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Blended Learning Principles for Effective Training Outcomes: A Literature Review

Charla Long
Brett Torrence

Civil Aerospace Medical Institute
Federal Aviation Administration
Oklahoma City, OK 73125

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16. Abstract Researchers conducted a literature review to describe the ability to integrate training technologies into the current Air Traffic Controller curriculum, specifically training at the FAA Academy. The literature review used research as a foundation to develop a comprehensive definition of adult learners, break down the various concepts of andragogy, and describe various training technologies used in blended learning. Best practices and recommendations in the areas of training design, instructional strategies, and technology support were also provided.		
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List of Acronyms

ATC	Air Traffic Controller
FAA	Federal Aviation Administration
NAS	National Airspace System
NEXTGEN	Next Generation Air Transportation System
OJT	On-the-Job Training
ROI	Return-On-Investment
SDL	Self-Directed Learning
STEM	Science, Technology, Engineering, and Math

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Introduction

The safety and efficiency of the National Airspace System (NAS) is dependent on the Federal Aviation Administration's (FAA) ability to develop highly-skilled air traffic controllers (ATCs). The FAA uses a multi-stage training program that requires new hires to complete FAA Academy training and field qualification training in order to certify as a professional controller[1]. Once becoming a certified controller, the FAA also offers additional refresher and proficiency trainings to support the knowledge and skill building of its workforce (FAA, 2019). Effective training is, therefore, critical for ensuring that the ATC occupation is well-staffed, that ATCs are qualified to perform their duties, and that controllers are able to meet the demands of the future aviation environment as the NAS transforms to the Next Generation Air Transportation System (NextGen; FAA, 2019). As the nature of the ATC occupation evolves, the FAA must continually look for ways to improve the efficiency and flexibility of the training program to meet the learning needs of controllers at different levels of experience.

Recent research suggests that ATC training practices have not progressed alongside advancements in training technology and design which is now increasingly technology-mediated, self-paced, and individualized (Brown et al., 2016; Schultheis, 2014). Implementation of advanced training delivery technology became necessary when the coronavirus pandemic caused the shutdown and delay of face-to-face training at the Academy. However, ATC training has historically relied extensively on classroom instruction and on-the-job training (OJT) with minimal computer-based and simulation trainings (Buck & Pierce, 2018). Brudnicki et al. (2006) offered that the integration of training technologies can assist the FAA in meeting the training needs of controllers by providing standardized, self-directed instruction as well as helping the organization deal with the high number of controllers that need to be trained. The application of these training technologies into the broader ATC training process needs to be addressed. The purpose of this literature review is to define adult learners, the theoretical concept of andragogy (which means methods for teaching adult learners), and training technologies used for blended learning. Additionally, the literature review will identify best practices and recommendations in training design, instructional strategies, and technology support in order to provide evidence-based recommendations for the integration of blended learning in initial ATC technical training content.

Adult Learning Theories

Air Traffic Control students are adult learners who attend technical training designed to teach the basic knowledge and skills required for the job. Educators of adult students, program administrators, and program planners must understand the adult learning concepts affecting these students in order to enhance the learner experience. Program administrators and researchers

[1] Candidates with at least 52 consecutive weeks of air traffic control experience within 5 years of application are allowed to bypass FAA Academy training if hired for the position. However, these candidates must complete facility-specific training at their assigned facility (FAA, 2019).

agree that including adult learning theories and practices in current and new training programs can richly enhance the learning experience. Andragogy and Self-Directed Learning, often known as the two pillars of adult education, are the theoretical constructs that support adult learning (Merriam, 2001).

Andragogy

Darkenwald and Merriam (1982) originally defined andragogy as "the process whereby persons whose major social roles are characteristic of adult status undertake systematic and sustained learning activities for the purpose of bringing about changes in knowledge, attitudes, values or skills (p. 9)". Knowles (1980) defined an adult learner as someone who "(1) has an independent self-concept and who can direct his or her own learning, (2) has accumulated a reservoir of life experiences that is a rich resource for learning, (3) has learning needs closely related to changing social roles, (4) is problem-centered and interested in immediate application of knowledge, and (5) is motivated to learn by internal rather than external factors" (Merriam, 2001, p. 5). In addition to these five characteristics, Knowles also stressed the need for the learning to be learner-centered, not instructor-centered in traditional education (Merriam, 2001). These definitions laid the foundation for the creation of an emergent model of andragogy entailing a set of six assumptions about the adult learner (Knowles, 1980). ATC training content should be designed and delivered to support the six assumptions required for successful adult learning to occur.

The Model of Andragogy

The first assumption states adults should be encouraged to discuss information presented by instructors while expressing their views on the topic. Collaborating in this manner allows adults to increase their self-confidence on a subject leading to higher performance on the information learned (McGrath, 2009). ATC students should be encouraged to ask questions and create their own understanding of the concepts delivered during training. Instructors should guide the learning process while creating opportunities for self-discovery. Supporting this assumption in training design and delivery can lead to greater knowledge retention of ATC students.

The second assumption states adults develop life and work experience, which is relied upon when faced with a learning challenge. Adults begin to draw conclusions and assimilate information by applying prior knowledge to the topic. New knowledge begins to be created by organically allowing these process to occur (Knowles, 1980). ATC students should be encouraged to make connections to past experience as examples that may be applicable to the concepts they are learning during the training. Training should be designed to include activities that allow students to make connections with past experiences. In addition, instructors should use practical examples, which are easily understood by a variety of individuals, to help support the new concepts being taught during training.

The third assumption asserts learning becomes a developmental task defined by the role maintained by the learner. The developmental task of learning a primary skill is contingent on the need for the skill in the social context, i.e. job development (Knowles, 1980). Developers should focus on the specific requirements pertaining to the ATC function and ensure the content focuses on the KSAOs/tasks relevant to the position. Instructors who are subject matter experts (SMEs) bring an authenticity to the learning environment and are able to teach the content from experience, focusing on the job relevant tasks. Activities should be built on ATC specific scenarios, as currently being done, in order for students to assimilate and appropriately apply solutions.

The fourth assumption states that adults learn by shifting information from content of topic to performance-centered outcomes. Learning initially begins when subject knowledge is being acquired, but continues to mature through performing a task in a desired manner and receiving an outcome for completing the task. The adult becomes interested in the application of the knowledge garnered. Designing curriculum to be taught through problem-solving with instructor support is essential for helping students meet this need (McGrath, 2009). ATC activities and scenarios should be built with the ability for students to work through problems to identify solutions for success. Students should receive supportive feedback during the training experience to identify the strengths and opportunities for growth.

The fifth assumption is that adults are motivated to learn. Adults are less concerned with a specific grade or reward, the primary motive for knowledge acquisition is found in the internal satisfaction gained from learning something new (Knowles, 1980). In addition, Maslow stated students are motived by the need to belong to a group. When students are comfortable in the group environment, they will excel academically and professionally (McGrath, 2009). Developers should focus on providing break-out rooms and/or small group exercises to support social engagement. Instructors should encourage students to create relationships. ATC students should be encouraged to create study groups and cohorts to support the learning environment. The different interactions can be done during face-to-face instruction or in remote learning across various platforms.

Self-Directed Learning

Intertwined with the theory of Andragogy is Self-Directed Learning (SDL). Adult educators and program administrators began using SDL in the 1970s and it has increased in popularity (Long, 1992). SDL allows the learning process to occur when “individuals take the initiative in assessing their own learning needs, formulate learning objectives, ascertain resources for learning, adopt appropriate learning strategies, and evaluate learning outcomes” (Knowles, 1975, p. 18). SDL happens when other types of learning assistance such as “teachers, tutors, mentors, resource people, and peers” (p. 18) work together to support the learning experience. SDL allows adults to create collaborative learning activities which are often preferred to traditional knowledge transfer from instructor to student (Kastner, 2019). Additionally, learners are able to focus on the learning process to gain knowledge and skills and continue growth with

little instructor support (Kastner, 2019). However, Knowles suggests if learners are struggling with some topics, instructors should guide and support the experience by providing opportunities for enrichment, but not prevent the self-creation of knowledge (Koc, 2019).

SDL allows the learner to organize, monitor, and evaluate their own learning (Koc, 2019). Allen and Seaman (2004) defined this as the intrinsic motivation of adults to continue to learn. By connecting information learned to previous life experiences, a deeper and more robust understanding and skills demonstration can occur (Kastner, 2019). Adults who are ready to learn will draw their own conclusions of the application of the concepts required during the educational experience leading to greater understanding of the concepts taught (Conrad and Openo, 2018).

Academic performance of learners is affected by SDL in online or blended learning settings. Researchers have found a positive relationship between SDL and academic achievement scores using blended learning more often than just one training modality (Hung et al., 2010; Kirmizi, 2015; Merriam & Caffarella, 1991).

Utilizing the model of andragogy combined with SDL principles can lead to a blended learning design of the ATC training curriculum, supporting knowledge and skill creation and retention of learners. Identifying the needs of the adult learner, including those related to training design, instruction principles, and technology can provide the foundation for developing a blended learning program at the FAA Academy.

Blended Learning

Many definitions of blended learning exist. However, researchers agree learning that occurs through a combination of online technology and face-to-face classroom instruction is considered blended learning (Conrad & Openo, 2018; Kastner, 2020; Lee, 2010; McGee & Poojary, 2020; Merriam & Caffarella, 1991; Prohorets, & Plekhanova, 2015; Zydney et al., 2018). Blended learning increases the opportunities to combine on-site and online learning allowing for flexibility, accessibility, and enhanced learning experiences (Kastner, 2020). Blended learning, compared to traditional instruction or online instruction only, has positive effects on the learning and student performance (Stein & Graham, 2014). Research shows that students in Science, Technology, Engineering, and Math (STEM) disciplines had improved learning outcomes in a blended environment than traditional classroom settings due to using active learning techniques focused on tasks and exercises (McGee & Poojary, 2020; Wibawa & Kardipah, 2018). In addition, using blended learning strategies allows students to gain technical knowledge to help prepare them for applied application outside the classroom (Wibawa & Kardipah, 2018).

Blended learning programs use synchronous and asynchronous activities for successful learning (Hratinski, 2008). The inclusion of both learning approaches in the design is viewed as essential for adult learning success. Past research has been limited due to the lack of

technological resources; however, with the invention and creation of multimedia tools that allow for greater enrichment, educators are beginning to see the benefits of integrating these modalities (Bower et al., 2014; Hrastinski, 2008; Prohorets, & Plekhanova, 2015; Yamagata-Lynch, 2014).

Synchronous Learning

Synchronous learning occurs when students attend the class at the same time (Hrastinski, 2008). These learning activities support group cohesion, social connection, and instructor engagement (Bower et al., 2014; Hrastinski, 2008; Yamagata-Lynch, 2014). While synchronous learning has traditionally been thought of as face-to-face instruction, new technology has afforded opportunities for online synchronous events to occur. Specifically, synchronous learning experiences occur through online chat forums, interactive discussion boards, small group meetings, and virtual classrooms (Bower et al., 2014; Hrastinski, 2008; Prohorets, & Plekhanova, 2015). Students are provided with flexibility and the ability feel connected due to the ability to co-create learning while remaining in their own environment (Prohorets, & Plekhanova, 2015). This approach is considered student-instructor focused (Sung et al., 2016).

Asynchronous Learning

Asynchronous learning activities are highly structured with little deviation from materials and students do not have to attend training at the same time (Hrastinski, 2008). These environments allow learners to complete learning activities on their own time, resulting in more control over the learning experience. Asynchronous learning is most often synonymous with e-learning environments. Asynchronous learning does not provide many opportunities to collaborate as students and instructors do not have to attend training at the same time (Prohorets, & Plekhanova, 2015). Additionally, asynchronous learning allows the participants to download materials, as well as view pre-recorded videos and webinars for learning at their own pace (Hrastinski, 2008; Holden & Westfall, 2006). Asynchronous learning is considered a student-focused approach (Reychav & Wu, 2015; Sung et al., 2016) as students enjoy the flexibility to learn on their own schedule at their own convenience (Bower et al., 2014, Hrastinski, 2019; Prohorets, & Plekhanova, 2015). In order for true blended learning to occur, using a combination of learning environments and tools is essential.

Training Environments and Modalities

A variety of training environments and modalities can be used to support student learning. The traditional classroom environment began in the United States in 1622 (Dexter, 1919). With the invention of distance education in the early 1970s, Michael Moore was the first to document the transition from traditional face-to-face instruction with the separation of student and teacher (Conrad & Openo, 2018). Since that time, rapid changes in technology and availability have occurred affording students the opportunity to participate in online learning environments (e-Learning and Virtual Learning) and experiences, as well as traditional classrooms.

Classroom Environment

The traditional framework for any educational experience is the teacher-led, face-to-face environment, known as an instructor-centered approach. Classrooms have been traditionally designed with a top down approach where the teacher is the subject matter expert. Traditional classrooms provide direct instruction to students and provide students with opportunities to apply what they learn at later time periods (Kim et al., 2000). An instructor-centered approach breaks information down into basic core concepts to develop a subject-knowledge base. This type of instruction removes learner autonomy while promoting the teacher as expert (Coffey & Davis, 2019). Problem-solving and independent thinking are developed later, once the baseline knowledge and information is received (Kim et al., 2000).

Flipped learning is a more recent advancement of the traditional instruction format (Zappe et al., 2009). The concepts are presented as foundational information by an instructor with opportunities for students to work in groups for collaboration (Coffey & Davis, 2019; Özüdoğru & Aksu, 2020). Flipped learning is especially effective when using technology to support the activities. Content is often delivered through online learning while classroom time is scheduled for activities, discussion, and expert insight (Özüdoğru & Aksu, 2020; Zydney et al., 2018). Research indicates flipped classrooms improve student learning and achievement specifically for STEM-related courses.

Online Environment

The use of online training has grown substantially in organizations and educational institutions given the availability of the internet and the continuing shift from instructor-centric to learner-centric training approaches (Brown et al., 2016; Zhang & Nunamaker, 2003). Online training refers to the use of internet resources to create a learning environment and deliver instructional content and materials (DeRouin et al., 2004). The training modalities most commonly used are e-learning and virtual learning classrooms (Lee, 2010). Formats such as webinars, videos, virtual classrooms, and e-learnings utilizing learning management systems for delivery of materials supplement the learning experience (Holden & Westfall, 2006). The flexibility afforded by online training environments makes it a potential replacement for portions of classroom instruction and amendable to different training efforts such just-in-time training (Jones, 2001). In contrast to classroom environment, the online training environment is learner-centered (Lee, 2010).

Online training requires the student to take responsibility for their learning experience. The learning is largely self-directed with information designed to cover a topic. The information presented highlights the most important concepts required, but assumes learners will continue to collect information to assimilate and scaffold this information (Conrad, & Openo, 2018). Scaffolding breaks the information learned, skill, or concept into discrete parts which provides a tool or structure to learn each chunk of information (Conrad & Openo, 2018). However, due to this requirement, research suggests delivering training exclusively online leads to a lack of

engagement, motivation, and authentic opportunities for students to engage with others (Kastner, 2020). Instructors struggle with the ability to appropriately assess student learning when online delivery of training is the only instruction students receive due to lack of interaction, uncertainty of knowledge gained, and primarily using polls or pass/fail questions for assessments (Conrad, & Openo, 2018).

Historically, online delivery has occurred in the form of e-learning and virtual learning experiences where technology supports the delivery of materials synchronously and/or asynchronously (Hrastinski, 2008; Kastner, 2020). However, in recent years, games and simulations have been designed to support online learning (Bell, et al, 2008; Landers, 2014).

e-Learning

e-Learning is traditionally defined as teaching and learning online using technology to deliver material to students, often asynchronously (Hrastinski, 2008). Courses designed using this technology are primarily static with little student to student interaction (Kastner, 2020). e-Learning makes it possible for students to log into the environment and learn at their own pace, often gaining knowledge of a new concept or idea through reading material or watching pre-recorded videos (Hrastinski, 2008). e-Learning has grown in popularity as technological advances have been made and mobile devices have become more prevalent in society (Conrad & Openo, 2018). Recent shifts in education have reflected the desire to move from a traditional e-Learning platform, which is largely depended on interactions between the student and course content with few interactions with the instructor, to a blended learning experience that utilizes a virtual platform to support learning. Virtual learning allows for student-instructor and student-student interaction to occur in real-time leading to an enriched learning experience (Conrad & Openo, 2018; McGee & Poojary, 2020).

Virtual Learning

Virtual learning began in 1960, when the University of Illinois created a network of computers where students could access recorded videos of instruction (Doan, 2020). Since that time, virtual learning has seen tremendous growth as institutions have looked for ways to supplement classroom learning, beyond brick-and-mortar schools (Kastner, 2019). Providing access to students in their own environment has allowed students to excel in their curriculum.

Today, virtual learning is used to supplement e-learning and/or face-to-face instruction (Hrastinski, 2008). Virtual learning is referred to as instruction that takes place where the instructor and students are geographically or physically distanced and the courses are delivered through an online platform synchronously (Doan, 2020; Yamagata-Lynch, 2014). Virtual learning uses webinar technology to engage students in discussions, breakout rooms, group activities, and instructor-led lectures (Kastner, 2019). Typically, virtual learning also includes assessments in the forms of polls, quizzes, and scenario responses (Conrad & Openo, 2018). Instructors can provide feedback in a timely manner, as well as clarify any challenges learners may have understanding concepts or content delivered through other formats (Doan, 2020).

Games

The use of educational games and game-like elements to enhance training has become increasingly popular due to the supposed benefits on learner engagement and motivation (Landers, 2014). Game-based training comprises both *serious games* which refer to the use of video games for educational purposes as well as *gamification* which involves the use of game-like elements (e.g., competition, rules) for training purposes (Vandercruysse et al., 2012; Yu, 2019). Olah (2020) describes that game-based trainings can range in the amount of gameplay (i.e., no gameplay to serious gameplay) and the focus of the training (e.g., attention, feedback, practice). Game-based trainings have been used in a variety of domains such as the military, law enforcement, education, and aviation domains (Hays, 2005, Moskaliuk et al., 2013; Vu, 2013). The development of game-based training grew from the belief that games, an entertainment technology, could be developed for instructional purposes and would better align with learner interests, thereby improving the intrinsic motivation and engagement of leaners (Hays, 2005). The use of games for training is also believed to have a positive effect on emotion and effort during training as well as knowledge and skill acquisition given the dynamic, interactive environment created by games (Korteling et al., 2013; Yu, 2019).

Simulations

Simulation training involves the use of artificial environments (e.g., virtual) to provide learners with learning experiences and practice opportunities in realistic, job-like settings (Bell et al., 2008). While there is some overlap between game-based training and simulation training, simulations are not structured around game elements and instead are concerned with the recreation of realistic environments. Simulation exercises immerse trainees in virtual settings characterized by instructional features to guide learning experiences and accelerate the acquisition of knowledge and skill. Simulations are useful for domains, such as aviation, emergency response, and medicine (Kunkler, 2006; McLean et al., 2016; Williams-Bell et al., 2015), where practice in real-world settings is too costly or too dangerous. Simulation training is also useful for training skills that are critical, but are infrequently used on the job (Salas, Rosen, et al., 2009). The term simulation covers a broad spectrum ranging from low-fidelity to high-fidelity simulations that are used to create a synthetic practice setting (Salas, Wildman, et al., 2009a). For example, Salas, Rosen, et al. (2009) describe three categories of simulations: role-playing simulations, physically-based simulations, and computer-based simulations. Even within these different environments, the cost and use of technology can range substantially.

Gegenfurtner et al., (2014) states that there are two assumptions underlying the effectiveness of simulation trainings. The first assumption is that simulations are more motivating than traditional training, in part, because simulations recreate work-like settings and provide the opportunity to practice trained skills. These elements can promote learner engagement and improve learner self-efficacy (i.e., the belief in one's ability to successful perform a task). The second assumption is that simulation training results in more transferable skills as simulation exercises elicit behaviors that are similar to what is required in on the job.

Since simulations are often an authentic representation of the job setting, learners should better recognize the similarities between the training environment and the task context, which as a result should increase the chance that individuals apply what they have learned to the job.

Training Design

Creating a blended learning program is not as simple as using a variety of tools to teach information to students. The transition between classrooms, online, games, and simulations should be minimal, limiting the time between each training modality (Allen et al., 2007). Creating a blended learning program requires careful alignment with the learning tasks using modalities that can create synchronous and asynchronous experiences (Bower et al., 2014; Conrad & Openo, 2018; Hrastinski, 2008; Kastner, 2019; Prohorets & Plekhanova, 2015). Embarking on this endeavor begins with a thoughtful plan for training design.

Fenwick and Parsons (2009) suggest specific questions should be asked before beginning any training design:

1. What are the most important things learners should know?
2. Is the knowledge created by the learners or provided by expert instructors?
3. Who should control the learning experience?
4. Is learning systematic and sequential or holistic and idiosyncratic?, and
5. Can learners be asked to demonstrate the learning immediately or do they need time for reflection and practice? (pg. 15).

These guiding questions are further supported by Caulfield (2012) who suggested incorporating andragogic principles in adult learning programs. Specifically, learning should be designed to support the reasons the information is being taught, apply scaffolding techniques such as group interaction, simulation, and case studies for higher learning to occur, and allow for synergy of the learning to occur between instructors and students (Caulfield, 2012). This can be achieved by providing students interactive learning activities which can be largely self-directed (Kastner, 2019).

The key to developing training is careful planning to incorporate the necessary content required for student success and identifying available technologies to support learning objectives and transfer of training. This cannot be done by directly applying face-to-face content and activities to an online format (Kastner, 2019). The design should be driven by the content and or learning needs, defined by the content taught, tasks required, and complexity of the learning, rather than focusing solely on the technology solution (Lieser et al., 2018). Simpson & Anderson, 2009). Thus, blended learning should be designed so instructors and learners are working together to accomplish objectives through the use of a variety of assignments, activities, and assessments appropriate for each training modality. Additionally, the activities should bridge the environments being used for delivery (McGee & Reis, 2012). Finally, research suggests allowing for synchronous and asynchronous interactions to be infused allowing for an increased sense of community and learning for students (Kastner, 2019).

Tools and Technology

The use of tools and technology increases as blended learning becomes more popular. Webinars, e-learnings, videos, chatrooms, wikis, blogs, podcasts, and discussion boards (Boulus, Maramba, & Wheeler, 2006; Coffey & Davis, 2019; Hrastinski, 2008; Kastner, 2019; Lieser et al., 2018; Pape, 2010). Four of the most common webinar tools used in blended learning environments include Zoom, GoTo Meeting, Adobe Connect, and Blackboard Collaborate (Lieser et al., 2018). Table 1 describes the capabilities for each of these platforms. In addition to using the tools, a system should be implemented for recording the use and access of these tools by students (Pape, 2010). Tracking the tools used can provide necessary information regarding learner preferences in order to ensure instructors are using the most platforms for delivering training (Pape, 2010).

Table 1
Embedded Functionalities of Common Webinar Tools

FUNCTIONALITY	ZOOM	GOTO MEETING	ADOBE CONNECT	BLACKBOARD COLLABORATE
HD Video/Audio	**X**	**X**	**X**	**X**
Dial-in Audio (Computer/Phone)	**X**	**X**		
Screen Sharing (Application/Desktop)	**X**	**X**	**X**	**X**
Chat (Private/Group)	**X**	**X**	**X**	**X**
Control (Host/Moderator)	**X**	**X**	**X**	**X**
Icons (Raise Hand/Clap)	**X**	**X**	**X**	**X**
Breakout Rooms	**X**	**X**	**X**	**X**
Screen Sharing (Small Group)	**X**	**X**	**X**	**X**
Keyboard Control	**X**	**X**		
Whiteboard	**X**	**X**	**X**	**X**

Note: Adapted from Lieser et al. (2018).

Training designed using computers, smartphones, and tablets as the primary delivery method adds an additional layer of complexity because the lack of physical connection to others, limits of the technology, and predictableness of the tools accessed can decrease the capacity for learning new information (Zydney et al., 2018). In addition, cognitive load on the learner should

be considered when implementing any tools and/or technology for training delivery. Regardless of learning modality, there are capacity limits for learning new information. Research suggests that new learning decreases after 15-20 minutes and cognitive capacity becomes limited (Clark et al., 2006). Thus, traditional instructional strategies have incorporated activities that are short and/or segmented to ensure knowledge transfer. One way to do this successfully is through "chunking" (Palis & Quiros, 2014).

Chunking has been used to teach new content to learners through the use of technology and tools (Palis & Quiros, 2014). Chunking allows the learner to link new information with previous information (Barkle, 2010; Clark et al., 2006). When designing training through technology the application of chunking must be deliberate and thoughtful. The use of multiple platforms and media to support the learning and opportunities to apply the learning throughout the training will help support this challenge. In addition, adding opportunities for immediate feedback, even during asynchronous events, will help students master concepts quicker (Conrad & Openo, 2018).

Advantages and Disadvantages for Students

Many advantages exist for students enrolled in blended learning programs. A few of note include flexibility, lower cost, and accessibility of information (Conrad & Openo, 2018; Kastner, 2019). Research reports that students enjoy the flexibility afforded by allowing learning to occur in their own environment (Kastner, 2019; Merriam & Caffarella, 1991). Students have also reported cost savings by not requiring them to be onsite at a specific time, including but not limited to decreases in transportation (gas, tolls, fees, maintenance, etc.), food costs, living expenses (especially if they are maintaining two households), and the cost of textbooks or other materials (Kastner, 2018). Access to materials 24/7 affords more opportunities to learn on their own time, outside of traditional course hours (Conrad & Openo, 2018). Additionally, as previously stated, knowledge retention and gain is often greater when using a blended approach (Hung et al., 2010; Kastner, 2019; Kirmizi, 2015; Merriam & Caffarella, 1991).

Although blended learning shows gains in learning for students, there are also some disadvantages including, but not limited to, excessive screen time on digital devices, lack of time for social interaction during class, and difficulties with technology (Doan, 2020). Students stated that excessive screen time affected their concentration as it was easy to become distracted during the learning event (Kastner, 2018). Social interaction was limited in class when students were focused on completing activities and learning new content. The lack of engagement between students can lead to fewer opportunities for informal learning and sharing of information (Conrad & Openo, 2018). Finally, difficulties with technology including inadequate network connection speeds and lagging were noted (Doan, 2020; Lieser et al., 2018)

Limited research is available documenting the impacts of screen time on learning. However, factors such as eyestrain (Coles-Brennan et al., 2019; Gon & Rawekar, 2017; Siegenthaler et al., 2012; Rosenfield, 2016) and lack of body movements have been researched

(Doan, 2020; Seghers et al., 2003). These challenges are impacted further by the size of the screen (Coles-Brennan et al., 2019; Gon & Rawekar, 2017; Seghers et al., 2003; Siegenthaler et al., 2012).

Social interaction and a sense of community can be built by providing opportunities for break out rooms, small group activities, and ongoing discussions. In addition, research suggests e-Learnings designed to provide foundational knowledge should be linked to well-designed virtual learning sessions where webinar technology is utilized for participant interaction. This interaction can be designed to include participant activities in break-out rooms, small group presentations, and multi-level discussions between students and instructors (Kastner, 2018; Margolis et al., 2017; McGee & Poojary, 2020).

Training technology can be unpredictable (Zydney et al., 2018). Difficulties with technology include slow download times, difficulty hearing instructors and peers, lack of concentration required when using digital training modalities, and struggles with self-discipline to complete work timely (Doan, 2020). Posting materials early can help students mitigate slower times for downloading, allowing them to work around high internet usage times (Margolis et al., 2017). Using technology that is flexible and allows for cloud access can also increase internet speeds and help with connectivity. Additionally, selecting tools that match the tasks required for learning the topic can help students assimilate the information needed for success (Lieser et al., 2018; Zydney et al., 2018). Students should also be provided with short training activities to supplement learning in order to help them stay on tasks. Using engaging practices such as polling, group chats, whiteboard exchanges, and breakout rooms can help students stay on task (Doan, 2020; Lieser et al., 2018). Considering the student challenges, training designers should determine ways to segment asynchronous with synchronous learning to help mitigate some of these learning disadvantages (Doan, 2020).

Instructor Engagement and Preparedness

Researchers suggest that instructors often struggle in blended learning environments with creating a balance between the various learning formats, maintaining high levels of student engagement (especially when using online formats), and motivating students to complete assignments (Kastner, 2019). Instructors also have difficulty shifting their instructional approaches between various modalities (Bliuc et al., 2007).

Managing the learning environments entails using the online and face-to-face time appropriately. Instructors value the online environment as an opportunity to deliver information using videos and other assessments for knowledge acquisition and retention (Conrad & Openo, 2018; Kastner, 2019). Face-to-face time is reserved for sharing expert knowledge and collaborating with students to scaffold information (Kastner, 2019). Instructors were less likely to identify individual differences in student's ability and treat the student autonomously in the online environment than during face-to-face sessions (Kastner, 2019). Learning events were

viewed as unique, stand-alone learning opportunities not considering the requirement for creating linkages and assimilation of information across the modalities (Bliuc et al., 2007).

For blended learning to be successful, instructors must adopt and buy-into the concept of blending curriculum across modalities for student success (Kastner, 2019). One way this can occur is by creating an environment that is interactive, designed to maximize student engagement (Lee, 2010). Instructors should work to incorporate current material and experience when teaching. Additionally, activities should be designed to support the application of these principles and collaborate to create community learning (Kastner, 2019).

Instructors should also be forthcoming of the course expectations and requirements for blending the material at the beginning of the program (Lieser et al., 2018). Level setting with the learners will allow them to create a schedule supporting motivation and SDL (Margolis et al., 2017). Utilizing a webinar, if the course or program utilizes technology as the first face-to-face instruction, at the beginning of the program to provide a clear overview of the program will help students feel connected, increasing SDL (Kastner, 2019).

Instructor support is needed to be able to learn how to teach using technology. This requires an investment from the instructor as well as the organization. Learning the technology in order to successfully utilize the modalities for teaching requires that instructors are trained on the functionalities of the technology (Zydney, et al., 2018). Additionally, mastering the learning environments will require additional support, especially for instructors who have primarily taught using traditional educational principles (Bell et al., 2014; Ocak, 2011). Support should include employing co-instructors and technology support technicians (McGee & Poojary, 2020). During online training events, support personnel can help mitigate workload on the instructor and make the experience more valuable for the learner (Kastner, 2019; McGee & Poojary, 2020; Zydney et al., 2018). In addition, instructors should learn the facilitation skills for each platform and training modality as the required skills may differ across platforms (Kastner, 2019; Zydney et al., 2018).

Best Practices and Recommendations

A thorough review of the literature has been provided in order to document the best practices for creating a blended learning program that will meet the need of students and instructors. Specifically, recommendations for training design, tools and technology, students, and instructors have been described to help guide the creation of a blended learning program. This list is not all inclusive as each training program has unique challenges and opportunities. Flexibility in implementing these recommendations is anticipated.

Training Design

- Promote collaborative and participatory learning activities by designing synchronous and asynchronous learning such as discussion boards, video chats, recorded lectures,

and breakout rooms for small group discussion (Fung, 2004; Gros & García-Peñalvo, 2016)

- Provide practice opportunities, such as quizzes or assignments, to allow students to assess their knowledge and track their learning progress (Sitzmann et al., 2006)
- Generate short learning videos (micro-learning <6 minutes) to reduce cognitive load and contribute to the retention of learning (Afify, 2020; Gon & Rawekar, 2017)
- Practice scenarios should be constructed to elicit desired knowledge and skills (Salas & Burke, 2002)
- Identify complexity of content areas before deciding on the appropriate delivery method (i.e. more complex areas may need more guidance from an instructor) (Hrastinski, 2004)
- Instructional strategies, including demonstration, deliberate practice, and feedback, must be integrated to create a meaningful learning environment (Gegenfurtner et al., 2014)
- Assessment matching real-world tasks should be used to engage students in order to make connections with the tasks and skills allowing the learner to identify multiple solutions to a problem or scenario (Conrad & Openo, 2018)

Tools and Technology

- Identify and beta-test user-friendly tools with the minimum level of functionality needed to support the instruction (i.e. breakout rooms, audio/visual capabilities, embedded content or videos, etc.) (Zydney et al., 2018)
- Choose technology that is flexible and can be accessed by various devices (Conrad & Openo, 2018; Margolis et al., 2017)
- Bandwidth and internet connectivity should be considered when selecting tools (Zydney et al., 2018; Alonso et al., 2005)
- Review tools implemented to ensure the selected tool is providing the appropriate information and solution for students as open-source applications allowing anyone to change, adapt, or modify information presented as factual (Kamel Boulos et al., 2006)

Students

- Allow opportunities for students to take personal responsibility for their own learning and mastery of new skills (Kastner, 2019)
- Provide opportunities for students to participate in social communities (formal and informal) to support growth and interaction (Conrad & Openo, 2018)
- Utilize the best tools for learning, allowing for collaboration and engagement throughout the training program (Kastner, 2019)
- Make students responsible for completing some of the work on their own, with little input or feedback from the instructor followed by instructor assessment supporting SDL (Alonso et al., 2005)

Instructors

- Create and encourage collaboration and interaction between the student and theinstructor within the program (Conrad & Openo, 2018; Kastner, 2019).
- Encourage autonomy of students by asking for volunteers, allowing students to choose which topics they are most comfortable with presenting during break out groups or presentations choices of topics for discussion, and activity participation (Conrad & Openo, 2018; Kastner, 2019)
- Utilize authentic assessments for student measures of learning tied directly to tasks or skills required for the job (Conrad & Openo, 2018)
- Attend professional development opportunities to use the technology appropriately and to support facilitation skills for blended learning environments (Kastner, 2019)
- Redirect conversations, chats, or group activities when the information is off topic or incorrect (Alonso et al., 2005)
- Avoid providing too much information at once or flooding students with messages even though the technology is available (Gon & Rawekar, 2017)
- Provide opportunities to engage students in small group sessions and breakout rooms, allowing for authentic assessment to occur (Conrad & Openo, 2018)

Additional Considerations

In order to document the success of training a few additional considerations should be made including costs and return-on-investment (ROI). Creating a comprehensive training evaluation strategy for any new program rollout and implementation should be completed in order to ensure the objectives taught are translated into on-the-job performance. Training costs should also be considered as implementing new programs, focusing on technology, can be costly and may lead to a minimal ROI.

Training Evaluation

In addition to the best practices and recommendations provided, formal evaluation methods should be used to assess the effectiveness of any training program. Training evaluation, or the collection of information, should be implemented to determine if the training objectives are achieved and/or the on-the-job performance is improved (Salas et al., 2012). Additional data should be collected on the needs for supporting the implementation of training technologies in order to assess if the environments and modalities were designed to complement the tools and technology in which they were delivered. Student and instructor experiences should also be collected for a comprehensive analysis of the training.

Training Costs and Return-On-Investment

Decisions regarding training must also account for cost and available resources. The research literature suggests that training using training technologies tends to be more expensive

to develop than traditional classroom training (Welsh et al., 2003). Online training requires substantial investment given the software and hardware expenses (Reynolds et al., 2014). Interactive game-based and simulation trainings are typically more expensive than other technology-based formats as well (e.g., web-based). However, the cost of simulation training can be reduced by investing in low-fidelity as opposed to high-fidelity simulation devices and in part-task trainers as opposed to whole-task (i.e., full mission) simulators with little to no impact on the efficacy of the training (Salas et al., 2008). Importantly, the design of the training course substantially influences the cost of training as well, not just the technology (Updegrove & Jafer, 2017).

While training technologies may be more expensive on the front-end, research notes long-term savings occur once the course has been developed. Online learning, for instance, can reduce several classroom costs associated with traditional, in-person training, including resource costs and printing expenses (Welsh et al., 2003). In particular, courses that (a) have a large number of enrollees, (b) will be repeated several times, and (c) include learners that are geographically dispersed will see the most cost benefits from online training (Welsh et al., 2003). However, considerations should also be made for the type of training conducted, the need for specific skill acquisition, and the opportunities to properly assess student learning in real-time (Conrad & Openo, 2018).

Conclusions

Overall, this literature review serves as a first step to introduce some factors that will contribute to the successful implementation of a blended learning program. Training design requirements, availability and usability of tools and technology for online environments, student, and instructor needs have all been introduced. Best practices and recommendations for creating a comprehensive learning program have also been provided based on current literatures. While the research literature reviewed in this report provides suggestions for how to implement and design blended learning, the evaluation of trainings during and after implementation is just as important. Designing formal evaluation and validation for these new training technologies can provide the FAA with information about the effectiveness of blended learning at the FAA Academy.

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