Federal Aviation Administration

DOT/FAA/AM-21/22
Office of Aerospace Medicine
Washington, DC 20591

Evaluation of Serious Games for Passenger Education I: Aircraft Safety Information Retention Across Media Types

Melissa S. Beben
David B. Weed
David J. Ruppel
Kelly J. Guinn

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

July 2021

NOTICE

This publication and all Office of Aerospace Medicine technical reports are available in full-text on 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-21/22		

4. Title and Subtitle	5. Report Date
Evaluation of Serious Games for Passenger Education I: Aircraft Safety Information Retention Across Media Types	July 2021
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Beben, M.S., Weed D.B., Ruppel, D.J., Guinn, K.J.	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
FAA Civil Aerospace Medical Institute PO Box 25082 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., SW Washington, DC 20591	14. Sponsoring Agency Code

15. Supplemental Notes

This study evaluated Serious Games as a tool for passenger education. Serious Games is a persuasive technology application developed by the University of Udine, Italy via OTA No. DTFACT-13-A-00003. The objective of this project was to improve the level of occupant safety and incident survivability by making safety information more transparent and effective to the flying public. This study evaluated information retention results from three topics of passenger education information presented to each participant in three different styles. The three passenger education safety topics presented were brace position, life vest, and oxygen mask. The three media presentation types were a briefing card, a video briefing, and a serious game. Participants were given a pretest (for a baseline), a posttest (i.e., after information was presented), and a second posttest approximately 90 minutes later. The study found a significant difference in retention based on presentation style. After playing the serious game, retention of information was significantly better than after reviewing the briefing card or a video briefing for all assessments. After viewing the video briefing, the retention of information was significantly better than reviewing the briefing card for the life vest topic only. There are significant differences in knowledge retention based upon the presentation style of safety information. Having a participant virtually perform the action being taught creates a better understanding of the action and results in better retention of the information. The finding that knowledge retention is improved with an interactive style of information presentation suggests that passenger safety briefing materials using an interactive presentation may improve passenger knowledge of safety procedures, which could improve adherence to those safety procedures during an emergency.

17. Key Words	18. Distribution Statement
Passenger Education, Briefing Cards, Video Briefings, Serious Games, Retention, Cabin Safety	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	28	

ACKNOWLEDGMENTS

The research reported in this paper was conducted under the Office of Aerospace Medicine, Protection, and Survival Research Branch, Engineering Sciences Research Section (AAM-632), Cabin Safety Research Team at the FAA Civil Aerospace Medical Institute.

Please address questions or comments to Melissa Beben, Human Factors Research Specialist, Cabin Safety Research Team (AAM-632), PO Box 25082, Oklahoma City, OK 73125.

The authors wish to thank Vista Life Sciences and The Cognitive Science Research Center at The University of Oklahoma for providing the Automated Neuropsychological Assessment Metrics program.

The authors also wish to thank the I-Zone Team at the Civil Aerospace Medical Institute for providing briefing cards and video briefing materials.

Table of Contents

EVALUATION OF SERIOUS GAMES FOR PASSENGER EDUCATION I: AIRCRAFT SAFETY INFORMATION RETENTION ACROSS MEDIA TYPES

INTRODUCTION

The Federal Aviation Administration (FAA) has the mission of assuring the safety of millions of passengers who fly on any given day. Federal aviation regulations require that airlines provide safety briefings (e.g., briefing cards, video briefing, and oral briefing) to passengers to inform them of routine and emergency safety procedures on-board transport aircraft (Briefing passengers before takeoff, 1965; Briefing passengers before flight, 1980; Briefing passengers before flight, 1978). The required minimum safety content in these briefings is outlined in both the FAA's Advisory Circular 121-24, *Passenger Safety Information Briefing and Briefing Cards* (2019) and in the Society of Automotive Engineers' (SAE's) Aerospace Recommended 1384, *Passenger Safety Information Cards* (2006). The airline's responsibility is to provide the minimum safety content required by the FAA; however, the presentation style is open to interpretation by the airline. One integral component that is sometimes overlooked is the role of the passengers in their own safety. The FAA asserts that an alert, knowledgeable person has a much better chance of surviving a life-threatening situation that could occur during an emergency. Being an informed passenger includes being an active listener to safety briefings and familiarizing oneself with their surroundings by reading the safety card.

In 2000, the National Transportation Safety Board (NTSB) released a safety study that investigated 46 accidents that occurred between September 1997 and June 1999 involving 2,651 passengers. Questionnaires were mailed to crew and passengers involved in these accidents. Of the 1,043 questionnaires mailed to passengers, 457 were returned. Of the 377 passengers who reported whether they watched the safety briefing, 50 passengers (13%) said they did not watch the briefing, and 182 passengers (48%) reported that they watched at least 75% of the briefing. Of the 457 returned questionnaires, 247 passengers (54%) reported that they had not watched the entire briefing because they had seen it before. An additional 70 passengers reported that they did not watch the entire briefing because it is basic common knowledge. There were differing opinions of the briefing's effectiveness from 141 passengers who watched more than half of the briefing. Of those, 71 passengers reported that the briefing was not helpful during evacuation; the other 70 believed it was helpful. Of the 431 passengers who reported reviewing the card, 293 (68%) reported that they did not read the safety card. Of those, 259 (89%) reported that they had read the card on the previous flight. The most detrimental finding was that, of 399 responses regarding whether a passenger watched the briefing and read the safety card, 175 (44%) responded that they neither listened to the safety briefing nor examined the safety card.

In 2009, US Airways flight 1549 made an emergency ditching into the Hudson River. The NTSB (2010) reported that of the 150 passengers, 25 (17%) reported watching most of the preflight safety briefing, and an additional 19 passengers (13%) reported watching some of the demonstration. Only 12 passengers (8%) reported reading the safety card before or during the flight. This report shows an even greater lack of passenger attention than reported in the 2000 NTSB safety study. Additionally, 70% of passengers did not watch any of the safety briefing, and over 90% did not read the safety card (NTSB, 2010).

More recently, there have been multiple emergency aircraft incidents where there is a concern that passengers were not paying attention to the safety briefings or not following the procedures. The

accident of American Airlines flight 383 showed that passengers evacuated from all usable exits with carry-on baggage. The NTSB (2016) reported that a flight attendant tried to stop a passenger from taking his/her baggage during the evacuation. The passenger refused to follow the crew's commands, and the flight attendant was forced to relent to continue the evacuation. Another accident, Southwest flight 1380, received considerable public attention after a photograph emerged showing multiple passengers incorrectly wearing their oxygen masks (Cummings, 2018). These and similar incidents and their press coverage and public outcry led to the addition of several items to the FAA Reauthorization Act of 2018, calling for research into methods to mitigate or eliminate future occurrences of these events. Passenger information efforts were identified by the Cabin Safety Research Team (CSRT) as a possibly beneficial area of research for changing passenger behavior during incidents/accidents.

Aside from the lack of attention to the briefings, studies have found that poor comprehension of safety briefing content is a concern. Previous research has shown comprehension levels of briefing cards are below both the International Organization for Standardization and American National Standards Institute criteria (Corbett & McLean, 2007; Corbett & McLean, 2008; Weed et al., 2013). Prior studies have also shown that safety briefing videos yielded low information retention (Seneviratne & Molesworth, 2015; Tehrani & Molesworth, 2015).

Persuasive technology is a relatively new approach to passenger education. The idea of using a simulation to impart information puts the passenger in a role to observe a cause-and-effect relationship between the safety information and the consequences of actions. Airlines are tasked to provide the minimum safety content, but it has been shown that passengers are often not paying attention to the briefing nor reading the safety card. Introducing persuasive technology puts the passenger in a simulation where information is not only presented but outcomes are presented as well. This gives the passenger an active role in obtaining safety information. Research has shown that using persuasive technology significantly affects passenger safety retention (Chittaro, 2012; Chittaro, 2014).

Passenger education is an integral component of aviation safety. Traditionally, passenger education has been communicated via oral briefings, video briefings, and printed safety cards. This research will look at both the traditional forms of passenger education and the new approach of using persuasive technology. Providing passengers with an interactive form of passenger education may provide a statistically significant difference in retaining safety information.

METHOD

Facilities/Materials

This project ran in conjunction with the study titled "Effects of Airplane Cabin Interiors on Egress I: Assessment of Anthropomorphics, Seat Pitch, and Seat Width on Egress" (Weed et al., 2021), using subjects from that project during times they would otherwise be waiting for fellow subjects to be processed. Participants were brought into a classroom (Figure 1) for the study briefing, informed consent, and testing. For data collected, participants used pens and paper copies of the pretest and posttest surveys. Thirty Samsung Galaxy Tab 6 tablets (CSRT tablets) were used for video briefings and serious games. Participants were each given a pair of disposable earbuds to hear both the video briefing and serious games without disrupting other participants.

Figure 1

Room 117 at Civil Aerospace Medical Institute

Data Collection/Reduction: Participant demographic information concerning age, gender, and education level were collected in the course of check-in during the Egress Study. Flight history and flight experience level were self-reported during the Egress Study. Data collection used pen and paper for pretest and posttest surveys. CSRT tablets were preinstalled with the Automated Neuropsychological Assessment Metrics (ANAM) program, the video briefing, and the Serious Games application. Laminated safety briefing cards were used for the briefing card presentation style.

ANAM: This cognitive assessment was provided by Vista Life Sciences and the University of Oklahoma. The use of this assessment accomplished several things. First, the assessment allowed the participant to become familiar with the tablet. Second, the de-identified data from the assessment will be shared with Vista Life Sciences and the University of Oklahoma and will contribute to their normative database. Lastly, an evaluation of these data regarding observed participant knowledge retention is planned for a future report.

Media Types: This project used three media presentation types to assess passenger information knowledge. To ensure that the knowledge presented was cohesive, a briefing card and video were constructed from the Serious Game, Air Safety World (HCI Lab, University of Udine, Italy). For the briefing card, stills were taken from the game that represented the correct procedure for each of the three safety topics. For the video, a media file was created and loaded onto the CSRT tablet to present the safety information to the participant. Lastly, the serious game was loaded on the tablet.

Briefing Cards: Three briefing cards were constructed from the serious game that illustrated the correct procedures for the safety information.

The Brace Position briefing card (Figure 2) was one-sided and had three stills: one depicting the proper position of the feet, one depicting proper location for the head, and one depicting where to place the hands.

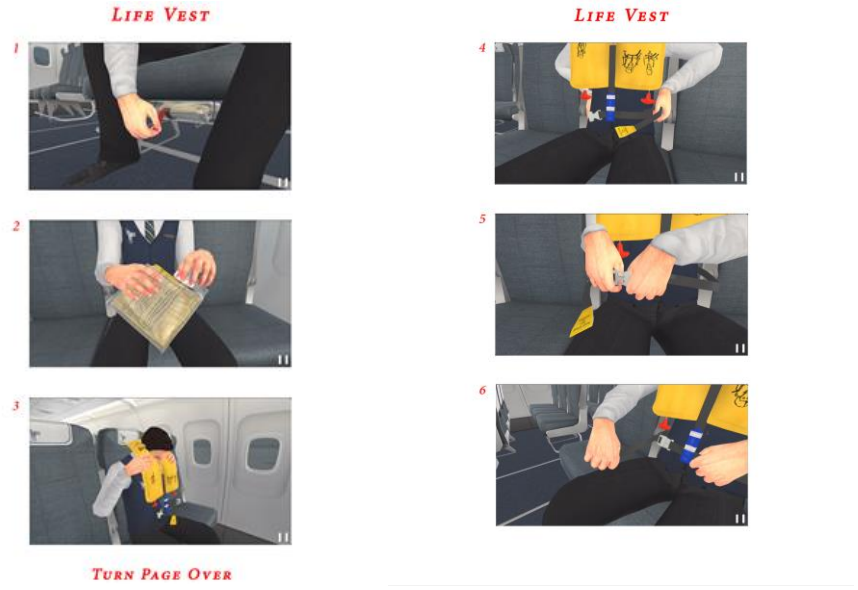
Figure 2

Briefing Card, Brace Position

The Life Vest briefing card (Figure 3) was two-sided and had six still images. The first page depicted where to find the life vest, how to open the life vest, and how to don the life vest. The other side of the briefing card depicted how to strap the vest around the waist, buckle the vest, and tighten the vest.

Figure 3

Briefing Card, Life Vest



The Oxygen Mask briefing card (Figure 4) was one-sided and had three still images. They depicted pulling down the oxygen mask, putting the mask over the nose and mouth, and tightening the mask via the straps on the side of the mask.

Figure 4

Briefing Card, Oxygen Mask

Videos: Three video files were created from the application, Air Safety World, installed on the CSRT tablets. The verbiage from the videos is as follows:

Brace Position: "During an emergency landing, you must assume a brace position. Tuck your feet firmly on the floor behind your knees. Place your head against the seat in front of you. Tuck your hands behind your knees or below the thigh. Remember to keep the brace position until the aircraft comes to a stop."

Life Vest: "During a water evacuation, you must be able to wear a life vest. Now, I will show you how to wear a double-chamber life vest located under the seat, but always pay attention to specific instructions concerning life vests available on your flight. Extract the pouch from the compartment under the seat. Open the pouch by pulling the tab. This is the hole for the head and the straps will go around your waist. This type of life vest can be worn on both sides. Slip the life vest over your head. Wrap the strap around your waist. Buckle up the strap. Firmly pull the tab on the end of the strap until it is snug around your waist. Inflate the life vest by pulling the red handles but do it only when leaving the aircraft."

Oxygen Mask: "In the event of loss of cabin pressure, oxygen masks will drop down automatically, and you should wear them as fast as possible. Reach up for a mask and pull it down to activate it. Place the mask over your nose and mouth and slip the elastic strap over your head. Pull the ends of the strap to adjust the mask. When you are wearing the oxygen mask, breathe normally. Be sure to wear and secure your own mask before helping others."

Serious Games: Air Safety World is an interactive 3D experience that includes both games and safety information. For this study, safety information was presented through the Safety Coach interactive experience. Safety Coach is an option that briefs the user on the topic and then allows the user to demonstrate what has been briefed. The Safety Coach categories were the brace position, life vest, and oxygen mask.

Passenger Safety Information Tests: Participants were tested on passenger safety information at three points in the study. The three tests were identical and consisted of nine open-ended questions.

There were three questions in the brace position portion of the test:

1. Describe where and how to position your feet.
2. Describe where and how to position your head.
3. Describe where and how to position your hands.

There were three questions in the life vest portion of the test:

1. Describe where the life vest is located.
2. Describe how to open the life vest pouch.
3. Describe the procedures for donning or wearing the life vest.

There were three questions in the oxygen mask portion of the test:

1. Describe how to activate the oxygen mask.
2. Describe how to wear an oxygen mask.
3. Describe how to secure the oxygen mask.

Experimental Design

This study evaluated three media presentation types by measuring the retention of passenger education information presented for each type using a 3 (topic) x 3 (presentation style) repeated measures study design. The three media presentation types were a briefing card, a video briefing, and a serious game. The three passenger education safety topics presented were brace position, life vest, and oxygen mask. Participants were given a pretest (for a baseline), a posttest (i.e., after information was presented), and a second posttest approximately 90 minutes later (while the participants were completing evacuation trials for the Egress Study). Participants were presented with all three of the passenger education safety topics but were presented with a new presentation type for each topic. There were six combinations of safety topics/presentation styles as follows:

1. Briefing Card (Brace), Video Briefing (Life Vest) Serious Game (Oxygen Mask)
2. Briefing Card (Brace), Video Briefing (Oxygen Mask) Serious Game (Life Vest)
3. Briefing Card (Life Vest), Video Briefing (Brace) Serious Game (Oxygen Mask)
4. Briefing Card (Life Vest), Video Briefing (Oxygen Mask) Serious Game (Brace)
5. Briefing Card (Oxygen Mask), Video Briefing (Brace) Serious Game (Life Vest)
6. Briefing Card (Oxygen Mask), Video Briefing (Life Vest) Serious Game (Brace)

Participants

This study was conducted under an Institutional Review Board-approved protocol (#19018). The study used six groups of 30 naive participants. The first 30 participants to complete the initial phase of the Egress Study were invited to participate in this study. Participation was voluntary, and the study took place during a period where participants would otherwise be idle waiting for the next phase of the

parallel study to begin. Participants were required to read, speak, and understand written and spoken English.

Procedure

Each group (test day) was assigned a different combination of briefing type/presentation style (Table 1). The participants received their initial briefing (Appendix A) followed by the informed consent form (Appendix B). After reviewing the informed consent form with the Principal Investigator and signing the form, they were given a pretest (Appendix C) to assess their passenger safety knowledge. Participants were then given a CSRT tablet to complete a cognitive test (the ANAM). Next, they were presented with three briefings with differing presentation styles (Table 1). After being presented with all three briefings, participants were given a passenger safety knowledge posttest (Appendix C) to recall the information presented. Afterward, participants returned to the Egress Study for data collection. Once that data collection ended, participants returned for a second posttest (Appendix C) and a group debriefing.

Table 1

Group Combinations Including Briefing Type/Presentation Style

Group Number/Egress Study Test Day	Presentation Style		
	Brace Position	Life Vest	Oxygen Mask
Group 1 (Egress Study Day 3)	Briefing Card	Video Briefing	Serious Game
Group 2 (Egress Study Day 4)	Briefing Card	Serious Game	Video Briefing
Group 3 (Egress Study Day 6)	Video Briefing	Briefing Card	Serious Game
Group 4 (Egress Study Day 7)	Serious Game	Briefing Card	Video Briefing
Group 5 (Egress Study Day 8)	Video Briefing	Serious Game	Briefing Card
Group 6 (Egress Study Day 9)	Serious Game	Video Briefing	Briefing Card

Scoring of Passenger Safety Information Assessments

Each question was scored by the number of points for each question based on correct keywords or phrases found in the participants' answers. The following procedures were followed for the scoring of each category.

Brace Position: The brace position portion of the test had a total score of 4 points for the three questions. The first question, "Describe where and how to position your feet," was worth 2 points, and the correct answer included phrases that encompassed having your "feet flat on the floor" (1 point) and positioned "behind knees" (1 point). The second question, "Describe where and how to position your head," was worth 1 point, and the correct answer included phrases that described the head "against the seat in front of you" and "lowered towards your knees." The third question, "Describe where and how to position your hands," was worth 1 point, and the correct answer included phrases that described the hands "behind the knees" or "below the thighs."

Life Vest: The life vest portion of the test had a total score of 7 points for the three questions. The first question, "Describe where the life vest is located," was worth 2 points, and the correct answer included phrases that located the life vest "in a compartment" (1 point) and "under the seat/chair (1 point). The second question, "Describe how to open the life vest pouch," was worth 1 point, and the correct answer included phrases that described how to "pull the tab." The third question, "Describe the procedures for donning or wearing the life vest," was worth 4 points. The correct answer included phrases that

described putting the life vest "over your head" (1 point), putting the strap "around your waist" (1 point), "buckling" the life vest (1 point), and pulling the strap "tight" (1 point).

Oxygen Mask: The oxygen mask portion of the test had a total score of 5 points for the three questions. The first question, "Describe how to activate the oxygen mask," was worth 1 point, and the correct answer included the instruction to "pull down." The second question, "Describe how to wear an oxygen mask," was worth 3 points, and the correct answer included the words "over nose" (1 point), "over mouth" (1 point), and "strap around head" (1 point). The third question, "Describe how to secure the oxygen mask," was worth 1 point, and the correct answer included the phrases "adjust" or "pull" straps.

Data Analysis

IBM SPSS Statistics for Windows, Version 24.0. (Armonk, NY: IBM Corp.) was used for all data entry and analysis. Descriptive statistics were calculated for all demographic information. These data were examined for relationships between individual demographics and test scores. Test scores were analyzed to examine the relationships between presentation styles. A one-way analysis of variance (ANOVA) was performed to test for differences among group means. A Tukey's Test was performed as the post hoc analysis. The significance levels were tested at 0.05.

RESULTS

Demographics

A total of 180 participants were recruited, of whom 175 completed the study with usable data. Five participants were censored due to self-elimination or other factors. Of the usable participants, 75 were female (42.9%), and 100 were male (57.1%). Ages ranged from 18 to 60 years *(M_{Age} = 35.0, SD_{Age} = 11.97).* Education level, number of flights in the past 12 months, and self-reported flight experience were collected during the initial phase of the other study. This information is summarized in Tables 2 through 4.

Table 2

Education Level

Education Level	Total	Percentage
Some High School	2	1.1%
High School Graduate	22	12.6%
Some College	75	42.9%
Associate's degree	21	12%
Bachelor's degree	32	18.3%
Graduate degree	23	13.1%

Table 3

Number of Flights in the Last 12 Months

Flights in the Last 12 Months	Total	Percentage
Missing data	3	1.7%
0	76	43.4%
1-3	53	30.3%
4-6	29	16.6%
7-9	8	4.6%
10+	6	3.4%

Table 4

Self-Reported Flight Experience

Experience Level	Total	Percentage
No experience	13	7.42%
Little experience	16	9.14%
Some experience	56	32%
Experienced	51	29.14%
Very experienced	39	22.3%

Influence of Passenger Demographics

The following paragraphs detail the participant safety knowledge determined by three separate assessments. As described previously, the assessments consisted of a pretest (a baseline of passenger safety information knowledge), a posttest following safety information presentation, and a second posttest taken after approximately 90 minutes. With 16 points possible, a total score was assigned to all three tests to facilitate a statistical analysis to determine if there were any significant differences in overall knowledge of safety information and other variables.

Retention of Safety Information by Age, Gender, or Number of Flights in the Past 12 Months

There were no significant differences for the variables of age, gender, or a number of flights in the last 12 months for any of the three assessments.

Retention of Safety Information by Education Level

Pretest Overall Score: A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(5,169) = 3.269$, $p = .008$). A post hoc Tukey test showed that High School and Bachelor's degree differed significantly at $p < .025$; High School and Graduate degree differed significantly at $p < .007$; no other results were significantly different. Participants with a Bachelor's or Graduate degree tended to score higher than others (Table 5).

Posttest Overall Score: A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(5,169) = 2.734$, $p = .021$). A post hoc Tukey test showed that High School and Graduate degree differed significantly at $p < .045$; no other results were significantly different. Participants with a Bachelor's or Graduate degree tended to score higher than others (Table 5).

Posttest 2 Overall Score: A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(5,169) = 3.261$, $p = .008$). A post hoc Tukey test showed that High School and Bachelor's degree differed significantly at $p < .036$; High School and Graduate degree differed significantly at $p < .018$; no other results were significantly different. Participants with a Bachelor's or Graduate degree tended to score higher than others (Table 5).

Table 5

Overall Mean Scores (Points) by Education Level

Education level	Mean Score		
	Pretest	Posttest	Posttest 2
Some high school	5.50	9.50	9.00
High school graduate	4.23	9.91	9.32
Some college	5.35	10.49	10.24
Associate's degree	5.19	11.19	10.76
Bachelor’s degree	6.22	11.47	11.44
Graduate degree	6.65	11.96	11.78

Retention of Safety Information by Self-Reported Flight Experience:

Pretest Overall Score: There was a statistically significant difference between groups as determined by one-way ANOVA ($F(4,170) = 5.116$, $p = .001$). A post hoc Tukey test showed that Little Experience and Experienced differed significantly at $p < .003$; Some Experience and Experienced differed significantly at $p < .019$; no other results were significantly different. Participants with Experience tended to score higher than those with Little or Some experience (Table 6).

Post-Test Overall Score: No results were significantly different (Table 6).

Post-Test 2 Overall Score: No results were significantly different (Table 6).

Table 6

Means of Overall Scores (Points) by Self-Reported Flight Experience

Flight Experience	Mean Score		
	Pretest	Posttest	Posttest 2
No experience	4.54	9.62	9.31
Little experience	4.06	10.88	10.38
Some experience	5.09	10.57	10.25
Experienced	6.45	11.10	11.20
Very experienced	5.85	11.38	10.82

Influence of Presentation Style

This set of results and analyses examined passenger retention of information after being presented with three information topics in three different presentation styles. Participants were given a Pretest assessment as a baseline. The results for the baseline testing of passenger safety information are shown in Table 7.

Table 7

Pretest Scores

Information Type (number of questions)	Score (points)								
	0	1	2	3	4	5	6	7	Total
Brace Position (4)	29	80	62	4	0	NA	NA	NA	175
Life Vest (7)	37	46	51	24	14	3	0	0	175
Oxygen Mask (5)	17	27	25	53	42	11	NA	NA	175

Note. NA = not applicable.

Retention of Safety Information by Presentation Style: Brace Position

Posttest: The results for the retention of safety information for the brace position by presentation style are shown in Table 8. There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,172) = 6.160$, $p = .003$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .003$; the video briefing and the serious game differed significantly at $p < .037$; the briefing card and video briefing results were not significantly different.

Table 8

Posttest, Brace Position

Presentation Style (Brace)	Score (points)					Total	Mean
	0	1	2	3	4		
Briefing Card/Number of Participants	0	6	8	43	0	57	2.65
Video Briefing/Number of Participants	1	4	16	23	15	59	2.80
Serious Game/Number of Participants	0	2	13	16	28	59	3.19
Total	1	12	37	82	43	175	

Posttest 2: The results for the retention of safety information for the brace position by presentation style are shown in Table 9. A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(2,172) = 9.082$, $p = .000$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .000$; the video briefing and the serious game differed significantly at $p < .002$; the briefing card and video briefing results were not significantly different.

Table 9

Posttest 2, Brace Position

	Score (points)						
Presentation Style (Brace)	0	1	2	3	4	Total	Mean
Briefing Card/Number of Participants	0	4	14	39	0	57	2.61
Video Briefing/Number of Participants	0	11	10	25	13	59	2.68
Serious Game/Number of Participants	0	0	12	23	24	59	3.20
Total	0	15	36	87	37	175	

Retention of Safety Information by Presentation Style: Life Vest

Posttest: The results for the retention of safety information for the life vest by presentation style are shown in Table 10. There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,172) = 17.546$, $p < .001$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .001$; the video briefing and the serious game differed significantly at $p < .013$; the briefing card and video briefing differed significantly at $p < .008$.

Table 10

Posttest, Life Vest

Presentation Style (Life Vest)	Score (points) 0	1	2	3	4	5	6	7	Total	Mean
Briefing Card/Number of Participants	0	4	10	17	13	10	6	0	60	3.55
Video Briefing/Number of Participants	1	1	4	10	15	13	11	3	58	4.33
Serious Game/Number of Participants	0	0	1	8	6	19	17	6	57	5.07
Total	1	5	15	35	34	42	34	9	175	

Posttest 2: The results for the retention of safety information for the life vest by presentation style are shown in Table 11. A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(2,172) = 15.692$, $p < .001$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .001$; the video briefing and the serious game differed significantly at $p < .022$; the briefing card and video briefing differed significantly at $p < .011$.

Table 11

Posttest 2, Life Vest

Presentation Style (Life Vest)	Score (points) 0	1	2	3	4	5	6	7	Total	Mean
Briefing Card/Number of Participants	1	4	10	17	15	10	3	0	60	3.38
Video Briefing/Number of Participants	1	3	5	10	13	13	10	3	58	4.16
Serious Game/Number of Participants	0	0	3	8	6	21	14	5	57	4.88
Total	2	7	18	35	34	44	27	8	175	

Retention of Safety Information by Presentation Style: Oxygen Mask

Post-Test: The results for the retention of safety information for the oxygen mask by presentation style are shown in Table 12. There was a statistically significant difference between groups as determined by one-way ANOVA ($F(2,172) = 8.021$, $p < .001$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .001$; the video briefing and the serious game differed significantly at $p < .016$; the briefing card and video briefing results were not significantly different.

Table 12

Posttest, Oxygen Mask

Presentation Style (Oxygen Mask)	Score (points) 0	1	2	3	4	5	Total	Mean
Briefing Card/Number of Participants	1	1	10	20	16	10	58	3.36
Video Briefing/Number of Participants	0	3	4	22	15	14	58	3.57
Serious Game/Number of Participants	0	1	0	13	23	22	59	4.10
Total	1	5	14	55	54	46	175	

Posttest 2: The results for the retention of safety information for the oxygen mask by presentation style are shown in Table 13. A statistically significant difference was noted between groups as determined by one-way ANOVA ($F(2,172) = 7.124$, $p = .001$). A post hoc Tukey test showed that the briefing card and serious game differed significantly at $p < .006$ the video briefing and the serious game differed significantly at $p < .003$; the results from the briefing card and video briefing were not significantly different.

Table 13

Posttest 2, Oxygen Mask

Presentation Style (Oxygen Mask)	Score (points) 0	1	2	3	4	5	Total	Mean
Briefing Card/Number of Participants	1	3	9	12	23	10	58	3.43
Video Briefing/Number of Participants	0	7	4	16	22	9	58	3.38
Serious Game/Number of Participants	0	1	3	10	21	24	59	4.08
Total	1	11	16	38	66	43	175	

DISCUSSION

This study looked at the retention of passenger safety information presented using three media types. Every participant was given the same topics (brace position, life vest, and oxygen mask) with a different presentation style (briefing card, video briefing, and serious game). Overall, a participant playing a serious game retained information more accurately than a participant reading a briefing card or watching a video briefing. Also, a participant watching a briefing video could recall information more accurately than just reading a briefing card. These findings suggest that virtually performing an action resulted in a higher level of retention than either viewing still images of an action or seeing/hearing an action being performed.

An interesting variable that further illustrates that performing an action is superior for information retention is the flight history of the participants. When asked about flight history over the last 12 months, 43.4% of participants reported not having flown. Another 30.3% reported one to three flights, 16.6% reported four to six flights, and the rest reported seven to 10 or more flights. When taking the pretest of safety information, there was no significant difference between these groups. Those individuals who had been on multiple flights within the past year did not have an advantage in retaining safety information over those participants with zero flights.

When it came to education levels, it was found that individuals with a Bachelor's degree or Graduate degree retained safety information better in all three assessments than other participants. There was no significant difference between participants with some college or an Associate's degree. This could suggest a higher level of attention to detail or a better retention strategy possessed by those with more academic experience.

LIMITATIONS

The participants in this study were a paid, captive audience. They were given an assignment and asked to complete the assignment in a classroom setting, without recourse to other distractions (such as cell phones or other devices). It is unknown how these results would translate to the real world, within an airplane cabin, with cell phones and other distractions. As previously stated, passenger attention is an issue that warrants further study but is outside the scope of this project.

CONCLUSIONS

This study has shown significant differences in knowledge retention based upon the presentation style of safety information. Having a participant virtually perform the action being taught creates a better

understanding of the action and results in better retention of the information. The finding that knowledge retention is improved with an interactive style of information presentation indicates that passenger safety briefing materials using such a style of presentation may improve passenger knowledge of safety procedures, potentially improving adherence to those safety procedures during an emergency.

REFERENCES

Briefing of passengers before flight, 14 CFR § 135.117 (1978). https://www.govinfo.gov/app/details/CFR-2001-title14-vol2/CFR-2001-title14-vol2-sec135-117

Briefing passengers before flight, 14 CFR § 125.327 (1980). https://www.govinfo.gov/app/details/CFR-2001-title14-vol2/CFR-2001-title14-vol2-sec125-327

Briefing passengers before takeoff, 14 C.F.R. § 121.571 (1965). https://www.govinfo.gov/content/pkg/CFR-2012-title14-vol3/pdf/CFR-2012-title14-vol3-sec121-571.pdf

Chittaro, L. (2012, June). Passengers' safety in aircraft evacuations: Employing serious games to educate and persuade. In *International Conference on Persuasive Technology* (pp. 215-226). Springer.

Chittaro, L. (2014). Changing user's safety locus of control through persuasive play: an application to aviation safety. In *International Conference on Persuasive Technology* (pp. 31-42). Springer.

Corbett, C. L., & McLean, G. A. (2007). Passenger Safety Awareness Reprise 2007: Still Ignorant After All These Years. In *Proceedings of the Fifth Triennial International Aircraft Fire and Cabin Safety Research Conference*.

Corbett, C. L., & McLean, G. A. (2008). *Effective Presentation Media for Passenger Safety I: Comprehension of Briefing Card Pictorials and Pictograms.* Federal Aviation Administration Office of Aerospace Medicine Report DOT/FAA/AM-08/20. https://www.faa.gov/data_research/research/med_humanfacs/oamtechreports/2000s/media/200820.pdf

Cummings, W. (2018, April 18). *Images from terrifying Southwest Airlines flight shows passengers didn't put oxygen masks on right.* USA Today. https://www.usatoday.com/story/news/nation/2018/04/18/southwest-1380-oxygen-masks-wrong/530867002/.

FAA Reauthorization Act of 2018, Pub. L. 115-254, § 536, 132 Stat. 3186. (2018). https://www.congress.gov/115/plaws/publ254/PLAW-115publ254.pdf

Federal Aviation Administration. (2019). *Advisory Circular 121-24D. Passenger Safety Information Briefing and Briefing Cards.* https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentid/1035568

National Transportation Safety Board. (2000). *Safety Study: Emergency Evacuation of Commercial Airplanes*. Report No. NTSB/SS-00/01. NTSB. https://www.ntsb.gov/safety/safety-studies/Documents/SS0001.pdf

National Transportation Safety Board. (2010). *Accident Report: Loss of thrust in both engines after encountering a flock of birds and subsequent ditching on the Hudson River.* Report No. NTSB/AAR-10/03. NTSB. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1003.pdf

National Transportation Safety Board. (2016). *Accident Report: Uncontained Engine Failure and Subsequent Fire*. Report No. NTSB/AAR-18/01. NTSB. https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR1801.pdf

SAE International. (2006). *Aerospace Recommended Practice 1384c, Passenger Safety Information Cards*. SAE.

Seneviratne, D., & Molesworth, B. R. C. (2015). Employing humour and celebrities to manipulate passengers' attention to pre-flight safety briefing videos in commercial aviation. *Safety Science, 75*, 130-135. https://doi.org/10.1016/j.ssci.2015.01.006

Tehrani, M, & Molesworth, B.R.C. (2015). Pre-flight safety briefings, mood and information retention. *Applied Ergonomics*, *51*, 377–382. https://doi.org/10.1016/j.apergo.2015.06.015

Weed, D. B., Beben, M. S., Ruppel, D. J., Guinn, K. J., & Jay, S. M. (2021). *Effects of Airplane Cabin Interiors on Egress I: Assessment of Anthropomorphics, Seat Pitch, and Seat Width on Egress* [submitted for publication]. Federal Aviation Administration Office of Aerospace Medicine Report DOT/FAA/AM-21/01.

Weed, D. B., Corbett, C. L., & McLean, G. A. (2013). Effective Presentation Media for Passenger Safety: Comprehension of Briefing Card Gestalt and Elements. In *Proceedings of the Seventh Triennial International Aircraft Fire and Cabin Safety Research Conference.*

Appendix A: Initial Participant Brief

Evaluation of Aircraft Cabin Configuration Initial Participant Briefing

Good morning. Welcome to CAMI. I am Melissa Beben, a Research Specialist in Cabin Safety. Today you are going to be participating in a study regarding passenger education. Thank you for your participation. This study will investigate the retention of safety information from multiple forms of presentation. It is important that passengers are aware of safety procedures and safety equipment on commercial aircraft. This study will compare multiple forms of safety briefings in order to assess best practices for retaining safety information.

This study is being ran in conjunction with "Effects of Airplane Seat Dimensions on Egress". In this supplemental study, you will be asked to first complete at pre-test questionnaire. After that, you will be given a tablet and asked to complete a cognitive assessment that will record your reaction time, speed of processing, and multiple other cognitive functions. You will next be presented with passenger safety briefing materials. You will then be given a post-test questionnaire. After completing, you will then return to the original study. At the end of the original study, you will return here for a second post-test questionnaire.

In a moment, you will receive an informed consent document, which I will read aloud to the group and answer any questions you may have about it. This document lets us know you have been told about the information we will record, the tests you will be participating in today, understand the procedures, and are willing to participate. If you are willing to participate, the study will begin

Are there any questions?

Appendix B: Informed Consent to Participate in Research Study

(Evaluation of Serious Games for Passenger Education)

Principal Investigator (PI): **Melissa Beben**, M.S., Civil Aerospace Medical Institute
Co-investigators: **David Weed,** M.A., Civil Aerospace Medical Institute
Sponsors: **Federal Aviation Administration**

Invitation to Participate in Research Study

Melissa Beben invites you to participate in a research study about the Evaluation of Serious Games for Passenger Education. This study is sponsored by the Federal Aviation Administration (FAA) and funded by the Fire and Cabin Safety Technical Committee Representative Group (F&CS TCRG), who have no financial interest in this study. The study will be conducted at the Mike Monroney Aeronautical Center (MMAC) Campus, Civil Aerospace Medical Institute (CAMI) Building.

You have been hired by (Contractor TBD) as a research subject for the project "Effects of Airplane Seat Dimensions on Egress". You have been selected as a possible subject in this supplemental study because you are a representative of the flying public. If you decide to participate, after consideration and review, please sign this form to show that you want to voluntarily take part.

Description of participant involvement

If you agree to participate in this study, your involvement will last approximately 1 hour. During this time, you will be in room 117 of the CAMI building. You will receive a group briefing about this form and project and given a chance to sign this form to signal your voluntary participation in this project. After signing, you will be given a pretest questionnaire. After, you will then be given a tablet to complete a cognitive assessment (ANAM) and then you will be presented with passenger education briefing materials. You will then be given a posttest questionnaire. You will then be taken to the Flexsim to participate in the original project. After completing the evacuation in the original project, you will return to the CAMI building, room 117 for a second posttest questionnaire and debriefing.

Potential Benefits

Your direct benefit for participating in this project is your payment from (Contractor TBD). This project is included in the projected 5-hour time period for the original study. This project will benefit aviation safety and the flying public as a whole by providing information to allow the FAA to maintain or improve safety on commercial aircraft.

Risks and Discomforts

The researcher has taken steps to minimize the risk and discomforts of this study. Even so, you may experience some discomforts related to your participation. You may experience discomfort being in a seated position for the approximate hour of the study. You may experience discomfort staring at and completing activities on an 8-inch tablet.

Compensation

You will be paid (TBD) by (Contractor TBD) for your participation in this study.

Participant's Rights

You will not give up any legal rights or release any individual or institution from liability for negligence by signing this form and participating in this study. You have the right to withdraw from this study at any point during the study without penalty or loss of benefits to which you are otherwise entitled. You have the right to be informed should any new findings develop during the course of this research project that may relate to your decision to continue participation.

You have the right to receive and keep an unsigned copy of this form for your records. You have the right to receive an electronic copy of any publications relating to this research project. You can contact the PI at the number provided at the bottom of this form.

Cost to Participant

You will not incur any costs for participating in this research study.

Confidentiality

All paper records created during the course of this study will be kept in a locked file cabinet maintained by the Protection and Survival Laboratory, Cabin Safety Research Team, in the CAMI building. All records of this study will refer only to the participant number you will be assigned should you agree to participate in this study. Electronic data collected during this research project will be kept on a password protected, external storage drive, kept in a locked filing cabinet when not in use. Data from the cognitive assessment (ANAM) will be de-identified and shared with the software licensee. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

Injury

Every effort to prevent injury as a result of your participation will be taken. It is possible, however, that you could develop complications or injuries as a result of participating in this research study. In the event of injury during this research project, first aid will be provided by on-site first responders. Any required follow-up care will be coordinated by your contractor's representative and the first responders.

Voluntary Nature of the Study

Participation in this research project is completely voluntary. You have the right to withdraw from this study at any point during or between trials without penalty or loss of benefits to which you are otherwise entitled. If you choose to withdraw before full completion of the study, you will be paid for the time worked by (Contractor TBD) as calculated from the time of initial briefing at the MMAC visitor's center to the time of your withdrawal. If you choose to withdraw, the information of data provided will be destroyed.

Participation and Withdrawal

Your participation in this study is voluntary and it is your choice whether to participate or not. You may decline or withdraw participation from the study at any time. The choice to decline or withdraw from the study will not cause any penalty or loss of any benefit to which you are entitled as described above.

Melissa Beben, or another research staffer, may decide to stop or withdraw you from the study under certain circumstances without your permission. Some possible reasons that you may be removed from the study are such as a risk or harm to your medical or psychological interest, not following the study instructions, or other administrative reasons. In the event that your participation in the study ends early, you may request or you may be requested to speak to the principal investigator and/or contractor representative.

At any time during this research study, the principal investigator or research team will share any new information that may affect your health or well-being and will discuss your continued participation in the study.

Contact Information

If you have questions about the study, please ask them before signing this form. You can ask any questions that you have about this study at any time.

For questions, concerns or complaints about this study, please contact the principal investigator, Melissa Beben at 405-954-7528 (email: Melissa.Beben@faa.gov) or David Weed at 405-954-9218 (email: David.Weed@faa.gov). If you feel that you have been treated unfairly, or you have questions regarding your rights as a research participant, you may contact the Civil Aerospace Medical Institute Institutional Review Board (a group of people who review the research to protect your rights) at 405-954-1000, Dr. Thomas Chidester.

Signature and Consent to be in the Research Study

I have been informed about the purpose, procedures, possible benefits and risks of this research study. I have read (or someone has read to me) this form, and I have received a copy of it. I have had the

opportunity to ask questions and to discuss the study with an investigator. My questions have been answered to my satisfaction. I have been told that I can ask other questions any time. I voluntarily agree to participate in this study. I am free to withdraw from this study at any time without the need to justify my decision. If I withdraw, I will not lose any benefits to which I am otherwise entitled. I agree to cooperate with the principal investigator and the research staff and to inform them immediately if I experience any unexpected or unusual symptoms.

Participant: By signing this consent form, you indicate that you are voluntarily choosing to take part in this research.

_____

Printed Name of Participant

_____ _____

Signature of Participant or Legal Representative Date

Investigator

Principal Investigator:

I have fully explained this study to the subject or his/her representative to the best of my ability. As a representative of this study, I have explained the purpose, the procedures, the possible benefits, and risks that are involved in this research study. I have answered the subject's questions to his/her satisfaction before requesting the signature(s) above. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily. There are no blanks in this document. A copy of this form has been given to the subject or his/her representative.

_____

Printed name of Principal Investigator

_____ _____ _____

Signature of Principal Investigator Date Time

Appendix C: Passenger Safety Knowledge Test

Brace Position

Participant Vest #: _____

Describe where and how to position your feet:

_____
_____
_____
_____
_____

Describe where and how to position your head:

_____
_____
_____
_____
_____

Describe where and how to position your hands:

_____
_____
_____
_____
_____

Life Vest

Describe where the life vest is located:

_____
_____
_____
_____
_____

Describe how to open the life vest pouch:

_____
_____
_____
_____
_____

Describe the procedures for donning or wearing the life vest:

_____
_____
_____
_____
_____

Oxygen Mask

Describe how to activate the oxygen mask:

_____
_____
_____
_____
_____

Describe how to wear an oxygen mask:

_____
_____
_____
_____
_____

Describe how to secure the oxygen mask:

_____
_____
_____
_____
_____
_____