

Best Practices and Methods for Virtual Training Delivery

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Abstract

With the hiring of young air traffic control (ATC) specialists, and the need to prepare those individuals to handle complex systems quickly, the Federal Aviation Administration (FAA) faces great challenges training millennial controllers to effectively and efficiently meet the requirements of the challenging job. Virtual training delivery such as interactive multimedia instruction by integrating gamification, video, audio, animation, simulations, augmented/virtual reality, or Intelligent Tutoring Systems supplemented by mobile learning becomes a necessity since it can offer an on-demand, self-paced, and less stressful practice environment. It can also preserve student progress while reducing costs and training time. It provides the means to ensure training that can be delivered nearly everywhere at any time and leave more in-class time for active learning such as in-person hands-on training, teamwork, and group discussion. However, teaching in a virtual training environment is different from instructing students in person. The course needs to be carefully designed to tailor the instructor's personal style and at a pace for the specifics of the engaged virtual environment. Virtual training environment needs to be an interactive learning community to accommodate learners with different learning styles and motivate learners with gamification approaches.

This research project examined the ATC training courses at the FAA Academy and investigated on how to apply the up-to-date technologies to help train today's air traffic controllers in a less stressful, more flexible, efficient, and cost-effective environment, and leave more in-class time for active learning to keep Millennials engaged.

Introduction

Air traffic control (ATC) specialists deal with very complex workload and traffic volume encompassing both commercial and non-commercial activities. The FAA is planning to hire 10,773 new controllers to keep pace with expected controller loss due to FAA Academy attrition, retirements, promotions and transfers through FY2027 (Federal Aviation Administration, 2018). Annual retirements appear to be leveling off and are expected to fall further over the next decades; however, the attrition rate at the Academy has edged higher than the projections in the past. The new controllers are Millennials who were born between 1981 and 1996 (Cannon & Broach, 2011; Dimock, 2019; Hadar, 2015a), and grew up in a digital world and prefer digital technologies and active learning to the traditional classroom teaching used to train their predecessors (McGlynn, 2005; McHaney, 2012).

The generational differences bring new challenges to today's training program, especially when the trainers are often retired controllers (Hadar, 2015a, 2015b) who were trained in a more traditional instructor-led environment. Also, the high cost of the training, \$128K per student leaves a heavy financial burden on the government (Brady & McGuirk, 2014; Brady & Stolzer, 2017). To effectively and efficiently train today's controllers and lower the attrition rate at the Academy, virtual training delivery becomes a necessity since it can offer on-demand, self-paced, and less stressful adaptive practice environment online, which leaves more active learning such as in-person training, teamwork, and group discussion during class time.

For this project, ATC training courses offered at the FAA Academy were examined. Face-to-face interviews, and online surveys were conducted at the Academy, facilities, and Air Traffic-Collegiate Training Initiative (AT-CTI) schools. Training courses offered at AT-CTI school, in the military, and medical area were studied. Recommendations are provided on how to apply the up-to-date technologies to train millennial controllers in a less stressful, more flexible, efficient, and cost-effective virtual environment, and leave more in-class time for active learning to keep Millennials engaged.

Background

Air Traffic Controllers Training Program at the Academy

In recent years, the FAA modified the hiring process for ATC candidates by establishing three categories for the applicants. The first category targets applicants who are previous controllers or Veteran Recruitment Appointment (VRA) candidates with previous ATC experience given priority consideration. The second category attracts graduates from AT-CTI programs and also military veterans, and the third category is open to the general public which does not require ATC experience (Federal Aviation Administration, 2018). Upon successful completion of clearances, developmental controllers (or “developmentals”) who are defined as new ATC specialists start their training at the FAA Academy in Oklahoma City, Oklahoma (Federal Aviation Administration, 2013).

Training at the FAA Academy is one of the key components for developmental controllers where they gain the knowledge through classroom lectures and simulation, which lasts 11 to 15 weeks (Celio, Jarvis, & Poore, 2005). Air Traffic Basics (AT Basics) is the first fundamental course, required for general public hires before entering one of the three tracks, which are the Initial Tower Cab Training (Tower), the Terminal Basic Radar Training (RTF), and the Initial En Route Qualification Course (En Route).

The Air Traffic Basics (AT Basics) course covers required subjects such as federal air regulations, aircraft performance, weather, procedures etc.. Developmentals sit in class for eight hours each day for approximately 25 days. Even though this course is required for developmental controllers, who enter the Academy from the general public only, the developmental controllers with previous ATC experience or from a AT-CTI program can request to take the AT Basics with the class to refresh their memory and the opt-out rate is currently less than 5%. This course is an instructor-led course taught by retired controllers using structured PowerPoint slides supplemented by quiz questions and discussion points, video segments, animated graphics, student handouts, and individual and group exercises. AT Basics has been maintained over time and the most recent version was introduced in October 2016 (SAIC, 2016). Developmentals can take end-of-lesson tests to check their concept understanding. End-of-lesson test scores are not included in their course grade. There are five block tests, which offer instructors and students with diagnostic information about the topic areas. There is one comprehensive final test given at the end and students must earn a score of 70% or above to pass the course. There is no simulation training during the AT Basics course (Federal Aviation Administration, n.d.).

The Initial Tower Cab Training (Tower) is designed for ATC specialists who are assigned to the terminal facilities. The course lasts 37 days, which consists of instructor-led lectures, hands-on Table Top practice, and simulation training in the lab. Developmentals receive instructor-led lectures in the first twelve days followed by hands-on tabletop training for another six days. After it they practice scenario-based, realistic air traffic control problems in full-fidelity lab environments for twelve days. Simulation fidelity is defined as the degree of similarity between the training situation and the operational situation, which is simulated (Loft, Hill, Neal, Humphreys, & Yeo, 2004). Their academic performance is evaluated by six knowledge-based tests in the classroom and four Performance Assessment (PA) scenarios in the lab. Developmentals must earn a score of at least 70% to successfully complete the course (Federal Aviation Administration, n.d.).

The Terminal Basic Radar Training (RTF) is designed for ATC specialists selected to report to Terminal Radar Approach Control (TRACON) facilities. The 21-day course covers eight days of academics in the classroom, eleven days of lab instruction and two days of performance assessment in a full fidelity STARS lab. The course is now being administered to new hires as a pass/fail job jeopardy course with a minimum passing score of 70%. A pass rate of 82% occurred in 2016 from 12 classes with 136 developmentals (Federal Aviation Administration, 2016).

The Initial En Route Qualification Course (EN Route) is a 59-day course, which consists of classroom instruction, medium fidelity skills practices utilizing and interactive computer instructional system, and full fidelity En Route Automation Modernization (ERAM) simulation in an En Route lab environment. The course is pass/fail with job jeopardy with a minimum passing score of 70%. The course pass rate has been declining from a rate of 80% in 2011 to 65% in 2014. A couple possible reasons for the declining pass rate for the EN Route class may be increased class size and short practice time as indicated by developmental from the course report (Federal Aviation Administration, 2015).

After graduating from the Academy, the developmental controllers begin their next level of training on their operational position at the assigned facility. The training is conducted by the certified professional controllers and includes classroom lectures, simulations and on-the-job training (OJT). The main goal of the field training is to attain the Certified Professional Controllers (CPC) status, which can take from two to five years depending on the complexity of the facility, the staffing numbers and the training resources available at the assigned facility. On-the-job training is conducted by the certified controllers and constitutes the major part of the fields training. Classroom and simulation training is taught either by FAA instructors or non-FAA contract instructors. Once developmental controllers are determined to have reached full performance level and certified as CPCs, they work independently in the position under the direction of a supervisor to gain experience (Federal Aviation Administration, 2018). Recurrent training for the controllers is conducted every six months and includes a combination of classroom and computer-based instruction. This project investigated the AT Basics, and the Tower courses because they are gateway courses with high enrollment. For example in fiscal year (FY) 2010-2012, the Academy trained 2,700 developmental ATCs. Of those 2,700, 60% of whom were Tower track, 8% were RTF/TRACON track and 32% were En Route track (Federal Aviation Administration, 2013).

Current Academy Course Issues

Report study

In 2013 the FAA released a findings and recommendation report, which detailed a review and evaluation of Academy training in three key areas including roles and responsibilities, communication of roles and responsibilities, and accommodation of developmental ATCs (Federal Aviation Administration, 2013). The study team pointed out the importance of technology in cost-effective ATC training since most Academy courses were still instructor-led courses taught in the traditional classroom with limited simulation done in labs. Less than 10% of Academy courses were web-based. The study team recommended the use of more online and mobile learning technologies such as iPads, and tablets to facilitate efficient and sustainable training approaches under a learning management system (LMS).

The MITRE Corporation has conducted extensive research on ATC training to document shortcomings and recommended the application of advanced training technology such as speech recognition, game technology, automated performance assessment and feedback, and simulation to ATC training (Brudnicki, Ethier, & Chastain, 2006; Schultheis, 2014; Schutheis, Winokur, & Hutson, 2014). Hadar (Hadar, 2015a, 2015b) has studied communication preferences between generations. He pointed out that Millennials are multitaskers who prefer to use a more diverse range of digital media, social technologies and texting to their full potential when compared to the older generations. He recommended the application of computer simulation such as augmented reality and serious games through mobile learning, implement social networks, and online repositories to enhance the information and knowledge sharing.

To understand students' concerns at the Academy and to help training administrators deliver ATC courses efficiently and effectively, end-of-course evaluation data collected between April and October of

2017 and the course report of AT Basics developed in 1999 were analyzed. Figure 1 shows student’s satisfaction ratings of the AT Basics and the Tower courses collected in 2017. Some knowledgeable and experienced instructors were preferred over others. Overall students commented favorably on instructor’s extensive knowledge, approachable attitude, and a variety of teaching styles, however students did not seem to be satisfied with the course organization, material quality, and the course pace of the two courses.

As to the AT Basics classes, many students, especially those with previous ATC experience, complained about the slow pace of the course topics, whereas few others with no prior experience felt the topics were too fast-paced or insufficiently well-paced. Many believed that some topics could be organized in a better order to be more understandable. Students especially disliked the outdated video clips (made in the 1970s), and graphics in the PowerPoint files.

In the Tower course, students felt that academic lessons and the tabletop practice exercises could be shortened and simulation practice should become a priority. The majority of students believed that the Tower course was fast-paced and that more simulation practice scenarios were needed in the lab. There were lots of complaints about the outdated equipment and the poor voice recognition in the lab. Students sometimes were confused by the conflicting instructions/procedures/rules given by the different instructors in the lab. To both courses students wanted more real-world application examples and exercises.

The course report for AT Basics, developed in 1999, summarized similar findings with a much smaller sample size (n<15) and higher ratings. Many students with previous ATC experience believed that the AT Basics course was too easy and slow-paced, but it was helpful for non-ATC experience students. Most thought that perhaps there could be a shorter refresher course for students with previous ATC experience. Students wanted more hands-on exercise time on ATC clearances and METARs. They also preferred having consistent knowledgeable instructors to model teamwork behavior and lead discussions during class time. Classroom should be switched from instructor-led lectures to student-centered active learning. They believe interactive video clips and animated graphics would help to keep their attention and reinforce materials such as the study of pilot’s environment and hazardous weather.

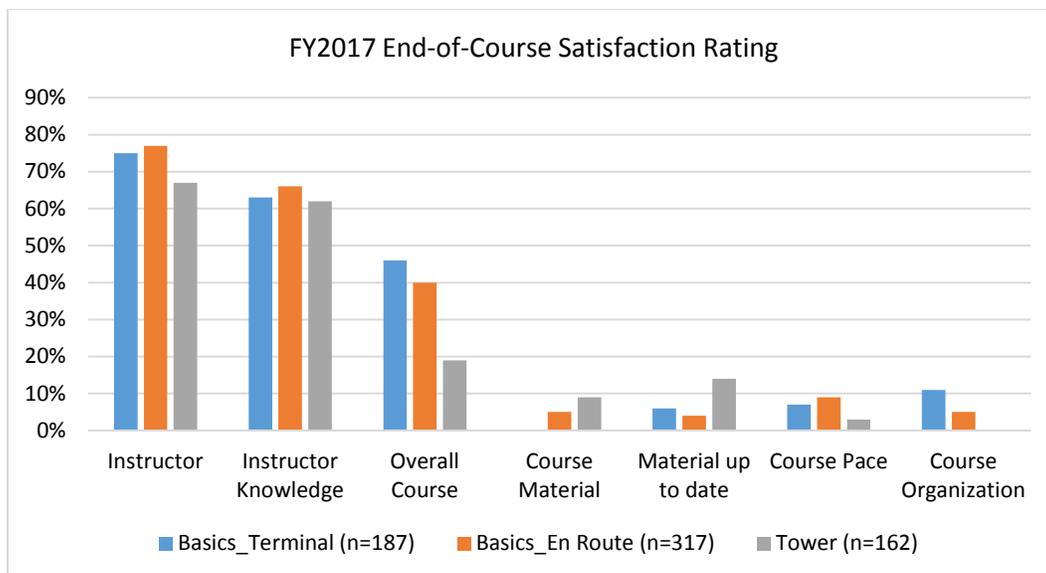


Figure 1. The AT Basics, and the Tower End-of-Course Satisfaction Rating collected in 2017

Virtual Training Delivery

The job of an air traffic controller is challenging and complex, which involves monitoring air traffic radar screens, anticipating flight paths, assessing potential conflicts, as well as communicating and interacting with pilots and other sectors or facilities (Federal Aviation Administration, 2018; Knecht, Muehlethaler, & Elfering, 2016). From the course analysis, we can see that students with different learning styles learned at different paces and wanted more simulation practice time in the labs at the Academy. The current curriculum design does not tailor learning to personal interests and needs and does not allow students to practice more in the simulation lab.

What are the best practices and methods that can help solve student's issues and train millennial controllers efficiently and effectively? We are experiencing a technological revolution and are seeing the fastest rate of technological growth and development in history. With the development of high speed internet, the virtual training environment, which is defined as "computer-based environments that are relatively open system, allowing interactions and encounters with other participants" and provides access to a wide range of resources, seems the most logical next step in the evolution of air traffic training (Piccoli, Ahmad, & Ives, 2001). Virtual training breaks the closed structure of traditional education, which includes time, place and space, and further expands the dimensions of education to the world of technology, interaction and control. In today's world people can be educated anywhere and at any time. It has greatly influenced both the education and the cooperative system.

There are different modalities of virtual training used to educate and train people in academia and industry. Some training can be accomplished on a personal computer with or without the internet connection. Some can be a blended or hybrid learning, which blends the traditional classroom with online learning or mobile learning. We define virtual training as either a computer-based training (CBT), web-based training (WBT), blended/hybrid learning, mobile learning, or a mixed modality as shown in Figure 2. The effectiveness of these modalities depends on the layout, content or material used, targeted trainees, and the training goals, whether it is for job training or for educational purpose.

Computer based training (CBT)

Computer based training (CBT) involves using a computer to access training materials. A specific software or program is used to install the training materials on the computer without or with internet access. It normally targets a specific training topic in a step-by-step, standardized and consistent manner, which helps reduce different teaching style that can negatively impact students in the traditional classroom. CBT also allows students to control their own learning at their own pace, which leads to increased engagement and knowledge retention (Andriotis, 2015). It can be especially effective for training recurrent and refresher courses at the facilities.

Web based training (WBT)

Web based training (WBT) is a subset of CBT, where the material is available for the students through the internet. This modality can be synchronous or asynchronous. In synchronous delivery, the student and the instructor meet online at the same time, which allows students to ask and instructors to answer questions immediately through instant messaging. Asynchronous delivery is typically a self-paced learning, as the students do not meet the instructor through real-time training. The communications in the asynchronous method are through emails, discussion board, podcasts, and wikis.

Blended or hybrid training

Blended learning, a combination of face-to-face and online instruction, has been increasingly used in a variety of educational contexts and levels. There are various names used interchangeably when referring to blended learning in current research literature such as hybrid, technology-enhanced instruction, web-enhanced instruction, and mixed mode instruction. Currently, blended learning is used with more regularity when referring to these mixed modes of learning environments.

Blended learning environment is defined as a combination of face-to-face and online learning environments to utilize strengths of both (Delialioglu, 2012; Delialioglu & Yildirim, 2007; Osguthorpe & Graham, 2003). Garrison and Kanuka (Garrison & Kanuka, 2004) defined blended learning as “the thoughtful fusion of face-to-face and online learning experiences”. Marsh (Marsh, 2012) mentioned that blended learning can provide students with a more individualized learning experience and allow for more personalized learning support. It can support and encourage independent and collaborative learning, as well as increase student’s engagement in learning. It can accommodate a variety of learning styles. It provides a less stressful practice environment for the target language beyond the classroom anytime or anywhere to meet learners’ needs.

Mobile learning

Mobile Learning or mlearning uses mobile devices or tablets to deliver training content. This modality can be used as a supplement just-in-time learning tool for shorter learning experience, since no one wants to perform a lengthy study on a handheld device.



Figure 2. Virtual training modalities

Academy Visit

To understand current training and collect students and instructor’s perceptions of virtual training delivery, the project team visited the FAA Academy in the summer of 2017. We observed the AT Basics and the Tower classes and interviewed graduated students and the instructors at the academy. During AT Basics, students had instructor-led lecture in a traditional classroom. Students were not allowed to use electronic devices in the classroom. Students were given a textbook handout for lecture study and review. Two instructors used PowerPoint slides to teach the class. At the end of each chapter, the

students had to complete the review questions in the textbook and had brief discussion about the correct responses with the instructor. After that, students used in-class computers to complete multiple-choice questions offline, which allowed instructors to understand a student's progress and for students to receive feedback about their progress and performance. Short videos of less than 15 minutes and animated graphics were used in class to help students understand the material. Key points were reviewed at the end of each video. The video played during the visit was a holding pattern film, which lasted only 10 minutes and was an old video with materials that needed updating.

The Tower course included instructor-led lectures covering Air Traffic Control Tower (ATCT) rules and procedures in classroom followed by practice in tabletop, tower 3D and Tower simulation system (TSS). The tabletop is a two-dimensional depiction of the all three ATCT control positions (Local, Ground and Clearance). The airport was laid out on a table with runways and small models of different aircraft types, which gave students a basic idea about the procedure and phraseology in the three-dimensional simulators. Tower 3D lab had same scenarios as seen in the Table Top lab but in a three-dimensional layout, which helped students see the real-world scenarios. The two labs were done alternatively at the same period and helped students prepare them for the next level of high-fidelity Tower Simulation System (TSS) lab. Tower 3D lab used medium fidelity simulation exercises and provided practice of individual controller task in isolation. The TSS lab attempted to recreate the real-world environment of a working facility with the actual controller's equipment. The feedback of student's performance during practice was documented by the instructor, which can be reviewed in the future as the scenarios in TSS lab cannot be recorded to playback. Performance Assessment was done on the last days for the Ground and Local control. The feedback of the student performance was provided as a verbal briefing by the instructor and documented on the official feedback form.

Four graduated students and one instructor were interviewed. Interviews were face to face and lasted for 30-40 minutes each. The open-ended questions focused on their course experience at the Academy and their perception of virtual learning experience. The interview questions can be found in the Appendix A.

All interviewed students had previous virtual learning experience. They indicated that they would love to use blended learning and mobile learning as their supplemental study tools. They believed that instructors' personal style and pacing should be tailored in the virtual training environment. They also insisted that the instructors cannot be totally replaced by online learning completely since teamwork, discussion, hands-on practice, and interaction with the instructor face-to-face in the traditional classroom are important key factors in ATC training. Students concerned the short practice time with poor voice recognition in the TSS lab, non-standard grading system by different instructors, and non-pretest and posttest for their performance evaluation in the Tower course. As Millennials, they wanted to see more interactive gaming and simulation to enhance their understanding of certain topics.

The instructor we interviewed had 37 years ATC work experience and was a strong believer of virtual learning. The instructor stated that with a well-organized content delivery online, students can refresh studied topics anytime and anywhere as needed. For example, instructors commonly found that students forgot what they just learned in the AT Basics, which was the prerequisite of the Tower course. They had to repeat the content, which took already limited course time in the Tower course. He also believed that as a new generation, students had the ability to learn materials by themselves using up-to-date technology virtually, which help free more class time for teamwork, discussion, and simulation practice.

Facility Visits

The project team visited DCA tower in summer 2017 and MCO tower in spring 2018 and interviewed the managers and instructors at the facilities to gather their perceptions of virtual training delivery. All managers and instructors interviewed unanimously agreed that virtual training can be applied as a supplemental learning resource but cannot replace the instructors in the classroom. Interactive and scenario driven videos/animations are needed to facilitate training process. All individuals interviewed suggested that sharing senior controllers' experiences in a virtual format is desirable.

A pilot study should be considered first to understand students and instructors' perception and assess project success. A learning management system is needed to standardize the course design and assessment online. The best practices and methods were from hands-on practice, teamwork, and instructor's past experiences. Virtual training if implemented, should be updated periodically to reflect new rules and procedures in the real-world.

AJI Visit

The project team visited AJI training specialists and management personnel in summer 2018 to seek their suggestions and feedback about virtual training. They suggested the importance of teamwork in the face-to-face class time. The military has more experience and success in training students in an immersive learning environment such as virtual reality and augmented reality. All AJI specialists and management personnel interviewed believe that there is much to be learned from the military learning model. They also pointed out that FAA should learn how to apply new technologies and design process from academic institutions such as AT-CTI schools.

AJI senior Management acknowledged that there is a difference in how the new millennial generation learns and how they retain skills and knowledge. Therefore, senior controllers should be taught to use new technologies to train young millennial controllers. Traditional classroom should be switched from instructor-centered teaching to student-centered learning to engage students in an active learning environment.

AJI training managers suggested the initiation of a pilot study to test the feasibility of the new design. Data obtained from the pilot phase should compare student success rates and retention rates between the traditional and the redesigned model. Indirect measures of student success can be obtained through student perception surveys.

Online surveys

To quantitatively understand students and instructors' perception of virtual training delivery at the Academy and the AT-CTI schools, the project team conducted online surveys in 2018 under assistance of ERAU institute research. The survey questionnaires focused on five areas: participant demographics, past virtual training experience, ATC course experience at the Academy or AT-CTI schools, preference of virtual training modalities, perception of virtual training and concerns.

The survey questionnaires of students and instructors are included in the Appendix B. Students and instructors from the Academy, ERAU, InterAmerican of Puerto Rico who involved in the AT-Basics and the Tower training courses took the online surveys. Table 1 shows online survey participants information.

Table 1. Online survey participants

Location	Type	Participants
FAA Academy	Instructors	12
	Students	6
AT-CTI Schools	Faculty	15
	Students	24

Figure 3 investigates current students and instructors' concerns of AT-Basics offered at the Academy and AT-CTI schools. Instructors expressed concern about the outdated videos and animated graphics. Students expressed concern about the lack of real-world experience, interaction with instructors, death by PowerPoint in the class, and access to course information online.

Figure 4 tells the negative factors in the Tower course offered at the Academy and AT-CTI schools. Both students and instructors expressed concern about outdated videos and animations. Students were also eager to see more interaction or collaboration work in the class and wanted to gain more real-world experience and simulation practices. Both instructor and students liked to see course materials available online with customized learning experience.

Figure 5 shows the preference of virtual training modalities identified by instructors and students at the Academy and AT-CTI schools. To the AT-Basics and the Tower, both students and instructors preferred blended learning because of the easy access of online materials and interaction with instructors in the classroom. The least preference of the modalities was mobile learning because of the distraction and short battery life comparing to the other modalities. Serious games and simulation could promote learning, which have been used by the military and healthcare on their training programs.

Figure 6 describes the importance of simulation and gaming in the AT-Basics and the Tower courses rated by the instructors and students at the Academy and AT-CTI schools. Both instructors and students are the strong believers of simulation and gaming, which should be applied in the ATC training courses to help retain information.

Figure 7 evaluates students' technology competencies in a virtual learning environment. Both students and instructors believed that as Millennials, they had the technology competencies to succeed in virtual learning, however students were reluctant to take virtual training and were afraid of losing the interaction with instructors in the face-to-face classroom as indicated in Figure 8.

We interviewed ATC instructors at ERAU, who are the advocates of the blended learning and applied the blended learning to the Tower course offered at ERAU eight years ago, they mentioned that they saw better end-of-course evaluations and engaged participation in classes because students had more time to do hands-on learning in the lab and more interaction with instructors in classes. Instructors also mentioned that the materials posted online must be interactive and offer immediate feedback such as the application of the gamification so that students can be engaged to learn at their own pace and understand their mistakes.

From instructor's past study, students in the blended and web-based learning mastered the learning objectives at a higher level than face-to-face traditional classroom learners. Students interviewed also preferred the blended learning and believed that as a new generation they had the ability to use new technology to teach themselves. They do not want to take away the instructors because of their real-world work experience and they wanted to practice more hands-on simulations in the lab. Both the

instructors and students believed that mobile learning can be a supplemental tool, but mobile devices can be a distraction as well.

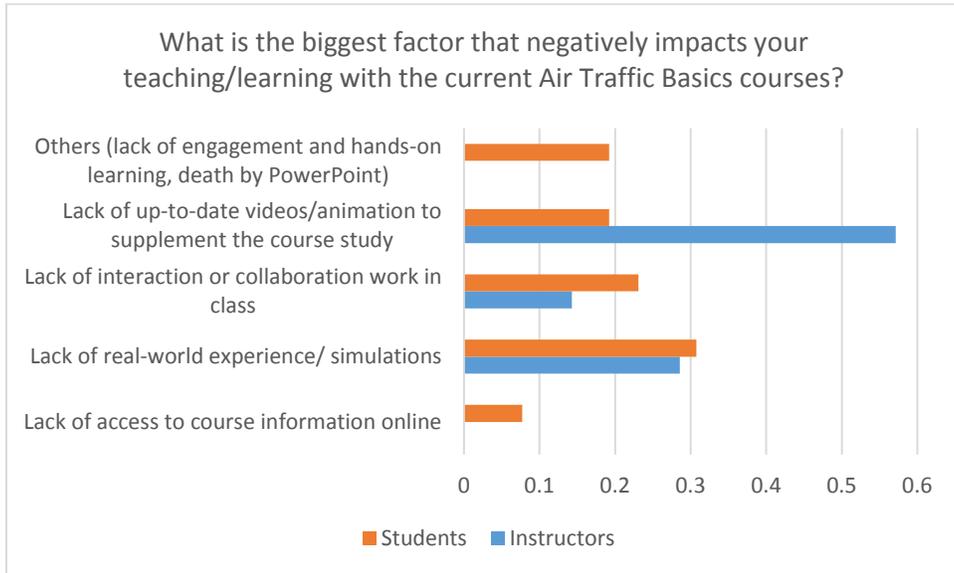


Figure 3. Current AT-Basics course issues identified by instructors and students at the Academy and AT-CTI schools

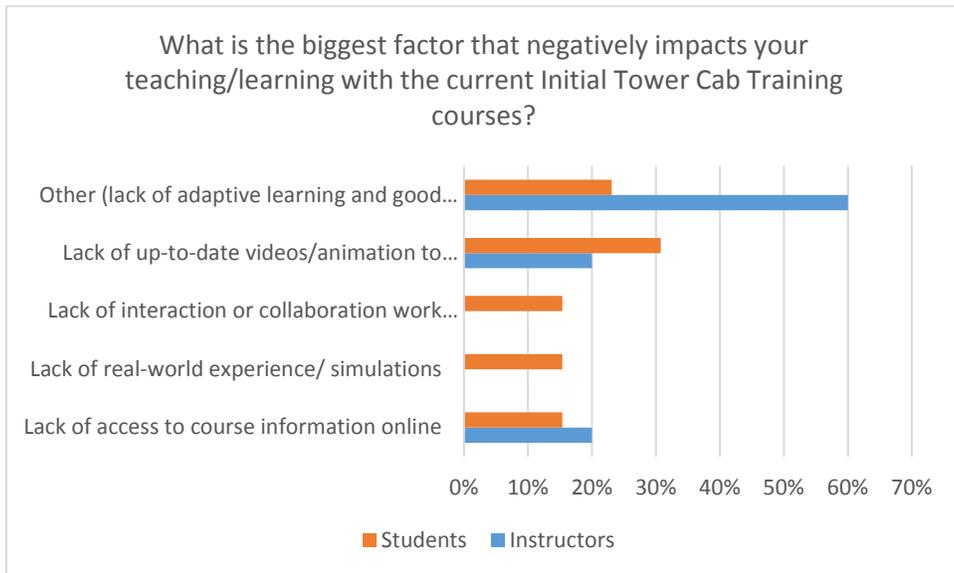


Figure 4. Current Tower course issues identified by instructors and students at the Academy and At-CTI schools

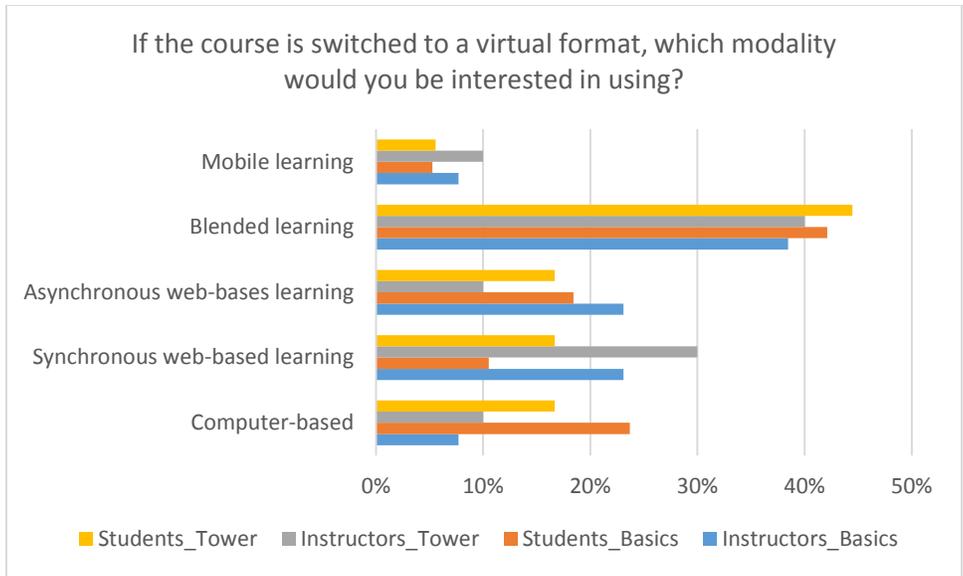


Figure 5 The preference of virtual training modalities identified by instructors and students at the Academy and AT-CTI schools

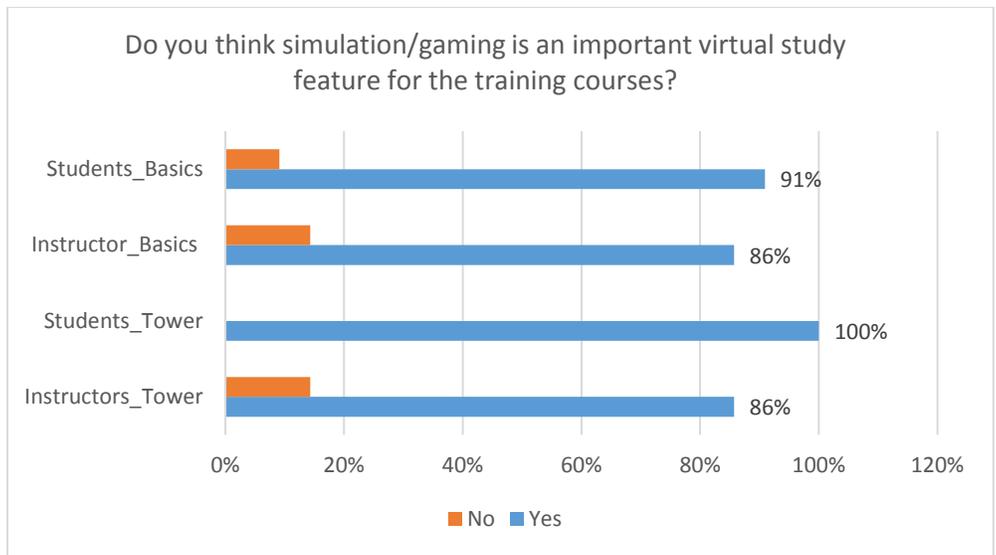


Figure 6 The importance of simulation and gaming in the AT-Basics and the Tower courses rated by the instructors and students at the Academy and AT-CTI schools

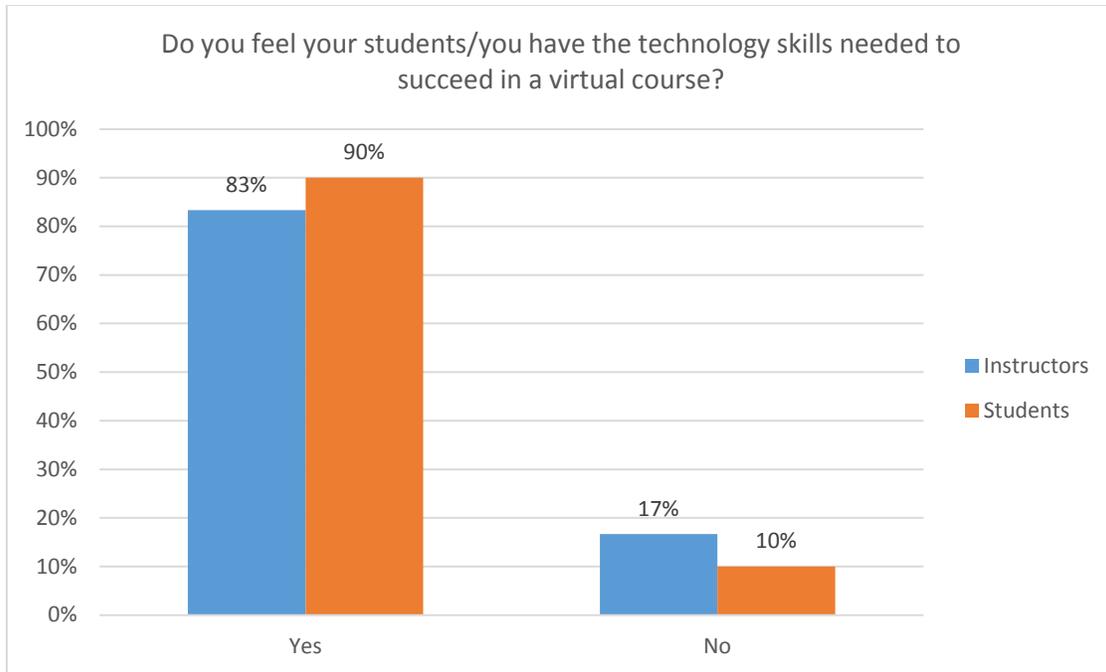


Figure 7 Students computer technology competency for virtual training delivery rated by instructors and students at the Academy and AT-CTI schools

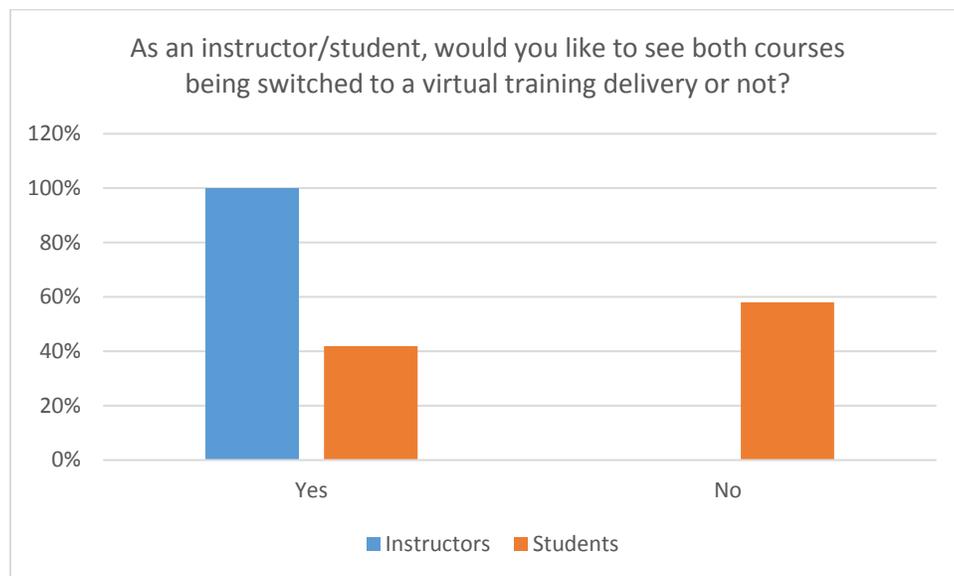


Figure 8. Instructors and students' perception of virtual training delivery

Summary of Recommendations

From the past two-year study, the project team studied the best practices and methods in virtual training delivery and summarized the following recommendations to improve ATC training courses offered at the Academy.

A learning management system and infrastructure requirements is needed so that all course materials can be accessed in a virtual environment

The project team strongly recommended the use of a learning management system (LMS) at the Academy for better administration, course assessment, content distribution, and student engagement. For Academy administration, LMS can be used for registration, course management, and as a central advising system. For faculty and students it offers a better communication and collaboration, instructional materials and assignments distribution, and a grading system online (Lonn & Teasley, 2009; Petherbridge & Chapman, 2007; Watson & Watson, 2007). Hawkins and Rudy (Hawkins & Rudy, 2008) reported that over 90% of responding American universities and colleges have applied LMS-type products for student and faculty use. Currently a LMS is only used for instructor training at the Academy, but is not available to students for use in the course.

Previous research has shown that a LMS can be used to engage students and create a sense of community if it is set up effectively (Lonn & Teasley, 2009). In the U.S. and Canada, the LMS market is dominated by Blackboard, Canvas, D2L Brightspace, and Moodle with Canvas and Blackboard as the two dominant competitors and they control over 50% of the US higher education LMS market (Hill, 2019; McKenzie, 2018). Blackboard was the number one LMS provider in early 2005, and once owned 70% of the U.S. and Canadian market, but it was overtaken by Canvas recently with 1218 LMS installations, which is two more than Blackboard (Etherington, 2018). Users highly favor Canvas's user-friendly interface, reliability, cloud-based service, and easy integration of third party tools such as Youtube, Khan Academy, 3D Game Lab etc. after they compared it with other leading LMS systems in the market, especially Blackboard (Cudney et al., 2017; Etherington, 2018; McKenzie, 2018).

A blended learning should be designed and implemented

Blended learning can also help students attain valuable and necessary twenty-first century learning skills. Instructors of air traffic management at ERAU started utilizing blended learning of the Tower course several years ago. They saw improved learning experience and academic performance of students compared to the traditional classroom teaching, because the individualized learning experience can be implemented online, which leaves more personalized support in the class time.

It is recommended that the FAA implements blended learning with a user-friendly LMS to train millennial controllers. By applying the up-to-date technologies to train today's air traffic controllers in a less stressful, more flexible, efficient, and cost-effective environment, millennial controllers will have more hands-on training time in the simulation labs and active learning in the face-to-face classroom. It is very important to have a clear layout of course modules under the user-friendly LMS for efficient navigation, which links student learning outcomes and course objectives to course activities and assignments supported by active learning strategy.

Team-based learning (TBL) is preferred and a community learning can allow Millennials help each other and support each other

The study shows that Millennials who grew up with social media and social networking are highly interconnected (Hadar, 2015a). They prefer teamwork and collaboration and feel more comfortable in a team environment than working independently (Roberts, Newman, & Schwartzstein, 2012). ATC requires specialists to collaborate and communicate with each other to enhance safe and efficient air traffic flows. From past ATC studies, ATC operational errors are associated with either faulty coordination between ATC specialists and pilots, or a failure of team coordination (Lintner & Buckles, 1992; Ruiz, 2004).

Team-Based Learning (TBL) is an instructional strategy developed by Larry Michaelsen (Michaelsen, Knight, & Fink, 2004; Michaelsen & Sweet, 2008), which has been applied in professional schools such as healthcare, law, business and STEM education (Sibley & Parmelee, 2008) and shown high levels of communication, problem solving, team and critical thinking skills. To TBL, student groups must be formed permanently by course instructor at the beginning of the course study. Students must finish a preparedness assessment as an individual Readiness Assessment Test (iRAT) before the teamwork. Teams complete same preparedness assessment as a team Readiness Assurance Test (tRAT). A consensus for the answers to the questions must be achieved by the team and immediate feedback is given to check the answer correctness (Sweet & Parmelee, 2009). A class discussion can be facilitated by instructors to clarify misconceptions and answer questions. Peer evaluation can be applied to improve teamwork effectiveness and evaluate each student's participation and contribution.

The project team recommends a TBL in the blended learning environment to empathize the importance of teamwork and coordination skills required in ATC tasks. Students can study the learning materials online and finish iRAT before class. They can finish tRAT by answering the same multiple-choice questions from the iRAT in the face-to-face class time together. Immediate feedback helps instructors catch students' common misconceptions and facilitate group discussions. Student groups can appeal scores by challenging the clarity of any RAT questions or supporting their response by citing corresponding reading materials. Formative peer evaluation can be applied at half-way through training course study to improve teamwork effectiveness. Summative peer evaluation at the end of course can be used to evaluate individual participation and contribution.

Pretest and posttest should be implemented as a formative assessment

Pretests and posttests as RAT can be used to measure the preparedness and performance of students at the beginning and the end of either the training course or the training modules. They can also be used as a diagnostic tool for more effective teaching and learning in the blended learning environment. Pretests and posttests as RAT normally contain multiple-choice questions (MCQ), which can be designed and implemented under any LMS. Since traditional multiple-choice assessment gives learners no way to express their confidence in an answer, the assessment may fail to accurately test students' baseline knowledge.

Certainty-Based Marking (CBM) solves this problem by asking students not only to indicate which answer they think is correct, but also how certain they are that their answer is correct. CBM based MCQ have been studied and evaluated in the health professions (Gardner-Medwin & Gahan, 2003; Khanal et al., 2012), which appear to improve students' critical thinking and raise students' awareness of areas of uncertainty (Nix & Wyllie, 2011; Schoendorfer & Emmett, 2012).

It is recommended that the FAA use CBM based MCQ pretests, iRAT at the start of the learning module, and posttests, iRAT at the completion within a limited time window as a formative assessment. Immediate feedback after the pretest can tell students if they get the right answers. It is hoped that immediate feedback about the elements of the learning module, students can find the correct answers when they take the posttest after the intervention. Instructors can collect common misconceptions and promote clarification and discussion in the face-to-face class time after tRAT in the class time. Revised summative assessments can be conducted to see whether desired learning outcomes have been achieved.

Emphasize active learning such as teamwork and discussion in class time with the facilitation of the instructor

Active learning is a student-centered learning strategy, which has recently gained considerable attention in higher education. The literature has shown that active learning has led to better student attitudes, improvements in their thinking, communication, leadership, and writing skills, (Bonwell & Eison, 1991). The core elements of active learning are student activities and engagement in the learning process, which reflect higher-order thinking tasks in Bloom's taxonomy (analysis, synthesis & evaluation) (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956), which was revised in 2001 by a group of cognitive psychologists to point to a more dynamic conception of classification (analyze, evaluate & create) (Anderson, Krathwohl, & Bloom, 2001).

Active learning is also consistent with Dale's Cone of Experience (Dale, 1969). Dale pointed out that after two weeks, people remember only 10% of what they read, but they remember 90% of what they do. The Chinese philosopher Confucius said, "I hear that I forget. I see and I remember. I do and I understand", which also speaks to the importance of active learning in retaining information. The cone of learning and Bloom's taxonomy are depicted in Figure 9 Cone of Learning by Edgar Dale

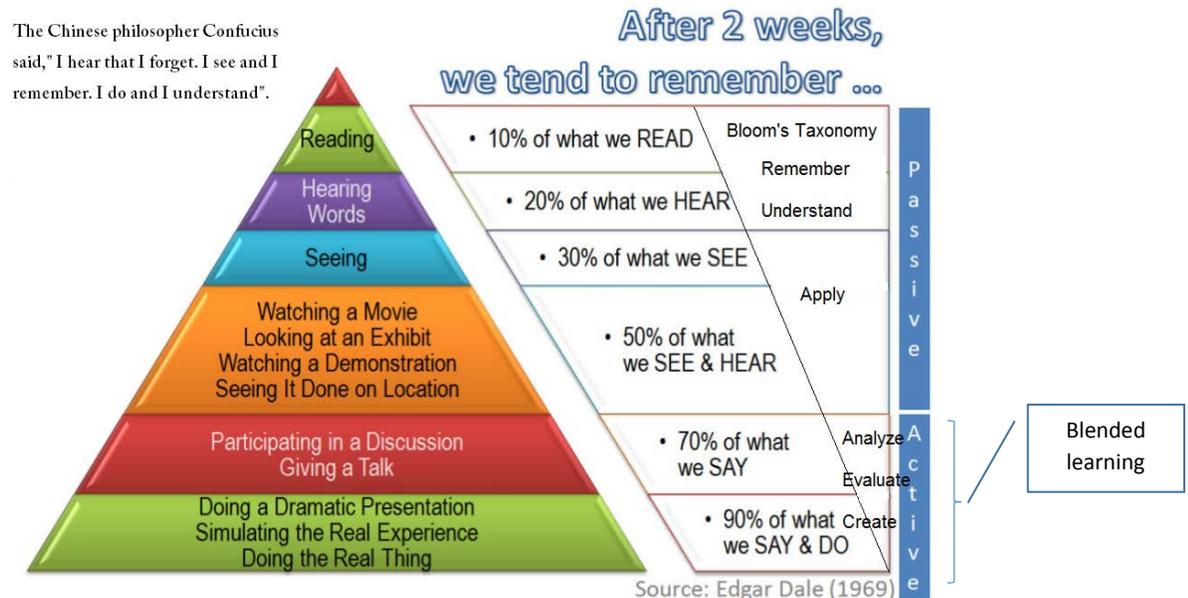


Figure 9 Cone of Learning by Edgar Dale and Bloom's taxonomy

As more content is moved online, there is more class time left for active learning. Think-Pair-Share (Kaddoura, 2013) classroom response systems such as Polleverywhere.com and Kahoot (Fies & Marshall, 2006), which offer immediate feedback and leaderboard challenge, group discussion, role playing, peer instruction, games, and the "muddiest point" assessment can be integrated into face-to-face classroom to catch students' most unclear point and promote achievement levels. Gamification can be integrated into active learning to engage students' critical thinking, promote collaboration, and continue to accumulate points that are earned from online study (Hall, 2014). However, the potential challenges for faculty with such an approach cannot be ignored. Active learning strategies can increase class preparation time, may risk additional student dissatisfaction, increase the use of instructional technology, and extend lecture time.

New high-quality short **multimedia** online instructions should be created with interactive tiered questions to test their understanding

Outdated low-quality videos are a major issue that Academy students mentioned in the study. It is well-known that Millennials have much shorter attention span, perhaps even shorter than that of a goldfish, which is nine seconds (Meltzer, 2017). But with engaging content such as a compelling narrative and great visuals, more Millennials can focus their attention for a longer period of time without distraction than Boomers and Gen Xers (Reporter, 2018). Guo (Philip, 2013) studied video usage from a few edX math and science courses. He found that the optimal video length is 6 minutes or shorter and student engagement times decreased as videos lengthen past 6 minutes.

It is recommended that to maximize student engagement, a high-quality short multimedia (6 minutes or less) information system that includes a combination of text, graphics, audio, video, animation, simulation, tiered questions to form an interactive content should be developed. Embedded tiered questions can be used to test students' self-understanding, which should offer immediate feedback to help clarify their mistakes and enhance the concept understanding.

Animation/simulation/gamification should be included in the interactive multimedia instruction

The quality of training can be standardized and improved by incorporating advanced technology and individual skills in the training system. The current ATC training methods focus on academic lecturing in the classroom followed by skill acquisition through extensive high-fidelity simulation. Between the academic and high-fidelity simulation training, there are low and medium fidelity simulation and gamification training missing, which can be integrated into blended learning to help engage and motivate learners master course material and enhance their learning experience. Low and medium fidelity simulation offers a simplified version of ATC training scenarios that focus on individual task components or investigates specific theoretic questions, and can be run on personal computers or tablets (Loft et al., 2004).

Gamification, also known as serious game, is the use of game thinking and game mechanisms in a non-game context to engage learners in solving problems (Dichev, Dicheva, Angelova, & Agre, 2014; Longley, 2018; Noran, 2016). Gamification can include the application of animation, simulation, and game elements and represents a shift from learning by listening to learning by doing. It also represents a shift from recalling information to finding and using it. From passive learning to positive learning, by including an instructional context, gamification can enhance the learning process (Hadar, 2015a). Gamification products have been developed by public and private organizations with positive feedback. Games such as SimCity and Second Life have been incorporated into STEM, healthcare, military training education (Angie & Berge, 2011; Cathell et al., 2008; Frye & Frager, 1996; Pahl, 1991; Stricker & Arenas, 2013).

It is recommended that the FAA consider applying gamification into their training courses to address learning preferences of the new generation. As millennial controllers are technology savvy and a generation of gamers, "the gamification of training" by integrating gamified simulation/animation with points, badges, leaderboard, progression through many levels etc. can make ATC training more engaging and more effective (Banner, 2018; Lawrence, 2018).

Virtual reality and augmented reality can be incorporated into virtual learning to improve student engagement and retention

Virtual reality (VR) and augmented reality (AR) have been used widely in the military, healthcare, entertainment etc. Recently they have been more prevalent than high-fidelity simulators in the military and healthcare because of the cost efficiency and hands-on engaging learning experiences in the training field (Best, 2018; Nichols, 2018). VR devices such as Oculus Rift™ or HTC Vive™ can offer a fully immersive artificial learning environment, while AR devices such as Microsoft HoloLens™ or Magic Leap™ can overlay certain objects onto the real world to create a mixed-reality experience. Combining the

smart phone with mobile VR such as Samsung's GearVR™ and Google Cardboard™ or mobile AR such as Holokit™, a more affordable VR or AR experience closes the gap between the new technology and consumers.

ATC training is not different from the training in the military or healthcare. Researchers in academia and industries from all over the world have been studying the application of VR and AR for ATC training courses and operational use at facilities for some time now (Bagassi, De Crescenzo, Lucchi, & Masotti, 2016; Graham, 2017; Reisman & Brown, 2006). From ARTT (augmented reality tower tool) project collaboratively between NASA and the FAA (Reisman & Brown, 2006) to RETINA (Resilient Synthetic Vision for Advanced Control Tower Air Navigation Service Provision), a European project sponsored by the SESAR (Single European Sky Air Traffic Management Research) Joint Undertaking (Bagassi et al., 2016), researchers have tried to apply new technology to enhance site weather visibility and situation awareness by overlaying AR 3D symbols over the out-of-window view through the AR headset.

ATC is work that relies heavily on spatial relationships. VR models can be used to train ATC specialists on the understanding of certain topics, which are normally difficult to understand without a 3D mental visualization. For example, to understand a "holding" procedure, VR can create a visualization of planning trajectories for the aircraft involved. In a "sector" study, VR can immerse students in 3D airspace so that they are able to visually perceive a sector and see how the traffic passes through (Akselsson et al., 2000).

We must understand that VR and AR are still at the early stage of implementations in training fields, including the military and healthcare industries. VR and AR should be developed and tested multiple times before implementation into ATC training to prevent technical failure and training confusions (Reisman & Brown, 2006). It is recommended that VR and AR should only be used as a supplemental tool to enhance learning experience.

An Intelligent Tutoring System (ITS), can be applied so that based on the test performance students can have the options to either repeat or move on to the next topic of study

Millennials welcome personalized training. They want to experience a training system, which can be tailored to meet their needs. They prefer hands-on experiential learning to reading long texts (Twenge, 2009). An Intelligent tutoring system (ITS) is a computer system with a set of automated capabilities combining human performance models that provide an objective assessment of learned skill levels, infers strengths and weaknesses of a student, and enables tailored instruction (Ma, Adesope, Nesbit, & Liu, 2014). According to the study, the system has been proven effective in several domains of similar complexity to ATC (Kulik & Fletcher, 2015) including STEM education in secondary and postsecondary, healthcare, law, language learning, military, and meta-cognitive skills (Abu-Naser, 2009; Albacete & VanLehn, 2000; Arroyo, Royer, & Woolf, 2011; Ayvaz & Fitzpatrick, 2007; Pinkwart, Ashley, Lynch, & Aleven, 2009; Woo et al., 2006). The system allows students to practice independently of an instructor and provides feedback on the areas in need of improvement. The study also talks about integrating instructor support feature, such as the recording and playback of scenarios in the training simulation, which gives instructors information about student performance on the simulation scenario.

It is recommended that ITS should be integrated into interactive multimedia online instruction to help individualized task selection and offer immediate feedback.

A disciplinary repository-based virtual community

A common feedback received from end-of-course evaluation reports and interviews is the lack of shared information online. Disciplinary repository or subject repository is an online library for storing,

managing, and sharing learning resources in a particular subject area, which can be research papers, presentations, videos, images etc. Virtual community operates on mechanisms for information sharing such as discussion board within a group of people who share a common interest or domain of practice (Lin, 2007; Reznik-Zellen & Adamick, 2012). The project team recommends creating a disciplinary repository-based virtual community. Through online networking, case studies and real-world experiences from retired controllers can be compiled and shared in this virtual community. For example, simulations that are used to illustrate wrong directions given by the controllers causing a pilot to come dangerously close to a mountain are especially important.

Mobile learning can be a supplemental portable study tool to enable more personalized training

Mobile phones and tablets cannot replace regular desktop computers, but they can be a flexible learning tool to engage learners by creating a personalized learning environment that also features the benefits of gamification. New Zealand Airways (NZA) uses Airbooks to create an interactive multimedia program by incorporating audio, video, games, animation and questions to assist ATC students with theory-based subject learning before a course starts (DeLambert, 2017). Positive feedback was received from students, since they were able to preview the content and raise questions to facilitate discussions with instructors during class time, which helped identify personalized training needs. NZA also reported a 60 percent time saving in the study of the theory component of the course compared to face-to-face training.

Based on all recommendations, the project team recommends the following ATC virtual training course redesign map in the Figure 10.

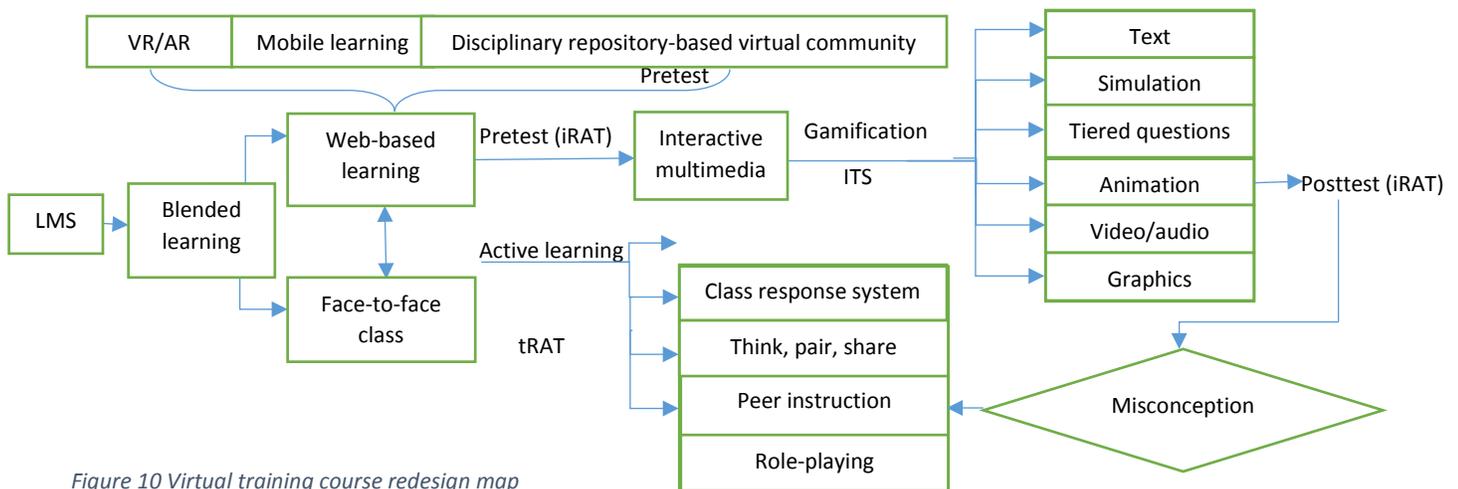


Figure 10 Virtual training course redesign map

Conclusion

The project team conducted extensive research to seek the best practices and methods in virtual training delivery to improve ATC training at the Academy efficiently and effectively. By studying the end-of-course evaluation reports collected at the Academy and at AT-CTI schools, communicating with training managers, facility managers and AJI managers, conducting the student and instructor face-to-face interviews, online surveys, and an extensive literature review, the project team strongly recommends the following best practices and methods in virtual training delivery.

- A blended training environment, which will emphasize an on-demand, self-paced, less stressful, interactive, and adaptive virtual training environment under a LMS, and in-person hands-on active learning in the face-to-face class and simulation labs.
- The online course content must be interactive multimedia instruction and offer immediate feedback so that students can be motivated to learn.
- Low and medium fidelity simulation with embedded tiered interactive questions can be implemented online to engage students learning in a gamification learning environment operated by an ITS. Points, leaderboard, and badges, progression through many levels can be applied to motivate students to compete in a virtual community.
- Formative pretests and posttests online can be designed as an iRAT by following team-based learning methodology so that students can test their self-understanding before and after the online module study. Immediate feedback should be given to clarify any misconceptions. Instructors can also check students' progress online and clarify common misconceptions during class time after conducting the tRAT.
- Mobile learning cannot replace the regular computer desktop study but can be a supplemental learning tool, which offers a flexible and personalized learning experience.
- Class time should be implemented in an active learning environment so that different teaching pedagogy can be applied to enhance students' understanding and achieve a higher level of Bloom's taxonomy.
- High fidelity simulation training time should be extended with the new blended learning design so that students can be more confident to solve real-world problems.

It is recommended that a pilot study of certain topics in certain training courses can be designed, implemented, and assessed first, which will help improve the success of full-scale design at the later time.

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Appendix A

Instructor Interview questions

AGREEMENT TO PARTICIPATE IN

Interview of Best Practices and Best Methods for Virtual Training Delivery in Air Traffic Control Courses

STUDY LEADERSHIP. I am asking you to take part in a research project that is led by Dr. Lulu Sun from Embry-Riddle Aeronautical University.

PURPOSE. The purpose of this study is to seek the best practices and best methods for virtual training delivery in air traffic control courses offered at Federal Aviation Administration (FAA) academy and Collegiate Training Initiative (CTI) schools such as Embry-Riddle Aeronautical University (ERAU).

ELIGIBILITY. To be in this study, you must be 18 years or older and a resident of the United States.

PARTICIPATION. During the study, you will be asked questions about your opinions concerning the Air Traffic Basics and the Initial Tower Cab Training courses offered either at the FAA academy or at the CTI schools and your overall virtual learning experience. The completion of the interview will take approximately 30 minutes.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal, no more than everyday life.

BENEFITS OF PARTICIPATION. I do not expect the study to benefit you personally. Your assistance in this project will help improve the air traffic course delivery at the FAA Academy and CTI schools and could possibly improve course learning experience at the FAA Academy or CTI schools.

COMPENSATION. We will give \$25 Amazon gift card/voucher to the participant after conducting the face-to-face interviews. Researcher and student assistants will conduct the interviews either over the phone or in researcher's office or in the participant's office.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may discontinue your participation at any time without penalty or loss of benefits to which the participant is otherwise entitled. Should a participant wish to discontinue the research at any time, no information collected will be used from that participant.

PARTICIPANT PRIVACY. Your individual information will be protected in all data resulting from this study. No identifying information will be collected. No one other than the researcher will have access to any of the responses.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Lulu Sun, sunl@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. Your signature below means that you understand the information on this form that the researcher has answered any and all questions you may have about this study, and you voluntarily agree to participate in it.

Signature of Participant _____ Date: _____

Printed Name of Participant _____

CMD001 Virtual Training Delivery

Instructors: ATC Face to Face interview questions

This interview is mainly focusing on your teaching experience at the academy and proficiency training in remote locations, which will help research best practices and methods to migrate to a virtual classroom environment with full immersive simulation and instruction.

Virtual training includes computer-based learning such as recurrent, refresher training, which could be offline; web-based learning, which is online learning and is delivered asynchronously or synchronously; blended learning which is a combination of the traditional face-to-face instruction and online learning; mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

1. Please identify your current position, and years of work experience.
2. Indicate your year of birth (Boomer: born before 1964; Gen x: born between 1965 and 1979; Gen y: born between 1980 and 1994).
3. How many year's teaching experience do you have? What courses have you taught before?
4. Before your current position, what other positions did you hold previously? Please indicate your years of experience related to ATC.
5. Do you have virtual teaching experience? What courses have you taught virtually? For how long? Can you identify the format (i.e. internet-based, blended, synchronous, etc.)
6. Have you taught Air Traffic Basics (FAA50043/FAA50143) before? For how long? if no proceed to question 7
 - a) Overall, describe your experience teaching this class.
 - b) What is the biggest challenge you faced teaching the current Air Traffic Basics course?
 - c) If the course is switched to the virtual format, what do you believe will be your biggest teaching challenge? Why?

- d) What strategies will you consider to deal with the challenge of teaching this virtual course?
 - e) What suggestions would you like to give to course developers for delivering Air Traffic Basics in a virtual training environment? Is there any content that you believe is not “translatable” to the online format? Please explain.
 - f) Do you think students have the preparation (i.e., motivation and basic content knowledge), and technology skills needed to use the online materials independent of an instructor?
 - g) Do you believe students will be successful in meeting course objectives in a virtual learning environment?
 - h) What benefits do you see in offering the course in a virtual format from the perspective of an instructor?
 - i) Do you think simulation/gaming is an important feature for the virtual version of the Air Traffic Basics course?
7. Have you taught Initial Tower Cab Training (FAA50046) before? For how long? If your answer is no, proceed to question 8.
- a) Overall, describe your experience teaching this class.
 - b) What is the biggest challenge you faced teaching the current Initial Tower Cab Training course?
 - c) If the course is switched to the virtual format, what do you believe will be your biggest teaching challenge? Why?
 - d) What strategies will you consider to deal with the challenge of teaching this virtual course?
 - e) What suggestions would you like to give to the course developers for delivering Initial Tower Cab Training in a virtual training environment? Is there any content that you believe is not “translatable” to the online format? Please explain.

f) Do you think students have the preparation (i.e., motivation and basic content knowledge), and technology skills needed to use the online materials independent of an instructor?

g) Do you believe students will be successful in meeting course objectives in a virtual training environment?

h) What benefits do you see in offering the course in a virtual format from the perspective of an instructor?

a) Do you think the following technologies are an important virtual study feature for the Initial Tower Cab Training course?

- Simulation
- Gaming
- VR

8. As an instructor, would you like to see both course materials posted online?

9. Would you like to see the courses being switched to a virtual training delivery in any one of the following modalities or not? Please explain. If no, why? If yes, what do you see as the greatest challenge in moving the courses to a virtual environment?

- Computer-based learning -instructors are physically available
- Web-based learning (synchronous or asynchronous)- instructors are not physically available
- Blended learning-Instructors are physically available
- Mobile learning-instructors are physically available

Student Interview Questions

AGREEMENT TO PARTICIPATE IN

Interview of Best Practices and Best Methods for Virtual Training Delivery in Air Traffic Control Courses

STUDY LEADERSHIP. I am asking you to take part in a research project that is led by Dr. Lulu Sun from Embry-Riddle Aeronautical University.

PURPOSE. The purpose of this study is to seek the best practices and best methods for virtual training delivery in air traffic control courses offered at Federal Aviation Administration (FAA) academy and Collegiate Training Initiative (CTI) schools such as Embry-Riddle Aeronautical University (ERAU).

ELIGIBILITY. To be in this study, you must be 18 years or older and a resident of the United States.

PARTICIPATION. During the study, you will be asked questions about your opinions concerning the Air Traffic Basics and the Initial Tower Cab Training courses offered either at the FAA academy or at the CTI schools and your overall virtual learning experience. The completion of the interview will take approximately 30 minutes.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal, no more than everyday life.

BENEFITS OF PARTICIPATION. I do not expect the study to benefit you personally. Your assistance in this project will help improve the air traffic course delivery at the FAA Academy and CTI schools and could possibly improve course learning experience at the FAA Academy or CTI schools.

COMPENSATION. We will give \$25 Amazon gift card/voucher to the participant after conducting the face-to-face interviews. Researcher and student assistants will conduct the interviews either over the phone or in researcher's office or in the participant's office.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may discontinue your participation at any time without penalty or loss of benefits to which the participant is otherwise entitled. Should a participant wish to discontinue the research at any time, no information collected will be used from that participant.

PARTICIPANT PRIVACY. Your individual information will be protected in all data resulting from this study. No identifying information will be collected. No one other than the researcher will have access to any of the responses.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Lulu Sun, sunl@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. Your signature below means that you understand the information on this form that the researcher has answered any and all questions you may have about this study, and you voluntarily agree to participate in it.

Signature of Participant _____ Date: _____

Printed Name of Participant _____

CMD001 Virtual Training Delivery

Students: ATC Face to Face interview questions

This interview is mainly focusing on your course experience at the academy, which will help research best practices and methods to migrate to a virtual classroom environment with full immersive simulation and instruction.

Virtual training includes computer-based learning such as recurrent, refresher training, which could be offline; web-based learning, which is online learning and is delivered asynchronously or synchronously; blended learning which is a combination of the traditional face-to-face instruction and online learning; mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

10. Indicate your year of birth.
11. What is the highest level of formal education you hold?
12. Before your current position, what other positions did you hold previously? Please indicate your years of work experience related to ATC.
13. Have you taken any virtual learning courses before? If yes, answer the following questions. If no, jump to question 5.
 - a. What virtual courses have you taken? Indicate the modality of the course (computer-based, internet-based, synchronous, blended etc.)
 - b. How many courses have you taken virtually? When – please tell us the approximate time periods (i.e., 1990s, 2000s, etc.)
 - c. Can you specify the technologies used in the virtual course such as audio, slides, videos, simulations, interactive games?
 - d. What assessment methods were used in the course (i.e., did you take quizzes or unit tests, did you fill out an evaluation sheet online following the course for you to evaluate the course)?
14. Have you taken Air Traffic Basics (FAA50043/FAA50143)? If no, jump to question 6
 - j) What was your overall impression of the course?
 - k)

- l) What is the biggest factor that negatively impacts your learning with the current Air Traffic Basics course?
 - m) If the course is switched to the virtual format, what do you believe will be the biggest challenge virtual learners taking this class will face? Why?
 - n) What strategies would you use to deal with the challenge of taking virtual courses? For example, a social media website or app helps you solve the course problem.”
 - o) What suggestions would you like to give for delivering Air Traffic Basics in the virtual training environment? Is there content that you believe is not translatable to the virtual format? Please explain.
 - p) Do current students have the technology skills needed to succeed in a virtual course? Why or why not?
 - q) What are the benefits for students of taking the virtual Air Traffic Basics course?
 - r) Do you think simulation/gaming/VR are an important virtual study feature for the Air Traffic Basics course?
15. Have you taken Initial Tower Cab Training (FAA50046)? If no, go to Question 7
- b) What was your overall impression of the course?
 - c) What is the biggest factor that negatively impacts your learning with the current Initial Tower Cab Training course?
 - d) If the course is switched to the virtual format, what do you believe will be the biggest challenge virtual learners taking this class will face? Why?
 - e) What strategies would you use to deal with the challenge of taking virtual courses? For example, a social media website or app helps you solve the course problem.”
 - f) What suggestions would you like to give for delivering Initial Tower Cab Training in the virtual training environment? Is there content that you believe is not translatable to the virtual format? Please explain.

- g) Do current students have the skills needed to succeed in a virtual course? Why or why not?

- h) What are the benefits for students of taking the Initial Tower Cab Training virtual course?
- i) Do you think the following technologies are an important virtual study feature for the Initial Tower Cab Training course?
 - Simulation
 - Gaming
 - VR

16. As a student, would you like to see both course materials posted online?

17. Would you like to see the courses being switched to a virtual training delivery in any one of the following modalities or not? Please explain. If no, why? If yes, what do you see as the greatest challenge in moving the courses to a virtual environment?

- Computer-based learning -instructors are physically available

- Web-based learning (synchronous or asynchronous)- instructors are not physically available

- Blended learning-Instructors are physically available

- Mobile learning-instructors are physically available

Appendix B

Instructor online survey

AGREEMENT TO PARTICIPATE IN

Survey of Best Practices and Best Methods for Virtual Training Delivery in Air Traffic Control Courses

STUDY LEADERSHIP. I am asking you to take part in a research project that is led by Dr. Lulu Sun from Embry-Riddle Aeronautical University.

PURPOSE. The purpose of this study is to seek the best practices and best methods for virtual training delivery in air traffic control courses offered at Federal Aviation Administration (FAA) academy and Collegiate Training Initiative (CTI) school.

ELIGIBILITY. To be in this study, you must be 18 years or older and a resident of the United States.

PARTICIPATION. During the study, you will be asked to complete a brief online survey about your opinions concerning the Basics and the Tower courses offered either at the FAA academy or at the CTI schools and your overall virtual learning experience. The completion of the survey will take approximately 10-15 minutes.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal, no more than everyday life.

BENEFITS OF PARTICIPATION. I do not expect the study to benefit you personally. Your assistance in this project will help improve the air traffic course delivery at the FAA Academy and CTI schools and could possibly improve course learning experience at the FAA Academy or CTI schools. Also by completing this survey, you are eligible to participate in an interview in the Fall of 2018. Not everyone who completes the survey will be selected for a 30-minute interview, but if you are selected for a 30-minute interview, you will receive a \$25 Amazon gift card/voucher. Since this survey is being used to select interview participants, you are HIGHLY encouraged to answer all items honestly and completely.

COMPENSATION. We will give \$25 Amazon gift card/voucher to the selected participant after conducting the face-to-face interviews. Researcher and student assistants will conduct the interviews either over the phone or in researcher's or participant's office.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time or refuse to answer any particular question without it being held against you. If you choose to 'opt-out' during the research process, no data collected will be used in the study. Your decision whether or not to participate will have no effect on your current or future connection with anyone at Embry-Riddle Aeronautical University.

RESPONDENT PRIVACY. Your individual information will be protected in all data resulting from this study. Your responses to this survey will be anonymous. No personal information will be collected other than basic demographic descriptors. The online survey system will not save IP address or any other identifying data. In order to protect the anonymity of your responses, I will keep your responses in a password protected file on a password protected computer. No one other than the researcher will have access to any of the responses.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Lulu Sun, sunl@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By checking AGREE below, you certify that: you are 18 years or older, a resident of the U.S., understand the information on this form, that someone has answered any and all questions you may have about this study, and you voluntarily agree to participate in the study.

If you do not wish to participate in the study, simply close the browser or check DISAGREE which will direct you out of the study.

Please print a copy of this form for your records. A copy of this form can also be requested from Lulu Sun, sunl@erau.edu.

AGREE

DISAGREE

Instructor at FAA Academy Online Survey

Start of Block: Default Question Block

1

Dear participant,

This survey is mainly focusing on your course experience at the academy, which will help research best practices and methods to migrate to a virtual classroom environment with full immersive simulation and instruction.

Again, thank you very much and we truly appreciate your participation. Please note that All the information included in this survey is confidential and only used in the project study.

Virtual training includes

1. Computer-based learning such as recurrent, refresher training, which could be offline
2. Web-based learning, which is online learning and is delivered asynchronously or synchronously
*asynchronous not occurring at the same time, synchronous is occurring at the same time
3. Blended learning which is a combination of the traditional face-to-face instruction and online learning
4. Mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

Page Break

3 What is the highest level of formal education you hold?

- Less than high school (1)
- High school graduate (2)
- Some college (3)
- 2 year degree (4)
- 4 year degree (5)
- Professional degree (6)
- Doctorate (7)

Page Break

Q38 How many years of instructing experience do you have?

1 (1)

2 (2)

3 (3)

4 (4)

5+ (5)

4 Have you instructed any virtual learning courses before?

Virtual training includes

1. Computer-based learning such as recurrent, refresher training, which could be offline
2. Web-based learning, which is online learning and is delivered asynchronously or synchronously
*asynchronous not occurring at the same time, synchronous is occurring at the same time
3. Blended learning which is a combination of the traditional face-to-face instruction and online learning
4. mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

Yes (1)

No - You will skip to question 11 (2)

*Skip To: 11 If Have you instructed any virtual learning courses before? Virtual training includes 1. Computer-b... =
No - You will skip to question 11*

Page Break

5 How many courses have you instructed virtually in the last 5 years?

1 (1)

2 (2)

3 (3)

4 (4)

5 + (5)

Specify (describe them briefly and where did you take them) (7)

6 Approximately when did you instruct the virtual courses?

Within the past year (1)

2 years ago (2)

3 years ago (3)

4 years ago (4)

5 + years ago (5)

Specify (6) _____

8 Can you specify the technologies used in the virtual course? (Select all that apply)

- Audio (1)
 - Slides (2)
 - Video (3)
 - Simulations (4)
 - Interactive Games (5)
 - Mobile Applications (6)
 - Specify (7) _____
-

9 What modality of virtual courses have you instructed with? (select all that apply)

- computer-based (offline) (1)
 - synchronous web-based learning (2)
 - asynchronous web-based learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

10 What assessment methods were used in the course? (Select all that apply)

- Online quizzes (1)
- Online unit tests (2)
- Online exams (3)
- Online Evaluation sheet (4)
- Personal evaluation (5)
- Online discussion (6)
- Specify (7) _____

Page Break

11 Have you instructed Air Traffic Basics? (FAA50043/FAA50143)

Yes (1)

No - You will skip to question 22 (2)

Skip To: 22 If Have you instructed Air Traffic Basics? (FAA50043/FAA50143) = No - You will skip to question 22

Page Break

12 What was your overall impression of the course curriculum design? (1 is the lowest 10 is the highest)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)



13 What is the biggest factor that negatively impacts your instruction with the current Air Traffic Basics courses?

- Lack of access to course information online (1)
 - Lack of real-world experience/ simulations (2)
 - Lack of interaction or collaboration work in class (3)
 - Lack of up-to-date videos/animation to supplement the course study (5)
 - Specify (4) _____
-

14 If the course is switched to a virtual format, which modality would you be interested in using ? (Select all that apply)

- computer-based learning (1)
 - synchronous web- based learning (2)
 - asynchronous web-bases learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

15 Please rank the modality of the course in order of which you would be most interested in using.
(1 being most interested, 6 being least interested)

- _____ computer-based learning (1)
 - _____ synchronous we- based learning (2)
 - _____ asynchronous web-based learning (3)
 - _____ blended learning (4)
 - _____ mobile learning (5)
 - _____ Specify (6)
-

16 What strategies would you use to deal with the challenge of instructing virtual courses? (Select all that apply)

- Social Media (1)
 - Applications (2)
 - Websites (3)
 - Blogs/ Chats/ Discussion board (4)
 - Specify (5) _____
-

17 Do you feel your students have the technology skills needed to succeed in a virtual course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

18 What are the benefits for students of taking the virtual Air Traffic Basics course virtually?

- Flexibility (1)
 - Increased access to information (2)
 - More time efficient (3)
 - More collaboration or interaction with classmates online (4)
 - Specify (5) _____
-

19 Do you think simulation/gaming is an important virtual study feature for the Air Traffic Basics course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

20 Is there any content in the Air Traffic Basics class that you believe is not translatable to the virtual format?

- FAA/ NAS/ Publication (1)
- Basics of ATC (2)
- Aircraft and navigation (3)
- Weather and emergencies (4)
- Specify (5) _____

21 What suggestions would you give for delivering Air Traffic Basics in the virtual training environment?

Page Break

22 Have you instructed Initial Tower Cab Training? (FAA50046)

- Yes (1)
- No - You will skip to question 33 (2)

Skip To: 33 If Have you instructed Initial Tower Cab Training? (FAA50046) = No - You will skip to question 33

23 What was your overall impression of the course curriculum design? (1 being the lowest, 10 being the highest)

- 1 (1)
 - 2 (2)
 - 3 (3)
 - 4 (4)
 - 5 (5)
 - 6 (6)
 - 7 (7)
 - 8 (8)
 - 9 (9)
 - 10 (10)
-

24 What is the biggest factor that negatively impacts your instruction with the current Initial Tower Cab Training courses?

- Lack of access to course information online (1)
 - Lack of real-world experience/ simulations (2)
 - Lack of interaction or collaboration work in the class (3)
 - Lack of up-to-date videos/animation to supplement the course stuy (5)
 - Specify (4) _____
-

25 If the course is switched to a virtual format, which modality would you be interested in using? (Select all that apply)

- computer-based (1)
 - synchronous web-based learning (2)
 - asynchronous web-bases learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

26 Please rank the modality of the course in order of which you would be most interested in using.
(1 being most interested, 6 being least interested)

- _____ computer-based (1)
 - _____ synchronous web-based learning (2)
 - _____ asynchronous web-based learning (3)
 - _____ blended learning (4)
 - _____ mobile learning (5)
 - _____ Specify (6)
-

27 What strategies would you use to deal with the challenge of taking virtual courses?
(Select all that apply)

- Social Media (1)
 - Applications (2)
 - Websited (3)
 - Blogs/ Chats/ Discussion board (4)
 - Specify (5) _____
-

28 Do you feel your students have the technology skills needed to succeed in a virtual course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

29 What are the benefits for students of taking the virtual Tower Cab Training course virtually?

- Flexibility (1)
 - Increased access to information (2)
 - More time efficient (3)
 - More collaboration or interaction with classmates online (4)
 - Specify (5) _____
-

30 Do you think simulation/gaming is an important virtual study feature for the Tower Cab Training course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

31 Is there any content that you believe is not translatable to the virtual format?

- Lecture in the class (1)
- Tabletop practice (2)
- Hands-on simulation in the lab (3)
- Specify (4) _____

32 What suggestions would you give for delivering Tower Cab Training in the virtual training environment?

Page Break

33 As an instructor, would you like to see both courses being switched to a virtual training delivery or not?

- Air Traffic Basics (FAA50043/FAA50143) (2)
- Initial Tower Cab Training (FAA50046) (3)
- Both (4)
- Neither (5)

Skip To: End of Survey If As an instructor, would you like to see both courses being switched to a virtual training deliver... = Initial Tower Cab Training (FAA50046)

Skip To: 34 If As an instructor, would you like to see both courses being switched to a virtual training deliver... = Neither

Skip To: 35 If As an instructor, would you like to see both courses being switched to a virtual training deliver... = Both

Skip To: Q39 If As an instructor, would you like to see both courses being switched to a virtual training deliver... = Air Traffic Basics (FAA50043/FAA50143)

34 Why would you not like to see the change or changes to virtual delivery?

Skip To: End of Survey If Why would you not like to see the change or changes to virtual delivery? Is Not Empty

35 What do you see as the greatest challenge in moving the courses to a virtual format, and what is the greatest benefit?

Skip To: End of Survey If What do you see as the greatest challenge in moving the courses to a virtual format, and what is... Is Not Empty

Q39 Why would you like Air Traffic Basics (FAA50043/FAA50143) to be in a virtual format and not Initial Tower Cab Training (FAA50046)

Skip To: End of Survey If Why would you like Air Traffic Basics (FAA50043/FAA50143) to be in a virtual format and not Initi... Is Not Empty

Q40 Why would you like Initial Tower Cab Training (FAA50046) to be in a virtual format and not Air Traffic Basics (FAA50043/FAA50143)

End of Block: Default Question Block

Student online survey

AGREEMENT TO PARTICIPATE IN

Survey of Best Practices and Best Methods for Virtual Training Delivery in Air Traffic Control Courses

STUDY LEADERSHIP. I am asking you to take part in a research project that is led by Dr. Lulu Sun from Embry-Riddle Aeronautical University.

PURPOSE. The purpose of this study is to seek the best practices and best methods for virtual training delivery in air traffic control courses offered at Federal Aviation Administration (FAA) academy and Collegiate Training Initiative (CTI) school.

ELIGIBILITY. To be in this study, you must be 18 years or older and a resident of the United States.

PARTICIPATION. During the study, you will be asked to complete a brief online survey about your opinions concerning the Basics and the Tower courses offered either at the FAA academy or at the CTI schools and your overall virtual learning experience. The completion of the survey will take approximately 10-15 minutes.

RISKS OF PARTICIPATION. The risks of participating in this study are minimal, no more than everyday life.

BENEFITS OF PARTICIPATION. I do not expect the study to benefit you personally. Your assistance in this project will help improve the air traffic course delivery at the FAA Academy and CTI schools and could possibly improve course learning experience at the FAA Academy or CTI schools. Also by completing this survey, you are eligible to participate in an interview in the Fall of 2018. Not everyone who completes the survey will be selected for a 30-minute interview, but if you are selected for a 30-minute interview, you will receive a \$25 Amazon gift card/voucher. Since this survey is being used to select interview participants, you are HIGHLY encouraged to answer all items honestly and completely.

COMPENSATION. We will give \$25 Amazon gift card/voucher to the selected participant after conducting the face-to-face interviews. Researcher and student assistants will conduct the interviews either over the phone or in researcher's or participant's office.

VOLUNTARY PARTICIPATION. Your participation in this study is completely voluntary. You may stop or withdraw from the study at any time or refuse to answer any particular question without it being held against you. If you choose to 'opt-out' during the research process, no data collected will be used in the study. Your decision whether or not to participate will have no effect on your current or future connection with anyone at Embry-Riddle Aeronautical University.

RESPONDENT PRIVACY. Your individual information will be protected in all data resulting from this study. Your responses to this survey will be anonymous. No personal information will be collected other than basic demographic descriptors. The online survey system will not save IP address or any other identifying data. In order to protect the anonymity of your responses, I will keep your responses in a password protected file on a password protected computer. No one other than the researcher will have access to any of the responses.

FURTHER INFORMATION. If you have any questions or would like additional information about this study, please contact Dr. Lulu Sun, sunl@erau.edu.

The ERAU Institutional Review Board (IRB) has approved this project. You may contact the ERAU IRB with any questions or issues at (386) 226-7179 or teri.gabriel@erau.edu. ERAU's IRB is registered with the Department of Health & Human Services – Number – IORG0004370.

CONSENT. By checking AGREE below, you certify that: you are 18 years or older, a resident of the U.S., understand the information on this form, that someone has answered any and all questions you may have about this study, and you voluntarily agree to participate in the study.

If you do not wish to participate in the study, simply close the browser or check DISAGREE which will direct you out of the study.

Please print a copy of this form for your records. A copy of this form can also be requested from Lulu Sun, sunl@erau.edu.

AGREE

DISAGREE

Students at FAA Academy Online Survey

Start of Block: Default Question Block

1

Dear participant,

This survey is mainly focusing on your course experience at the academy, which will help research best practices and methods to migrate to a virtual classroom environment with full immersive simulation and instruction.

Again, thank you very much and we truly appreciate your participation. Please note that all the information included in this survey is confidential and only used in the project study.

Virtual training includes

1. Computer-based learning such as recurrent, refresher training, which could be offline
2. Web-based learning, which is online learning and is delivered asynchronously or synchronously
*asynchronous not occurring at the same time, synchronous is occurring at the same time
3. Blended learning which is a combination of the traditional face-to-face instruction and online learning
4. Mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

Page Break

2 Age

3 What is the highest level of formal education you hold?

- Less than high school (1)
 - High school graduate (2)
 - Some college (3)
 - 2 year degree (4)
 - 4 year degree (5)
 - Professional degree (6)
 - Doctorate (7)
-

Page Break

4 Have you taken any virtual learning courses before?

Virtual training includes

1. Computer-based learning such as recurrent, refresher training, which could be offline
2. Web-based learning, which is online learning and is delivered asynchronously or synchronously
*asynchronous not occurring at the same time, synchronous is occurring at the same time
3. Blended learning which is a combination of the traditional face-to-face instruction and online learning
4. mobile learning which delivers the learning through mobile devices such as laptops, smartphones or tablets.

Yes (1)

No - You will skip to question 11 (2)

*Skip To: 11 If Have you taken any virtual learning courses before? Virtual training includes 1. Computer-based... =
No - You will skip to question 11*

Page Break

5 How many courses have you taken virtually in the last 5 years

- 1 (1)
 - 2 (2)
 - 3 (3)
 - 4 (4)
 - 5 + (5)
-

6 Approximately when did you take the virtual courses?

- Within the past year (1)
 - 2 years ago (2)
 - 3 years ago (3)
 - 4 years ago (4)
 - 5 + years ago (5)
 - Specify (6) _____
-

7 What virtual courses have you taken? (describe them briefly and where did you take them)

8 Can you specify the technologies used in the virtual course? (Select all that apply)

- Audio (1)
 - Slides (2)
 - Video (3)
 - Simulations (4)
 - Interactive Games (5)
 - Mobile Applications (6)
 - Specify (7) _____
-

9 What modality of virtual courses have you taken? (select all that apply)

- computer-based (offline) (1)
 - synchronous web-based learning (2)
 - asynchronous web-based learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

10 What assessment methods were used in the course? (Select all that apply)

- Online quizzes (1)
- Online unit tests (2)
- Online exams (3)
- Online Evaluation sheet (4)
- Personal evaluation (5)
- Online discussion (6)
- Specify (7) _____

Page Break

11 Have you taken Air Traffic Basics? (FAA50043/FAA50143)

Yes (1)

No - You will skip to question 22 (2)

Skip To: 22 If Have you taken Air Traffic Basics? (FAA50043/FAA50143) = No - You will skip to question 22

Page Break

12 What was your overall impression of the course? (1 is the lowest 10 is the highest)

1 (1)

2 (2)

3 (3)

4 (4)

5 (5)

6 (6)

7 (7)

8 (8)

9 (9)

10 (10)

13 What is the biggest factor that negatively impacts your learning with the current Air Traffic Basics courses?

- Lack of access to course information online (1)
 - Lack of real-world experience/ simulations (2)
 - Lack of interaction or collaboration work in class (3)
 - Lack of up-to-date videos/animation to supplement the course study (5)
 - Specify (4) _____
-

14 If the course is switched to a virtual format, which modality would you be interested in using ? (Select all that apply)

- computer-based learning (1)
 - synchronous web- based learning (2)
 - asynchronous web-bases learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

15 Please rank the modality of the course in order of which you would be most interested in using.
(1 being most interested, 6 being least interested)

- _____ computer-based learning (1)
 - _____ synchronous web- based learning (2)
 - _____ asynchronous web-based learning (3)
 - _____ blended learning (4)
 - _____ mobile learning (5)
 - _____ Specify (6)
-

16 What strategies would you use to deal with the challenge of taking virtual courses? (Select all that apply)

- Social Media (1)
 - Applications (2)
 - Websites (3)
 - Blogs/ Chats/ Discussion board (4)
 - Specify (5) _____
-

17 Do you feel you have the technology skills needed to succeed in a virtual course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

18 What are the benefits for students of taking the virtual Air Traffic Basics course virtually?

- Flexibility (1)
 - Increased access to information (2)
 - More time efficient (3)
 - More collaboration or interaction with classmates online (4)
 - Specify (5) _____
-

19 Do you think simulation/gaming is an important virtual study feature for the Air Traffic Basics course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

20 Is there any content in the Air Traffic Basics class that you believe is not translatable to the virtual format?

- FAA/ NAS/ Publication (1)
 - Basics of ATC (2)
 - Aircraft and navigation (3)
 - Weather and emergencies (4)
 - Specify (5) _____
-

21 What suggestions would you give for delivering Air Traffic Basics in the virtual training environment?

Page Break _____

22 Have you taken Initial Tower Cab Training? (FAA50046)

- Yes (1)
- No - You will skip to question 33 (2)

Skip To: 33 If Have you taken Initial Tower Cab Training? (FAA50046) = No - You will skip to question 33

23 What was your overall impression of the course? (1 being the lowest, 10 being the highest)

- 1 (1)
 - 2 (2)
 - 3 (3)
 - 4 (4)
 - 5 (5)
 - 6 (6)
 - 7 (7)
 - 8 (8)
 - 9 (9)
 - 10 (10)
-

24 What is the biggest factor that negatively impacts your learning with the current Initial Tower Cab Training courses?

- Lack of access to course information online (1)
 - Lack of real-world experience/ simulations (2)
 - Lack of interaction or collaboration work in the class (3)
 - Lack of up-to-date videos/animation to supplement the course study (5)
 - Specify (4) _____
-

25 If the course is switched to a virtual format, which modality would you be interested in using? (Select all that apply)

- computer-based (1)
 - synchronous web-based learning (2)
 - asynchronous web-bases learning (3)
 - blended learning (4)
 - mobile learning (5)
 - Specify (6) _____
-

26 Please rank the modality of the course in order of which you would be most interested in using.
(1 being most interested, 6 being least interested)

- _____ computer-based (1)
 - _____ synchronous web-based learning (2)
 - _____ asynchronous web-based learning (3)
 - _____ blended learning (4)
 - _____ mobile learning (5)
 - _____ Specify (6)
-

27 What strategies would you use to deal with the challenge of taking virtual courses?
(Select all that apply)

- Social Media (1)
 - Applications (2)
 - Websites (3)
 - Blogs/ Chats/ Discussion board (4)
 - Specify (5) _____
-

28 Do you feel you have the technology skills needed to succeed in a virtual course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

29 What are the benefits for students of taking the virtual Tower Cab Training course virtually?

- Flexibility (1)
 - Increased access to information (2)
 - More time efficient (3)
 - More collaboration or interaction with classmates online (4)
 - Specify (5) _____
-

30 Do you think simulation/gaming is an important virtual study feature for the Tower Cab Training course?

- Yes (1)
 - No (2)
 - Specify (3) _____
-

31 Is there any content that you believe is not translatable to the virtual format?

- Lecture in the class (1)
- Tabletop practice (2)
- Hands-on simulation in the lab (3)
- Specify (4) _____

32 What suggestions would you give for delivering Tower Cab Training in the virtual training environment?

Page Break

33 As a student, would you like to see both courses being switched to a virtual training delivery or not?

Yes (1)

No (2)

Specify (3) _____

Skip To: 35 If As a student, would you like to see both courses being switched to a virtual training delivery or... = Yes

34 Why would you not like to see the change or changes to virtual delivery?

Skip To: End of Survey If Why would you not like to see the change or changes to virtual delivery? Is Not Empty

35 What do you see as the greatest challenge in moving the courses, and what is the greatest benefit?

End of Block: Default Question Block

Best Practices and Best Methods of Virtual Training Delivery for Air Traffic Controllers

Project Investigator: Lulu Sun, Ph.D. Engineering Fundamentals Department

Undergraduate student researcher: Haley Dennis, Air Traffic Management Department

Embry-Riddle Aeronautical University, Daytona Beach, FL



Why are we doing this?

- The Federal Aviation Administration (FAA) faces great challenges training millennial controllers to **effectively** and **efficiently** meet the requirements of the challenging job
- FAA training delivery methods such as instructor led-courses, and PowerPoint with no accompanying assessment, have not kept pace with advances in **simulation** and **gaming** technologies
- Millennial controllers** have expertise in media, tools, and technology than the Boomers, who are current trainers. The FAA must change its traditional means of training since the new hires grew up in a digital world and prefer digital technologies to the more static teaching methods used to train their predecessors

How will we accomplish it?

- Study **training courses**, **end-of-course evaluation reports** offered by the FAA Academy and Air Traffic-Collegiate Training Initiative (AT-CTI) schools
- Study **best practices** and **methods** in healthcare, military, and STEM
- Conduct **surveys** and face-to-face **interviews** to examine the current controller's training experience and expectation
- Collaborate with **industry partners** to research training curricula, delivery improvements and identify potential impacts

What do we hope to accomplish?

- Best practices** and **methods** will be identified and presented to the FAA
- Research **findings** from training courses offered by the FAA Academy, AT-CTI schools, in-field facilities, healthcare, military, and STEM will be presented
- Develop **recommendations** for changes to the FAA training process
- Identify potential **impacts** on training for both current and future training delivery systems
- Communicate** with FAA administrators and **collaborate** with course developers to improve training course delivery

Impact

- It will benefit students, instructors, and managers at the FAA Academy
- It will benefit students, instructors, and administrators at AT-CTI schools
- It will benefit administrators at the FAA headquarters
- It will benefit controllers, and managers at facilities
- It will benefit people who are interested in being in air traffic control /management field



Figure 1. Virtual training modalities

Why virtual training

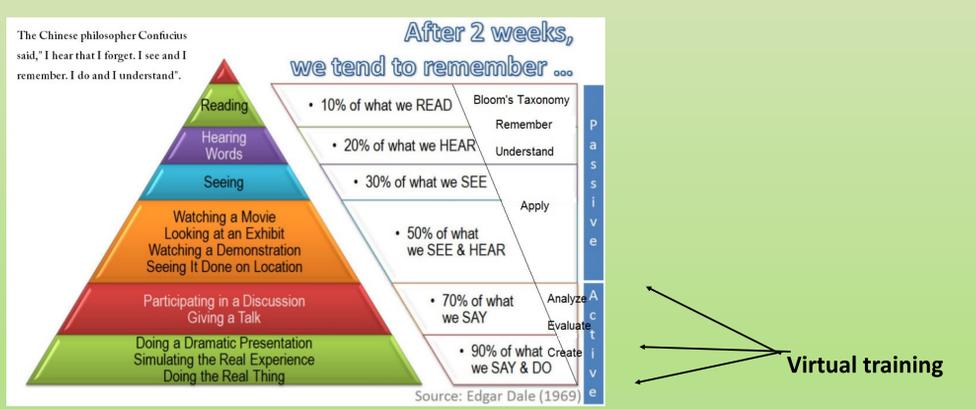


Figure 2. Cone of Learning by Edgar Dale and Bloom's taxonomy

The FAA Academy classroom report summary

- Traditional classrooms without learning management system (LMS)
- Video quality is **outdated**
- No **pre-tests** and **post-tests** to understand their knowledge level
- Lack of **simulation** practice time after class
- No interactive **animation/simulation/gaming** involved in the student study
- Some lesson **pace** was not appropriate

Online surveys and face-to-face interviews at the FAA Academy (students and instructors) and at the facilities (instructors, managers at DCA, and MCO towers)

- More **time** in the simulation labs
- Current videos are **outdated**
- Pre-tests** and **post-tests** are needed
- Good instructor's style should be shared **virtually**
- More **teamwork** in class
- Millennials** can teach themselves virtually
- Blended learning** is preferred
- Do not take the **instructor** away completely, but just add additional effective resources
- Start with something like a learning management system (LMS)
- Sharing senior controllers' experiences in a **virtual** format is desirable
- Team** building activities are important for controller success
- Additional **resources** should be available to passionate students
- Stories such as the US Airways Hudson River landing need to be compiled and shared **virtually** with all, not in a single one or two classes
- Interactive** training materials should be accessible to the students
- Interactive and scenario driven **videos/animations** are needed

Recommended Solutions

- ⇒ Learning management system (LMS)
- ⇒ **Blended learning**
- ⇒ **Team-based learning (TBL)** with individual Readiness Assessment Test (iRAT) and team Readiness Assurance Test (tRAT) is preferred and a community learning can allow millennial controllers help each other and support each other
- ⇒ Emphasize **active learning** such as teamwork and discussion in class time with the facilitation of the instructor
- ⇒ **Pretest** and **posttest** should be implemented as a formative assessment
- ⇒ **Animation/simulation/gamification** should be included in the interactive multimedia instruction
- ⇒ **Virtual reality (VR)** and **augmented reality (AR)** can be incorporated into virtual learning to improve student engagement and retention
- ⇒ An **Intelligent Tutoring System (ITS)**, which empathize the personalized learning should be applied so that based on the test performance students can have the options to either repeat or move on to the next topic of study
- ⇒ A **virtual community** with disciplinary **repository** should be available to Millennials
- ⇒ **Mobile learning** can be a supplemental portable study tool to enable more personalized training

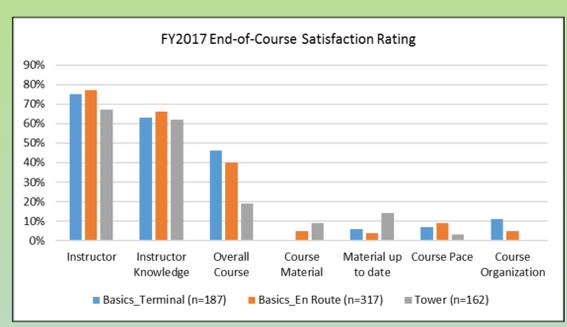


Figure 3. The AT Basics, and the Tower End-of-Course Satisfaction Rating collected

Online survey participants		
Location	Type	Participants
FAA Academy	Instructors	12
	Students	6
AT-CTI Schools	Faculty	15
	Students	24

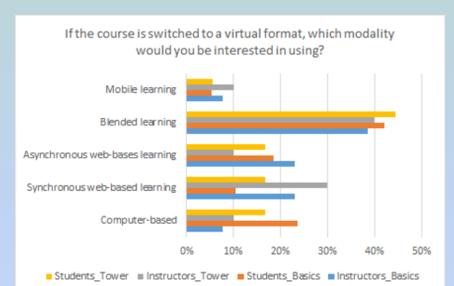


Figure 4. The preference of virtual training modalities identified by instructors and students at the Academy and AT-CTI schools

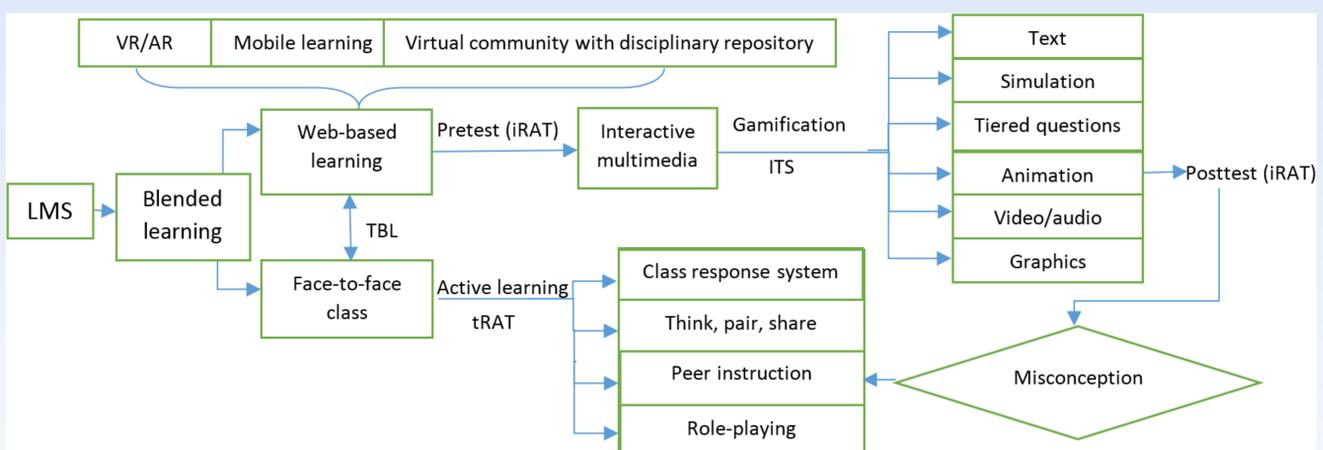


Figure 5. Virtual training course redesign map

EXPLORING THE BEST PRACTICES OF VIRTUAL TRAINING DELIVERY FOR THE PROSPECTIVE AIR TRAFFIC CONTROLLERS

LULU SUN, PI – EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

MARK MARCHESE, ARNIE SELNICK, JMA SOLUTIONS LLC

SID MCGUIRK, PROJECT ADVISOR, EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

HALEY DENNIS, UNDERGRADUATE STUDENT, EMBRY-RIDDLE AERONAUTICAL UNIVERSITY

OUTLINE

- Introduction
- Objectives
- Assessments
- Results
- Application of Augmented Reality and Virtual Reality in ATC
- Recommendations
- Acknowledgement

BEST PRACTICES AND METHODS FOR VIRTUAL TRAINING DELIVERY, CA-I, LULU SUN, PH.D. ERAU

INTRODUCTION

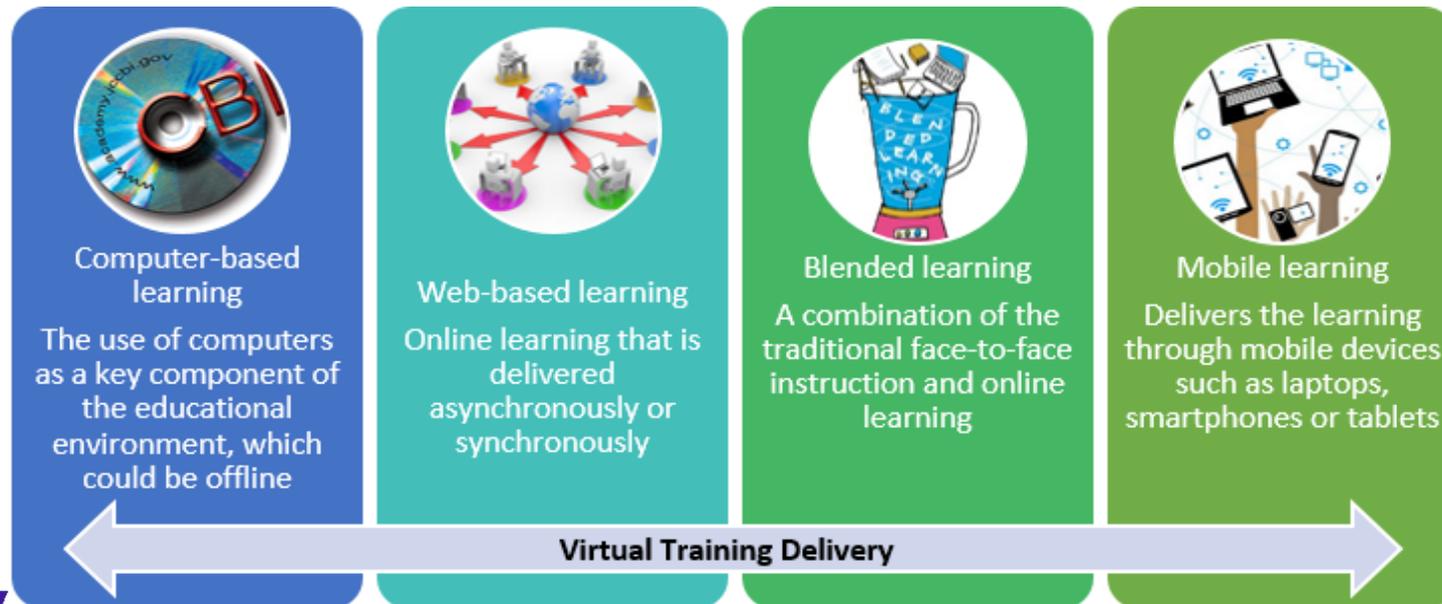
- Why are we doing this?
 - FAA training delivery methods, such as instructor led-courses, and PowerPoint with no accompanying assessment, have not kept pace with advances in simulation technologies.
 - Air traffic volume and complexity have steadily increased, along with innovative technologies and methodologies.
 - Millennials have expertise in media, tools, and technology than boomers. The FAA must change its traditional means of training since the new hires grew up in a digital world and prefer digital technologies to the more static teaching methods used to train their predecessors.

OBJECTIVES

- What do we hope to accomplish?
 - Best practices and methods, including synchronous and asynchronous delivery techniques, will be synthesized and presented to the FAA.
 - Training courses including the Air Traffic Basics (AT Basics) and the Initial Tower Cab offered by the FAA academy and Air Traffic Collegiate Training Initiative (AT-CTI) schools research findings will be presented.
 - Develop recommendations for changes to the FAA Training process.
 - Identify potential impacts on training for both current and future training delivery systems.

METHODS

- How will we accomplish it?
 - Examine training courses offered by the FAA academy, CTI schools, and other training area.
 - Conduct surveys and face-to-face interviews to understand the current controller's training experiences and expectations.
 - Collaborate with industry partners and consultants to research potential training curriculum and delivery improvements and identify potential impacts



ASSESSMENTS

- Face to face interviews
 - FAA Academy, DCA tower, and MCO tower
- Online surveys
 - FAA Academy, and CTI schools

RESULTS

- What did our students and instructors at the FAA academy say? (August 2017)
 - Responded unanimously that they believe they should have more hours in the simulation labs with a virtual format.
 - Current course videos and animations are outdated. Poor quality of graphics and videos.
 - No automated pre-test and post-test to ascertain students' understanding before and after each topic.
 - Instructors' personal style and pacing should be tailored in the virtual training environment.
 - More teamwork is needed for AT Basics course.
 - Students believe that as millennials, they have the ability to use new technology to teach themselves in a virtual environment.
 - Students preferred hybrid learning with information online and traditional hands-on training methods, rather than a completely virtual format.

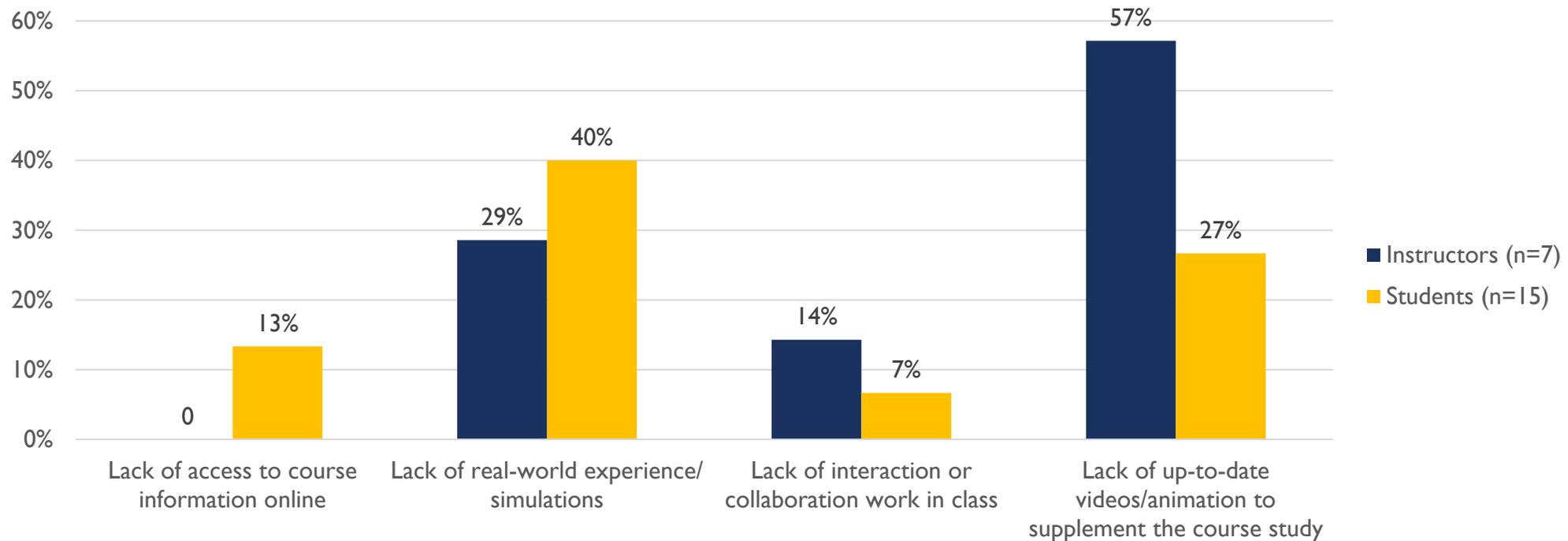
RESULTS: FACE-TO-FACE INTERVIEWS

- What did our managers and instructors at DCA and MCO towers say?
 - Do not take the instructor away completely, but just add additional effective resources.
 - Start with something small like a learning management system.
 - Focus on key areas that enhance controllers technical abilities.
 - Sharing senior controllers' experiences in a virtual format is desirable.
 - Team building activities are important for controller success.
 - Passing tests is important, but instructors prefer students who are passionate about learning everything there is to know about air traffic control. Stories such as the US Airways Hudson River landing and other ATC events need to be compiled and shared virtually with all, not in a single one or two classes.
 - Find ways to get training materials to the user faster, more robust, and easier to adapt.
 - Some simulation labs are outdated.
 - Interactive and scenario driven videos/animations are needed.

RESULTS: ONLINE SURVEYS

- FAA Academy, and CTI schools

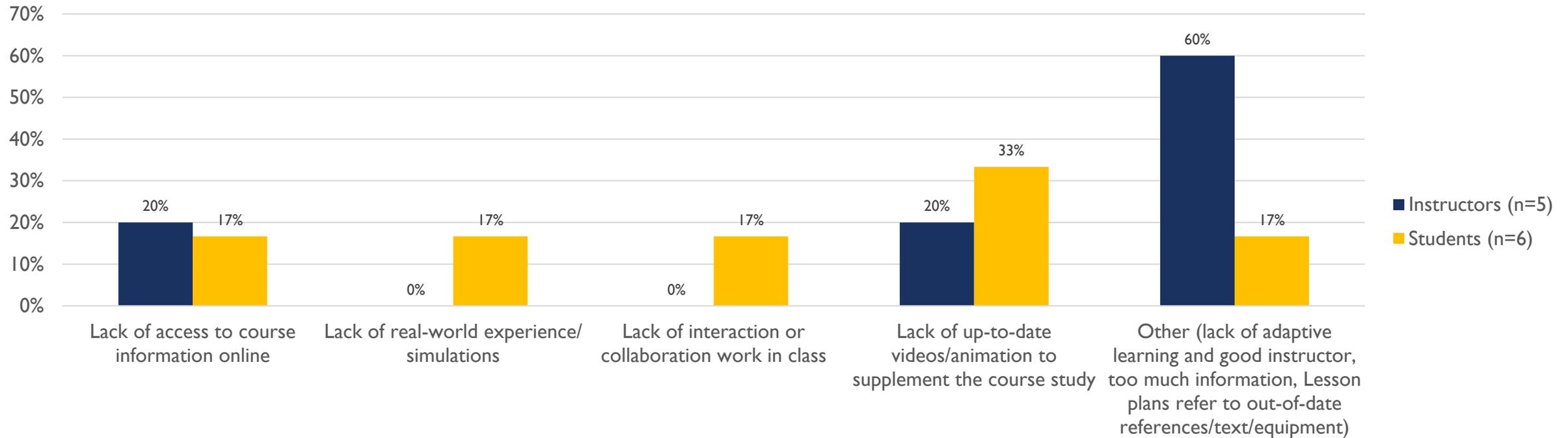
What is the biggest factor that negatively impacts your teaching/learning with the current Air Traffic Basics courses?



RESULTS: ONLINE SURVEYS

- FAA Academy, and CTI schools

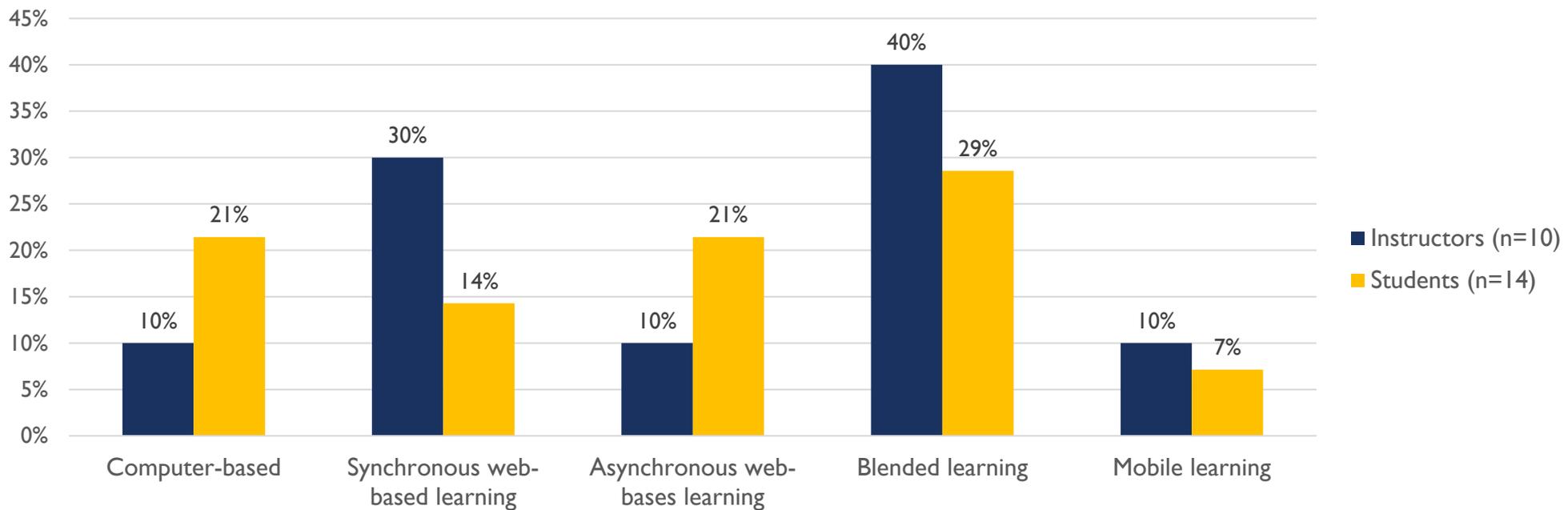
What is the biggest factor that negatively impacts your teaching/learning with the current Initial Tower Cab Training courses?



RESULTS: ONLINE SURVEYS

- FAA Academy, and CTI schools

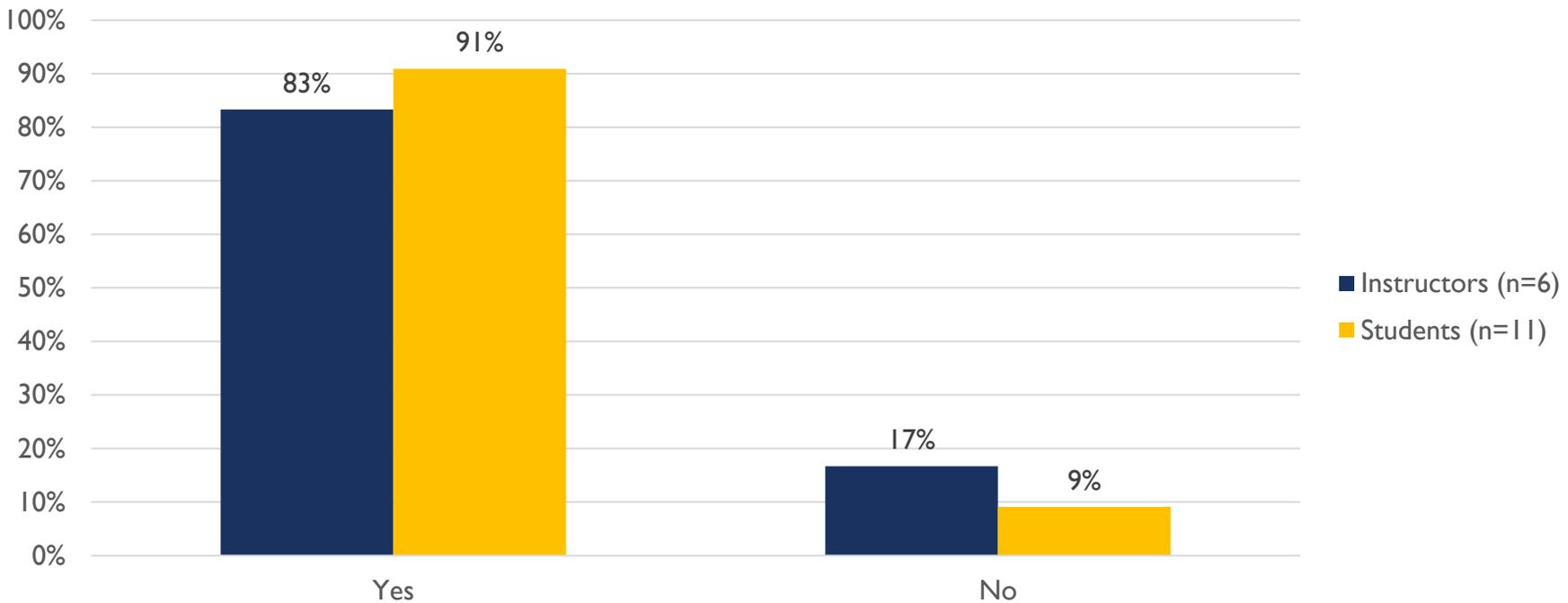
If the course is switched to a virtual format, which modality would you be interested in using? (Select all that apply)



RESULTS: ONLINE SURVEYS

- FAA Academy, and CTI schools

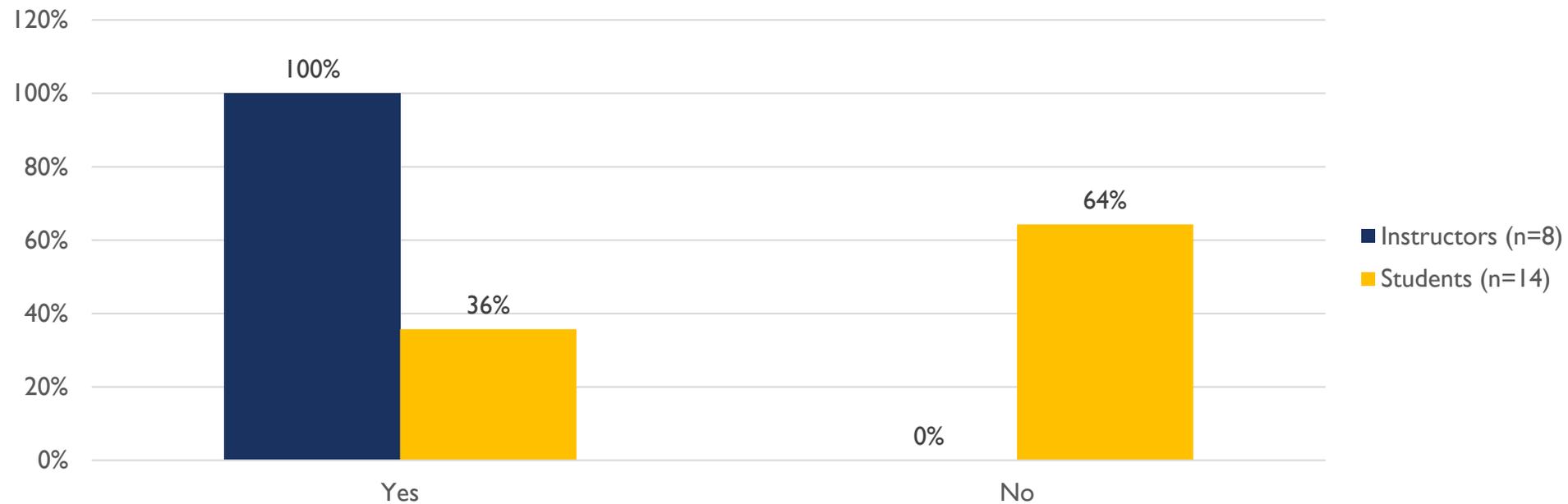
Do you feel your students/you have the technology skills needed to succeed in a virtual course?



RESULTS: ONLINE SURVEYS

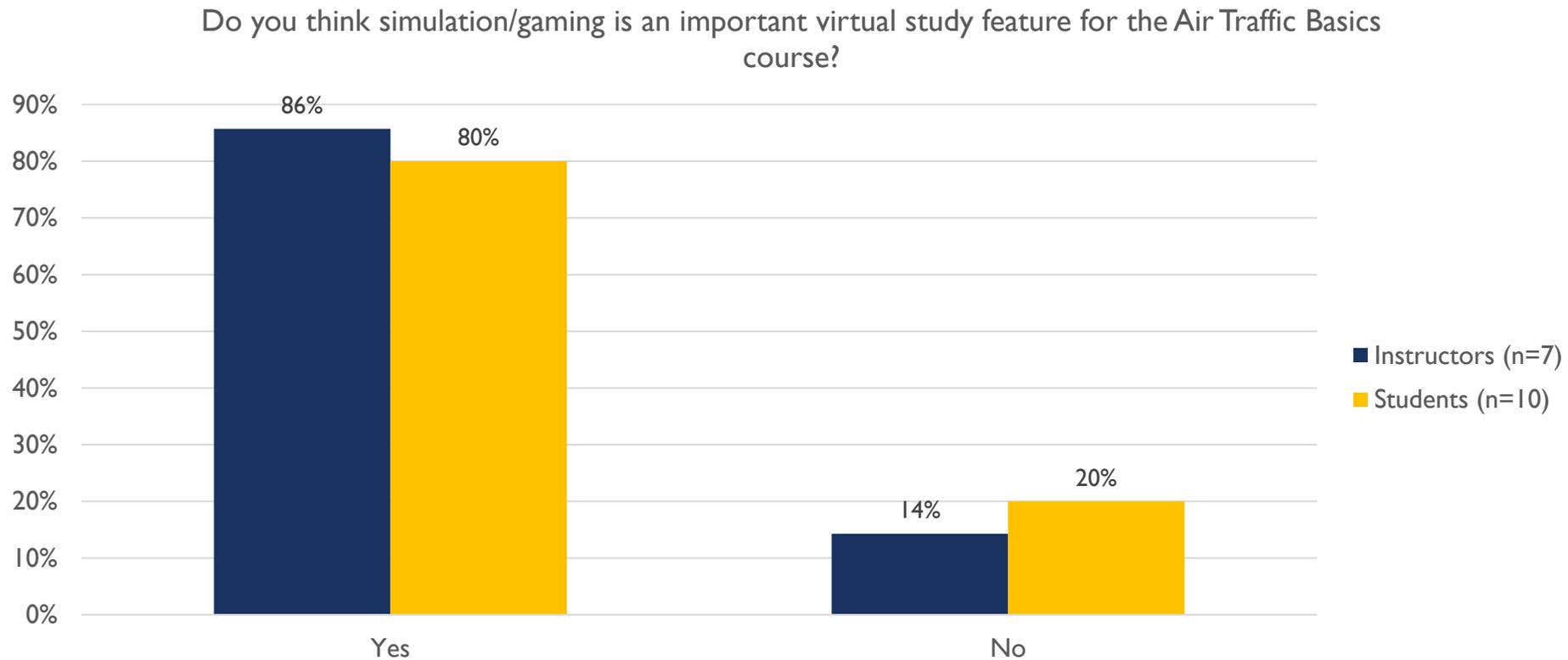
- FAA Academy, and CTI schools

As an instructor/student, would you like to see both courses being switched to a virtual training delivery or not?



RESULTS: ONLINE SURVEYS

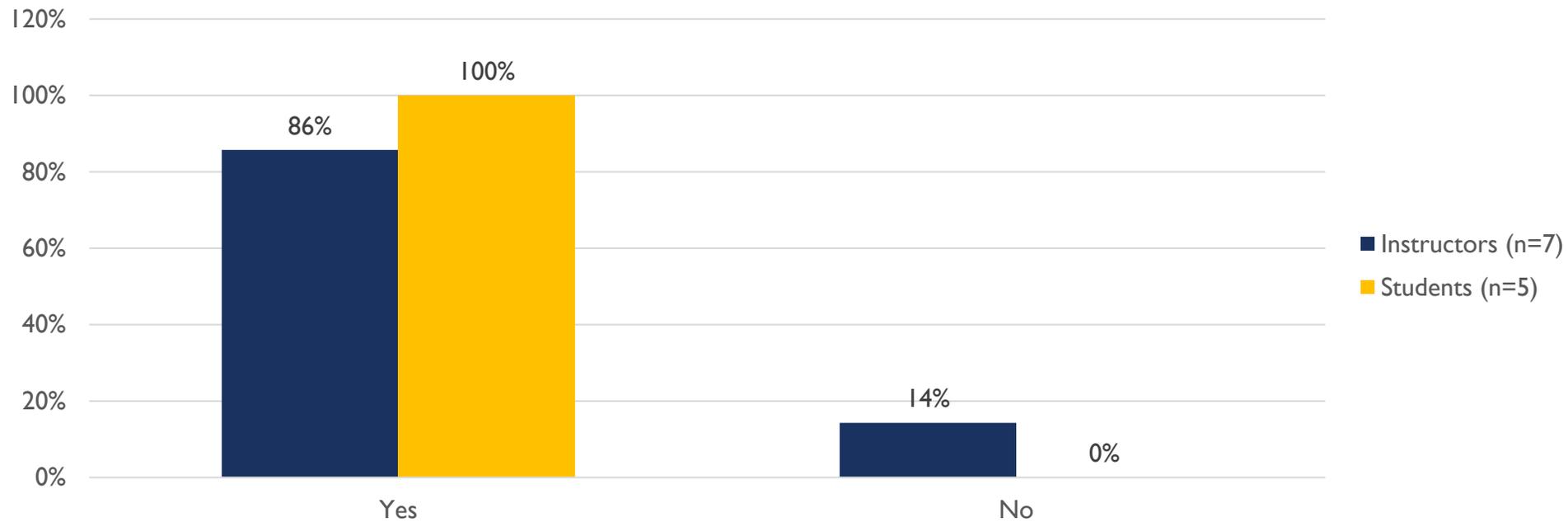
- FAA Academy, and CTI schools



RESULTS: ONLINE SURVEYS

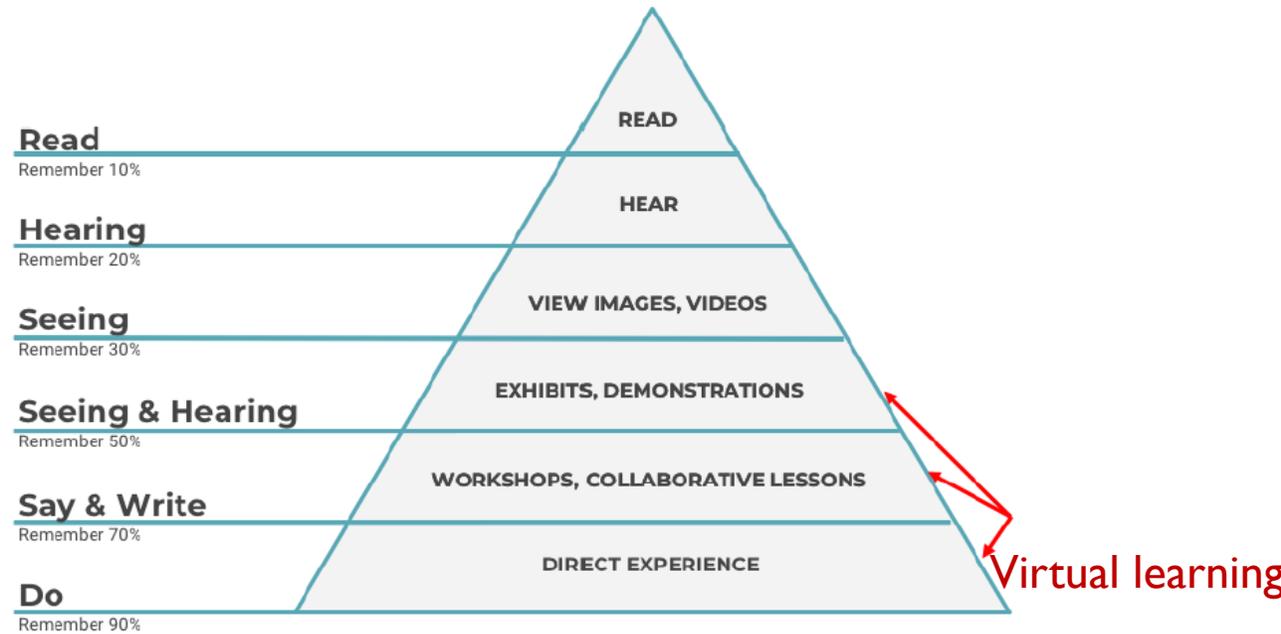
- FAA Academy, and CTI schools

Do you think simulation/gaming is an important virtual study feature for the Tower Cab Training course?



APPLICATION OF AUGMENTED REALITY AND VIRTUAL REALITY IN ATC

- Multi-sensory learning
 - Vision (sight); Auditory (hearing); Gustatory (taste); Olfaction (smell); Vestibular (balance/movement); Somatic sensation (touch)
- Application of Virtual Reality (VR) in ATC (https://www.youtube.com/watch?time_continue=4&v=MDv0CJVudoo)
 - Offer more interactive and immersive learning environment
 - More engaged and adaptive gamification learning environment
 - Enhancing the ability of understanding and memorizing knowledge
- Application of Augmented Reality (AR) in ATC
 - Enhanced visual information under low-visibility condition
 - Reduction of head-down time
 - Clear blocking of important line-of-sights



Edgar Dale, Cone of experience (1969)

RECOMMENDATIONS

- A learning management system and infrastructure requirements is needed so that all course materials can be accessed in a virtual environment.
- Based on the study courses, a **blended learning** should be designed and implemented.
- New high quality short screencasts should be created with **interactive** questions/answers to test their understanding online.
- Emphasize teamwork and discussion in class time with the facilitation of the instructor.
- Reduced lecture time and extended simulation practice of the Tower Cab Training course with virtual training.
- Animation/simulation/gaming should be included in the virtual training so that students are more **engaged** to study by themselves.
- Virtual reality can be incorporated into virtual learning to improve student engagement and retention.
- Augmented reality can be a great learning tool especially helping ATC-in-training at the facility.
- Create a **virtual community** so that students can help each other and support each other.
- People learn more from **mistakes**. For example, simulations that are used to illustrate wrong directions given by the controllers causing a pilot to come dangerously close to a mountain are especially important.
- An adaptive learning should be applied so that based on the test performance students can have the options to either repeat or move on to the next topic of study.

- **ACKNOWLEDGEMENT**

The FAA has sponsored this project through the Center of Excellence for Technical Training and Human Performance. However, the agency neither endorses nor rejects the findings of this research. The presentation of this information is in the interest of invoking technical community comment on results and conclusions of the research.