Federal Aviation Administration

DOT/FAA/AM-22/05
Aviation Safety
Office of Aerospace Medicine
Washington, DC 20591

An Evaluation of Virtual Basics for Air Traffic Control: Trainee Perceptions and Course Outcomes

Brett Torrence
Charla Long

Civil Aerospace Medical Institute (CAMI)
Federal Aviation Administration
Oklahoma City, OK 73169

May 2022

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents thereof.

This publication and all Office of Aerospace Medicine technical reports are available in full-text from the Civil Aerospace Medical Institute's publications website: http://www.faa.gov/go/oamtechreports

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-22/05		

4. Title and Subtitle	5. Report Date
An Evaluation of Virtual Basics for Air Traffic Control: Trainee Perceptions and Course Outcomes	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Torrence, B., & Long, C.	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Civil Aerospace Medical Institute (CAMI), FAA Oklahoma City, OK 73125	11. Contract or Grant No.

12. Sponsoring Agency name and Address	13. Type of Report and Period Covered
Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

16. Abstract

Basics for Air Traffic Control is a key course in the Air Traffic Training program as it provides trainees with foundational air traffic knowledge and influences trainee throughput to subsequent phases of training. To enable the safe delivery of training during the pandemic, this course was converted from an in-person, classroom training to a virtual training environment. Virtual Basics for Air Traffic Control is taught in a synchronous, online format that allows trainees to attend from geographically dispersed locations using video teleconferencing and learning software. In the present study, an evaluation of the virtual Basics for Air Traffic Control course was conducted to assess the effectiveness of the virtual format. Data on trainee perceptions of the virtual environment, learning activities, instructor-trainee interactions, trainee-trainee interactions, and technology were collected from $N = 480$ trainees who successfully completed the virtual course. Additionally, test score and pass rate data from $N = 79$ virtual classes were compared to archival outcome data from the in-person, classroom training. Overall, trainees generally held positive views of the virtual learning environment and felt confident in their knowledge of subject areas covered in the course. However, there were some identified areas of improvement, such as trainee-trainee interactions and the number of devices needed for training. Although analyses revealed few statistically significant differences in test scores between the virtual and classroom formats, the difference in average test scores were small and thus had no practical significance. There were no statistically significant differences in pass rates between the training formats. Implications of these findings for the virtual Basics for Air Traffic Control course are discussed.

17. Key Words	18. Distribution Statement
Air Traffic Control, virtual training, trainee reactions, training technology, FAA Academy	Document is available to the public through the Internet: http://www.faa.gov/go/oamtechreports/

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	25	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized.

Acknowledgements

The authors would like to thank the Federal Aviation Administration (FAA) Academy for their collaboration and support during this project. Their assistance was invaluable to this effort. We would also like to thank Alfretia Scarborough for her assistance with this project. Research was conducted under the Air Traffic Program Directive/Level of Effort Agreement between the Human Factors Division (ANG-C1), FAA Headquarters, and the Aerospace Human Factors Research Division (AAM-500) at the Civil Aerospace Medical Institute (CAMI).

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Acronym	Term
AAM-500	Aerospace Human Factors Research Division
AJI-2	Technical Training Directorate
ANG-C1	Human Factors Division
ATC	Air Traffic Control
CAMI	Civil Aerospace Medical Institute
COVID-19	Coronavirus Disease 2019
FAA	Federal Aviation Administration
NAS	National Airspace System

Abstract

Basics for Air Traffic Control is a key course in the Air Traffic Training program as it provides trainees with foundational air traffic knowledge and influences trainee throughput to subsequent phases of training. To enable the safe delivery of training during the pandemic, this course was converted from an in-person, classroom training to a virtual training environment. Virtual Basics for Air Traffic Control is taught in a synchronous, online format that allows trainees to attend from geographically dispersed locations using video teleconferencing and learning software. In the present study, an evaluation of the virtual Basics for Air Traffic Control course was conducted to assess the effectiveness of the virtual format. Data on trainee perceptions of the virtual environment, learning activities, instructor-trainee interactions, trainee-trainee interactions, and technology were collected from $N = 480$ trainees who successfully completed the virtual course. Additionally, test score and pass rate data from $N = 79$ virtual classes were compared to archival outcome data from the in-person, classroom training. Overall, trainees generally held positive views of the virtual learning environment and felt confident in their knowledge of subject areas covered in the course. However, there were some identified areas of improvement, such as trainee-trainee interactions and the number of devices needed for training. Although analyses revealed few statistically significant differences in test scores between the virtual and classroom formats, the difference in average test scores were small and thus had no practical significance. There were no statistically significant differences in pass rates between the training formats. Implications of these findings for the virtual Basics for Air Traffic Control course are discussed.

Keywords: Air Traffic Control, virtual training, trainee reactions, training technology, FAA Academy

Introduction

Effective air traffic control (ATC) training is critical for ensuring that controllers have the necessary technical knowledge and skills for monitoring and managing the flow of air traffic in the National Airspace System (NAS). To certify as a professional controller, the Federal Aviation Administration (FAA) requires ATC trainees to complete a multi-stage training program consisting of academic courses, lab scenarios, simulation, and on-the-job training. The ATC training program entails training at the FAA Academy and an assigned field location. Instruction at the FAA Academy traditionally occurs via classroom lecture, computer-based activities, and low- to high-fidelity simulations. For new hires without prior ATC experience, FAA Academy training involves two courses, Basics for Air Traffic Control and Initial Qualification. The first course, Basics for Air Traffic Control, covers foundational aviation and air traffic concepts and principles, and serves as a prerequisite for Initial Qualification training, which provides option-specific training for terminal or en route environments.

Training at the FAA Academy has significant influence on the ATC training pipeline as all new hires without prior ATC experience are required to attend training at the FAA Academy in Oklahoma City, OK. Both Basics for Air Traffic Control and Initial Qualification courses are considered job jeopardy as failure to pass either course results in termination from the controller position. If successful at the FAA Academy, trainees advance to field qualification training at their assigned facility for training on facility-specific concepts and procedures. As such, the success and efficiency of training at the FAA Academy is critical for ensuring adequate staffing levels since it has direct impact on the throughput of trainees to the field.

The COVID-19 pandemic has had extensive impacts on the FAA's Air Traffic Training program, as well as the volume of air traffic in the NAS. The FAA significantly reduced certain activities, such as on-the-job training, and temporarily stopped training at the FAA Academy to maintain the safety of employees (FAA, 2021). Traditionally, newly hired controllers are required to travel on-site to the FAA Academy for face-to-face training. Fortunately, the Basics for Air Traffic Control course had begun conversion to a virtual format prior to the pandemic to save costs and increase trainee throughput. Therefore, the virtual course was quickly made available to continue training and mitigate delays because of the pandemic. The conversion of the Basics course to a virtual format enabled trainees to complete the course from geographically dispersed locations in a synchronous, online environment.

The transition from a classroom setting to a virtual environment was a significant shift for the Air Traffic Training program, particularly for a high-demand course such as Basics for Air Traffic Control. While the training content and objectives are equivalent between the classroom and virtual courses, the change in delivery method requires evaluating the potential impacts of the new format on trainee reactions, learning, and success, to identify the benefits and challenges of virtual delivery. The purpose of this training evaluation study was to collect evaluation evidence on the effectiveness of the virtual Basics for Air Traffic Control course by examining

trainee perceptions of the virtual environment and comparing test scores and pass rate outcomes between the classroom and virtual courses.

Overview of Virtual Training

The use of online and virtual training technologies have rapidly changed how individuals learn and how organizations approach the training of their workforce. The advancement and availability of cost-effective learning technology has enabled employees to acquire job-relevant knowledge and skills through technology-mediated means. Instruction of this type relies on the use of internet resources and software to deliver training content and materials. Typically, these training environments consist of webinars, virtual classrooms, and learning management systems allowing trainees to participate from physically distanced locations. Virtual training also supports synchronous (real-time) and asynchronous (non real-time) learning environments (Hrastinski, 2008).

In general, evidence from the scientific literature suggests that online and virtual training, similar to classroom training, can be an effective form of instruction. A meta-analysis by Sitzmann et al. (2006) found that online training produced slightly better outcomes for declarative knowledge (e.g., facts, concepts, rules), and approximately equivalent outcomes for procedural knowledge compared to classroom training. However, online and classroom formats were equally effective for declarative knowledge outcomes when the same instructional methods and learning principles were used for training (Sitzmann et al., 2006). Additionally, the meta-analysis by Sitzmann et al. revealed that trainee reactions were similar for online and classroom training suggesting that the format itself does not necessarily influence trainee attitudes or satisfaction. Likewise, a meta-analysis performed by Means et al. (2013) found that fully online courses were not significantly different from face-to-face instruction in terms of trainee learning outcomes. However, Means et al. did find that blended training, which combined online and face-to-face instruction, had better outcomes than classroom only training.

The physical distance and lack of face-to-face interaction in virtual training requires systematically thinking about the content of the course and the learning and design principles used to deliver the content. For instance, virtual training may be more suitable for basic and intermediate knowledge and skills where learning objectives are focused on acquiring knowledge and comprehending learned concepts (Welsh et al., 2003). Nonetheless, the ongoing advancement of immersive technologies (e.g., mobile applications, simulations) has made it possible for trainees to apply learned skills in distanced online settings (e.g., Callaghan et al., 2012; Hess & Gunter, 2013). Design elements such as practice opportunities, feedback, active learning, and interactivity appear to contribute to effective virtual training (e.g., DeRouin et al., 2004; Orvis et al., 2009; Zhang et al., 2006). However, virtual trainings have a tendency to provide fewer opportunities for feedback and trainee-instructor interactions than classroom environments (Means et al., 2013). A lack of social engagement with instructors and peers can limit the learning of trainees and lead to a less effective training environment (Yang et al., 2016).

In general, six broad dimensions underlie successful virtual training (Sun et al., 2008):

- learner (e.g., attitudes toward technology, self-efficacy),
- instructor (e.g., feedback timeliness, attitudes toward virtual training),
- course (e.g., flexibility, quality),
- technology (e.g., device and internet quality),
- design (e.g., ease of use, engagement), and
- environment (e.g., interactions with others).

These dimensions illustrate that training design elements, trainee characteristics, and environmental factors interact to influence learning outcomes such as knowledge retention, trainee reactions, and satisfaction. Examining trainees' perceptions of training factors, such as the dimensions listed above, can provide information to support the ongoing evaluation of the virtual Basics for Air Traffic Control course.

Basics for Air Traffic Control

Basics for Air Traffic Control is the introductory course in the Air Traffic Training program. This course is required for all trainees without previous controller experience and successful completion of the course is needed to advance to Initial Qualification training. Basics covers basic aviation and air traffic concepts such as ATC systems, the NAS, principles of flight, aircraft characteristics, airspace classifications, basic navigation, flight rules and procedures, principles of weather, stripmarking, and ATC communication and clearance procedures. This course provides trainees with the fundamental air traffic knowledge needed prior to beginning option-specific training for the terminal or en route environment. Course assessments include block tests after each block of instruction and a final, cumulative assessment at the end of the course. Prior to the pandemic, the Basics for Air Traffic Control course was completed in-person at the FAA Academy and administered in a classroom environment. Content was delivered primarily through in-person lectures with some group-based discussions and exercises.

Coincidentally, the virtual Basics for Air Traffic Control course was developed by Technical Training (AJI-2) at the same time as the COVID-19 pandemic began to affect in-person training at the FAA Academy. As discussed previously, several changes were made to the delivery of Basics when it was converted to a virtual format. The conversion of the course shifted the learning environment from a classroom setting to a synchronous, web-based format. The virtual course occurs over video teleconferencing software that allows trainees to attend the training from physically distanced locations. Instructional content is primarily delivered virtually via instructor lectures, facilitated discussions, individual activities, and group-based activities. Training materials are managed and accessed through the Blackboard® learning management system. Each trainee is provided an iPad that contains software applications, such as the learning management system and teleconferencing software, and the training manual needed for training.

The purpose of the Basics for Air Traffic Control course is to ensure ATC trainees have the requisite knowledge in aviation and air traffic needed for subsequent training at the FAA Academy and in the field. As such, this course plays a critical role, not only in developing the future ATC workforce, but also in maintaining the throughput of newly hired controllers in the training program. Ensuring that the outcomes of the virtual format are comparable to the previous classroom format is necessary as the FAA Academy is relying on virtual Basics for Air Traffic Control to prepare trainees for option-specific training (terminal, en route) in Initial Qualification. Additionally, there is interest in continuing the delivery of the virtual Basics for Air Traffic Control post-pandemic. Thus, this training evaluation study investigated the effectiveness of the virtual Basics for Air Traffic Control course and provided data and recommendations to support the FAA in delivering virtual training. This evaluation effort evaluated trainees' reactions and learning outcomes, which correspond to Level 1 and Level 2 outcomes in the Kirkpatrick (1994) evaluation framework. In this study, information was collected on trainees' perceptions of the virtual learning environment as well as trainees' confidence in what they learned in virtual Basics for Air Traffic Control. Additionally, test scores and pass rates in the course were compared to test scores and pass rates from the previous classroom training to estimate if there were any differences in trainee success across learning environments.

Method

Trainee Reactions

Sample

Evaluation data were collected from 480 ATC trainees enrolled in Initial Qualification training at the FAA Academy. Participants (M_{Age} = 27.87 years; SD_{Age} = 3.30 years) included trainees assigned to the En Route (n = 165), Tower Cab (n = 303), and Terminal Radar (n = 12) training options. Approximately 70% of the sample had previously taken at least one online course prior to participating in virtual Basics for Air Traffic Control. All participants had successfully completed Virtual Air Traffic Basics prior to completing the survey. Trainees who failed virtual Basics for Air Traffic Control were not available for participation in the evaluation survey.

Procedure

The evaluation questionnaire was administered via an online survey. Data collection occurred from August 2020 to August 2021. Trainees completed the survey on their first day of in-person Initial Qualification training and provided consent to participate in the study prior to answering the questions. The evaluation questionnaire measured perceptions and attitudes toward the virtual environment, learning activities, interactions, and technology. Participants responded to statements such as "The online learning environment was easy to navigate", "The online learning environment was engaging", "The learning activities were useful for developing

air traffic control knowledge", "There were adequate opportunities in class to interact with the instructors", and "I frequently interacted with other students during the class". Participants also responded to a series of statements about the use of technology in the course such as "The FAA-issued iPad was the only device that I needed to complete the course", "The technology that I used was easy to use for training purposes", and "The technology that I used supported my learning". Additionally, participants reported their confidence in their knowledge of the topics covered in the course (e.g., separation procedures, phraseology, airspace classification) and overall satisfaction with the training course. Participants responded to a series of open-ended questions about the virtual format and use of technology.

Course Outcomes

Sample

Course data, including test scores and pass rates, were collected from both the virtual and classroom Basics for Air Traffic Control courses in order to compare outcomes across formats[1]. Data were gathered from 79 completed virtual Basics for Air Traffic Control courses ($N = 759$ trainees). The median class size for virtual format was 8 trainees and ranged from 4 to 18 trainees. Data were also collected from the previous 79 classroom courses completed prior to the pandemic to serve as a comparison group ($N = 874$ trainees). The median class size for classroom format was 11 trainees and ranged from 4 to 18 trainees. Test score data included individual-level scores on the five block tests and final end-of-course assessment. The block tests and end-of-course assessment were scored out of 100 points. Pass rate data consisted of the number of trainees passing from each course. Pass rate was calculated as the ratio of successful students to total students in each training format to get an overall pass rate for the classroom and virtual formats.

Analytic Approach

For trainee perceptions, item-level frequency and descriptive statistics are reported from the evaluation questionnaire to describe the average response and distribution of responses for each item. For the course comparisons, paired samples t-tests and a two-proportion z-test were performed to evaluate outcome differences across training format. Paired samples t-tests were conducted to assess if there was a significant difference in test scores between the classroom and virtual courses. Corrections for multiple testing were made for the t-test comparisons to control the false positive rate. A two-proportion z-test was used to evaluate if the pass rate, or proportion of students successfully completing Basics, significantly differed between the classroom and virtual formats.

[1] The classroom group is a quasi-experimental comparison group since participants were not randomly assigned to the instructional format and the classroom training was completed at a different time. Nonetheless the use of this comparison group can serve as a benchmark for estimating the influence of the virtual format on learning outcomes and success.

Results

Perceptions of Virtual Training

Trainee perceptions of the virtual format were measured via statements about the virtual environment, learning activities, instructor-trainee interactions, and trainee-trainee interactions. These items asked trainees to rate on a 4-point Likert scale (1 – *strongly disagree*, 4 – *strongly agree*) the extent to which they agreed with the statements about the virtual training. Table 1 displays the item-level means and standard deviations for the items about the virtual environment, learning activities, and interactions. The percentage of trainees that agreed or strongly agreed with each of these statements will be presented to illustrate the percent of trainees with favorable responses about the training. Trainees *agreed* or *strongly agreed* that the online learning environment was easy to navigate (93.1%), supported their learning (84.7%), and was engaging (72.9%). Trainees agreed or strongly agreed that the activities in the virtual course were engaging (82.2%), required active participation (80.6%), provided an opportunity to practice what was learned (89.1%), and were useful for developing ATC knowledge (94.3%). In general, trainees reacted positively toward the environmental and instructional components of the virtual course.

In terms of instructor-trainee interactions, trainees agreed or strongly agreed that they frequently interacted with instructors (80.0%) and that there were adequate opportunities in class to interact with the instructors (97.5%). Additionally, trainees agreed or strongly agreed that they were provided feedback by the instructors (73.8%) and that the feedback provided by the instructors was clear (82.5%) and timely (87.2%). In terms of trainee-trainee interactions, trainees agreed or strongly agreed that there were adequate opportunities in class to interact with other students (65.4%), they frequently interacted with other students in the course (61.3%), and were able to turn to other students for help when they had a question (87.7%). This suggests that trainees perceived that there were sufficient interactions with instructors, but that trainees may prefer more planned interactions with other trainees during the course.

Trainee Confidence

Trainees rated their confidence in several knowledge areas covered in the virtual Basics for Air Traffic Control course. Items were assessed on a 4-point Likert scale (1 – *not confident*, 4 – *very confident*). Table 2 displays the item-level means and standard deviations for the confidence items, and the percentage of trainees that were *moderately confident* or *very confident* in these topic areas is presented below to describe the percentage of trainees feeling confident in these knowledge areas. Trainees were *moderately confident* or *very confident* in their knowledge of: ATC job responsibilities (90.2%), separation procedures (79.8%), aircraft characteristics and identifiers (56.4%), airspace classification and airspace types (87.0%), weather principles and its impact on aviation (92.5%), communication and phraseology (79.1%), and flight progress strips (58.0%). Trainees were also *moderately confident* or *very confident* in their ability to be

Table 1.
Means and Standard Deviations for Perceptions of Virtual Training Items

Item	Mean	SD
Virtual Environment		
1. The online learning environment was easy to navigate.	3.22	0.59
2. The online environment supported my learning.	3.06	0.67
3. The online learning environment was engaging.	2.85	0.76
Learning Activities		
1. The learning activities were engaging.	2.96	0.64
2. The learning activities required active participation.	3.00	0.70
3. The learning activities provided an opportunity to practice what we had learned in the course.	3.12	0.64
4. The learning activities were useful for developing ATC knowledge.	3.18	0.55
Instructor-Trainee Interactions		
1. I frequently interacted with the instructors.	3.05	0.73
2. There were adequate opportunities in class to interact with the instructors.	3.58	0.57
3. I was provided feedback by the instructors on my learning progress.	2.87	0.75
4. The feedback I received from the instructors was clear.	3.02	0.67
5. The feedback I received from the instructors was timely.	3.13	0.66
Trainee-Trainee Interactions		
1. There were adequate opportunities in class to interact with other students.	2.80	0.85
2. I frequently interacted with other students during the class.	2.73	0.82
3. I was able to turn to other students for help when I had a question.	3.16	0.71

Note. Survey scale: 1 = *strongly disagree*, 2 = *disagree*, 3 = *agree*, 4 = *strongly agree*.

successful in Initial Qualification training (84.5%). These results suggest that trainees were confident in their knowledge for subject areas, such as job responsibilities, separation procedures, and phraseology, but were less confident about aircraft characteristics and flight progress strips.

Trainees' responses to open-ended questions about the virtual format also point to some unique benefits and challenges of this format. Trainees indicated that a major benefit of the virtual training was that it allowed them to complete training at home, which provided a comfortable learning environment, reduced the amount travel needed for training, and enabled trainees to spend more time with their family. Conversely, trainees indicated that a challenge of virtual training was that it was difficult to remain engaged and interact with others in a meaningful way compared to classroom training.

Table 2.
Means and Standard Deviations for Trainee Confidence Items

Item	Mean	SD
Knowledge Topics		
1. Knowledge of ATC job responsibilities.	3.24	0.64
2. Knowledge of separation procedures.	3.03	0.74
3. Knowledge of aircraft characteristics and identifiers.	2.62	0.89
4. Knowledge of airspace classification and airspace types.	3.21	0.66
5. Knowledge of weather principles and its impact on aviation.	3.33	0.63
6. Knowledge of ATC communication and phraseology.	3.02	0.78
7. Knowledge of flight progress strips.	2.59	0.84
Training Success		
1. Ability to be successful in Initial Qualification training.	3.08	0.66

Note. Survey scale: 1 = *not confident*, 2 = *minimally confident*, 3 = *moderately confident*, 4 = *very confident*.

Perceptions of Technology

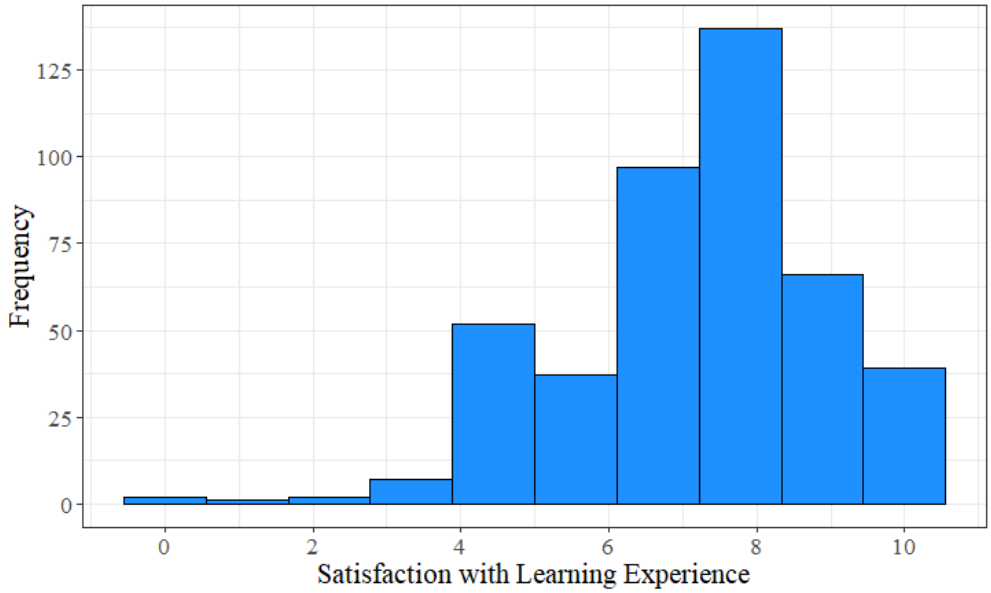
Selecting the appropriate technology for virtual training ensures that the content is accessible to trainees and is delivered in a way that supports the learning process. The virtual Basics for Air Traffic Control course relies on learning management software for storing and accessing training content, video teleconferencing software for delivering lectures, and learning applications for trainee activities. Trainees are provided an iPad with access to this software. Trainees *agreed* or *strongly agreed* that the technology used in the course was easy to use (97.7%), increased their engagement in the class (91.6%), and supported their learning (96.4%). Interestingly, 82.8% of trainees agreed or strongly agreed that they needed multiple devices to access the course materials and virtual environment at the same time. This resulted in the majority of trainees using a personal device (e.g., laptop, computer) in addition to the iPad to access materials during training. For instance, one device may be used for attending the lecture on the video teleconferencing software, while the other is used to access the training manual and content. Trainees' responses to the open-ended questions highlight trainee use of technology during training. Trainees reported that the iPad enabled easy access of learning materials and lectures, was useful for note-taking and reading training materials, and provided all the needed materials on a single device. However, some challenges with the iPad included difficulties arising from its relatively small screen size and the inability to use multiple applications simultaneously, which resulted in trainees using a personal device in addition to the iPad.

Satisfaction with Training

Trainee satisfaction with training was measured using a single item asking participants to rate their overall learning experience on a 0 to 10 scale. Trainees, on average, were satisfied and perceived their virtual learning experience as positive (M = 7.38, SD = 1.73). Figure 1 displays

the frequency of responses to the satisfaction item. The distribution of responses suggests that the majority of trainees were satisfied with their virtual training experience.

Figure 1.
Histogram of Responses to Training Satisfaction Item



Note. Item scale: 0-10. Histogram displays the frequency of trainees' responses to the satisfaction item.

Comparison of Classroom and Virtual Training

A comparison of mean test scores and pass rates between the classroom and virtual training groups was conducted to determine whether there were differences in outcomes across the different formats. An equal number of classroom (N = 79) and virtual training classes (N = 79) were identified for this analysis. All virtual training classes that had finished by the time of this analysis were included and an equal number classroom classes were included in the analysis as well. Importantly, the classroom and virtual training courses were held at different time points, so trainees were not randomly assigned to a training format. Trainees were assigned to a training format based on their date of entry into the FAA since only classroom training was used prior to the pandemic and only virtual training has been used since the start of the pandemic. Since participants were not randomized, trainees in the classroom and virtual groups may not be identical. As such, differences in training outcomes may be due to factors outside of the virtual environment. Nonetheless, a comparison between the classroom and virtual format provides a useful benchmark for assessing the influence of the virtual format on Basics outcomes, though results should be interpreted with caution.

The Basics for Air Traffic Control courses consists of five block tests and an end-of-course test. Each block test is administered at the end of each training module and covers content

covered in that block of instruction. For example, Block 1 includes instruction on the ATC system and NAS, airports, separation, FAA orders, and standard operating procedures. Block tests do not contribute to the pass/fail decisions determined at the end of the course, but serve as an indicator of content mastery. The end-of-course test is a comprehensive exam covering content from each of the five blocks of instruction. A minimum score of 70% must be achieved on the end-of-course test for a trainee to advance to Initial Qualification training.

Means and standard deviations of the Air Traffic Basics tests are displayed in Table 3. A series of t-tests were conducted to assess if there were significant differences in test scores across the classroom and virtual formats. Results displayed in Table 3 suggest that there are statistically significant differences between the classroom and virtual courses on Block Test 1, Block Test 3, Block Test 5, and the End-of-Course test. Trainees in the virtual training had higher mean scores on Block Test 1, whereas trainees in the traditional classroom training had higher mean scores on Block Test 3, Block Test 5, and End-of-Course test. However, the difference in mean test scores was small, and not considered to be of any practical significance. For instance, the difference on End-of-Course test scores between the classroom training and virtual training formats was only 1.7 points. Importantly, the mean scores for the End-of-Course test were well above the 70% threshold in both formats.

The virtual and classroom training formats were compared on their overall pass rate, or the proportion of trainees that successfully completed the course. The pass rate for each format was derived by dividing the number of successful trainees by the total number of successful and unsuccessful trainees in the respective formats. For the virtual training, the pass rate was 96.8% (735/759). For the classroom training, the pass rate was 97.5% (852/874). A two-proportion z-test was conducted to assess if there were significant differences in the proportion of successful trainees between the virtual and classroom training. Findings suggest that there is no significant difference in pass rates between the virtual and classroom format, $z = 0.62$, $p = .432$, 95% CI [-0.01, 0.023].

Table 3
Test Score Comparisons between Classroom and Virtual Basics

	Mean (SD)					
	Classroom	Virtual	*t*	*p-value*	Absolute Diff.	Effect Size
Block Test 1	88.9 (8.73)	91.5 (7.61)	-6.43*	< .001	2.6	-0.32
Block Test 2	90.1 (8.58)	89.9 (7.66)	0.43	.669	0.2	0.02
Block Test 3	87.5 (9.51)	84.9 (9.71)	5.30*	< .001	2.6	0.27
Block Test 4	90.3 (10.0)	89.7 (7.92)	1.30	.195	0.6	0.08
Block Test 5	91.0 (8.66)	88.9 (18.6)	2.96*	.003	2.1	0.14
End of Course Test	86.3 (8.68)	84.6 (6.35)	4.48*	< .001	1.7	0.22

Note. $N = 874$ trainees in 79 face-to-face courses. $N = 759$ trainees in 79 virtual courses. Each test was scored out of 100 points. Bonferroni corrected $\alpha = .008$. Absolute Diff = absolute

difference in mean test scores between formats. Effect size is Cohen's *d* estimate.

Discussion

Basics for Air Traffic Control provides ATC trainees with the foundational air traffic knowledge, such as communication procedures, flight principles, and stripmarking, needed to be successful in subsequent, option-specific training. The conversion of Air Traffic Basics, a critical course in Air Traffic Training program, to a virtual format represents a significant shift in the delivery of controller training. This study provides initial evaluation evidence for the effectiveness of the new Virtual Basics course. Specifically, this study provides insight into trainees' perceptions of the virtual format and the impact of the format on training outcomes.

First, trainees' perceptions of the virtual Basics for Air Traffic Control course were generally positive. The majority of trainees found the virtual environment to be easy to use, engaging, and supportive of their learning. Additionally, trainees believed that the learning activities promoted active participation, provided opportunities to practice what was learned in class, and were useful for developing ATC knowledge. Active learning activities and practice opportunities are two instructional features linked to effective training outcomes. Active, as opposed to passive, activities promote positive outcomes as they can foster trainee engagement and meaningful learning experiences (Sitzmann et al., 2008; Zhang et al., 2006). Guided practice is beneficial as it enables trainees to assess their mastery of training content and learning progress. Providing practice opportunities can also promote knowledge retention and prevent skill loss from nonuse (Arthur et al., 1998).

Instructor-trainee and trainee-trainee interactions can support learning through idea sharing, meaningful discussions, and feedback (Cercone, 2008; Garrison & Cleveland-Innes, 2005). Trainees perceived that there were adequate opportunities to interact with instructors and that instructors provided sufficient feedback on their learning progress. However, in terms of trainee-trainee interactions, trainees appeared to desire more opportunities for interactions with other trainees. Incorporating more planned interactions through guided activities and discussion may be a useful way to increase trainee-trainee interactions. Interactions can also promote online presence, which reflects the ability of trainees to participate in meaningful social exchanges and gain knowledge through collaboration and reflection (Yang et al., 2016). Quality interactions can be difficult to achieve in virtual settings due to the absence of face-to-face interaction.

In addition to trainee perceptions of the training course, trainee confidence in knowledge areas was assessed since training should promote beliefs in one's own knowledge and ability to be successful (Chen et al., 2000). Trainees displayed the highest level of confidence in the following knowledge domains: job responsibilities, separation procedures, airspace classification, weather principles, and ATC communication and phraseology. Trainees reported lower confidence levels for aircraft characteristics and identifiers as well as flight progress stripmarking, which correspond to the second and fifth block of instruction, respectively. While

these findings may point to areas in need of further emphasis in the training course, it is important to note that confidence is not a direct indicator of actual learning.

Appropriately designed technology is critical for delivering virtual training as the tools used in training need to match the tasks of the course and promote processes that support trainee learning (Lieser et al., 2018). In general, the majority of the trainees found the technology to be easy to use and supportive of their learning. Trainees also reported that the use of technology in the course increased their engagement. While trainees are provided an iPad as a learning device for training, the majority of trainees reported that they often used multiple devices for training. For a given lesson plan, trainees must log in to the video teleconferencing software for lectures and access the training materials in order to follow along and take notes. These findings suggest that using a single device for multiple, simultaneous activities (e.g., attending web-based lecture, electronic note-taking) may be less user-friendly than using two devices. Since the FAA provides the iPad to trainees, it may be worthwhile to examine how technology can best support the multiple tasks trainees engage in during virtual training.

Lastly, trainee outcomes were compared between the virtual and classroom formats. Basics for Air Traffic Control plays a key role in the Air Traffic Training program and ensuring that the virtual Basics course is similar to the classroom format in terms of content mastery and success is essential for evaluating the viability of virtual training methods. There were some differences in trainee test scores across the virtual and classroom formats. Specifically, trainees in the virtual format, on average, scored higher on Block Test 1 and trainees in classroom training, on average, scored higher on Block Test 3, Block Test 5, and the End-of-Course test. While there were statistically significant differences across test scores, whether such differences reflect a practical difference in content mastery is highly doubtful. The mean End-of-Course test score, which is used to determine advancement to Initial Qualification, differed between the two formats by 1.7 points. Additionally, the average End-of-Course test score in both formats was well above the 70% pass/fail benchmark. However, reviewing the activities used to teach content in Block 3 (basic navigation and flight procedures) and Block 5 (communication, clearances, stripmarking) can help identify if there are different ways to teach these instructional blocks that enhance knowledge acquisition.

The pass rate, or proportion of trainees successfully passing the course, was compared as well. There was no significant difference in pass rates between the virtual and classroom format. This suggests that the pass rates do not differ as a function of the new training delivery format. The pass rate for both courses was high with virtual training having a pass rate of 96.8% and classroom training having a pass rate of 97.5%. Basics has traditionally had a high pass rate and it appears that trend has continued since the conversion to the virtual format. These findings align with the statements made by Clark (1994) that it is not necessarily the medium that influences training, but the instructional features used to teach the training content.

Limitations

While there are a number of key takeaways from this evaluation, limitations must be noted as well. Results from this evaluation study provide insight into trainee reactions and learning outcomes associated with the Virtual Air Traffic Basics course. However, the data here do not speak to the extent to which the knowledge gained in the virtual training is successfully transferred to subsequent phases of training or on-the-job behavior. Future evaluation work should expand to include assessments of how and when learned concepts are transferred to the job, and the conditions that enable trainees to maintain and generalize their knowledge and skill. Additionally, as emphasized above, trainees were not randomly assigned to the two training conditions, but instead were assigned to the classroom or virtual format based on their entry date. Therefore, the few differences evidenced between tests score may be due to extraneous factors not directly related to the training format. While the comparison between the virtual and classroom formats allowed for an evaluation of the impact of the virtual setting on learning, the comparison data should be interpreted with caution given trainee placement into a training format could not be controlled.[2]

Conclusion

Overall, findings suggest that the virtual Basics for Air Traffic Control course provides an effective and efficient training experience for newly hired ATC trainees. The conversion of Basics to a virtual format enabled the safe and cost-effective delivery of mission-critical training as it allowed trainees to complete training in a safe, geographically dispersed location and significantly reduced travel costs on part of the FAA. Additionally, the conversion to virtual training aligns with the broader training community, which is continually shifting from traditional to more novel, learner-centric methods (Brown et al., 2016). In recent years, the FAA has shown considerable interest in not only improving the efficiency of controller training, but modernizing the tools used to delivery training content (Schultheis, 2014; Updegrove & Jafer, 2017). The virtual Basics for Air Traffic Basics course, therefore, represents a significant step in modernizing the training of controllers, and will likely serve as a guide for future changes to the Air Traffic Training program, such as approaches that combine in-person and virtual environments in a single course (Long & Torrence, 2021). Future studies on the effect of class size in the delivery of virtual instruction on trainee reactions and performance outcomes might be helpful, since little is currently known about how to best use this method of instruction in the ATC domain. Training evaluation should be a cornerstone of future training initiatives as evaluation is a critical step for ensuring that changes to a training program or course achieve the

[2] While we have no direct evidence of extraneous factors that affected trainee performance in either of the training conditions, we note how remarkable it is that success rates were comparable despite the fact that during the virtual training classes, the trainees had to make many adaptations to cope with the pandemic and its stresses. It would likely be worthwhile to conduct a follow-up evaluation of the virtual training format after the pandemic to see whether trainee reactions and performance differ from or surpass those that we found in this study.

anticipated benefits.

References

Arthur, W., Jr., Bennett, W., Jr., Stanush, P. L., & McNelly, T. L. (1998). Factors that influence skill decay and retention: A quantitative review and analysis. *Human Performance*, 11, 57–101.

Brown, K. G., Howardson, G., & Fisher, S. L. (2016). Learner control and e-learning: Taking stock and moving forward. *Annual Review of Organizational Psychology and Organizational Behavior*, *3*, 267-291.

Callaghan, M. J., McCusker, K., Losada, J. L., Harkin, J., & Wilson, S. (2012). Using game-based learning in virtual worlds to teach electronic and electrical engineering. *IEEE Transactions on Industrial Informatics*, *9*, 575-584.

Cercone, K. (2008). Characteristics of adult learners with implications for online learning design. *AACE journal*, *16*, 137-159.

Chen, G., Gully, S. M., Whiteman, J. A., & Kilcullen, B. N. (2000). Examination of relationships among trait-like individual differences, state-like individual differences, and learning performance. *Journal of Applied Psychology*, 85, 835–847.

Clark, R. E. (1994). Media will never influence learning. *Educational Technology Research and Development*, 42, 21-29.

DeRouin, R. E., Fritzsche, B. A., & Salas, E. (2004). Optimizing e-learning: Research-based guidelines for learner-controlled training. *Human Resource Management*, 43, 147-162.

Federal Aviation Administration. (2021). *Air traffic controller workforce plan 2021-2030.* Federal Aviation Administration. Retrieved from https://www.faa.gov/air_traffic/publications/controller_staffing/

Garrison, D. R., & Cleveland-Innes, M. (2005). Facilitating cognitive presence in online learning: Interaction is not enough. *The American Journal of Distance Education*, *19*, 133-148.

Hess, T., & Gunter, G. (2013). Serious game-based and nongame-based online courses: Learning experiences and outcomes. *British Journal of Educational Technology*, *44*, 372-385.

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause Quarterly*, 31, 51-55.

Kirkpatrick, D. L. (1994). *Evaluating training programs: The four levels*. Berrett-Koehler.

Lieser, P., Taf, S. D., & Murphy-Hagan, A. (2018). The webinar integration tool: A framework for promoting active learning in blended environments. *Journal of Interactive Media in Education, 2018*, 1-8.

Long, C., & Torrence, B. S. (2021). *Blended learning principles for effective training outcomes:*

A literature review. Federal Aviation Administration.

Means, B., Toyama, Y., Murphy, R., & Baki, M. (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. *Teachers College Record,* 115, 1-47.

Orvis, K. A., Fisher, S. L., & Wasserman, M. E. (2009). Power to the people: Using learner control to improve trainee reactions and learning in web-based instructional environments. *Journal of Applied Psychology*, *94*, 960-971.

Salas, E., Tannenbaum, S. I., Kraiger, K., & Smith-Jentsch, K. A. (2012). The science of training and development in organizations: What matters in practice. *Psychological Science in the Public Interest, 13*, 74-101.

Schultheis, S. (2014). Integrating advanced technology into air traffic controller training. In *14th AIAA Aviation Technology, Integration, and Operations Conference*, 1-5.

Sitzmann, T., Ely, K., & Wisher, R. (2008). Designing web-based training courses to maximize learning. In K. L. Orvis & A. L. R. Lassiter (Eds.), *Computer-supported collaborative learning: Best practices and principles for instructors* (pp. 1-19). IGI Global.

Sitzmann, T., Kraiger, K., Stewart, D., & Wisher, R. (2006). The comparative effectiveness of web-based and classroom instruction: A meta-analysis. *Personnel Psychology*, 59, 623-664.

Sun, P. C., Tsai, R. J., Finger, G., Chen, Y. Y., & Yeh, D. (2008). What drives a successful e-Learning? An empirical investigation of the critical factors influencing learner satisfaction. *Computers & Education*, *50*, 1183-1202.

Updegrove, J. A., & Jafer, S. (2017). Optimization of air traffic control training at the Federal Aviation Administration Academy. *Aerospace*, 4, 1-12.

Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-learning: Emerging uses, empirical results and future directions. *International Journal of Training and Development*, *7*, 245-258.

Yang, J. C., Quadir, B., Chen, N. S., & Miao, Q. (2016). Effects of online presence on learning performance in a blog-based online course. *The Internet and Higher Education*, *30*, 11-20.

Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker Jr, J. F. (2006). Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. *Information & Management*, *43*, 15-27.