive learning modules would be enhancing the learning process, increasing learning flexibility and student engagement, and decreasing the cost associated with obtaining pilot licenses and certificates. The shift from primarily F2F learning and teaching to virtual or blended options also underscored the need to analyze how flight students learn, how they would utilize and adopt new materials that require self-regulated learning, and how the materials should best be implemented.

Purpose of Research

The goal of the research was to provide insight into how flight students learn a dynamic task in an online or blended learning environment. A review of the relevant literature was conducted to answer the research questions. Although not systematic, the review was thorough and delimited to full-text, English-language, scholarly and peer-reviewed articles from open-access journals, databases, and research registers. Publication dates were not limited. Numerous search terms were used in varying combinations, including: "aviation student," "tone AND (scripted OR conversational)," "learning AND (2D OR 3D) AND animation." A summary of the relevant findings yielded recommendations on how to develop and implement interactive modules for flight students to independently enhance their learning outside of ground courses.

Research Questions

A series of research questions were asked to ensure that the interactive learning modules enhance the learning process, learning flexibility, and student engagement while decreasing associated costs.

1. How do flight students learn and what do the students need to support their learning?
2. What technology makes sense for flight students to learn the material?
3. How do flight students engage with interactive materials to master a dynamic subject/task?

DOI: https://doi.org/10.15394/jaaer.2021.1901

3.1. Do flight students prefer interactive learning materials over more traditional methods?

3.2. Is there a difference in learning using 2D and 3D interactive materials?

3.3. Is there a learning or preference difference between scripted audio for the learning materials and a more conversational tone?

Review of Relevant Literature

Characterizations of Generation Y and Generation Z Flight Students

Research question 1 asked a two-part question: “How do these students learn,” and “what do the students need to support their learning?” To answer the first part of the question, it is essential to understand the makeup of the flight student population (e.g., students enrolled in a 14 CFR 141 Pilot School) as well as the broader Generation Y (also known as “Gen Y” or “Millennial”) and Generation Z (“Gen Z”) student population in general. Higher education institutions have a mixture of Gen Y and Gen Z students who share many similarities and distinct differences (Nicholas, 2020; Parker & Igielnik, 2020). Additionally, many higher education institutions have Generation X (“Gen X”) students who are pursuing degrees (Miller & Mills, 2019); this generation was born between the mid-1960s and early-1980s (Bialik & Fry, 2019; Dimock, 2019). Gen Y includes individuals who were born between the early- to mid-1980s and early- to mid-1990s (Dimock, 2019). Gen Z includes those born in the mid- to late-1990s and the early- to mid-2000s (Dimock, 2019). There are currently over 31,000 Gen X student pilots (aged 40 to 54), over 91,000 Gen Y student pilots (aged 25 to 39), and over 53,000 college-aged Gen Z student pilots (aged 17 to 24) in the United States (FAA, 2020d). Notably, the reported numbers include student pilots from Pilot Schools and other training facilities.

Gen X students represent the older portion of enrolled students who may have delayed enrollment in secondary education, work full-time while attending college part-time, or may be pursuing a degree to further their career or provide the opportunity for a new career (Pelletier, 2010). Gen X students experienced many advancements in educational technology, and are tech-savvy, hardworking, and entrepreneurial; these skills are often applied to the academic pursuits of Gen X students (Mhatre & Conger, 2011; Postolov et al., 2017). They prefer self-directed, informal learning with social aspects, wherein they are active participants in the learning process (Crappell, 2018). Gen X students desire autonomy and may be viewed as "more cynical, less optimistic, and less idealistic" than Gen Y students (Mhatre & Conger, 2012, p. 73).

Gen Y students have been studied thoroughly (Baghdasarin, 2020; Niemczyk, 2017; Roehl et al., 2013). The literature on the nature of Gen Y individuals is conflicting, with characterizations of self-interested, over-confident, entitled, and unstructured, yet optimistic, educated, connected, and tolerant (Mohr & Mohr, 2017). From an educational standpoint, Gen Y students have been called "digital natives" (Prensky, 2001) and are characterized as students who have grown up with technology at their fingertips (Baghdasarin, 2020). As such, these students expect that technology will be used to enhance the learning process, and there is a preference for smartphones, social media, and mobile devices to be incorporated into education (Baghdasarin, 2020). Furthermore, those in Gen Y work well in teams and solve problems in a participatory and collaborative manner (Rainer & Rainer, 2011).

Gen Z learners are also digital natives and have seen a wide variety of technology throughout their lives. For these students, technology is not a novelty or even a tool, but a facet of their everyday life to receive and transmit information (Kalkhurst, 2018; Nicholas, 2020). Unlike Gen Y, Gen Z students prefer to work independently and use synchronous, online tools (i.e., Google Docs) to work in a collaborative effort without the need to interact directly (Nicholas, 2020). Barber (2020) noted that although Gen Z learners are passionate and driven,

https://commons.erau.edu/jaaer/vol30/iss2/3
DOI: https://doi.org/10.15394/jaaer.2021.1901

they have also witnessed the quadrupling of student loan debt, have had their educational platforms abruptly shifted due to the COVID-19 pandemic, and are, therefore, “constantly seeking value and return on investment” (p. 24) from their education. This is reflected in their desire to work individually as opposed to relying on others in a team, as Gen Z students seek to ensure personal advancement and not “trust others with matters important to them” (Schlee et al., 2020). These students have also been characterized with conflicting descriptors, including responsible and entrepreneurial, thoughtful and open-minded yet critical of peers, and lacking in focus, creativity, and competitiveness (Mohr & Mohr, 2017).

Both the Y and Z generations have been labeled as having short attention spans and a need for instant gratification, often attributed to the fact that they grew up with, or came of age with, Internet access at their fingertips (Baghdasarin, 2020). However, Gen Y and Gen Z students also have a desire to learn practical information and skills that applies to their future; interactive learning is especially preferred as students take the opportunity to hone skills and apply what they have learned (Nicholas, 2020). Despite generational shifts, the characterizations of flight students and how they learn have remained stable. Decades of research has characterized pilots and flight students as emotionally stable, highly assertive and conscientious, competitive and striving for high achievement, and tending toward higher levels of extraversion (Campbell et al., 2009; Fitzgibbons et al., 2004; Gao & Kong, 2016). Flight students use reasoning, theoretical models, and observations to form explanations and may prefer abstract conceptualization, in which learning occurs through logical thinking and planning (Harriman, 2011; Kanske & Brewster, 2001). Fussell et al. (2018) profiled Gen Y and Gen Z flight students as highly observant of their surroundings, making them adaptable to dynamic changes, as well as logical and objective when decisions are required. Fussell et al. (2018) concluded that these students preferred hands-on learning and worked well with others (see also Kutz et al., 2004; Robertson & Putnam, 2008).

Applicable Instructional Theories

Instructional theory can also be considered when evaluating how to teach flight students. Pedagogy and andragogy are two basic distinctions of instruction. Pedagogy is teaching for children while andragogy is teaching for adult learners (Bass, 2012; Knowles, 1977). Pew (2007) argued that student motivation can be related to the pedagogical or andragogical practices used by the teacher. Students have a variety of intrinsic and extrinsic motivating factors (i.e., from within and from without, respectively), such as a desire for knowledge, familial pressure, and career aspirations. Brady et al. (2001) found that aviation students behave as adult learners. The authors surmised that aviation students in flight training programs have clear goals and aspirations, are intrinsically motivated, approach learning as a way to gain experience and learn life lessons and should be taught using adult-education learning methodologies.

In discussing the use of andragogical models in science instruction for adults, Bass (2012) maintained that a goal of lifelong learning may be a more appropriate way to work with learners in both formal and informal educational settings. The model of andragogy may be combined with transformational, experiential, and self-directed learning practices. Transformational learning, which is deep, meaningful, and constructive learning beyond basic knowledge acquisition, is applicable because adult learners often have a prior knowledge base on which to build and transform new information (Bass, 2012). Flight students often arrive with a foundational knowledge of aviation concepts through formal education and/or personal research, and some have flight experience, making them more similar to the adult learner (Brady et al., 2001). Experiential learning is how people learn from their experiences and apply them to future scenarios. Collegiate flight students have been characterized as being highly adaptable to changing environments and often draw from prior experiences to make the best decision (Fussell et al., 2018). Thus, flight students combine classroom instruction, ground instruction, simulator use, and time in the aircraft to internalize lessons and hone skills.

An overview of instructional theory and learning for flight students would not be complete without including the point of view of the regulatory body that oversees flight training standards, the FAA. The *Aviation Instructor's Handbook* (*AIH*) (FAA, 2020a) notes that although learning can be defined in several ways, there are four general characteristics of learning: (1) it is purposeful, (2) it may occur as the result of an experience, (3) it is multifaceted, and (4) it is part of an active process. Behaviorism and cognitive theory are both described in the *AIH*. In aviation teaching and learning environments, behaviorism refers to how behaviors and psychomotor skills are developed and may be designed into learning outcomes, competency-based curricula, and learning models (Merriam & Bierema, 2014; Thomas, 2018). Cognitive theory in an aviation learning environment stresses the need for mental processing, information storage and retrieval, and the formation of conceptual ideas (Merriam & Bierema, 2014; Thomas, 2018). The *AIH* also describes constructivism, a derivative of cognitive theory, as “a philosophy of learning that holds that learners do not acquire knowledge and skills passively but actively build or construct them based on their experiences” (FAA, 2020a, 3-5). Antonacci and Modress (2008) further the definition by emphasizing the importance of knowledge building through interaction and collaboration as well as using educational games and simulations. These activities encourage higher-level cognitive processes, including analyzing, interpreting, evaluating, and problem-solving. Scenario-based training (SBT) is often utilized in flight training to develop realistic decision-making skills that can be utilized outside of the training environment. Craig (2009) found that more realistic scenarios for SBT resulted in higher-level thinking and problem-solving skills for pilots. The greater challenge can elicit greater pilot buy-in, subsequently increasing confidence and decision-making skills. Numerous studies demonstrate the usefulness of SBT, simulators, and training devices for flight training to learn, practice, and hone psychomotor skills that can transfer to the real world (Byrnes, 2017; Neal et al., 2020). These concepts are critical for flight students because, as Thomas (2018) says, “being a pilot involves both the physical skill of flying an aircraft and the decision-making skills to safely complete a flight” (p. 22).

Educational Environment Designs

Research question 2 asked what technology makes sense for the student to learn the material. There are many instructional theories and modes applicable to teaching flight students, as well as the design of the learning environment. As the research focuses on the learning of flight students in blended and online environments using interactive learning modules, this next section will focus on non-traditional learning environments – or those learning environments not confined to a classroom. This is especially relevant as many educators have adapted how they teach due to social distancing requirements from COVID-19. The sudden shift forced many to hastily reconfigure curricula and learning objectives in the spring of 2020, only to reorganize for the fall of 2020 as new guidelines were introduced. Students’ desire to connect with their peers, instructors, and advisers, and the flexibility and interaction that can come through virtual learning environments may afford that (Barber, 2020). Generally speaking, a “traditional” learning environment is F2F, includes lectures by the educator to introduce a topic, and utilizes homework to be completed outside of class to build knowledge. Mavin and Roth (2015) found that pilots may benefit from using a variety of instructional modes to aid their training and, consequently, their job performance.

Of interest to instructors that utilize non-traditional learning environments is Moore's (1997) transactional distance theory. The separation of educators and learners can cause communication gaps and potential misunderstanding (Moore & Kearsley, 1996). Dialogue between the learner and teacher, the structure of the course in terms of the level of flexibility, and learner autonomy, which is contingent upon dialogue and structure, are all components of this pedagogical concept. There is an inverse relationship between the three factors, such that an increase in one factor will cause the other factors to decrease. Falloon (2011) found that virtual learning activities may be viewed negatively if they were perceived as irrelevant to learning and completing a larger assignment. The communication tools embedded into a web-based learning platform can enhance perceived information efficiency as well as students' confidence to communicate with peers and instructors. Falloon (2011) stressed that negative perceptions of course aspects are often tied to the structure of the course and the guidance provided through explicit expectations. Moore's (1997) theory is relevant to the design of non-traditional learning environments that utilize a web-based learning component contingent upon the learner being responsible for knowledge acquisition and construction.

The Flipped Classroom

Teaching higher education in the 21st century often includes using advanced technologies to transform the educational experience (Albert & Beatty, 2014). The flipped classroom is an approach to learning that shifts the focus from the instructor to the learner. The traditional in-class lecture becomes an outside-of-the-class activity, wherein the student may watch a video lecture and read materials before the F2F class, and the F2F class time is reserved for interactive learning activities (Albert & Beatty, 2014). By moving the lecture and reading outside of the classroom, the teachers can focus on enhancing knowledge application and engagement through discussions, hands-on exercises, and other activities.

The flipped classroom design has been shown to impact student performance, satisfaction, and engagement with a course. Students in a flipped classroom may have higher performance and academic success when compared to those in a F2F classroom if they have a more positive perception of the design and the learning materials (Albert & Beatty, 2014; Beatty & Albert, 2016). Designing a curriculum to include videos to watch before F2F class time and integrating active learning exercises during F2F instruction may have a significant, positive impact on student performance (Albert & Beatty, 2014). A flipped classroom design may yield less satisfaction among the students if they do not “perceive the value of interactive learning approaches” (Missildine et al., 2013, p. 599). However, satisfaction does not necessarily correlate with learning achievement (Leatherman & Cleveland, 2020; Missildine et al., 2013). The instructor must ensure the structure of the course enables students to meet learning outcomes and objectives regardless of when lectures and activities are scheduled.

The Blended/Hybrid Classroom

The blended or hybrid classroom is a design that is like the flipped classroom design. The terms “hybrid” and “blended” are often used synonymously, although “blended” will be used in this paper. In this design, the instructor utilizes F2F and synchronous or asynchronous online learning environments in a harmonious combination (Helms, 2014). The difference between flipped classrooms and blended learning is how and when the materials are consumed by the learner. In blended learning, learning is emphasized in the classroom *and* online, and traditional teaching methods are used alongside online videos, games, etc. The online materials do not replace F2F teaching; rather, it is supporting information.

DOI: https://doi.org/10.15394/jaaer.2021.1901

A review of the literature indicates that blended learning classrooms can positively impact retention, engagement, and sense of community (Helms, 2014). Additionally, blended learning environments can positively impact academic achievement when compared to learning in traditional, F2F classrooms (Helms, 2014; Saritepeci & Çakir, 2015). Sitzmann et al. (2006) compared the effectiveness of classroom and blended instruction for declarative and procedural knowledge. The authors defined declarative knowledge as "the memory of the facts and principles taught in training and the relationship among knowledge elements" and procedural knowledge as "information about how to perform a task or action" (Sitzmann et al., 2006, p. 627). The comparison between blended learning and F2F instruction indicated that blended courses were 13% more effective than F2F for learning declarative knowledge and 20% more effective for learning procedural knowledge. Of note, Sitzmann et al. (2006) found that learners were more favorable toward F2F instruction, which is something an instructor would need to examine.

Klemm (2012) found that the use of a blended course for flight students allowed them to accomplish group work easily using online resources and students reported that they learned more in the blended environment as compared to a F2F course. Flight students must master many principles and recall facts (i.e., declarative knowledge) as well as task-related and psychomotor skills (i.e., procedural knowledge). Blended learning may be beneficial for flight students when the course activities are developed to promote learning in and out of the classroom. A blended learning structure may promote engagement with non-traditional materials to enhance the learning of complex topics and provide students with flexible learning opportunities.

The Online Classroom

Online learning, also called web-based instruction, is a widely used option for higher education, government, and industry (Sitzmann et al., 2006). True to its name, online learning environments happen wholly online with no traditional classroom for F2F instruction. Any synchronous instruction is done through an online platform as well.

Although the impact of shifting from F2F environments to online due to COVID-19 remains to be seen, we can refer to older publications on how online learning best occurs. This is a concern because how the environment is designed impacts learning and the students' experience. The user interface, quality of the lesson and content, perceived usefulness, and perceived ease of use can impact student acceptance of and usage of an online learning platform (Servidio & Cronin, 2018). Learning activities of the flipped classroom design can be successfully incorporated into an online learning environment and can be positively correlated to engagement, quiz scores, and semester grades; however, experience with the course may not correlate to the achievement of learning outcomes (Lin, Hung et al., 2019). Online learning can be more effective for declarative knowledge skills as compared to a F2F environment (Sitzmann et al., 2006). Learner control, practice time of material, and instructor feedback can all moderate the impact of the effectiveness of web-based learning, although the level of human interaction may not (Sitzmann et al., 2006). Krull and Duart (2018) demonstrated that a variety of support affects the formal and informal development of cognitive skills and could positively impact students' experience and learning in an online course.

Flight students share similar learning characteristics with adult learners (Brady et al., 2001). Many are balancing classes, flight lessons, jobs, and other responsibilities, making online and blended learning a valuable option for schedule flexibility. The use of technology and varying activities in different learning environments can empower students to take charge of their learning and academic achievement. However, the design of the activities and learning environment itself must be considered, as well as what technology is utilized and how.

Designing the Course Content

Research question 3 and its sub-questions ask whether students prefer the interactive learning materials over more traditional methods, if learning differences vary between the use of 2D and 3D interactive materials, and how tone (e.g., narrative language) can impact learning. These questions will be addressed through a discussion on designing interactive course content, including the use of multimedia and slide presentations, animation, video, and narration. When designing activities that align with learning outcomes, multimedia and technology should be chosen with purpose to meet a learning outcome and enhance the learning process.

The Use of Multimedia and Slide Presentations

The choice of medium to convey information should be made based on what will enhance student learning and not increase the cognitive load (Mayer & Moreno, 2003). *Multimedia* may be defined as pictures and words that can be used to foster learning and may be printed or spoken, static or dynamic (Mayer & Moreno, 2003). Multimedia can be utilized to deepen learning through enhanced mental models and cognitive structures. However, Mayer and Moreno (2003) caution that such meaningful learning can be prohibited by cognitive processing (e.g., overloading). Cognitive load theory (CLT) is an instructional theory that focuses on presenting materials to optimize the performance of individual learning (Mutlu-Bayraktar et al. 2019). If a student experiences a higher cognitive workload due to numerous stimuli, the information will not transfer from working memory to long-term memory, thus inhibiting the learning process (Wold, 2011).

The cognitive theory of multimedia learning (CTML; Mayer & Moreno, 1998) combines and extends several other theories and research related to memory, cognition, and learning. The theory has three assumptions: (1) that humans have separate channels for processing pictorial/visual and verbal/auditory representations, or the *dual-channel assumption*; (2) that a few pieces of information can be actively processed at once per channel, or the *limited capacity assumption*; and (3) that meaningful learning will occur when the learner is engaged in cognitive processes, or the *active processing assumption* (Mayer & Moreno, 1998; Mayer & Moreno, 2002). According to the CTML, corresponding pictorial/visual and verbal/auditory representations in working memory is the best way to ensure the cognitive process of integrating and to deepen learning (Mayer & Moreno, 2002).

Engaging the student is a way to incite passion and emotional involvement in learning activities, thus increasing the time invested in a learning task (Alsawaier, 2018). By engaging the student, instructors strive to make learning more interesting, increase attention and focus, and enhance knowledge acquisition. Many instructors utilize Microsoft PowerPoint or a similar slide software to present information during a lecture. One alternative is Prezi, which allows the creator to use narration combined with visual, textual, aural, and graphical information in a single visuospatial canvas, wherein zooming and panning control the navigation between content. However, the misuse of the medium can be ineffective and lead to "death by PowerPoint," in which the student disengages from learning due to boredom. The misuse may stem from too much text, the instructor simply reading what is on the slide without adding extra information, a lack of graphical information and abundance of text, irrelevant confusing graphics that detract from the material, or lengthy lectures that do not stimulate cognition. The effectiveness of PowerPoint as a learning medium has been investigated. Irrelevant material,

DOI: https://doi.org/10.15394/jaaer.2021.1901

such as non-pertinent graphics, may negatively impact learning while non-textual elements may stimulate students (Bartsch & Cobern, 2003; Brock & Joglekar, 2011). Brock and Joglekar (2011) found that although the number of slides did not impact teaching effectiveness, lower textual density on a slide (e.g., fewer bullet points and words per slide) had a positive impact and was associated with positive student feedback. In an experimental comparison of oral, PowerPoint, and Prezi presentations, Moulton et al. (2017) found that oral and PowerPoint presentations were viewed as comparable modes of learning while the Prezi presentations were evaluated more favorably. The authors also found that recall was similar among the presentations and concluded that the difference in the evaluation of effectiveness may be due to communication preferences (Moulton et al., 2017).

Garner and Alley (2013, 2016) contended that slide structure can influence the understanding and comprehension of the content being presented. They argued that slide show presentations should follow the principles of multimedia learning to ensure learning and comprehension; however, they pointed out that presentation mediums do not incorporate these principles by default. Instead, the educator must actively design a presentation with the principles in mind. Garner and Alley (2013, 2016) call presentations that utilize principles of multimedia learning *assertion-evidence structured*. This structure utilizes a succinct sentence that is the main point of the slide (the *assertion*) in place of a typical header. The body of the slide contains the *evidence* that provides support, explanation, or organization of the assertion. The evidence may be a visual graphic, animation or video, table, or even text. A key difference is the lack of bulleted lists and overwhelming text that is often featured in slide presentations. The researchers compared the learning outcomes of students who viewed a presentation with the design principles enforced or violated, and found that comprehension and recall were higher, misconceptions were lower, and perceived cognitive load was lower when the principles of multimedia learning were followed (Garner & Alley, 2013).

In the classroom, instructors must be active participants in engaging students and encouraging the learning process. The effectiveness of PowerPoint and other similar slide-sharing instruments is based not on the medium itself, but the design of the content (Bartsch & Cobern, 2003; Brock & Joglekar, 2011; Garner & Alley, 2013, 2016; Moulton et al., 2017). Mayer and Moreno (2002) provided several principles to follow to ensure multimedia presentations are used properly in a learning environment, as depicted in Table 1. How, then, should presentations be structured to ensure effective learning? Presentations and multimedia need to be designed to minimize unnecessary cognitive load while enhancing the learning process, such as through an assertion-evidence slide structure (Garner & Alley, 2013, 2016; Mayer & Moreno, 2003). Brock and Joglekar (2011) reported that experienced instructors would gauge student engagement during a lecture and adapt lessons according to the needs of the student. Berk (2011) asserted that presentations must be built to engage the students through the incorporation of activities, such as questions and discussion opportunities, quick polls or surveys, problem-solving exercises, watching a short video or animation, etc. Mayer (2014a) described several ways that multimedia can be integrated into a learning environment to foster motivation and generative processing among learners. Among these is the addition of emotionally appealing elements, decorative illustrations, and challenging learning tasks, all of which have pros and cons. Mayer urged educators and instructional designers to utilize instructional design features that foster deep processing during learning “while not overloading the learner’s information processing system” (2014a, p. 173). He concluded that a “focused more is more” (p. 172)

DOI: https://doi.org/10.15394/jaaer.2021.1901

approach can improve learning by using design features that motivate learners to engage in generative processing which leads to deeper learning.

Table 1

Principles to Guide the Design of Multimedia Representations

Principle	Description	Rationale	Supporting Evidence
Multimedia Principle	The combination of animation and narration further deepens the learning process than narration alone.	Students can build connections between the representations.	Demonstrated in four experiments; strong effect size of 1.73.
Spatial Contiguity Principle	Learning is enhanced when on-screen text is physically close to the animation it refers to.	Cognitive capacity is wasted when the learner has to search for corresponding text.	Demonstrated in one experiment; moderate effect size of 0.48.
Temporal Contiguity Principle	Simultaneous narration and animation result in deeper learning.	Better mental connections occur in working memory with a simultaneous presentation.	Demonstrated in eight experiments; strong effect size of 1.30.
Coherence Principle	Excluding extraneous sensory input will deepen learning.	Irrelevant input may negatively impact cognitive capacity.	Demonstrated in five experiments; strong effect size of 0.90.
Modality Principle	Animation and narration enhance learning more than animation and on-screen text.	The visual channel may be overloaded by processing animation and text.	Demonstrated in six experiments; strong effect size of 1.17.
Redundancy Principle	Animation and narration deepen learning more than the combination of animation, narration, and on-screen text.	The visual channel may be overloaded by processing animation, narration, and text.	Demonstrated in two experiments; moderate effect size of 0.77.
Personalization Principle	Deeper learning occurs with conversational narration or on-screen text as opposed to formal.	Students personally involved in the conversation work harder to understand.	Demonstrated in five experiments; strong effect size of 1.55.

Note. Transfer scores were calculated in multiple studies to measure learning and understanding in mechanical, mathematical, and scientific topics. Principles were adapted from R. E. Mayer and R. Moreno, 2002, *Animation as an Aid to Multimedia Learning;* see Table 1, p. 93.

The Use of Animation

Educators often use animations to demonstrate both simple and complex concepts, thereby supporting visualization and mental representation processes. In contrast to a video, animation is a "simulated motion picture" (Mayer & Moreno, 2002, p. 88). Rias and Zaman

(2011) state it plainly: "Animation in computer-based instruction holds powerful instructional potential" (p. 12). Animations allow the student to explore a concept in a meaningful way and can promote understanding when the theories of cognitive load and multimedia learning are considered (Mayer & Moreno, 2002). Four characteristics are relevant for discussing cognitive modeling to guide the design and integration of animation, as described by Wouters et al. (2008): (1) animations can present information changing over time, such as a procedure or movement; (2) animations are depictive, external representations of concrete and abstract concepts; (3) animations have features to focus attention on a certain part of the screen, such as an arrow or flashing light; and (4) animations can be motivating when visually appealing.

Animations can help students meet learning objectives, although English and Rainwater (2006) found that more procedural or conceptual learning objectives may not translate well to an animated representation. This finding highlights the fact that multimedia and animation must be utilized appropriately. 3D animations in particular are engaging, can be interactive, and can facilitate recall and retention through dynamic representation as opposed to static, 2D graphics (Korakakis et al., 2009; Rias & Zaman, 2011). The incorporation of animation into learning materials allows easy access and review for the students and designing a 3D animation to be interactive can further deepen learning. Rias and Zaman (2011) identify three levels of animation interactivity. The model can be designed to *react*, as in, the student can use a keyboard- or mouse-stroke to progress the animation; this is a low level of interaction. An *interactive* model allows the learner to control the sequence of learning. The highest level of interactive design, a *proactive* model, utilizes cognitive approaches to actively engage the learner in knowledge construction (Rias & Zaman, 2011). Korakakis et al. (2009) assessed how different levels of 3D representation (illustration, animation, and interactive animation, all with narration and text)

DOI: https://doi.org/10.15394/jaaer.2021.1901

impacted the learning processes of middle school students in a science course. They found that 3D animation and interactivity were more interesting and appealing, and a benefit of 3D illustration was that the students had control of the pace of learning, which can decrease cognitive load. The authors concluded that the combination of the three types of 3D representation can augment the learning process, but the unilateral use of one representation may be ineffective and negatively impact cognitive load (Korakakis et al., 2009).

Although animations are a powerful tool that can be used to deepen learning, Mayer and Moreno (2002) cautioned that it is not a "magical panacea" (p. 97) for ensuring that a student understands a concept. Multimedia and animation should not replace instruction; rather, they can and should enhance the instructional method (Rias & Zaman, 2011). Wouters et al. (2008) also argued that animation, particularly animated models, is ineffective if cognitive capacity is not optimally employed. The animation or modeling of complex tasks represented visually with narration may cause a learner to become overloaded. The authors referenced studies in which dynamic visualizations were equally effective, or less than effective, as static visualizations (Wouters et al., 2008; see also Hegarty et al., 2003; Koroghlanian & Klein, 2004). Just as Mayer and Moreno (2002) provided principles to guide the use of animation in learning, Wouters et al. (2008) provided guidelines for designing animated models to decrease extraneous cognitive load and increasing germane cognitive load during the learning process. The guidelines focus on managing subject matter complexity, designing activities to enhance learning, and engaging learners in active cognitive processing (Wouters et al., 2008). They may be summarized as:

- Scaffold the learning of whole tasks, beginning with foundation knowledge and simple tasks and increasing in task and knowledge complexity;

- Pace and segment the learning of the material and the viewing of presentations as well as incorporate breaks into the learning;
- Utilize the correct modality (i.e., the sensory mode of representation) and design the animation with visual/pictorial, verbal/auditory, and written representation in mind;
- Adhere to the spatial and temporal contiguity principles (see Table 1);
- Design the animation with signaling or cueing to focus learner attention;
- Incorporate active learning, self-explanation, and recall into the design;
- Encourage the learner to imagine the task being animated and model the steps/task in their mind; and
- Present differing models and ask the learner to identify differences and similarities.

In 2018, Mayer provided a personal account of online learning research spanning 30 years. His reflection on applying the science of learning to education also serves as a summary of this portion of the research. Mayer (2018) has found that learning is not caused by the instructional media; rather, it occurs through the instructional method. Passive media can result in active learning when designed to elicit cognitive activity and processing. Researchers and educators must consider the features and affordances of different learning environments and incorporate them into the instructional method. Three principles to guide instructional methods that manage essential cognitive processing during learning include the personalization principle (i.e., the use of conversational language), the embodiment principle (i.e., the use of human-like gestures for a digital instructor), and the voice principle (i.e., the use of a friendly, human voice) (Mayer, 2018, p. 157). The incorporation must be based on learner-centered theories and consider how the media or technology can be adapted to support learning, as opposed to asking the learner to adapt to the media or technology. Mayer (2018) concluded that instructional practice must be grounded in research that is rigorous, systematic, contributes to learning theory, and identifies those conditions that make instructional techniques effective.

The Use of Video

As noted by Mayer and Moreno (2002), a video differs from an animation. Whereas animation is a simulated creation, a video is the live-motion capture of an event. Video-based learning (VBL) allows educators to present knowledge in a consistent manner that is visually stimulating and engaging (Yousef et al., 2014). Like animated models, videos can help students visualize complex tasks and procedures in a realistic environment. The media share the same guiding principles of design to decrease extraneous cognitive load and increase germane cognitive load during the learning process, as previously discussed. Videos are often used in flipped courses and online learning environments as a lecture medium and as supplemental instructional content (Beatty et al., 2019).

In their critical analysis of VBL research spanning from 2003 to 2014, Yousef et al. (2014) found that some of the literature on VBL is conflicting. The use of videos can positively impact learning outcomes, but not when the pedagogical aspect is inappropriate for the learning process. Videos can be used for interactive learning, but access issues may inhibit learning from home, causing the students to seek another learning environment. The integration of videos to develop, discuss, and explore learning options can enhance collaborative learning and prompt students to share in the responsibility of learning (Yousef et al., 2014).

A study by Herron et al. (2019) explored the use of video simulation as a way to provide experiential learning activities for nursing students. Similar to flight students, nursing and medical training require mastery of declarative and procedural knowledge. Practicing skills using simulated environments is a common practice (Herron et al., 2019). The researchers compared the use of video and written case studies to evaluate learning effects. Satisfaction, confidence, and knowledge scores were higher for those who learned using the video simulation case study than for those who utilized the written case study, although not statistically significant. The learners who used the video simulation also showed increased engagement with the material and commented that the video helped with visualization (Herron et al., 2019). Their findings may also translate to the flight training environment. Experiential Education ("ExpEd") modules were developed for an FAA Weather Technology in the Cockpit research project (Whitehurst et al., 2019). ExpEd modules utilize computer videos to simulate training and experience of flying in hazardous weather for pilots. The accessible videos allow pilots to recognize weather conditions they may not often encounter or which they need to identify and avoid. By training general aviation pilots using video simulations with deteriorating weather conditions, Whitehurst et al. (2019) found that decision-making and situation awareness can be improved as well as fill gaps in weather-related training. These training videos result in safer flight operations. The use of immersive video instruction can augment learning in the classroom, through which students can engage and better visualize a dynamic environment.

Understanding why a student will access a video is important. Beatty et al. (2019) found that most students in flipped classrooms prefer shorter video lectures. The researchers also found a positive relationship between video length, video usefulness, and the tendency to watch the videos. That is, if the student finds the video to be of value and an appropriate length, they will be more likely to watch more videos (Beatty et al., 2019). Yousef et al. (2014) reported that 10-minute videos may be too long to keep the attention of students. This finding emphasizes the importance of video design and ensuring the content enhances learning, as discussed previously in the section on animation. Bardakci (2019) explored high schooler's use of YouTube for educational purposes, such as supplementing their education and knowledge by watching videos, using the unified theory of acceptance and use of technology. Although his study concerned Turkish students, Bardakci's (2019) participants were members of Gen Z and the findings provide insight into these students in general. His results indicated that performance expectancy (i.e., perceptions regarding the potential benefits of using YouTube) and social influence (i.e., the likelihood of use based on the perceived value by others) were significant predictors of behavioral intention to use YouTube for educational purposes. Behavioral intention (in this study, how much effort will be exerted, as measured by preferences and intentions) was a significant predictor of the actual use of YouTube. Bardakci (2019) concluded that high school students will be more likely to watch YouTube videos for educational purposes if they believe that doing so will improve academic performance and if they perceive that their peers and teachers find the practice acceptable. Stronger intentions will also make it more likely that the student will use YouTube for educational purposes (Bardakci, 2019). Knowing this, educators can utilize educational videos in the classroom to normalize using the medium, they can provide video recommendations or create content for students to access outside of the classroom, and they can encourage students to share videos that enhanced understanding. These actions may help students to accept using YouTube for educational purposes and motivate them to engage with educational materials on their own time.

The conclusions of Beatty et al. (2019) and Bardakci (2019) are echoed by Leatherman and Cleveland (2020), who found that the clearest defining characteristic of the dissatisfied students was the dislike of learning from videos. Dissatisfaction arose from video length, lack of interaction with the content (such as the inability to ask questions), distraction, and learning preference (Leatherman & Cleveland, 2020). Appropriate videos as a break from a lecture, as a learning tool in an activity, or as supplemental material can enhance understanding for a generation of students who are visual learners and utilize social media daily (Roseberry-McKibbin, 2017). The accessibility of a video through the learning platform allows students to revisit the content at their convenience. Educators can also discuss the value of using videos for educational purposes, an important consideration for Gen Z students (Barber, 2020).

The Use of 360º Video

Having discussed the benefit of using animations and videos to deepen learning and cognitive processes, the question of immersion may be discussed. A 360º video is an omnidirectional, live-motion capture of an event and its surroundings (Snelson & Hsu, 2019). Using 360º video, learners are more immersed in the environment through interaction via panning and tilting as well as sensory input. These videos can be accessed through computers, mobile devices, and virtual reality (VR) head-mounted displays. The main difference between 360º video and VR is that the former is created through real-world video footage and the latter is generated through computer software (Snelson & Hsu, 2019). VR also allows the user to virtually interact with the surrounding environment and objects, while 360º video is limited to interaction via panning and tilting for viewing purposes. This trend is relatively new, given the recent decreasing cost and the increasing availability of the technology.

Snelson and Hsu (2019) used a scoping review approach to examine the research on using 360º video in educational environments. The authors found that immersion (i.e., the subjective, perceived level of participation in a realistic experience) was a key consideration in using 360º video to enhance learning (Snelson & Hsu, 2019). Higher levels of immersion (e.g., exploration of content through a mobile screen or using VR) can increase student enjoyment and interest in a topic. However, the novelty of the technology may also be distracting, which could negatively impact the learning process. Like animation and regular video, 360º videos can be augmented with additional information through text and narration.

Snelson and Hsu (2019) found that although 360º videos have mixed impacts on understanding, recall and retention were deemed comparable between different levels of immersion in several studies (Snelson & Hsu, 2019; see also Dolgunsöz et al., 2018; Harrington et al., 2017). Others have found 360º video to benefit the learning process. Rupp et al. (2019) compared learning outcomes related to declarative knowledge across four devices with varying immersion levels. They found that the use of more immersive devices was associated with increased student interest in the subject matter, positive affect, and recall of narrated information. Yoganathan et al. (2018) compared the use of 2D video and 360º VR video on learning knot tying for surgical trainees. Participants received training using the video, practiced the skill independently, and had F2F instruction followed by a final evaluation. Participants who watched the 360º VR video had significantly higher knot tying scores; the finding persisted with face-to-face instruction. Although there was no significant difference in time to construct the knot, more participants who watched the 360º VR video were able to complete the knot tying successfully (Yoganathan et al., 2018).

Snelson and Hsu (2019) concluded that although more research is needed, 360º video and 360º video with VR may benefit skill-based knowledge acquisition (i.e., procedural knowledge) as opposed to conceptual knowledge acquisition. Yoganathan et al. (2018) demonstrated that 360º video can aid training on physical tasks, both as an independent training medium and as a supplement to face-to-face instruction. Animation and video have been researched to understand how to increase germane cognitive load and decrease extraneous cognitive load during the learning process. Immersive 360º video must also be rigorously researched to ensure its use is grounded in instructional theory and adheres to the principles that guide the design of less-immersive media (Mayer, 2018; Mayer & Moreno, 2002; Wouters et al., 2008).

The Use of Tone in Narration

This subsection is relevant to answer the sixth research question, which asked if students have a preference for the tone of narration in multimedia or if it impacted learning. The works of Mayer and his associates (2014b, 2018; Mayer & Moreno, 2002; Mayer et al., 2003) examined tone and narration and may be used to answer the research question succinctly. Mayer and Moreno (2002) utilized the personalization principle in their research, stating that deeper learning occurs when narration or on-screen text is conversational and uses first and second person constructions (i.e., “I” and “you” language) as opposed to formal language. They surmised that personal involvement in a situation prompts students to work harder to understand what they are learning. In a review of his 30 years of research, Mayer (2018) stated that the personalization principle and the voice principle (i.e., using a friendly human voice rather than a synthesized one) should be considered when recording narration for multimedia. Furthermore, voice and tone can be used to stress key terms as a way to audibly signal the learner (Mayer, 2018). Pickering (2012) also concluded that the tonal choice of instructors can be exploited to increase the accessibility of a subject and establish rapport. Her results suggested that tone can contribute to communication success or failure in a classroom setting. This finding may apply to recorded narration associated with a video or animation. It is evident that a conversational tone is more beneficial than a formal tone.

Conclusions and Recommendations

The goal of this research was to provide an understanding of how flight students learn in order to implement interactive learning materials into courses effectively. There is strong evidence that well-designed interactive modules enhance the learning process of a dynamic task in an online or blended learning environment. Interactive modules capture student attention, enhance understanding, and provide variety in the learning materials while upholding the FAA's standards for training (Baghdasarin, 2020; Niemczyk, 2017). The interactive modules should align with Mayer and Moreno's (2002) and Wouters et al.'s (2008) principles and guidelines to create multimedia that will decrease extraneous cognitive load while increasing germane cognitive load during the learning process. The effective implementation of web-based instruction depends on the intended learning outcomes as well as the learning environment (Sitzmann et al., 2006). Education through experiential, active, and transformative learning activities can also guide the implementation of interactive learning materials that allow students to take ownership of their academic experience (Bass, 2012; Leatherman & Cleveland, 2020; see also Freeman et al., 2014).

The FAA allows for internet-based pilot training under 14 CFR § 141.53 (Approval procedures for a training course, 2020). Augmenting a flight course to include interactive modules, accessible online, does not lessen the impact of the educator on student learning. Miller and Mills (2019) studied the impact of teacher "caring" on Gen Y and Gen Z's willingness to learn. They found that students value approachable and relatable traits in their educators, and that in-class pedagogical practices can reflect the extent to which a teacher cares about the class, the students, the subject, etc. A student who perceives their instructor as uncaring may disengage and lose motivation. In any learning environment, educators must foster rapport with their students in their pedagogical models, in how they communicate, and by encouraging community (Helms, 2014; Falloon, 2011; Miller & Mills, 2019).

Recommendations for Future Research

The literature review demonstrated that interactive learning materials in a variety of learning environments can promote understanding, recall and retention, and cognitive processing. However, many of the studies did not consider flight students specifically. The exceptions include the personality type and learning style studies, which give insight into how flight students learn and, subsequently, can be effectively taught. Numerous studies consider how training can effectively transfer from a training device to the real-world environment; however, these studies were not examined as they do not directly address the research questions and because many others have written on the topic (Neal et al., 2020). Guidance on implementing interactive modules into flight courses can be drawn from Klemm (2012), Whitehurst et al. (2019), and similar studies, as well as research on students in other science, technology, engineering, and mathematics (STEM) fields.

DOI: https://doi.org/10.15394/jaaer.2021.1901

References

Albert, M., & Beatty, B. J. (2014). Flipping the classroom applications to curriculum redesign for an introduction to management course: impact on grades. *Journal of Education for Business, 89*(8), 419–424. https://doi.org/10.1080/08832323.2014.929559

Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology, 35*(1), 56-79. https://doi.org/10.1108/IJILT-02-2017-0009

Approval procedures for a training course: General. 14 CFR § 141.53. (2020). https://www.law.cornell.edu/cfr/text/14/141.53

Antonacci, D. M., & Modress, N. (2008). Envisioning the educational possibilities of user-created virtual worlds. *AACE Journal*, *16*(2), 115–126.

Baghdasarin, D. (2020). Aviation maintenance instructional design: How to teach the millennial and Gen-Z cohorts. *International Journal of Aviation, Aeronautics and Aerospace, 7*(1). https://doi.org/10.15394/ijaaa.2020.1441

Barber, V. H. (2020). Teaching and engaging generation Z during the coronavirus. *The Department Chair, summer 2020*. https://dx.doi.org/10.1002/dch.30335

Bardakci, S. (2019). Exploring high school students' educational use of YouTube. *International Review of Research in Open and Distributed Learning, 20*(2). https://doi.org/10.19173/irrodl.v20i2.4074

Bartsch, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers and Education*, *41*(1), 77-86. https://doi.org/10.1016/S0360-1315(03)00027-7

Bass, C. (2012). Learning theories & their application to science instruction for adults. *The American Biology Teacher, 74*(6), 387-390. https://doi.org/10.1525/abt.2012.74.6.6

Beatty, B. J., & Albert, M. (2016). Student perceptions of a flipped classroom management course. *Journal of Applied Research in Higher Education, 8*(3), 1–16. https://doi.org/10.1108/JARHE-09-2015-0069

Beatty, B. J., Merchant, Z., & Albert, M. (2019). Analysis of student use of video in a flipped classroom. *Techtrends, 63*(4), 376-385. https://doi.org/10.1007/s11528-017-0169-1

Berk, R. A. (2011). "PowerPoint® engagement" techniques to foster deep learning. *The Journal of Faculty Development*, *25*(2), 45.

Bialik, K. & Fry, R. (2019, January 30). *Millennial life: How young adulthood today compares with prior generations*. Pew Research Center. https://www.pewresearch.org/social-trends/2019/02/14/millennial-life-how-young-adulthood-today-compares-with-prior-generations-2/

Brady, T., Stolzer, A., Muller, B., & Schaum, D. (2001). A comparison of the learning styles of aviation and non-aviation college students. *Journal of Aviation/Aerospace Education & Research*, *11*(1). https://doi.org/10.15394/jaaer.2001.1286

Brock, S., & Joglekar, Y. (2011). Empowering PowerPoint: Slides and teaching effectiveness. *Interdisciplinary Journal of Information, Knowledge, and Management*, *6*, 85-94. https://doi.org/10.28945/1366

Byrnes, K. P. (2017). Employing flight simulation in the classroom to improve the understanding of the fundamentals of instruction among flight instructor applicants. *Journal of Aviation/Aerospace Education & Research*, *26*(1), 49-63. https://doi.org/10.15394/jaaer.2017.1623

Campbell, J. S., Castaneda, M., & Pulos, S. (2009). Meta-analysis of personality assessments as predictors of military aviation training success. *The International Journal of Aviation Psychology, 20*(1), 92-109. https://doi.org/10.1080/10508410903415872

Craig, P. A. (2009). Evaluating pilots using a scenario-based methodology: A guide for instructors and examiners. *International Journal of Applied Aviation Studies, 9*(2), 155-170.

Crappell, C. (2018). The ABCs of Gen X, Y (P), Z. *The American Music Teacher*, *67*(5), 42-44.

Dimock, M. (2019, January 17). *Defining generations: Where Millennials end and Generation Z begins*. Pew Research Center: Fact Tank. https://www.pewresearch.org/fact-tank/2019/01/17/where-millennials-end-and-generation-z-begins/

Dolgunsöz, E., Yıldırım, G., & Yıldırım, S. (2018). The effect of virtual reality on EFT writing performance. *Journal of Language and Linguistic Studies, 14,* 278–292.

Eades, T. (2021, March 12). 3 major post-COVID changes in higher education. *eCampus News*. https://www.ecampusnews.com/2021/03/12/3-major-post-covid-changes-in-higher-education/2/

English, B. M., & Rainwater, S. B. (2006). The effectiveness of animations in an undergraduate operating systems course. *Journal of Computing Sciences in Colleges, 21*(5), 53-59.

Falloon, G. (2011) Making the connection. *Journal of Research on Technology in Education, 43*(3), 187-209. https://doi.org/10.1080/15391523.2011.10782569

Federal Aviation Administration. (2020a). *Aviation instructor's handbook*. U.S. Department of Transportation.

Federal Aviation Administration. (2020b, April 6). *FAA aviation safety memorandum*. FAA General Aviation and Commercial Division, U.S. Department of Transportation.

Federal Aviation Administration. (2020c). *Part 141 pilot schools, application, certification, and compliance* (Advisory Circular 41-1B). U.S. Department of Transportation.

Federal Aviation Administration. (2020d). *2019 Active Civil Airmen Statistics*. Report from U.S. Civil Airmen Statistics, U.S. Department of Transportation.

Fitzgibbons, A., Schutte, P., & Davis, D. (2004). Pilot personality profile using NEO-PI-R. National Aeronautics and Space Administration. http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20040191539.pdf

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Fussell, S., Dattel, A. R., & Mullins, K. (2018). Personality types and learning styles of collegiate aviation students. *International Journal of Aviation, Aeronautics, and Aerospace, 5*(3). https://doi.org/10.15394/ijaaa.2018.1223

Gao, Y., & Kong, S. (2016). Personality types of pilot students: A study of an Australian collegiate aviation program. *International Journal of Aviation, Aeronautics, and Aerospace, 3*(3). https://doi.org/10.15394/ijaaa.2016.1130

Garner, J. K, & Alley, M. P. (2013). How the design of presentation slides affects audience comprehension: A case for the assertion–evidence approach. *International Journal of Engineering Education, 29*(6), 1564–1759.

Garner, J. K, & Alley, M. P. (2016). Slide structure can influence the presenter's understanding of the presentation's content. *International Journal of Engineering Education, 32*(1A), 39–54.

Harriman, S. L. (2011). *The impact of collegiate aviation student learning styles on flight performance: A scenario-based training approach* [Doctoral dissertation, Purdue University]. Purdue e-Pubs. https://docs.lib.purdue.edu/dissertations/AAI3479494/

Harrington, C. M., Kavanagh, D. O., Ballester, G. W., Ballester, A. W., Dicker, P., Traynor, O., . . . Tierney, S. (2017). 360° operative videos: A randomised cross-over study evaluating attentiveness and information retention. *Journal of Surgical Education*, *75*, 993–1000. https://doi.org/10.1016/j.jsurg.2017.10.010

Hegarty, M., Kriz, S., & Cate, C. (2003). The roles of mental animations and external animations in understanding mechanical systems. *Cognition and Instruction, 21*, 325-360. https://doi.org/10.1207/s1532690xci2104_1

Helms, S. A. (2014). Blended/hybrid courses: A review of the literature and recommendations for instructional designers and educators. *Interactive Learning Environments*, *22*(6), 804-810. https://doi.org/10.1080/10494820.2012.745420

Herron, E. K., Powers, K., Mullen, L., & Burkhart, B. (2019). Effect of case study versus video simulation on nursing students' satisfaction, self-confidence, and knowledge: A quasi-experimental study. *Nurse Education Today*, *79*, 129-134. https://doi.org/10.1016/j.nedt.2019.05.015

Kalkhurst, D. (2018, March 12). *Engaging Gen Z students*. Pearson Higher Education. pearsoned.com/engaging-gen-z-students/

Kanske, C. A., & Brewster, L. T. (2001). The learning styles of college aviation students. *Collegiate Aviation Review, 19*(1), 62-70. https://doi.org/10.22488/okstate.18.100298

Klemm, M. F. (2012). Hybrid courses in aeronautical science curriculums. *The Journal of Aviation/Aerospace Education & Research, 21*(3), 9-15.

Knowles, M. S. (1977). *The modern practice of adult education - Andragogy versus pedagogy*. The Association Press.

Korakakis, G., Pavlatou, E. A., Palyvos, J. A., & Spyrellis, N. (2009). 3D visualization types in multimedia applications for science learning: A case study for 8th grade students in Greece. *Computers & Education, 52*, 390-401. https://doi.org/10.1016/j.compedu.2008.09.011

Koroghlanian, C., & Klein, J. D. (2004). The effect of audio and animation in multimedia instruction. *Journal of Educational Multimedia and Hypermedia, 13*, 23-46.

Krull, G., & Duart, J. M. (2018, July 5-6). *Meeting the needs of digital learners: Learner support patterns and strategies* [Paper presentation]. Icel 2018 - 13th International Conference on E-Learning, Cape Town, South Africa. https://dl.acm.org/doi/book/10.5555/3279400

Kutz, M. N., Carmichael, D. B., Shandiz, M., & Brown, D. M. (2004). A comparative study of collegiate aviation students and business students related to Myers-Briggs type indicator preferences. *Journal of Aviation/Aerospace Education & Research, 14*(1), 43-49. https://doi.org/10.15394/jaaer.2004.1532

Leatherman, J. L., & Cleveland, L. M. (2020). Student exam performance in flipped classroom sections is similar to that in active learning sections, and satisfaction with the flipped classroom hinges on attitudes toward learning from videos. J*ournal of Biological Education, 54*(3), 328-344. https://doi.org/10.1080/00219266.2019.1575266

Lederman, D. (2020, March 18). Will shift to remote teaching be boon or bane for online learning? *Inside Higher Ed.* https://www.insidehighered.com/digital-learning/article/2020/03/18/most-teaching-going-remote-will-help-or-hurt-online-learning

Lin, L., Hung, I., Kinshuk, & Chen, N. (2019). The impact of student engagement on learning outcomes in a cyber-flipped course. *Educational Technology, Research and Development, 67*(6), 1573-1591. https://doi.org/10.1007/s11423-019-09698-9

Martinez, J. (2020, June 22). Take this pandemic moment to improve education. *EdSource*. https://edsource.org/2020/take-this-pandemic-moment-to-improve-education/633500

Mavin, T. J., & Roth, W. (2015). Optimizing a workplace learning pattern: A case study from aviation. *The Journal of Workplace Learning, 27*(2), 112-127. https://doi.org/10.1108/JWL-07-2014-0055

Mayer, R. E. (2014a). Incorporating motivation into multimedia learning. *Learning and Instruction, 29*, 171-173. https://doi.org/10.1016/j.learninstruc.2013.04.003

Mayer, R. E. (2014b). Principles based on social cues in multimedia learning: Personalization, voice, image, and embodiment principles. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (2nd ed.) (pp. 345–368). Cambridge University Press. https://doi.org/10.1017/CBO9781139547369.017

Mayer, R. E. (2018). Thirty years of research on online learning. *Applied Cognitive Psychology, 33,* 152-159. https://doi.org/10.1002/acp.3482

Mayer, R. E., & Moreno, R. (1998). A cognitive theory of multimedia learning: Implications for design principles. *Journal of Educational Psychology, 91*(2), 358-368. https://doi.org/10.1037/0022-0663.91.2.358

Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review, 14*(1), 87-99. https://doi.org/10.1023/A:1013184611077

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist, 38*(1), 43-52. https://doi.org/10.1207/S15326985EP3801_6

Mayer, R. E., Sobko, K., & Mautone, P. D. (2003). Social cues in multimedia learning: Role of speaker's voice. *Journal of Educational Psychology, 95*(2), 419-425. https://doi.org/10.1037/0022-0663.95.2.419

Merriam, S. B., & Bierema, L. L. (2014). *Adult learning: Bridging theory and practice*. Jossey-Bass.

Mhatre, K. H., & Conger, J. A. (2011). Bridging the gap between Gen X and Gen Y: Lessons from authentic leadership. *Journal of leadership studies, 5*(3), 72-76. https://doi.org/10.1002/jls.20235

Miller, A. C., & Mills, B. (2019). "If they don't care, I don't care": Millennial and Generation Z students and the impact of faculty caring. *Journal of the Scholarship of Teaching and Learning, 19*(4), 78-89. https://doi.org/10.14434/josotl.v19i4.24167

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open, 1*(2020). https://doi.org/10.1016/j.ijedro.2020.100012

Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. *The Journal of Nursing Education, 52*(10), 597-599. https://doi.org/10.3928/01484834-20130919-03

Mohr, K. A. J. & Mohr, E. S. (2017). Understanding Generation Z students to promote a contemporary learning environment. *Journal on Empowering Teaching Excellence, 1*(1), 84-94. https://doi.org/10.15142/T3M05T

Moore, M. (1997). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education* (pp. 22-38). Routledge.

Moore, M., & Kearsley, G. (1996). *Distance education: A systems view*. Wadsworth Publishing Company.

Moulton, S. T., Türkay, S., & Kosslyn, S. M. (2017). Does a presentation's medium affect its message? PowerPoint, Prezi, and oral presentations. *PLoS ONE, 12*(7). https://doi.org/10.1371/journal.pone.0178774

Mutlu-Bayraktar, D., Cosgun, V., & Altan, T. (2019). Cognitive load in multimedia learning environments: A systematic review. *Computers & Education, 141*. https://doi.org/10.1016/j.compedu.2019.103618

Neal, J. G., Fussell, S. G., & Hampton, S. (2020). Research recommendations from the airplane simulation transfer literature. *Journal of Aviation/Aerospace Education & Research, 29*(2). https://doi.org/10.15394/jaaer.2020.1830

Nicholas, A. J. (2020). *Preferred learning methods of generation Z*. Salve Regina University Digital Commons.

Niemczyk, M. (2017, August 14–16). *Generational shift: Why we should modify our instructional strategies for the next generations of aviators* [Conference session]. National Training Aircraft Symposium (NTAS), Daytona Beach, FL. https://commons.erau.edu/ntas/2017/presentations/28

Parker, K., & Igielnik, R. (2020, May 14). *On the cusp of adulthood and facing an uncertain future: What we know about Gen Z so far*. Pew Research Center. https://www.pewsocialtrends.org/essay/on-the-cusp-of-adulthood-and-facing-an-uncertain-future-what-we-know-about-gen-z-so-far/

Pelletier, S. G. (2010). Success for adult students. *Public Purpose, Fall 2010*, 2-6.

Pew, S. (2007). Andragogy and pedagogy as foundational theory for student motivation in higher education. *InSight: A Collection of Faculty Scholarship, 2,* 14-25. https://doi.org/10.46504/02200701pe

Pickering, L. (2012). The role of tone choice in improving ITA communication in the classroom. *TESOL Quarterly, 35*(2), 233-255. https://doi.org/10.2307/3587647

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon*, *9*(5). https://doi.org/10.1108/10748120110424816

Postolov, K., Sopova, M. M., & Iliev, A. J. (2017). E-learning in the hands of Generation Y and Z. *Poslovna izvrsnost/Business Excellence, 11*(2), 107-119. https://doi.org/10.22598/pi-be/2017.11.2.107

Rainer, J. W. & Rainer, T. S. (2011). *The Millennials: Connecting to America's largest generation*. B&H Publishing.

Rias, R. M., & Zaman, H. B. (2011). Designing multimedia learning application with learning theories: A case study on a computer science subject with 2-D and 3-D animated versions. *Asia-Pacific Forum on Science Learning and Teaching, 12*(2), 1-32.

Robertson, M. F., & Putnam, A. R. (2008). Personality types of student pilots admitted to the aviation flight program at Southern Illinois University Carbondale. *Collegiate Aviation Review, 26*(1), 111-124. https://doi.org/10.22488/okstate.18.100370

Roehl, A., Reddy, S. L., & Shannon, G. J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning strategies. *Journal of Family and Consumer Sciences, 105*(2), 44-49. https://doi.org/10.14307/JFCS105.2.12

Roseberry-McKibbin, C. (2017). Generation Z rising. *ASHA Leader, 22*(12), 36-38. https://doi.org/10.1044/leader.AE.22122017.36

Rupp, M. A., Odette, K. L., Kozachuk, J., Michaelis, J. R., Smither, J. A., & McConnell, D. S. (2019). Investigating learning outcomes and subjective experiences in 360-degree videos. *Computers and Education*, *128*, 256-268. https://doi.org/10.1016/j.compedu.2018.09.015

Saritepeci, M., & Çakir, H. (2015). The effect of blended learning environments on student motivation and student engagement: A study on social studies course. *Education and Science, 40*(177), 203-216. https://doi.org/10.15390/EB.2015.2592

Schlee, R. P., Eveland, V. B., & Harich, K. R. (2020). From Millennials to Gen Z: Changes in student attitudes about group projects. *Journal of Education for Business, 95*(3), 139-147. https://doi.org/10.1080/08832323.2019.1622501

Servidio, R., & Cronin, M. (2018). PerLE: An "open source", ELearning moodle-based, platform. A study of university undergraduates' acceptance. *Behavioral Sciences, 8*(7), 63. https://doi.org/10.3390/bs8070063

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology, 59*(3), 623-664. https://doi.org/10.1111/j.1744-6570.2006.00049.x

Snelson, C., & Hsu, Y. (2019). Educational 360-degree videos in virtual reality: A scoping review of the emerging research. *TechTrends, 64,* 404-412. https://doi.org/10.1007/s11528-019-00474-3

Thomas, R. L. (2018). *Effect of active learning on instrument rated pilots' knowledge and self-efficacy* [Doctoral dissertation, Embry-Riddle Aeronautical University]. Scholarly Commons.

Whitehurst, G., Brown, L., Rantz, W., Nicolai, D., & Bradley, J. (2019). The effect of experiential education on pilots' VFR into IMC decision-making. *Journal of*

Aviation/Aerospace Education and Research, 28(2), 27. https://doi.org/10.15394/jaaer.2019.1793

Wold, K. A. (2011). Blending theories for instructional design: Creating and implementing the structure, environment, experience, and people (SEEP) model. *Computer Assisted Language Learning, 24*(4), 371-382. https://doi.org/10.1080/09588221.2011.572900

Wouters, P., Paas, F., & van Merriënboer, J. J. G. (2008). How to optimize learning from animated models: A review of guidelines based on cognitive load. R*eview of Educational Research, 78*(3), 645-675. https://doi.org/10.3102/0034654308320320

Yoganathan, S., Finch, D. A., Parkin, E., & Pollard, J. (2018). 360° virtual reality video for the acquisition of knot tying skills: A randomised controlled trial. *International Journal of Surgery, 54*(Pt A), 24-27. https://doi.org/10.1016/j.ijsu.2018.04.002

Yousef, A. M. F., Chatti, M. A., & Schroeder, U. (2014). The state of video-based learning: A review and future perspectives. *International Journal on Advances in Life Sciences, 6*(3/4), 122-135.