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Exploring Differences Of Age And Gender On Perceived Experience Of Active Participation Cybersecurity Learning

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Honors Thesis

EXPLORING DIFFERENCES OF AGE AND GENDER ON PERCEIVED EXPERIENCE OF ACTIVE PARTICIPATION CYBERSECURITY LEARNING

by
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ABSTRACT

EXPLORING DIFFERENCES OF AGE AND GENDER ON PERCEIVED EXPERIENCE OF ACTIVE PARTICIPATION CYBERSECURITY LEARNING

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Bachelor of Cybersecurity

Many organizations including the United States government have identified a shortage of cybersecurity professionals in the workforce. This thesis explores the effectiveness of escape room/simulation based learning in an active participation and immersive education to motivate pursuing cybersecurity. A survey was administered to the participants of the 2021 BYU Cybersecurity Camp regarding their experience in the Interactive Cybersecurity Experience (ICE). The ICE is a simulator/escape room that challenges participants to complete a Star Trek themed mission by overcoming cybersecurity obstacles. The three demographics that were surveyed included a camp for educators, a camp for boys, and a camp for girls. A statistical analysis was performed to determine significant differences between the groups. Age seems to play a factor in how the simulator experience is perceived.

Keywords: cybersecurity, education, escape room, learning, simulation

ACKNOWLEDGEMENTS

I want to thank my Faculty Advisor Justin Giboney, my Faculty Reader Amanda Hughes, and Cybersecurity Honors Coordinator Derek Hansen for their support of this thesis project.

The 2021 BYU Cybersecurity Camp was a success and much gratitude goes to the participants of that camp who participated, hopefully gained cybersecurity awareness and motivation, and provided the data for this thesis project. The camp also would not have been possible with the many volunteers that gave of their time and talents to create a fantastic environment for participants to engage in technology and cybersecurity.

I attended and volunteered at the Christa Mcauliffe Space Center (CMSC) growing up and was consistently inspired by the wonder this brought to my life. Time spent at the CMSC kept me motivated moving through the tasks and missions in the hopes to come out on top (or sometimes just survive) in this simulated Star Trek bridge environment. I am grateful for these space centers that have inspired me and continue to inspire the coming generation. Through this research of combining a motivating simulated experience with cybersecurity learning I hope to advance possible cybersecurity interest building activities and provide new insights for learning to the CMSC and other organizations that have branched off from the CMSC.

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1.1 Motivation and Objectives

There is a shortage of about three million cybersecurity professionals and part of the reason is attributed to a lack of motivation (Beuran et al., 2018) (Kam, Menard, Ormond, & Crossler, 2020). In addition to a lack of cybersecurity professionals, providing real-world cybersecurity education can be difficult when attacks are targeted at private institutions or are handled in a classified environment (Mayes, 2019). Mortimer Adler once said “Education: the central aim of which has always been recognized, from Socrates’ day down to our own, as the freeing of the mind through the discipline of wonder” (Adler, 1972). Many associate wonder with childhood and not everyday life. A study of wonder can be a key to improving motivation tactics. The goal of this thesis is to further understand how to increase the effectiveness of hands-on escape room type learning to help inspire wonder, increase motivation, and plant the seed of cybersecurity in future professionals. By building off successes and remediating failures, the frontier of hands-on escape room and simulator-based learning can be advanced.

The purpose of this thesis is to analyze interactive immersive simulation learning as a method to improve cybersecurity understanding, awareness, and career interest. The project includes analysis of interactive immersive simulation cybersecurity training in role-playing team environments of diverse demographics. Specifically, the Immersive Cybersecurity Experience (ICE) will be observed. As the ICE is an educational

experience, educators and students were selected as the participants of this study. Data has been obtained from participants of the 2021 BYU cybersecurity camps following hands-on simulation experiences. Statistical analysis of survey results is presented along with an evaluation.

1.2 Project overview

The research question of this project is: what are the effects of age and gender on the perceived experience of active participation cybersecurity learning? The challenges and tasks involved in the simulator missions are designed to increase the motivation of students to learn cybersecurity skills. By working in a team environment individuals work together and can try out various roles letting them explore the field. Students also do not want to let the team down, further increasing effort and motivation (Kam, Menard, Ormond, & Crossler, 2020). This simulator environment contains flow in the story and tasks along with well-defined learning outcomes (Ellington, 2011). By gaining further understanding of how a simulator environment and game elements affect different demographics, new methods can be developed to teach students in a more personalized manner. The purpose of this thesis is to further the research between cybersecurity and active participation simulator theory training by increasing the effectiveness of hands-on escape room type learning by learning from current shortcomings and current successes and by measuring the desire to study or recommend cybersecurity as a future career.

1.3 Scope

This scope of this research was exploratory as little data has been compiled on simulators/escape room type learning in the field of cybersecurity. This research is directed towards furthering the knowledge of how activity-based learning affects separate demographics. The intention being to analyze current data and find methods to introduce better simulator education in the field of cybersecurity.

An Immersive Cybersecurity Experience (ICE) has been created by the BYU Cybersecurity Research Laboratory (CSRL) which involves solving cybersecurity themed puzzles, tasks, and challenges in a space-themed/Star Trek experience. The simulator experience was presented at the BYU Cybersecurity 2021 summer camps offered to youth ages 12-18 and educators across Utah. The participants voluntarily signed up for the BYU summer camp and likely already had some interest in cybersecurity.

Overall, this research is meant to examine the differences between girls, boys, and educators from the ICE experience. Possible explanations for these differences are offered. Also, possible improvements to the efficacy of simulator/escape room type learning are suggested.

1.4 Outline

This project is outlined as follows. The introduction explains the nature of the thesis. A review of literature is completed to explore the state of the research question. The methodology used in this project is then explained. Findings are then presented. Finally, a conclusion is given.

2 Review of Literature

Current literature of simulator/escape-room based learning is examined, and the current effectiveness of novel ways to engage students in creative teaching activities is scrutinized. The focus of this review is on strategies and techniques that are being used to deliver better education. Then, further focus is directed at novel cybersecurity motivation or teaching methods.

2.1 Introduction

The shortage of cybersecurity professionals was so alarming that the President of the United States issued Executive Orders 13800 and 13870 to expand the cybersecurity workforce in 2017 and 2019 respectively (Duke & Ross, 2017). The United States government has felt the need and taken action to train the American cybersecurity workforce of the future. Many organizations have also faced or felt threatened by crippling cybersecurity threats, increasing the desire for proper security personnel in place. Two driving factors to drive down this shortage include increasing professional development opportunities and reducing barriers surrounding diversity (Riley, 2021). Another focus is encouragement of opportunities in cybersecurity to youth at the K-12 level (Mello-Stark, VanValkenburg, & Hao, 2020).

2.2 Escape Room Framework

Educational gamification frameworks such as Serious Game Design Assessment Framework (SGDA) (Mitgutsch & Alvarado, May 29, 2012) or the Snyder Escape Room Framework (SERF) are tools available to assess the simulator/escape room experience (Snyder, 2018). The BYU ICE has been previously analyzed with the SERF in 2018 by Justin Snyder. The pieces of the SERF included goals and objectives, players, activities, contexts, trajectory, and evaluation. Results from the SERF showed that Education through escape room games shows promise. It demonstrated that the BYU ICE could improve focus on specific goals and objectives in the room/game design. The puzzles in the ICE could be improved by incorporating principles of good puzzle design. The ICE was successfully able to draw on game pleasures like awe, realism, identity, and thrill. The theme and story of the ICE were also enjoyed by the players. More objects to interact with in the experience was suggested as well, however, many more elements have been added to the prototype room since this analysis was completed.

Another cybersecurity-based escape room was developed for K-12 education at Worcester Polytechnic Institute (Mello-Stark, VanValkenburg, & Hao, 2020). They suggest that an innovative way to assess and teach cybersecurity principles is through an escape room. The escape room initially involved a group “locked” in a conference room with the challenge of piecing together letters to form the idiom “Know your Enemy.” Some letters were hidden in plain sight while others required solving a puzzle to earn. This conference room-based escape room was hard to scale or move. The next iteration created something on a smaller scale that could easily be setup and moved around. The

briefcase that was prepared involved simple ciphers, which are algorithms used for encryption or decryption, and the concept of least privilege access, which involves giving subjects only the permissions needed to complete their tasks. When it was discovered that the briefcase was again, not scalable enough, a card game that simulated the briefcase was invented. This card game was also adapted as an IOS application.

2.3 Simulation Theory

Simulation and role-playing based education have been used in classrooms and programs in the past. Research has been conducted at the Christa McAuliffe Space Center (CMSC) to look for the effectiveness of simulation theory in education (Ellington, 2011). The goal of the CMSC is engaging students' minds and getting them excited about science and social studies. Another goal of the CMSC is to practice the discipline of wonder. Participants can enact problem solving, teamwork, and information processing skills in the simulator experience. The CMSC is unique from most educational settings as the main classroom is a simulation experience.

> Visitors to the CMSEC participate as crew members on a space trip in one of the center's space ship simulators. School field trips provide about 80% of CMSEC business, but the center also provides after school and volunteer programs. Of those participating in after school and volunteer programs, 80% are return business from students who participated in a school field trip experience. The other 20% hear about the center through word-of-mouth as the CMSEC does no marketing (pg. 2)
>
> The CMSEC's simulator attempts to establish physical fidelity for a fictional system (i.e., a fictional starship in a fictional universe). This is done to provide a realistic model in which specific cognitive outcomes can be taught (i.e., information processing, problem-solving, and teamwork). The story in each scenario provides the context for the simulation. (pg. 16-17).

The CMSC has many aspects that are well loved by its many participants, volunteers, and staff. 82% of students reported learning something from the simulation experience. Recommendations for improvement include making the CMSC staff and volunteers more aware of the goals of the experience, how the goals can be achieved, and the impact of these goals on participants.

2.4 Novel Teaching Techniques

Recent news has highlighted a disruptive new school that was paid for by Billionaire Elon Musk. New interviews and articles have brought focus and shed light on the school he had created for his children called Ad Astra (Del Río, 2021). Some novel aspects are that students are not separated by age, but instead work together as a team ranging from ages seven to 14. The education is tailored to the student instead of the other way around. Students are taught to problem solve using learning and tools. Also, gamification of learning is used as children usually do not need to be motivated to play games. Education through games is even something that comes naturally to children (Gee & Price, 2021). Subjects of study are also different, involving topics like artificial intelligence, applied science, mechatronics, and coding rather than music, sports, or language. This school, while novel, is said to be entirely experimental. Also, private curriculum is out of reach because only SpaceX employees can send their children there. However, the creators of Ad Astra (now called Astra Nova) have expressed on their website that they want to use the results of the experimentation in the school to better

education worldwide and have already released some broad reaching curriculums such as Conundrums and Synthesis (Dahn, 2021).

2.5 Demographics

A large gender gap has been identified in science, technology, engineering, and math (STEM) and even though many efforts and changes to the business industry have taken place, the gap remains. The STEM gender gap has several negative effects on the world and in societies. Several benefits take place when girls are encouraged to pursue STEM topics (Wood, 2021). Women in the STEM workforce will encourage new perspectives. Companies that have more women employees in STEM roles are more successful. It is important that girls receive just as much encouragement to pursue a STEM career as boys do. Studies have even suggested that STEM interest among teen boys is declining and that a big influence over what career an individual wants to pursue depends on guidance from their parents (Schaffhauser, 2018).

Diversity of demographics is also an area of focus in the realm of shortage of cybersecurity professionals. Cybersecurity experts have reported that supporting African-Amarican professionals is key to reducing workforce shortage (Riley, 2021). The level of interest in cybersecurity among diverse populations is shockingly low (Mello-Stark, VanValkenburg, & Hao, 2020). It will take employees from different backgrounds and with different interests to diversify the future workforce, meet the demands of the field, and reduce cyberattacks. Diversity increases new perspectives on a team which leads to better group success and creative thinking.

3 Methodology

3.1 Approach

A measure is needed to assess how participating in an active, simulated, and hands-on learning situation affects participants' perceptions about cybersecurity. This measure will allow the hypothesis to be tested and to know how different demographics respond to the learning situation. The approach taken to measure effectiveness of participating in an escape room learning environment was through an anonymous survey asking participants to rate their feelings towards aspects of the experience. By asking participants to rate topics regarding ability, teamwork, entertainment, learning, connection to the story, and career desires, a baseline is captured as to how the experience affects them.

3.2 Recruitment

Participants of this study were selected based on attendance at one of the three 2021 BYU Cybersecurity Camps and participation in the Immersive Cybersecurity Experience (ICE). The participants voluntarily signed up for the BYU summer camp yet likely already had some interest in cybersecurity over their peers. Participants themselves or their guardians signed them up for the camp. The youth participants were 12 to 18 years old and involved two separate week-long camps, one for boys and one for girls. There was also a third week-long camp for adult educators. The purpose of the camps was to introduce and teach technology and cybersecurity concepts to participants with the

ICE being one aspect of the camp. 69 boys, 69 girls, and 11 educators participated and took the survey.

3.3 Interactive Cybersecurity Experience (ICE)

The Interactive Cybersecurity Experience (ICE) is an escape room or simulator designed to put participants into a Star Trek bridge environment and provide the necessary workstations, atmosphere, and mood to carry out the role-playing story while providing cybersecurity challenges that are to be completed by the participants. The experience is designed to be conducted in groups of eight participants. Enough sessions were held to accommodate every participant of the 2021 BYU Cybersecurity Camp. This means that even though the story and script were the same for every group, the people, choices, and experience varied.

For each session, before entering the room and starting the experience, the group of participants are given a brief on the story, their mission, and the rules of engagement. This was their onboarding onto the “TSN Phoenix”, their starship for this mission. The crew roles included captain, tactical officer, maintenance officer, science officer, engineering officer, helm, and communications officer. The group members are given the chance to pick the crew role based on their interests. These roles provided goals and expectations for everyone to follow and increased excitement of the coming mission and their role in it.

Upon entering the room participants are transported into the experience when they see the main view screen (figure 3.1), workstations (figure 3.2), runner lights, and many

other design choices that add to the atmosphere of the room as shown in figure 3.3. The staff of the ICE room are portrayed as “engineers” and are already on the bridge to help participants to the workstation assigned to their role. A staff “engineer” would explain to each participant what duties were assigned to their role and give guidance on how to complete these tasks using the workstation.

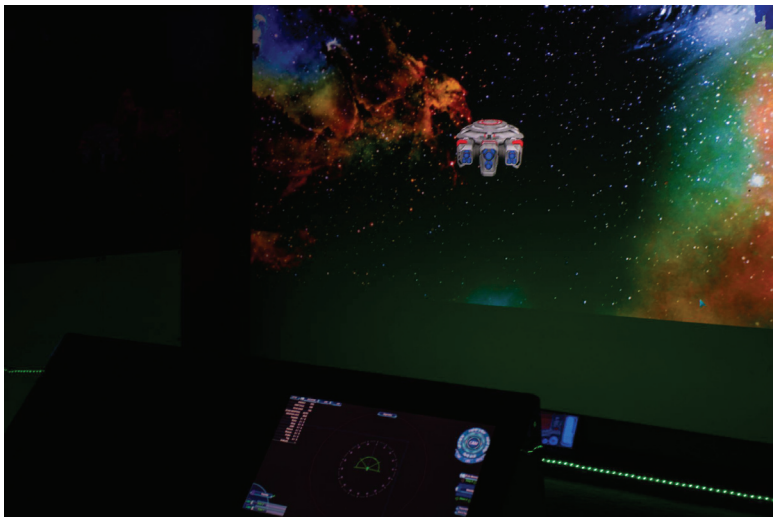

Figure 3.1 - The main view screen of the ICE room

Figure 3.2 - The maintenance officer workstation of the ICE room

After training is complete participants are guided primarily through on-screen prompts on the main view screen as shown in figure 3.1 or the workstations as shown in figure 3.2 and an overhead speaker voice called the “computer”. They proceed through the story and mission, completing menial duties and solving obstacles that could prevent success. These obstacles require more skill by presenting cybersecurity challenges that need to be solved. Some of these cybersecurity challenges involved interacting with a Linux system to find and restore a missing file with the added pressure of running out of oxygen and checking logs to find that a python file had been modified and needed a code fix to restore a power failure.

Figure 3.3 - The ICE room

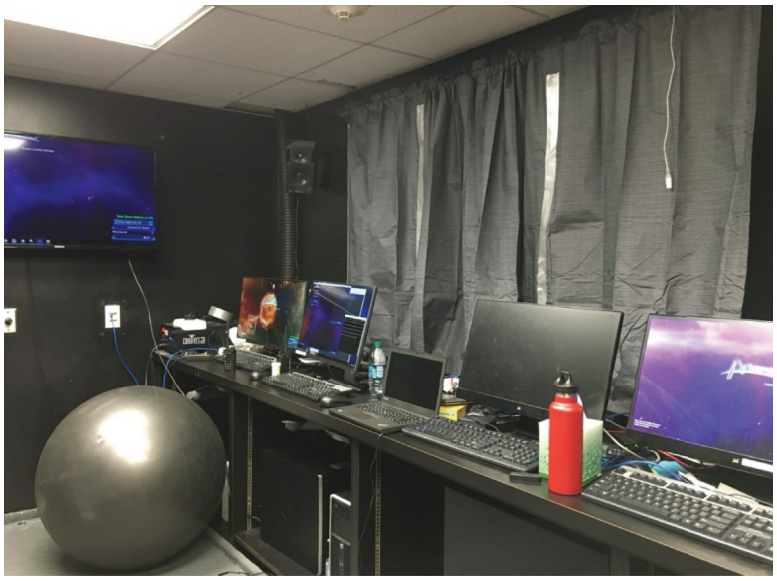

Figure 3.4 - The control booth of the ICE

In a room just behind the ICE room was the control booth as shown in figure 3.4. The control booth is set up with TVs and computers to aid in the behind-the-scenes administrative duties of the ICE staff. These various monitors display the Artemis software along with camera feeds into the ICE room. The Artemis software is the backbone behind controlling the participant workstations, triggering events or actions for participants to interact on their own workstations and the main view screen. The camera views into the ICE room are to help the staff know how the participants are doing.

3.4 Survey Design

Survey questions were designed for participants of the BYU Cybersecurity Camp to reflect on their time in the Immersive Cybersecurity Experience (ICE) and to gauge the desires to enter a computer or cybersecurity related career. Questions such as “How likely are you to have a computer-related career?” or “How likely are you to have a cybersecurity-related career?” were asked to assess how the BYU ICE affected each

audience regarding career topics of computers or cybersecurity. Learning excitement or self-efficacy was measured by asking participants to rate statements such as “I feel confident in my ability to LEARN new technologies” or “I feel confident in my ability to USE new technologies”. The participants were also asked to fill out a user experience questionnaire regarding the simulator experience. See Appendix A to view the full survey.

The survey was compiled and reviewed by facility advisor Dr. Justin Giboney before being given to participants, to test for validity and readability. The survey also received BYU’s institutional review board approval. The survey was given to participants of the 2021 BYU Cybersecurity camp on the last day of the camp. The participants were asked to direct their anonymous responses towards their time in the ICE.

3.5 Analysis

The survey results were exported from the Qualtrics survey platform and analyzed using RStudio. The project is validated using pairwise t-tests to analyze the differences in participant answers. Investigation into the engagement of cybersecurity concepts, flow of learning, and task significance could show the most or least helpful aspects to hands-on cybersecurity learning. Ideally, variations in the responses from the studied demographics will be found.

4 Findings from the BYU Cybersecurity Camp Experience

4.1 Analysis

The primary findings presented in this section involve the results of a pairwise t-test performed to compare participants' responses. A focus is placed on presenting results that had a statistically significant difference between one or more of the three groups surveyed. An evaluation of these findings is given in the next section. All data results can be found in Appendix B.

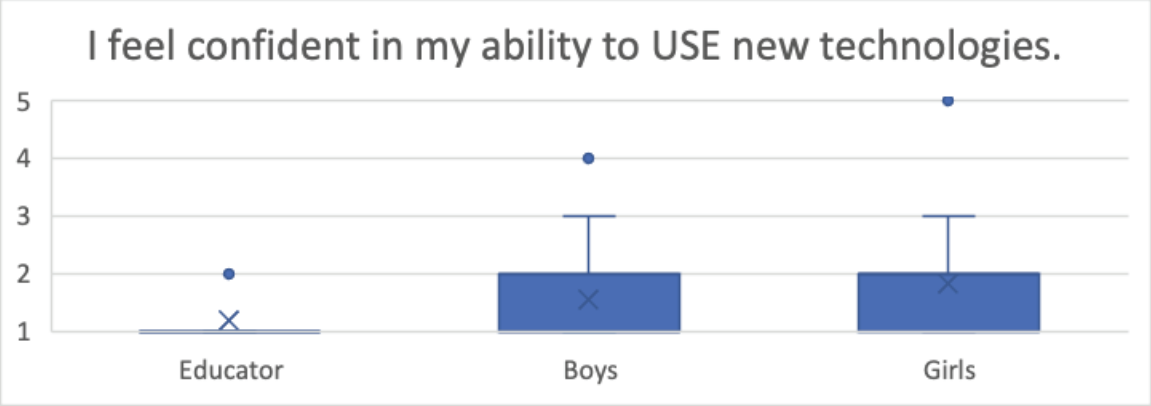

Figure 4.1 - Box and Whisker plot - "I feel confident in my ability to USE new technologies"

The question "I feel confident in my ability to USE new technologies" was answered on a 5-point scale of "1" being "strongly agree" and "5" being "strongly disagree". The educators are very confident in using new technologies with a mean of 1.18 and a standard deviation of 0.41. The boys and the girls also mostly answered in agreement to this statement as well. The boys had a mean of 1.55 and standard deviation of 0.74. The girls had a mean of 1.81 and a standard deviation of 0.73. However, after a

statistical analysis was performed a significant difference was found between girls and educators with a p value less than 0.05. The educators were almost unanimous in their selection of being confident to use new technologies. The youth also tended to have more confidence than not in their ability to use new technologies, but many answered with less confidence.

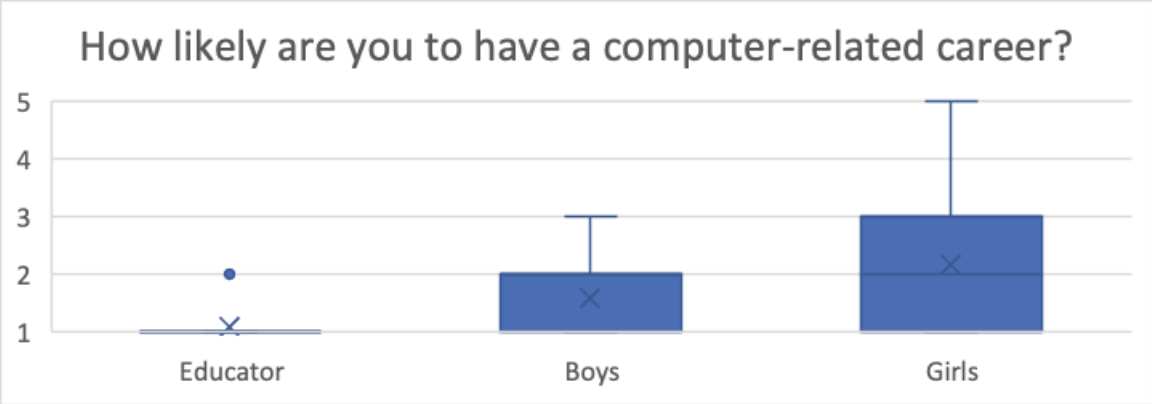

Figure 4.2 - Box and Whisker plot - "How likely are you to have a computer-related career?"

The question "How likely are you to have a computer-related career?" was answered on a 5-point scale of "1" being "extremely likely" and "5" being "extremely unlikely". The educators all answered that they are likely to have a computer related career with a mean of 1.09 and a standard deviation of 0.30. The mean was a little higher for the boys at 1.58 and a standard deviation of 0.63, but most were likely to have a computer related career. The mean was even higher for the girls at 2.16 and a bigger standard deviation of 1.07, with some even indicating that they were not likely to have a computer related career. After a statistical analysis was performed a significant difference was found between the girls and educators with a p value less than 0.001 and between the girls and the boys with a p value less than 0.001. The educators were almost unanimous

in their selection of having a computer-related career. The boys also were much more likely than not to have a computer-related career. While many of the girls tended to be likely to have a computer-related career, they also had some answers neither likely or unlikely, or even unlikely.

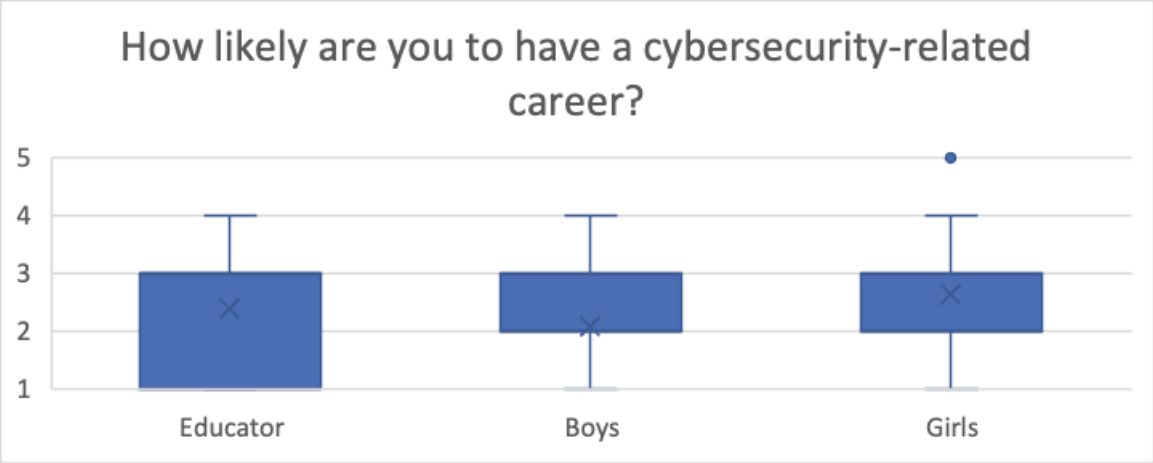

Figure 4.3 - Box and Whisker plot - "How likely are you to have a cybersecurity-related career?"

The question "How likely are you to have a cybersecurity-related career?" was answered on a 5-point scale of "1" being "extremely likely" and "5" being "extremely unlikely". The educators answered that some are likely to have a cybersecurity related career with a mean of 2.36 and a standard deviation of 1.03. The mean was lower for the boys at 2.06 and a standard deviation of 0.73. The mean was higher for the girls at 2.64 and a standard deviation of 1.15. After a statistical analysis was performed a significant difference was found between the girls and boys with a p value less than 0.001. The educators had mixed answers to having a cybersecurity-related career, however, they trend towards the likely end of the spectrum. Boys and girls had a similar spread, however, more boys selected they were likely to have a cybersecurity-related career.

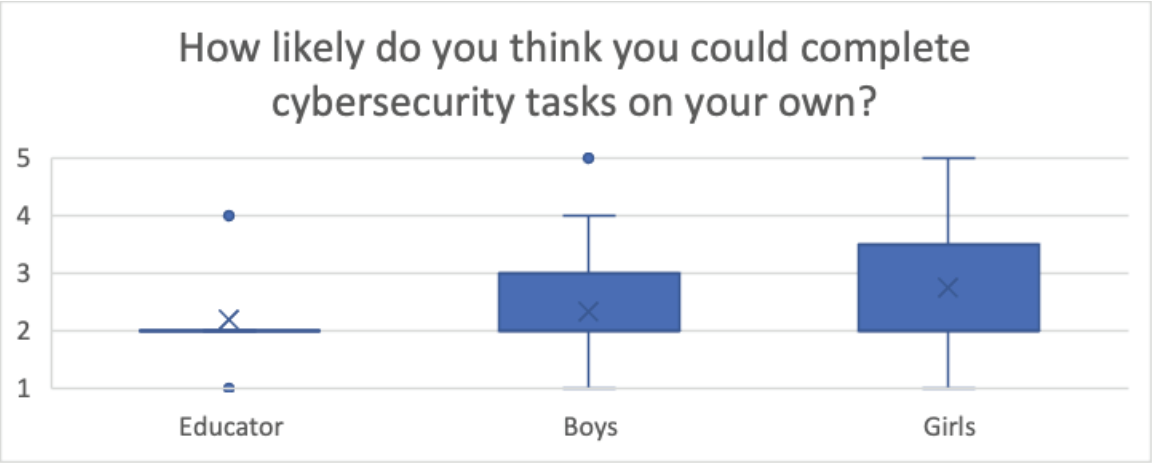

Figure 4.4 - Box and Whisker plot - "How likely do you think you could complete cybersecurity tasks on your own?"

The question "How likely do you think you could complete cybersecurity tasks on your own?" was answered on a 5-point scale of "1" being "extremely likely" and "5" being "extremely unlikely". The educators tightly answered that they are likely able to complete cybersecurity tasks on their own with a mean of 2.18 and a standard deviation of 0.98. The mean for the boys was a little higher at 2.32 and a standard deviation of 0.83. The mean was even higher for the girls at 2.74 and a standard deviation of 1.07. After a statistical analysis was performed a significant difference was found between the girls and the boys with a p value less than 0.05. The educators tended to answer that they were at least somewhat likely to be able to complete cybersecurity tasks on their own while the boys were fairly less likely and the girls the least likely.

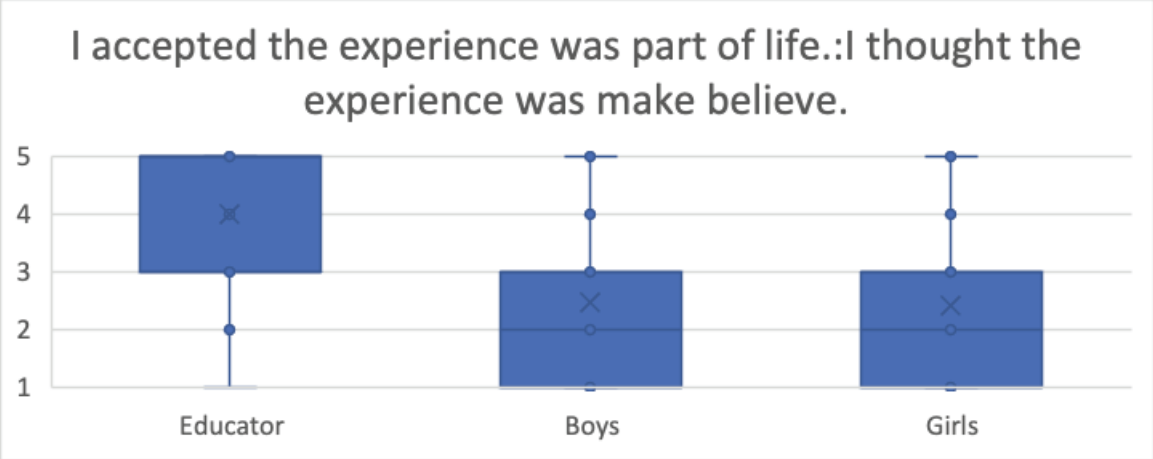

Figure 4.5 - Box and Whisker plot - “I accepted the experience was part of life. vs. I thought the experience was make believe.”

The question regarding accepting the experience as part of life versus thinking the experience was make-believe was answered on a 5-point scale of “1” being “I accepted the experience was part of life” and “5” being “I thought the experience was make-believe”. The educators leaned much more towards thinking the experience was make-believe with a mean of 4.00 and a standard deviation of 1.41. The mean was much lower for the boys at 2.43 and a standard deviation of 1.28. The mean was lower for the girls at 2.39 and a standard deviation of 1.26. After a statistical analysis was performed a significant difference was found between the girls and the educators with a p value less than 0.001, and between the boys and the educators with a p value less than 0.001. Educators tended to answer that they thought the ICE environment was make-believe while the youth answered that the experience was part of life.

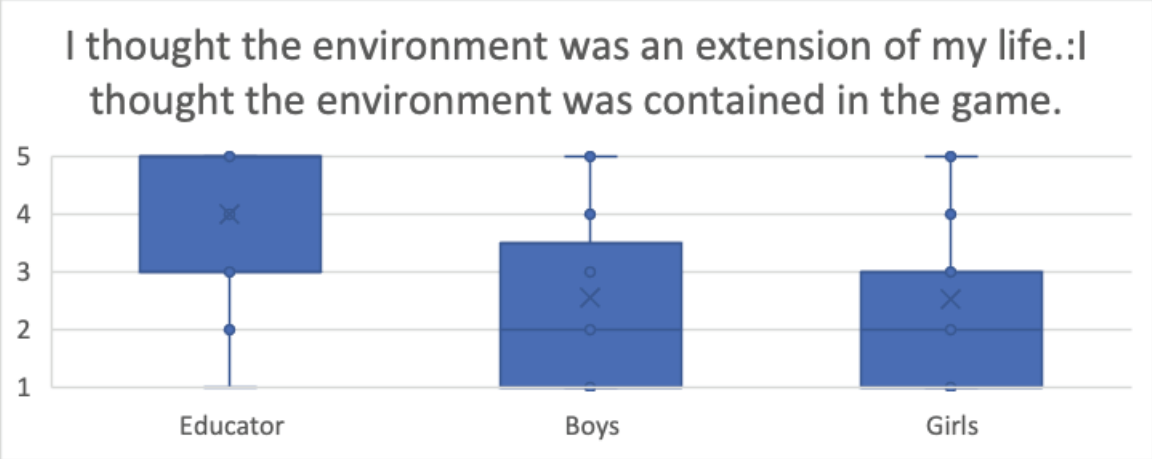

Figure 4.6 - Box and Whisker plot - "I thought the environment was an extension of my life. vs. I thought the environment was contained in the game."

The question regarding thinking the experience was an extension of life versus thinking the experience was contained in the game was answered on a 5-point scale of "1" being "I thought the environment was an extension of my life" and "5" being "I thought the environment was contained in the game". The educators leaned much more towards thinking the environment was contained in the game with a mean of 4.00 and a standard deviation of 1.41 matching the previous question with thinking the experience was make-believe. The mean was much lower for the boys at 2.54 and a standard deviation of 1.36. The mean was lower for the girls at 2.51 and a standard deviation of 1.34. After a statistical analysis was performed a significant difference was found between the girls and the educators with a p value less than 0.01, and between the boys and the educators with a p value less than 0.01. The educators tended to answer that the ICE environment was contained in the game while the youth answered that the ICE environment was an extension of their lives.

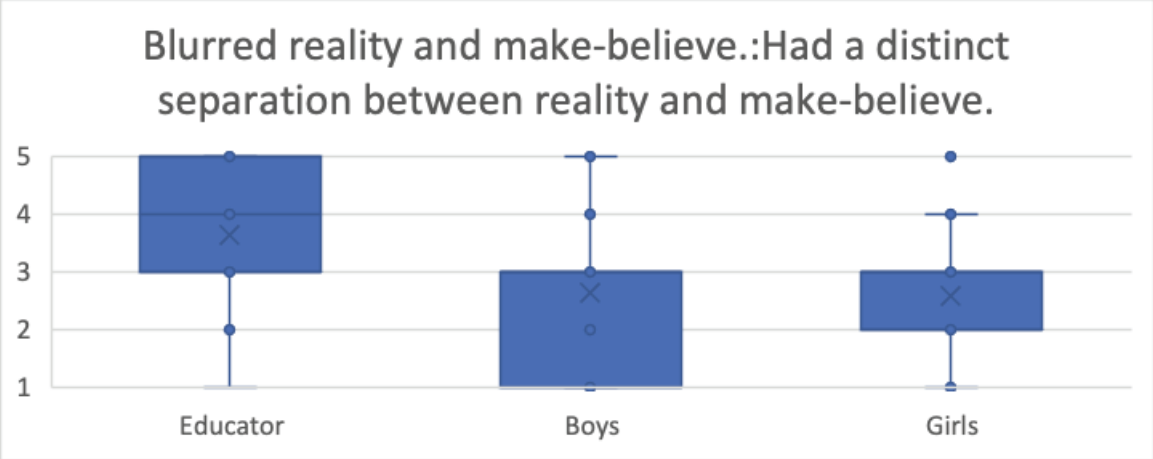

Figure 4.7 - Box and Whisker plot - "Blurred reality and make-believe. vs. Had a distinct separation between reality and make-believe."

The question regarding reality and make-believe were blurred versus a separation between reality and make-believe was answered on a 5-point scale of "1" being "Blurred reality and make-believe" and "5" being "Had a distinct separation between reality and make-believe". The educators leaned much more towards believing there was a separation between reality and make-believe with a mean of 3.64 and a standard deviation of 1.36. The mean was lower for the boys at 2.62 and a standard deviation of 1.34. The mean was even lower for the girls at 2.58 and a standard deviation of 1.22. After a statistical analysis was performed a significant difference was found between the girls and the educators with a p value less than 0.05, and between the boys and the educators with a p value less than 0.05. The educators tended to answer that there was separation between reality and make-believe while the youth leaned more towards a blurred reality and make-believe vision.

4.2 Similar Findings

Although no significant difference was found, a few of the questions showed similar results between educators, boys, and girls. This data is now presented.

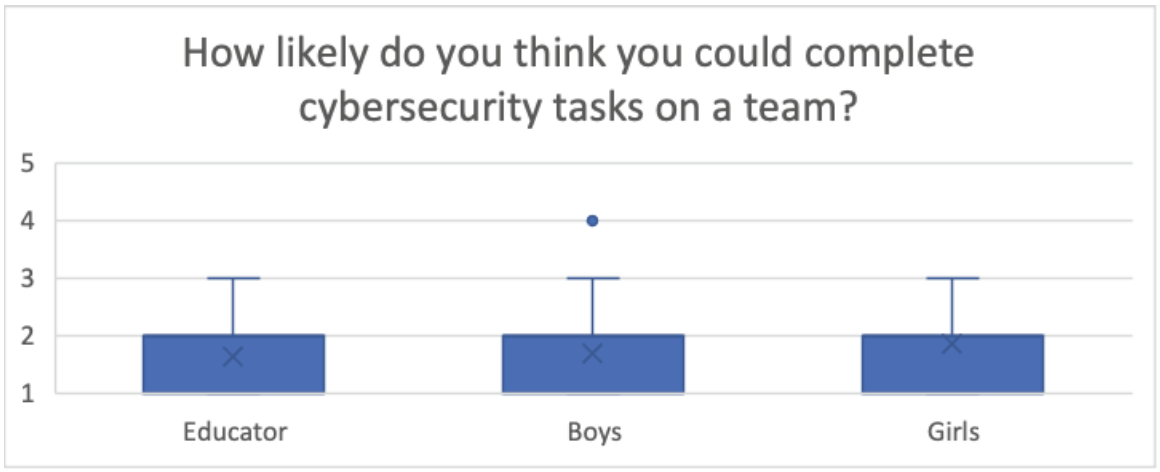

Figure 4.8 - Box and Whisker plot - “How likely do you think you could complete cybersecurity tasks on a team?”

The question “How likely do you think you could complete cybersecurity tasks on a team?” was answered on a 5-point scale of “1” being “extremely likely” and “5” being “extremely unlikely”. The educators had a mean of 1.64 and a standard deviation of 0.67. The boys had a mean of 1.68 and a standard deviation of 0.76. The girls had a mean of 1.84 and a standard deviation of 0.82. Each group mostly answered that they were “likely” to be able to complete cybersecurity tasks on a team.

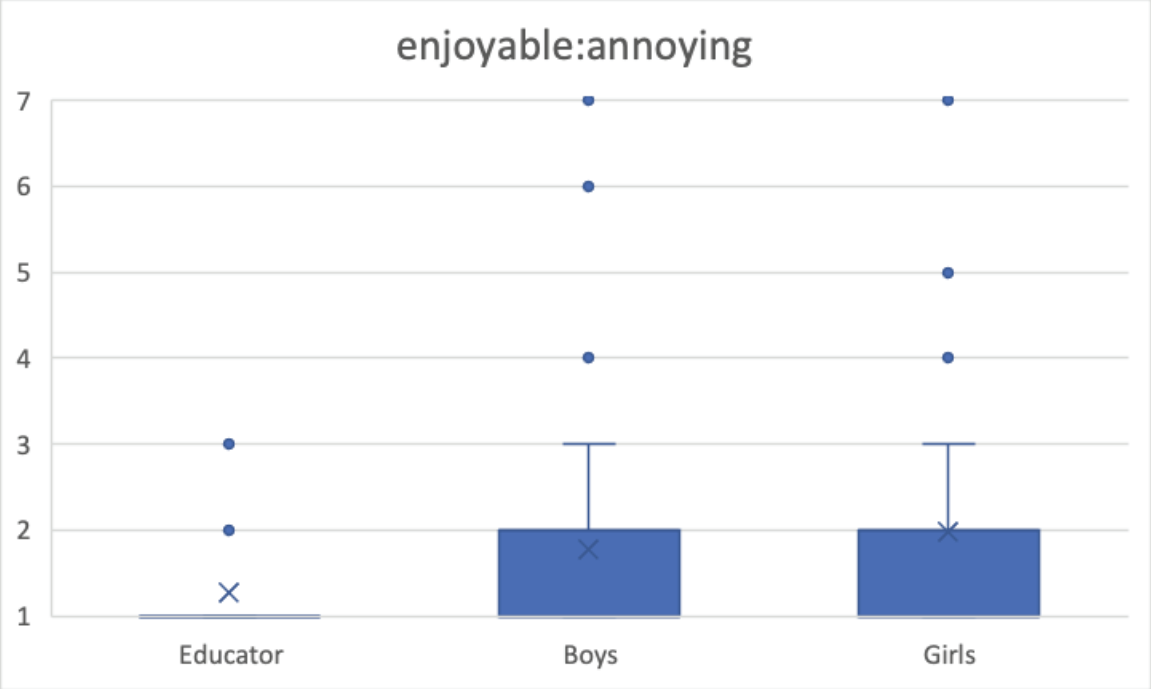

Figure 4.9 - Box and Whisker plot - “enjoyable vs. annoying”

The question “Please assess your attitude toward Simulator Experience Learning by selecting the circle that most closely reflects your current impression” was answered on a 7-point scale of “1” being completely “enjoyable” and “7” being completely “annoying”. The educators had a mean of 1.27 and a standard deviation of 0.65. The boys had a mean of 1.78 and a standard deviation of 1.66. The girls had a mean of 1.99 and a standard deviation of 1.49. Each group mostly answered that the ICE simulator was “enjoyable”.

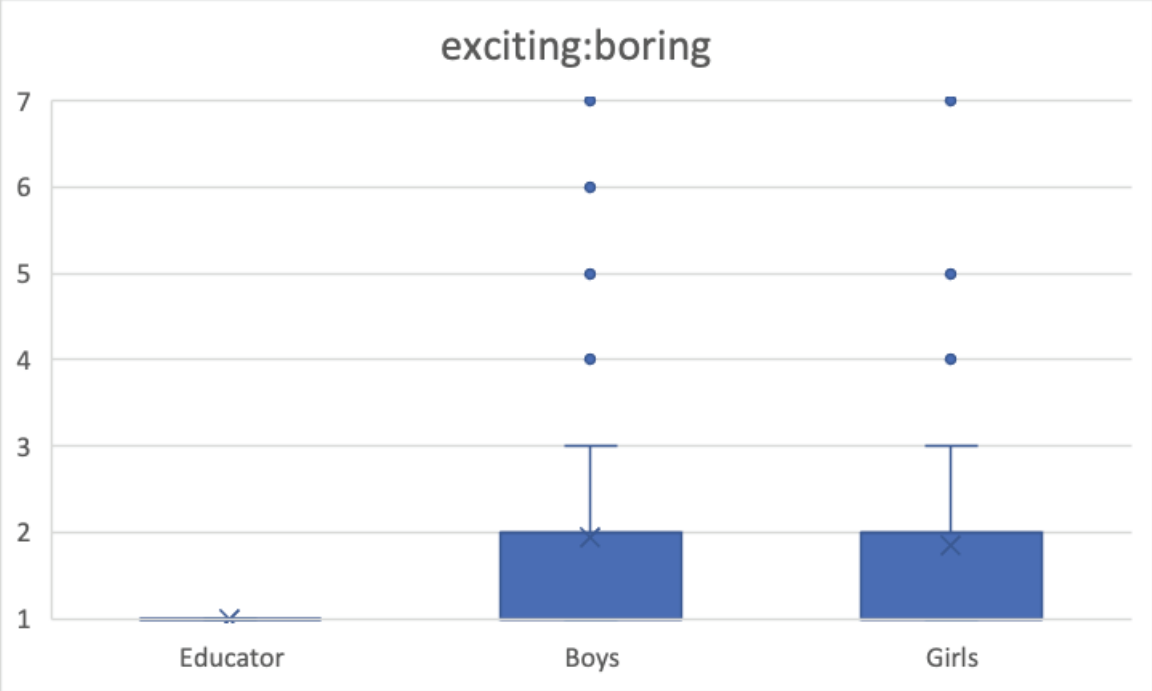

Figure 4.10 - Box and Whisker plot - “exciting vs. boring”

The question “Please assess your attitude toward Simulator Experience Learning by selecting the circle that most closely reflects your current impression” was answered on a 7-point scale of “1” being completely “exciting” and “7” being completely “boring”. The educators had a mean of 1.00 and a standard deviation of 0.00. The boys had a mean of 1.94 and a standard deviation of 1.61. The girls had a mean of 1.86 and a standard deviation of 1.33. Each group mostly answered that the ICE simulator was “exciting”.

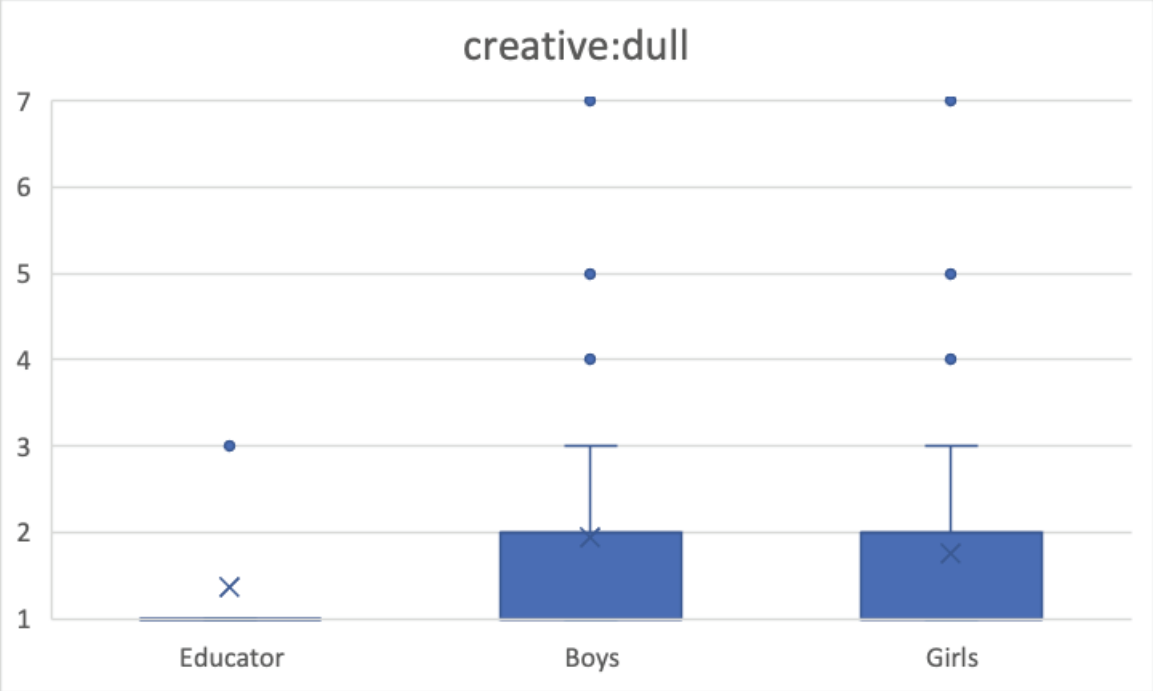

Figure 4.11 - Box and Whisker plot - “creative vs. dull”

The question “Please assess your attitude toward Simulator Experience Learning by selecting the circle that most closely reflects your current impression” was answered on a 7-point scale of “1” being completely “creative” and “7” being completely “dull”. The educators had a mean of 1.36 and a standard deviation of 0.81. The boys had a mean of 1.94 and a standard deviation of 1.56. The girls had a mean of 1.75 and a standard deviation of 1.17. Each group mostly answered that the ICE simulator was “creative”.

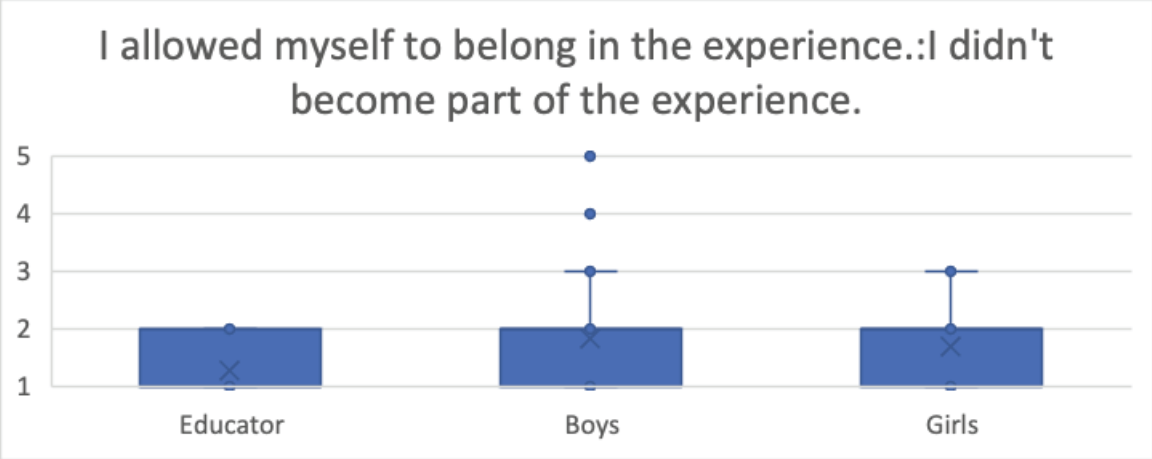

Figure 4.12 - Box and Whisker plot - "I allowed myself to belong in the experience. vs. I didn't become part of the experience."

The question regarding allowing oneself to belong in the experience versus not to belong in the experience was answered on a 5-point scale of "1" being "I allowed myself to belong in the experience" and "5" being "I didn't become part of the experience". The educators had a mean of 1.27 and a standard deviation of 0.47. The boys had a mean of 1.83 and a standard deviation of 0.99. The girls had a mean of 1.70 and a standard deviation of 0.75. Each group mostly answered that they allowed themselves to belong in the experience.

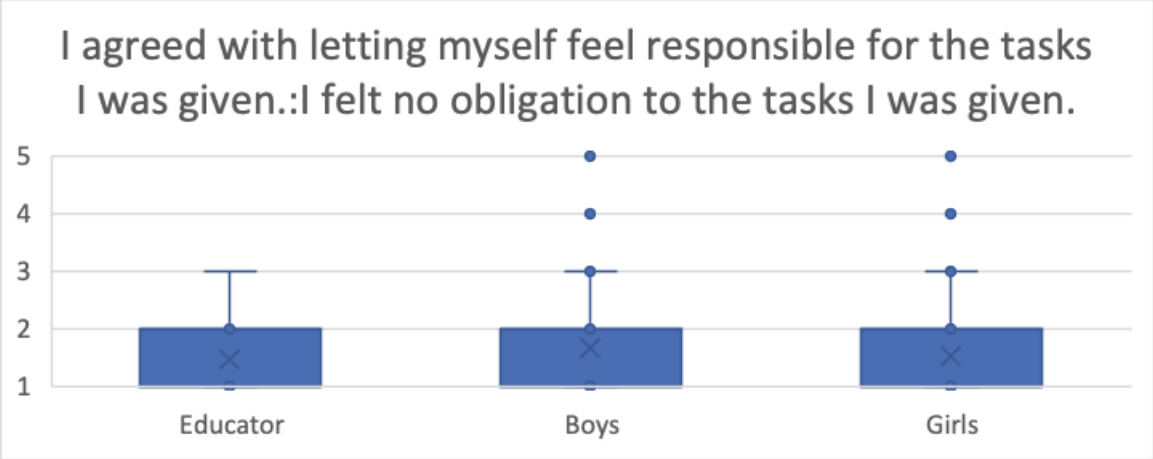

Figure 4.13 - Box and Whisker plot - "Blurred reality and make-believe. vs. Had a distinct separation between reality and make-believe."

The question regarding agreeing to feel responsible for tasks given versus feeling no obligation to tasks given was answered on a 5-point scale of "1" being "I agreed with letting myself feel responsible for the tasks I was given" and "5" being "I felt no obligation to the tasks I was given". The educators had a mean of 1.45 and a standard deviation of 0.69. The boys had a mean of 1.67 and a standard deviation of 1.07. The girls had a mean of 1.52 and a standard deviation of 0.90. Each group mostly answered that they agreed to letting themselves feel responsible for the tasks given.

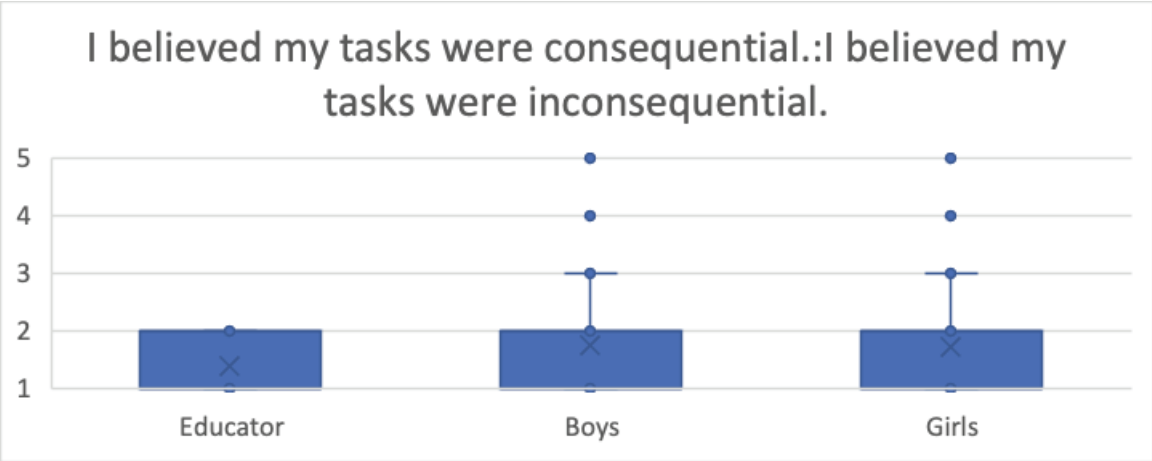

Figure 4.14 - Box and Whisker plot - "I believed my tasks were consequential. vs. I believed my tasks were inconsequential."

The question regarding believing tasks were consequential versus believing tasks were inconsequential was answered on a 5-point scale of "1" being "I believed my tasks were consequential" and "5" being "I believed my tasks were inconsequential". The educators had a mean of 1.36 and a standard deviation of 0.51. The boys had a mean of 1.74 and a standard deviation of 1.11. The girls had a mean of 1.71 and a standard deviation of 0.97. Each group mostly answered that they agreed that their tasks were consequential.

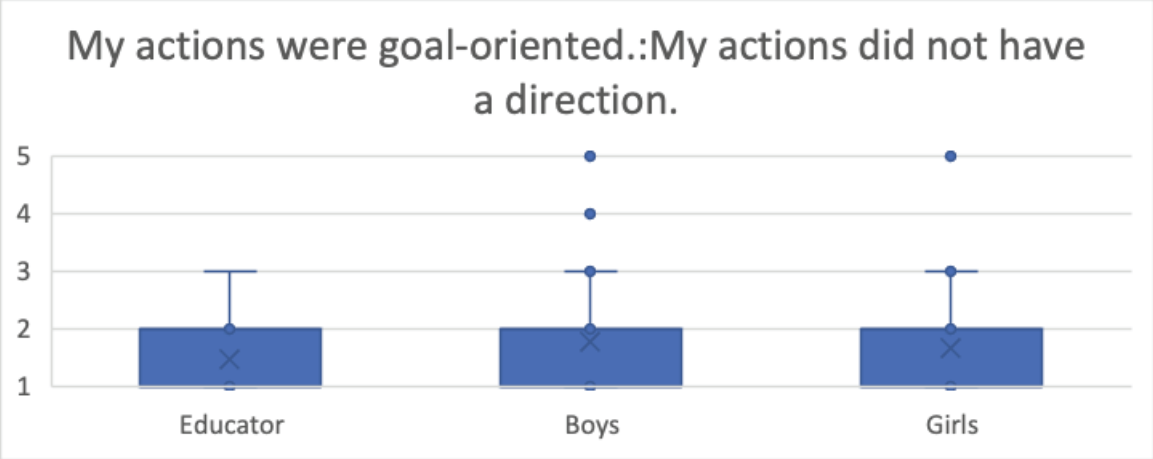

Figure 4.15 - Box and Whisker plot - “My actions were goal-oriented. vs. My actions did not have a direction.”

The question regarding actions being goal-oriented versus actions not having a direction was answered on a 5-point scale of “1” being “My actions were goal-oriented” and “5” being “My actions did not have a direction”. The educators had a mean of 1.45 and a standard deviation of 0.69. The boys had a mean of 1.75 and a standard deviation of 1.16. The girls had a mean of 1.65 and a standard deviation of 1.04. Each group mostly answered that their actions were goal oriented.

4.2 Evaluation

An evaluation is presented as to the differences occurring in the survey responses of the participants of the ICE. A focus is again placed on questions that showed a statistically significant difference.

4.2.1 “I feel confident in my ability to USE new technologies”

Some reasons that the educators had almost unanimous agreement to being confident in their ability to use new technologies could be that they were generally from computer related fields. A purpose of the camp was to learn how to teach new technologies. Also, being in a computer related field generally means that you often interact with new technologies. Regarding the ICE, these educators might have also been very confident in adapting to the tools and technologies used in the simulated environment. Prior skills or experience may have made the transition into the technologies of the simulated environment simple. Age might also be a factor as educators have had more chances and opportunities to run into and use new technologies.

The youth may have expressed less confidence in using new technologies as they have had less time learning and using new technologies. Although, this idea may counter the position that the upcoming generation are digital natives and are natural at using technologies. In a former study on the comparison of before and after the ICE the participants rated that they were more confident in their ability to use new technologies after being trained on and using the new technologies in the experience (Snyder 2018).

This suggests that the more opportunity an individual has to use new technologies, the more confident they become at using them in the future.

4.2.2 "How likely do you think you could complete cybersecurity tasks on your own?"

The results from this question become even more interesting when compared with the question: "How likely do you think you could complete cybersecurity tasks on a team?". All groups gave confident answers if they were in a team versus less confident answers when being on their own. It looks like all team members are more confident completing cybersecurity tasks if they are a part of a team. This could be due to the cumulative experience team members bring together when facing challenges. Certain team members may bring expertise or at least some unique knowledge that one individual does not have on their own. This is reflective of effective cybersecurity teams working in the field. A cybersecurity team is better able to fend off a malicious attack if there are more members of the team that have the chance to use their experience to identify threats.

The educators may have been the most confident in competing cybersecurity challenges on their own because of their experience in tackling many tasks throughout their life. Age and experience likely gave the educators the belief that they can accomplish what they set out to do. These educators may also deal with technology challenges in their careers and have had continual confidence in completing technological challenges.

The greater confidence in the boys over the girls in completing cybersecurity tasks may be attributed to the STEM gender gap. Society may afford boys to have more confidence in completing cybersecurity challenges. Perhaps girls in this age range also have less confidence overall. Also, it is possible that the teaching experience during the camp for the girls afforded less confidence in completing cybersecurity tasks individually. It's possible the girls were more distracted during the camp classes, maybe due to distraction within friend groups.

4.2.3 "I accepted the experience was part of life. vs. I thought the experience was make believe."

The large difference between educators and youth in believing the experience was part of life or make-believe can likely be attributed to age. Age has been associated with lower creativity and being more grounded in reality (Gopnik Alison et al., 2017). The ability of educators to make-believe or play pretend may be lower than that of the youth. The educators may have also had a harder time integrating themselves inside the ICE. They may have been able to see past the story or plot and put a greater focus on the tasks and challenges that needed to be solved. The lack of believing the experience was part of life may have taken away from the gamification elements intended to motivate participants. This difference may also be attributed to the possibility that educators came into the ICE with better cybersecurity skills, making the learning curve and challenges too easy.

Both the girls and the boys had significant differences to the educators in their belief that the experience was part of life. This may be attributed to their young age.

Youth can be more open when encountering new life experiences and often embrace new games. They also have not worked in full-time jobs and may better believe that the role they took in the ICE could be a real job. If they have less experience in cybersecurity concepts or technology skills compared to the educators, perhaps believing in the experience provided extra motivation that led to greater problem solving. They also may have felt that the experience was real because their actions in the game had consequences, even if these consequences were contained in the game, feeling more lifelike. The ICE was likely challenging but very engaging for the youth, leaving reinforced memories and leading to later discussions about the experience with their peers.

4.2.4 "I thought the environment was an extension of my life. vs. I thought the environment was contained in the game."

The educators may have thought the environment was contained in the game for many of the same reasons that they thought the game was make-believe. They likely had a hard time putting themselves into the experience of being on a Star Trek bridge solving a mission in space. They might have thought the roles or characters were fictitious and unlike any full-time job. They may have seen the story and plot as a wrapper for the cybersecurity challenges and may have thought that the ICE was just adding overhead to teaching/testing the intended learning outcomes. Being older may be related with less ability or desire to make-believe which may have hindered the benefits of gamification in this experience. Educators also may have been thinking about how they could implement aspects of the simulator into their classrooms and curriculum when answering.

Both the boys and the girls more starkly answered that they believe the ICE environment was an extension of their life. This may be that youth have more ability to put themselves into and to believe in the story or plot of a simulation/escape room environment. The youth probably felt the live-action experience was inspiring, thrilling, and exciting, leading to a desire for the environment to be an extension to life. The imagination of the youth is likely greater than that of adulthood. This may lead to a more motivating and satisfying experience. Being able to extend the environment into life and take on the roles and challenges given likely lead to taking the experience seriously. The imagination of youth may make simulation/escape room based learning more suited to them.

4.2.5 "Blurred reality and make-believe. vs. Had a distinct separation between reality and make-believe."

The educators might have had the view that there was a distinct separation between reality and make-believe in the ICE because of their age. Being older and having more life experience may make reality easier to live in rather than giving into make-believe and temporary scenarios. Adults may also define what is reality and what is make-believe differently than youth do. Maturity may involve defining what is reality and what is make-believe and separating the two clearly. A role of educators may be to instill more reality into students.

The youth may have a natural tendency to blur reality and make-believe. Children seem to be very good at imagining and playing games which seems to be how reality and make-believe are blurred. Blurring the two may make live action/role-playing games

more effective. The youth may have been more engaged in the ICE simulator because they were more willing to blur the line between reality and make-believe.

4.2.6 “How likely are you to have a computer-related career?”

A big reason why educators were almost unanimous in being likely to have a computer-related career is that they already come from computer careers or backgrounds. The BYU Cybersecurity Camp aimed to teach new computer-related technologies and the educators were in attendance to increase their teaching abilities in this area. This question also could have been interpreted with the mindset that many careers today are centered around a computer, and the number of computer-related careers could have been very numerous. Another possibility of this significance is that the educator’s group data was not separated by gender as were the youth’s data. Of the 11 educators in the study, only three were female.

The difference between girls and boys in likelihood of having a computer-related career, even at a computer centered camp, sparks the need for further discussion. The girls may have interpreted a computer-related career to be very narrow and therefore not a fit for their career desires. They may also have different careers in mind than those of the boys. Another aspect is the STEM gender gap that may dissuade girls from pursuing a computer-related career.

4.2.7 “How likely are you to have a cybersecurity-related career?”

One reason the educators might have answered that they were not extremely likely to have a cybersecurity-related career is that they already are in a career. They

might not have been in a cybersecurity related field or considered their current career to only be partly made up of cybersecurity tasks. As educators they may teach cybersecurity concepts to students, but that may not be their main focus. Also, trying out some of the cybersecurity concepts or tasks in the camp may have given the topic a more realistic view in their minds or that it is more complex than portrayed in the movies.

The boys being more likely than the girls to have a cybersecurity-related career might be similar to the reasons for having a computer-related career. The mean for all of the groups went up (meaning less likely) when compared with the computer-related careers. This change between questions could be a natural buffer between having a computer-related career vs a cybersecurity-related career. Not everyone who wants a computer-related career is necessarily interested in the cybersecurity subset of the field. Also, the reason girls were less likely to have a cybersecurity-related career may again be attributed to the STEM gender gap.

4.2.8 Similar Findings

Although there were no significant findings, there are some answers from the survey that appear similar between educators, girls, and boys. These similar results are interesting and are worth discussing.

The answers when asking for likelihood of being able to complete cybersecurity tasks by oneself rather than as a team were striking. The answers were very similar and very confident between the groups when they thought of a team situation. Being in a team increases the self-efficacy of completing cybersecurity tasks for both educators and students. The collective knowledge and skill of those on a team appear to be greater than

that of an individual and look to boost the confidence of everyone. This is likely due to team members having experience or expertise that fills the knowledge gaps of their teammates.

The surveyed groups each answered that the ICE simulator was enjoyable, exciting, and creative rather than annoying, boring, and dull. The participants likely found the ICE a novel educational experience. The briefings, room design elements, and story likely aided participants in having an enjoyable time. Having cybersecurity challenges as obstacles that halted the progress of their story and mission in the ICE brought new pressure to their problem-solving abilities and skills, bringing more excitement upon completion and success. Having a Star Trek simulator as class of the cybersecurity camp was likely seen as creative.

Most of the participants reported that they allowed themselves to belong in the experience, let themselves feel responsible for their tasks, believed their tasks were consequential, and thought their actions were goal oriented. Each participant reported similar answers to these elements of the ICE. Many of the students may have enjoyed becoming a part of the storyline and assuming a position with important duties pertaining to their mission. Challenging tasks that helped or hindered the mission likely engaged many of the participants. The educators likely had the mindset of how the ICE elements could be used in their own teaching methods and put themselves in the shoes of students as they participated in the experience.

5 Conclusion

5.1 Summary of Thesis Achievements

Education through escape room/simulation-based learning led to differences between the three demographics of participants in the 2021 BYU Cybersecurity camp. Significant differences were identified between the students and the educators regarding confidence in one's ability to use new technologies, accepting the experience as part of life versus thinking the experience was make-believe, thinking the experience was an extension of life versus thinking the experience was contained in the game, and reality and make-believe were blurred versus a separation between reality and make-believe. Significant differences were identified between the boys and the girls regarding, likelihood of completing cybersecurity tasks on one's own, likelihood of pursuing a computer related career, and likelihood of pursuing a cybersecurity related career. Overall, the simulator experience had a different effect on the three surveyed demographics, most notably in the youth versus the educators.

5.2 Applications

Differences were identified between the youth and the educator participants of the camp. This was evident in the questions relating to accepting the experience as part of life, thinking the experience was an extension of life, and blurring reality and make-believe. Educators seem to think the experience is not so much an extension to life while youth may think that it could be. Age may be a factor into the effectiveness of

simulator/escape room-based learning. Educators trying to understand the ICE in a way in which they could take the teaching concepts back to their own classrooms and apply them to their curriculums may have influenced their answers. However, identified differences between educators and youth may suggest adults learn less effectively than youth through the ICE.

Boys are more likely than girls to go into a computer or cybersecurity-related field and this may be due to the STEM gender gap. Even at a STEM and cybersecurity-oriented camp that likely drew individuals who were at least somewhat interested in computers as a future career, less girls than boys reported that they were likely to enter a computer-related field. This may be due to stereotypes that STEM jobs are typically filled by men. Parents also may be suggesting to their children to pursue a certain career that will bring them the most success. Also, the youth might believe their passions and skills are elsewhere. Many youth want to be good at what they do and to use their skills to help others, and a computer-related career may not fulfill that desire.

Some similarities were identified between all the youth and the educator participants of the camp. Being on a team increased confidence in completing cybersecurity tasks. Most participants agreed that they thought the ICE was enjoyable, exciting, creative, valuable, motivating, practical, and innovative. Most also agreed that they allowed themselves to belong in the experience, become a character in the experience, felt responsible for the tasks they were given, and believed their tasks were consequential. In addition, agreement between the groups included believing that they were a contributor, that they had many choices, had goals to follow, and that they could change what occurred.

5.3 Future Work

There was a low number of educators that participated in the camp and survey and participants chose to come to the 2021 BYU Cybersecurity Camp rather than being randomly selected. Only 11 educators were surveyed. Survey results with a greater number of educators would increase the efficacy of data. This same study could be completed on participants that are randomly selected and with a greater recruitment of educators.

Questions regarding one's confidence in a topic may be more related to one's self-efficacy rather than being an actual measure. Confidence may be a fine indicator, however, in many cases actual ability or skill would be a better measure. For example, girls had a significantly lower difference than boys in their reported confidence in completing cybersecurity challenges. However, measured ability would likely provide better data to compare boys and girls. Another study could put more focus on graded cybersecurity challenges. This would allow comparing how an individual scores to their beliefs about how they think they scored or how well they think they can complete cybersecurity challenges. This would afford more insight to the connection between one's confidence and actual skill, especially for students.

Because of the differences between educators and students regarding accepting the experience as a part of life and blurring reality and make-believe, more information should be obtained about the efficacy of simulation/escape-room based learning and how much an individual believes in or is a part of the experience. The striking difference in educators and students in how much they believed the experience was or was not part of

life may have implications into the effectiveness of this type of learning. Great consideration should be taken into understanding if believing the experience is part of or extension of life is a key component to learning motivation. If so, simulation/escape-room based learning may not be as effective for adults as it is for youth.

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Appendix A - Survey

Start of Block: Intro

My name is James Lakko, I am an undergraduate student at Brigham Young University and I am conducting this research under the supervision of Professor Justin Giboney, a faculty member in the IT and Cybersecurity program. You are being invited to participate in this research study of cybersecurity educational experiences. I am interested in finding out how effective different educational experiences are. Your participation in this study will require you to experience a cybersecurity educational simulation and then complete the survey which should take no more than 10 minutes of your time. Your participation will be anonymous and you will not be contacted again in the future. You will not be paid for being in this study. This survey involves minimal risk to you. The benefits, however, may impact society by helping increase knowledge about how to more effectively learn cybersecurity concepts. You do not have to be in this study if you do not want to be. You do not have to answer any question that you do not want to answer for any reason. We will be happy to answer any questions you have about this study. If you have further questions about this project or if you have a research-related problem you may contact me, James Lakko at james_lakko@byu.edu my advisor, Justin Giboney, at justin_giboney@byu.edu.
Research title: Exploring the Discipline of Wonder Through Active Participation CybersecurityIRB ID#: IRB2021-218 If you have any questions about your rights as a research participant you may contact the Human Research Protections Program irb@byu.edu or (801) 422-1461. The IRB is a group of people who review research studies to protect the rights and welfare of research participants. The completion of this survey implies your consent to participate. If you choose to participate, please complete the survey. Thank you!

End of Block: Intro

Start of Block: Both Survey Questions

Q10 I feel confident in my ability to LEARN new technologies.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q11 I feel confident in my ability to USE new technologies.

- Strongly agree
- Somewhat agree

- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q14 How likely are you to have a computer-related career?

- ○ Extremely likely
- ○ Somewhat likely
- ○ Neither likely nor unlikely
- ○ Somewhat unlikely
- ○ Extremely unlikely

Q15 How likely are you to have a cybersecurity-related career?

- ○ Extremely likely
- ○ Somewhat likely
- ○ Neither likely nor unlikely
- ○ Somewhat unlikely
- ○ Extremely unlikely

Q16 How likely do you think you could complete cybersecurity tasks on your own?

- ○ Extremely likely
- ○ Somewhat likely
- ○ Neither likely nor unlikely
- ○ Somewhat unlikely
- ○ Extremely unlikely

Q17 How likely do you think you could complete cybersecurity tasks on a team?

- ○ Extremely likely
- ○ Somewhat likely
- ○ Neither likely nor unlikely
- ○ Somewhat unlikely
- ○ Extremely unlikely

Q12 Please assess your attitude toward **Simulator Experience Learning** by selecting the circle that most closely reflects your current impression

	1	2	3	4	5	6	7	
	1	2	3	4	5	6	7	
enjoyable	○	○	○	○	○	○	○	annoying
exciting	○	○	○	○	○	○	○	boring
creative	○	○	○	○	○	○	○	dull
valuable	○	○	○	○	○	○	○	inferior
motivating	○	○	○	○	○	○	○	demotivating

practical	○	○	○	○	○	○	○	impractical
innovative	○	○	○	○	○	○	○	conservative
leading edge	○	○	○	○	○	○	○	usual

Q18 The next statements are about your interaction with the game. Rate how much you agree or disagree with the following statements about the game:

During my interaction...

	1	2	3	4	5	
I accepted that I was part of the experience.	○	○	○	○	○	The experience was external to me.
I allowed myself to belong in the experience.	○	○	○	○	○	I didn't become part of the experience.
I embraced being a member of the experience.	○	○	○	○	○	I remained a bystander in the experience.
I welcomed becoming a character inside the experience.	○	○	○	○	○	I was merely controlling a character.

I recognized characters as real people.	○	○	○	○	○	I treated characters as fictional.
I let my actions be part of the experience.	○	○	○	○	○	I kept my actions external to the experience.
I agreed with letting myself feel responsible for the tasks I was given.	○	○	○	○	○	I felt no obligation to the tasks I was given.
I enjoyed letting myself believe I was part of the story.	○	○	○	○	○	I didn't feel part of the story.
I empowered myself to make-believe.	○	○	○	○	○	I didn't suspend reality.
I let the experience become part of me.	○	○	○	○	○	I kept the experience separate from me.
I played pretend during the experience.	○	○	○	○	○	I did not play pretend during the experience.
The interfaces helped me feel believe in the experience.	○	○	○	○	○	The interfaces made me feel like I was on the outside looking into the experience.
It was easy to believe the experience was real.	○	○	○	○	○	It was hard to believe the experience was real.

I accepted the experience was part of life.	○	○	○	○	○	I thought the experience was make believe.
I believed the veracity of the story.	○	○	○	○	○	I thought the story was imaginary.
I felt the other characters were other people.	○	○	○	○	○	I felt the characters were computer-generated.
I presumed my tasks affected people's lives.	○	○	○	○	○	I presumed my tasks did not affect others.
I thought the environment was an extension of my life.	○	○	○	○	○	I thought the environment was contained in the game.
The interfaces connected me to actual systems in the world.	○	○	○	○	○	The interfaces were simulated.
It was an illusion.	○	○	○	○	○	It was factual.
Was non-fiction.	○	○	○	○	○	Was fiction.
Blurred reality and make-believe.	○	○	○	○	○	Had a distinct separation between reality and make-believe.
I believed my tasks were consequential.	○	○	○	○	○	I believed my tasks were inconsequential.

I assumed I was a contributor to what was happening.	○	○	○	○	○	I assumed I was an observer.
I had many choices.	○	○	○	○	○	I had few choices.
My actions were goal-oriented.	○	○	○	○	○	My actions did not have a direction.
Everything was open-ended.	○	○	○	○	○	Everything was scripted.
I had complete freedom.	○	○	○	○	○	I had a narrow path to follow.
I could change what occurred.	○	○	○	○	○	Things just happened.
Characters reacted to what I did.	○	○	○	○	○	Characters were unaware of my actions.
My tasks altered the story.	○	○	○	○	○	My tasks were just tasks to complete.
The interface allowed me to modify my circumstances.	○	○	○	○	○	The interface acted like a television.

End of Block: Both Survey Questions

Start of Block: Pre Survey Questions

Q16 Have you participated an Educational Simulator Experience before this week? (ie. the Christa McAuliffe Space Center, other space center, or other simulation based training)

○ Yes ○ No ○ Not Sure

End of Block: Pre Survey Questions

Start of Block: Demographics

Q5 Are you attending the youth camp or the educator camp?

○ Youth ○ Educator

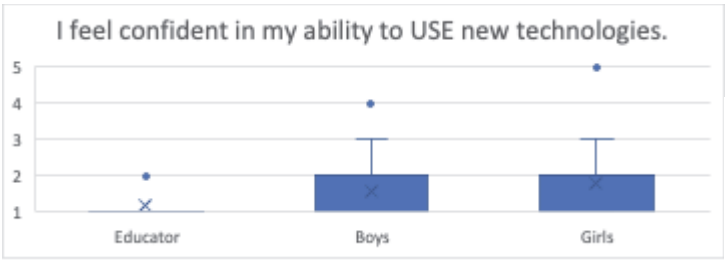
Q11 Select your Sex:

○ Male ○ Female ○ Prefer not to answer

End of Block: Demographics

Appendix B - Survey Data

group	mean	sd
<chr>	<dbl>	<dbl>
Boys	1.54	0.698
Educator	1.18	0.405
Girls	1.67	0.834



group	mean	sd
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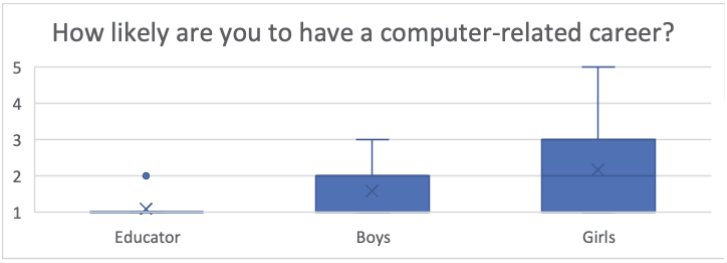
Boys	1.55	0.738
Educator	1.18	0.405
Girls	1.81	0.733



group	mean	sd
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Boys	1.58	0.628
Educator	1.09	0.302
Girls	2.16	1.07

group	mean	sd
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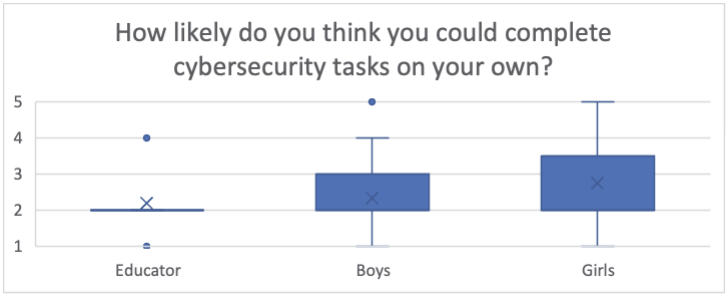
Boys	2.06	0.725
Educator	2.36	1.03
Girls	2.64	1.15



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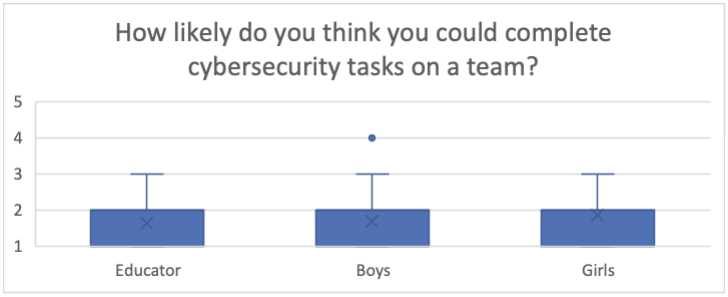
Boys	2.32	0.831
Educator	2.18	0.982
Girls	2.74	1.07



group	mean	sd
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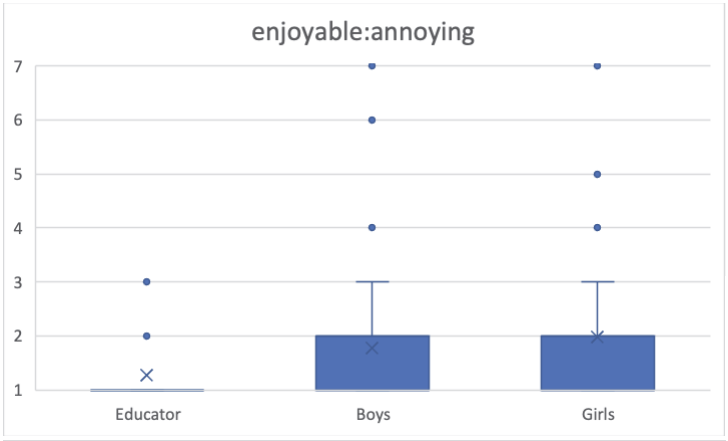
Boys	1.68	0.757
Educator	1.64	0.674
Girls	1.84	0.816

Please assess your attitude toward Simulator Experience Learning by selecting the circle that most closely reflects your current impression



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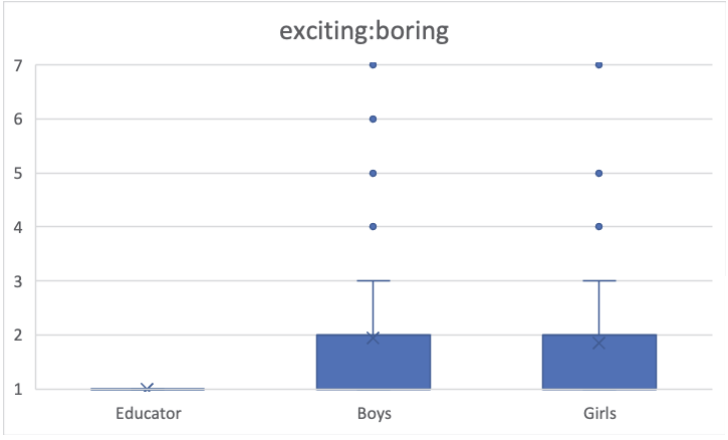
Boys	1.78	1.66
Educator	1.27	0.647
Girls	1.99	1.49



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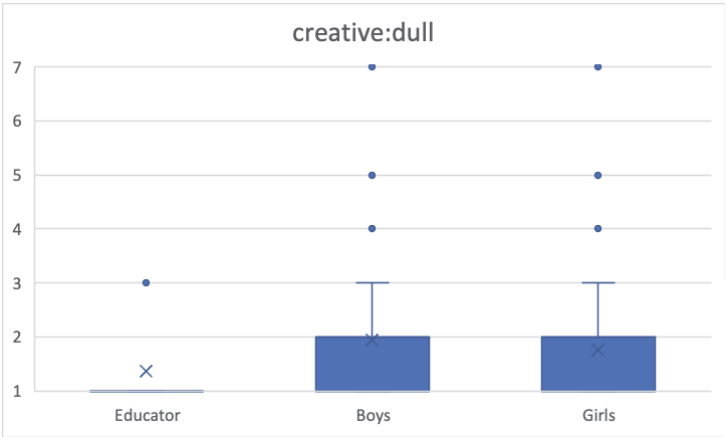
Boys	1.94	1.61
Educator	1	0
Girls	1.86	1.33



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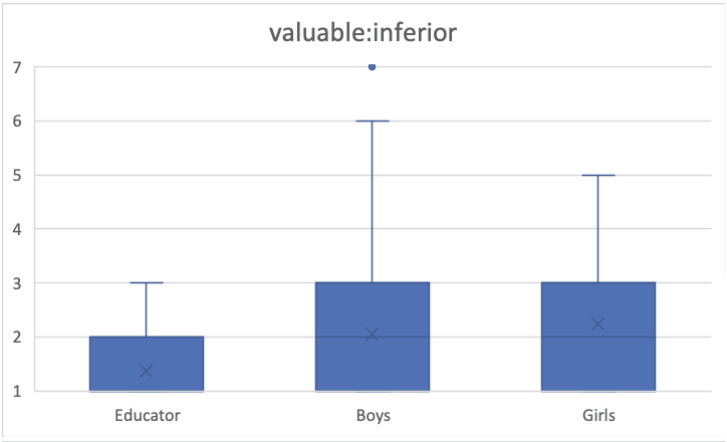
Boys	1.94	1.56
Educator	1.36	0.809
Girls	1.75	1.17



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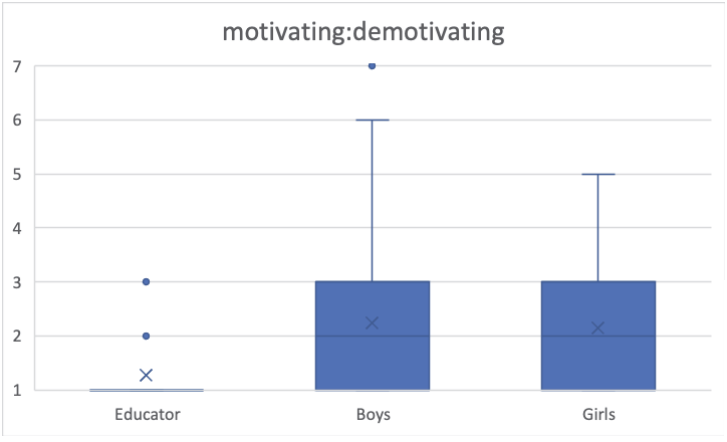
Educator	1.36	0.674
Girls	2.23	1.34



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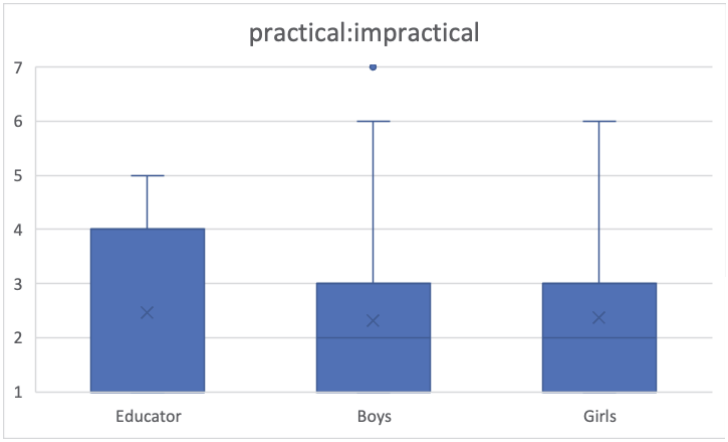
Boys	2.23	1.65
Educator	1.27	0.647
Girls	2.14	1.31



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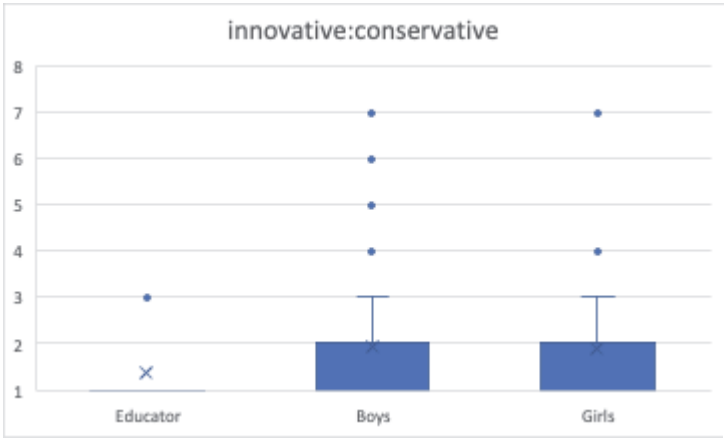
Boys	2.32	1.68
Educator	2.45	1.75
Girls	2.36	1.49



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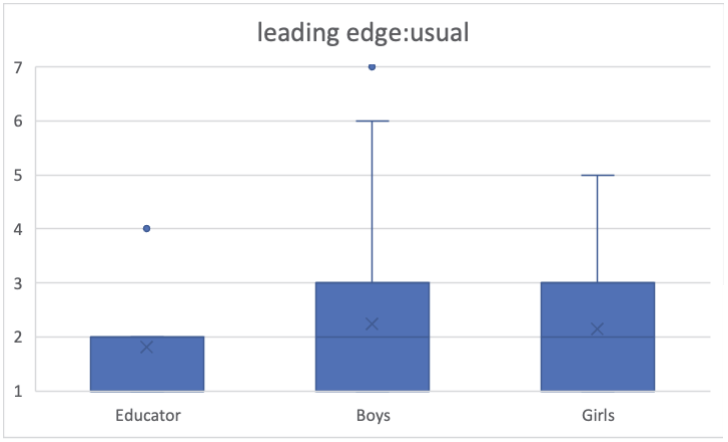
Boys	1.93	1.43
Educator	1.36	0.809
Girls	1.88	1.19



group	mean	sd
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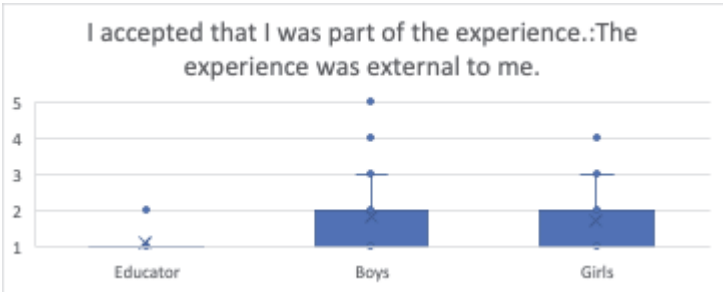
Boys	2.23	1.50
Educator	1.82	1.17
Girls	2.14	1.29

During my interaction...



group	mean	sd
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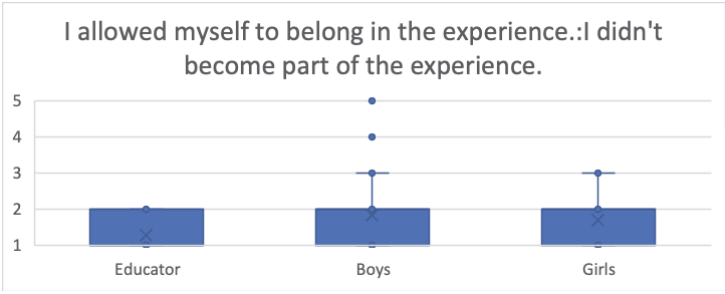
Boys	1.78	1.11
Educator	1.09	0.302
Girls	1.71	0.876



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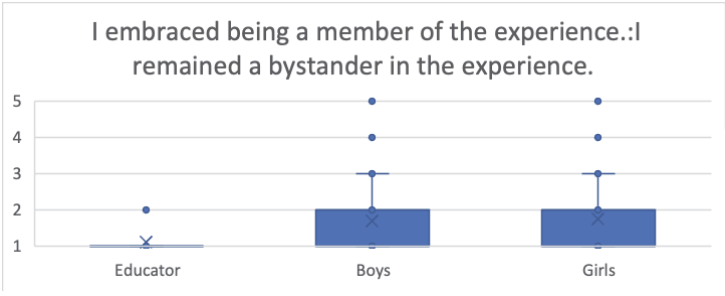
Boys	1.83	0.985
Educator	1.27	0.467
Girls	1.70	0.754



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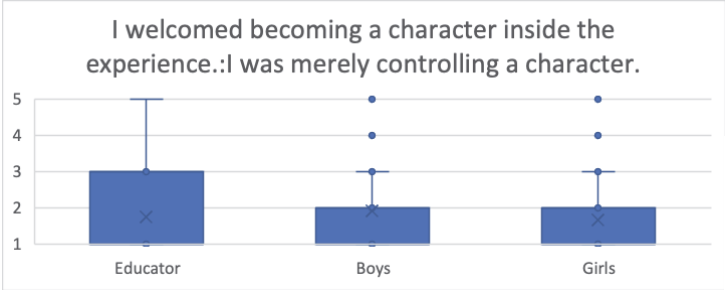
Boys	1.70	1.02
Educator	1.09	0.302
Girls	1.72	1.01



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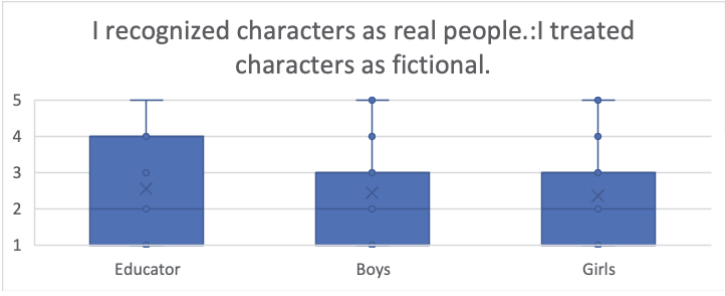
Boys	1.90	1.20
Educator	1.73	1.35
Girls	1.65	0.921



group	mean	sd
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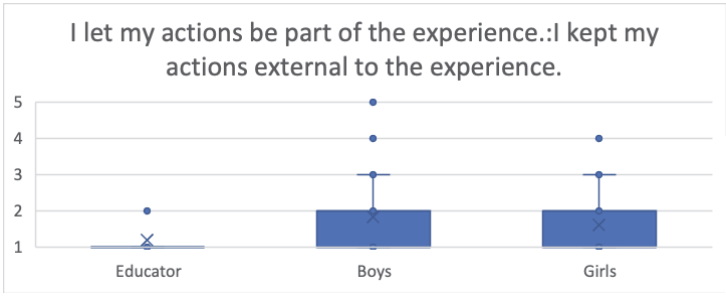
Boys	2.43	1.41
Educator	2.55	1.37
Girls	2.35	1.30



group	mean	sd
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Boys	1.81	1.18
Educator	1.18	0.405
Girls	1.59	0.828

group	mean	sd
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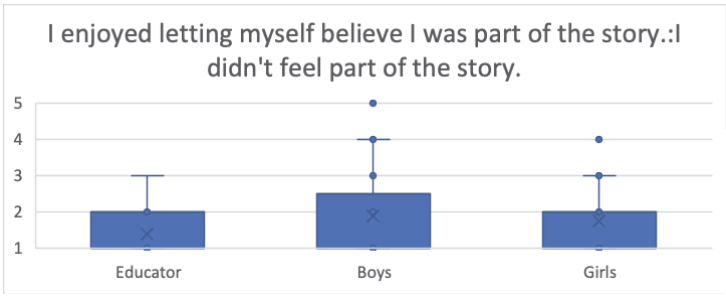
Boys	1.67	1.07
Educator	1.45	0.688
Girls	1.52	0.901



group	mean	sd
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Boys	1.88	1.21
Educator	1.36	0.674
Girls	1.72	0.889

group	mean	sd
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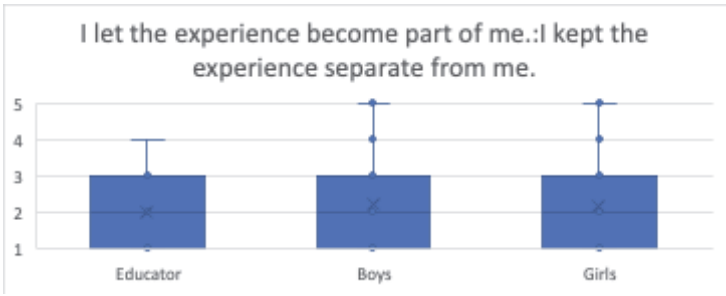
Boys	2.30	1.28
Educator	1.55	0.688
Girls	2.09	1.11



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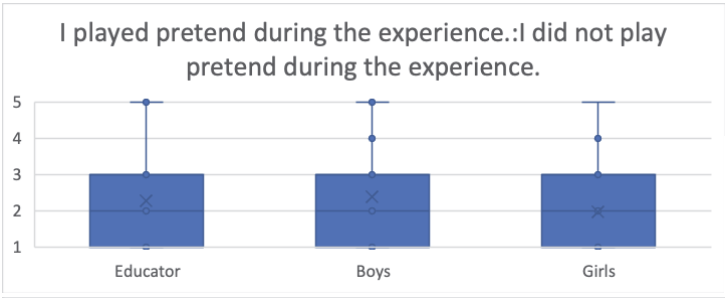
Boys	2.17	1.21
Educator	2	1
Girls	2.14	1.19



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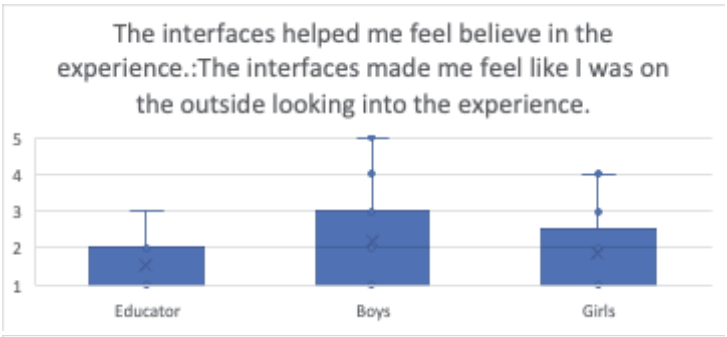
Boys	2.38	1.37
Educator	2.27	1.56
Girls	1.97	1.04



group	mean	sd
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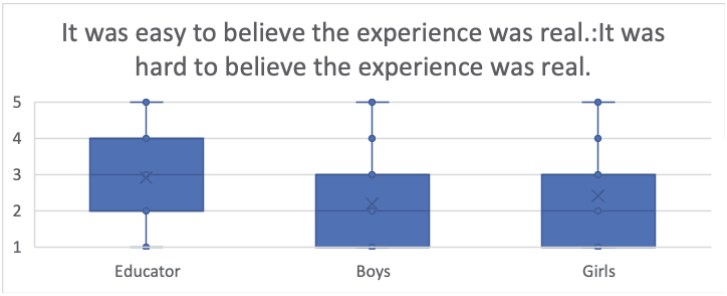
Boys	2.19	1.32
Educator	1.55	0.688
Girls	1.86	0.928



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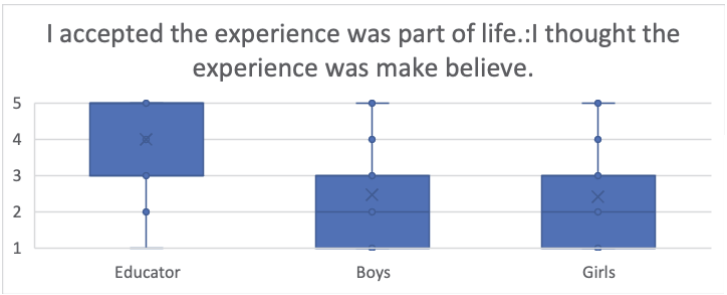
Boys	2.20	1.12
Educator	2.91	1.45
Girls	2.41	1.24



group	mean	sd
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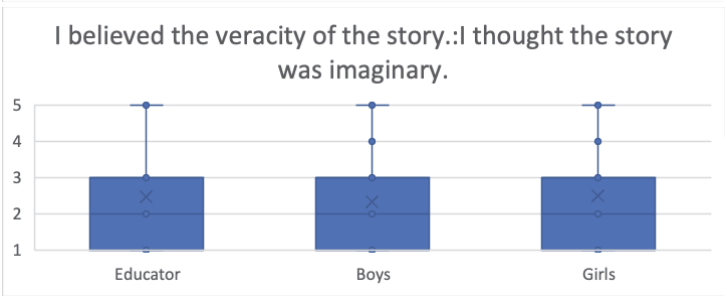
Boys	2.43	1.28
Educator	4	1.41
Girls	2.39	1.26



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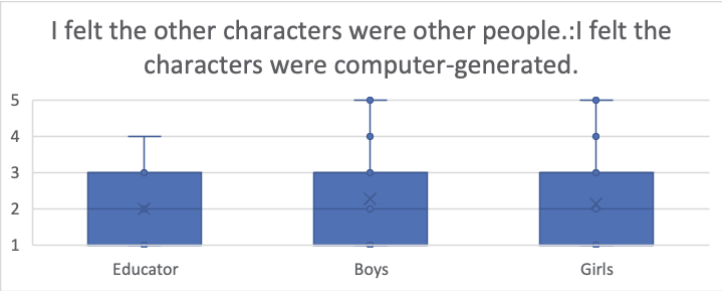
Boys	2.33	1.24
Educator	2.45	1.51
Girls	2.48	1.28



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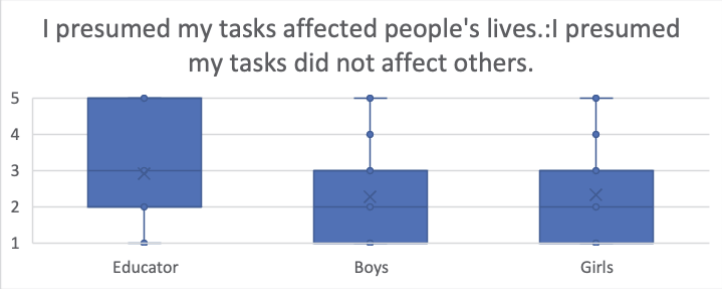
Boys	2.28	1.36
Educator	2	1.10
Girls	2.12	1.22



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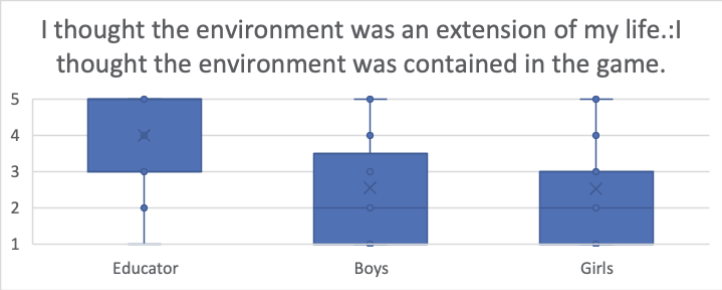
Boys	2.26	1.21
Educator	2.91	1.51
Girls	2.32	1.19



group	mean	sd
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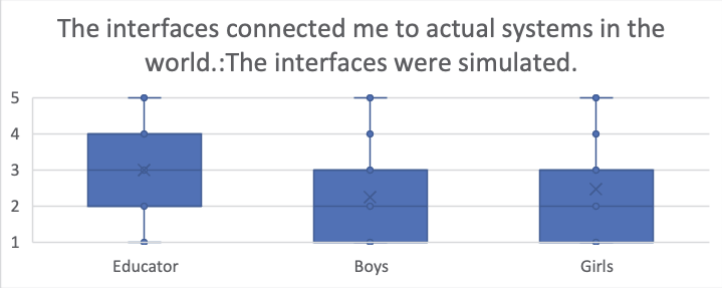
Boys	2.54	1.36
Educator	4	1.41
Girls	2.51	1.34



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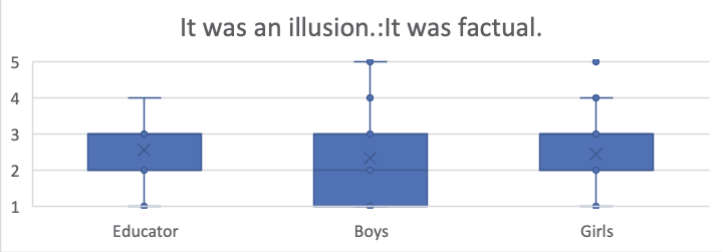
Boys	2.23	1.21
Educator	3	1.48
Girls	2.45	1.21



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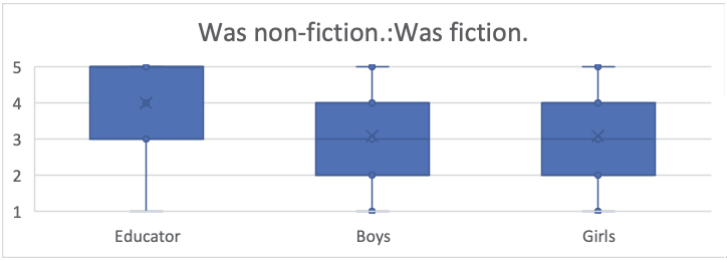
Boys	2.35	1.12
Educator	2.55	0.934
Girls	2.48	1.07



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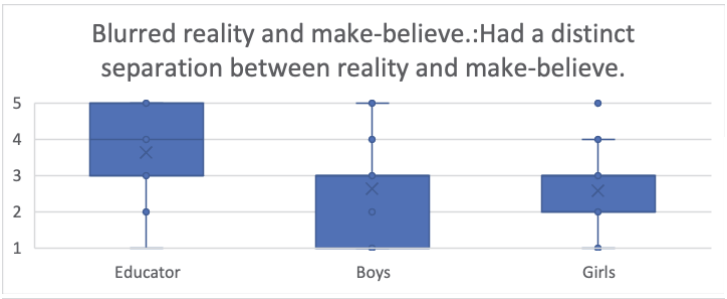
Boys	3.09	1.44
Educator	4	1.34
Girls	3.07	1.34



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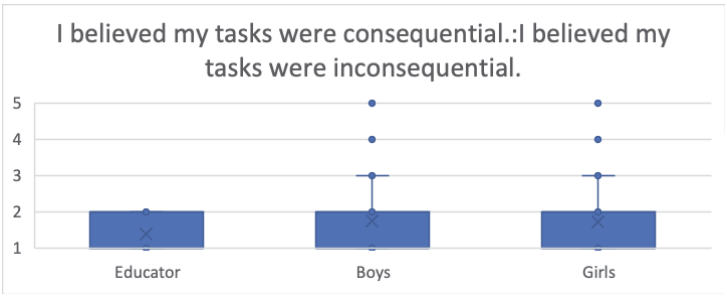
Boys	2.62	1.34
Educator	3.64	1.36
Girls	2.58	1.22



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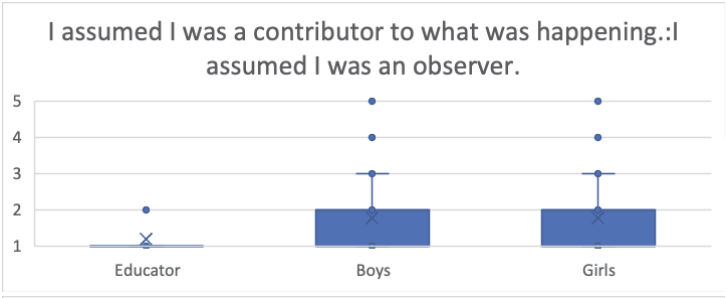
Boys	1.74	1.11
Educator	1.36	0.505
Girls	1.71	0.972



group	mean	sd
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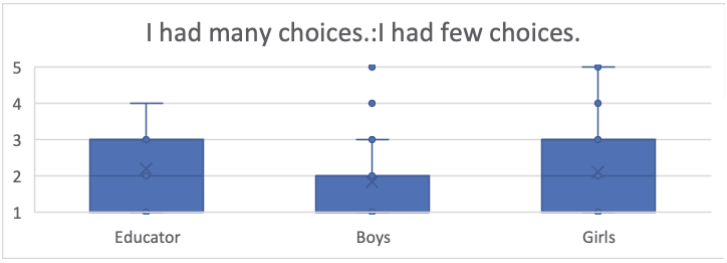
Boys	1.75	1.01
Educator	1.18	0.405
Girls	1.75	0.961



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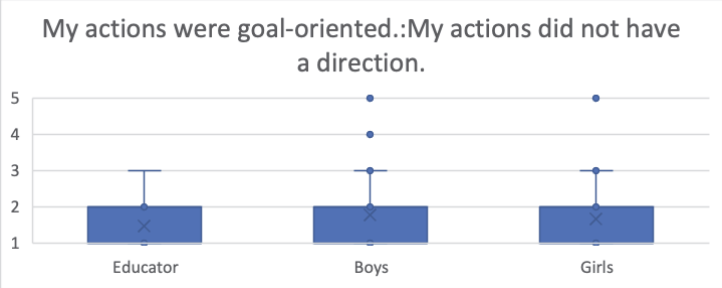
Boys	1.84	1.12
Educator	2.18	1.08
Girls	2.10	1.07



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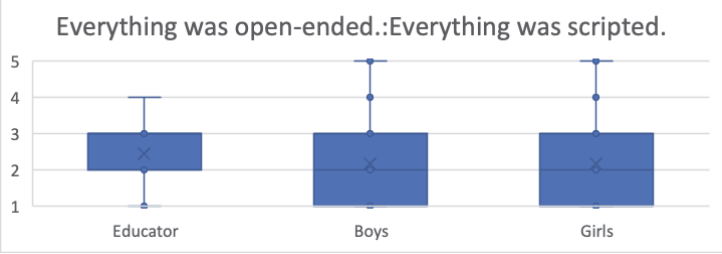
Boys	1.75	1.16
Educator	1.45	0.688
Girls	1.65	1.04



group	mean	sd
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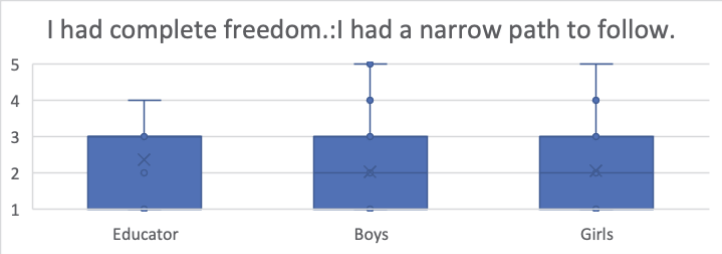
Boys	2.16	1.22
Educator	2.45	0.934
Girls	2.17	1.11



group	mean	sd
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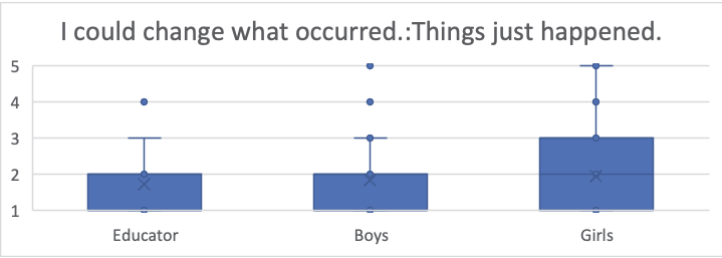
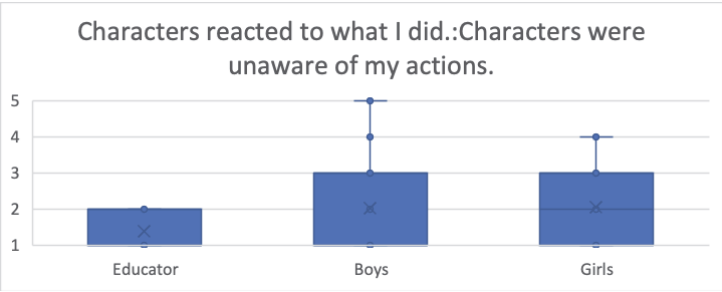
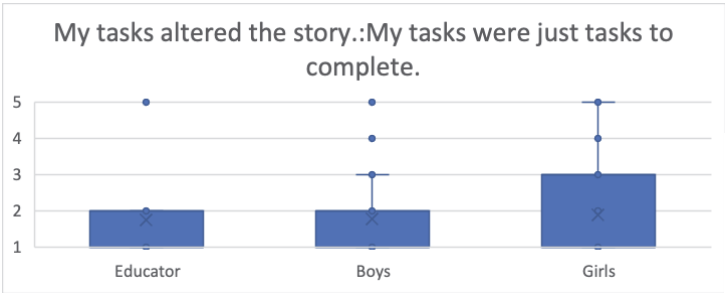
Boys	2.03	1.20
Educator	2.36	1.03
Girls	2.04	1.02



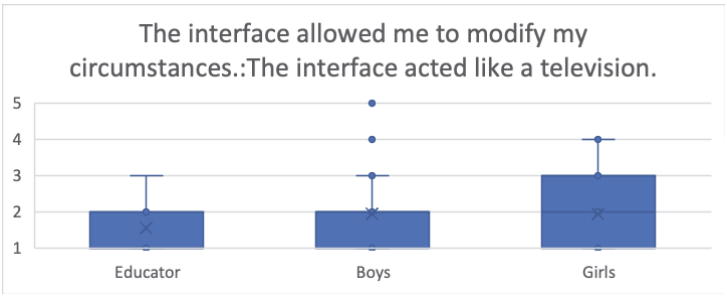
group	mean	sd
<chr>	<dbl>	<dbl>
Boys	1.84	1.22
Educator	1.73	1.01
Girls	1.96	1.08



group	mean	sd
<chr>	<dbl>	<dbl>
Boys	2.01	1.29
Educator	1.36	0.505
Girls	2.04	0.992



group	mean	sd
<chr>	<dbl>	<dbl>
Boys	1.75	1.16
Educator	1.73	1.19
Girls	1.87	1.08



group	mean	sd
<chr>	<dbl>	<dbl>
Boys	1.93	1.13
Educator	1.55	0.688
Girls	1.91	0.887

Appendix C - R Code

```
library(ggplot2)
library(dplyr)
ice_data <- read.csv(file = "~/Downloads/cybersecurity_camp_data.csv")
ice_data %>%
  count(group)

ggplot(ice_data, aes(group, y=learn_tech)) + geom_boxplot()
results <- aov(learn_tech ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(learn_tech),sd=sd(learn_tech))

ggplot(ice_data, aes(group, y=use_tech)) + geom_violin()
ggplot(ice_data, aes(group, y=use_tech)) + geom_boxplot()
results <- aov(use_tech ~ group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$use_tech, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(use_tech),sd=sd(use_tech))


ggplot(ice_data, aes(group, y=comp_career)) + geom_boxplot()
results <- aov(comp_career ~ group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$comp_career, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(comp_career),sd=sd(comp_career))

ggplot(ice_data, aes(group, y=cyber_career)) + geom_violin()
results <- aov(cyber_career ~ group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$cyber_career, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(cyber_career),sd=sd(cyber_career))

ggplot(ice_data, aes(x=complete_cyber_tasks_own)) +
  geom_histogram(aes(color=group, fill=group), position="dodge", alpha=0.4, bins=5)
ggplot(ice_data, aes(group, y=complete_cyber_tasks_own)) + geom_boxplot()
results <- aov(complete_cyber_tasks_own ~ group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$complete_cyber_tasks_own, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(complete_cyber_tasks_own),sd=sd(complete_cyber_tasks_own))

ggplot(ice_data, aes(group, y=complete_cyber_tasks_team)) + geom_boxplot()
results <- aov(complete_cyber_tasks_team ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(complete_cyber_tasks_team),sd=sd(complete_cyber_tasks_team))

ggplot(ice_data, aes(group, y=enjoyable.annoying)) + geom_boxplot()
results <- aov(enjoyable.annoying ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(enjoyable.annoying),sd=sd(enjoyable.annoying))

ggplot(ice_data, aes(group, y=exciting.boring)) + geom_boxplot()
results <- aov(exciting.boring ~ group, data=ice_data)
```

```
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(exciting.boring),sd=sd(exciting.boring))

ggplot(ice_data, aes(group, y=creative.dull)) + geom_boxplot()
results <- aov(creative.dull ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(creative.dull),sd=sd(creative.dull))

ggplot(ice_data, aes(group, y=valuable.inferior)) + geom_boxplot()
results <- aov(valuable.inferior ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(valuable.inferior),sd=sd(valuable.inferior))

ggplot(ice_data, aes(group, y=motivating.demotivating)) + geom_boxplot()
results <- aov(motivating.demotivating ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(motivating.demotivating),sd=sd(motivating.demotivating))

ggplot(ice_data, aes(group, y=practical.impractical)) + geom_boxplot()
results <- aov(practical.impractical ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(practical.impractical),sd=sd(practical.impractical))

ggplot(ice_data, aes(group, y=innovative.conservative)) + geom_boxplot()
results <- aov(innovative.conservative ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(innovative.conservative),sd=sd(innovative.conservative))

ggplot(ice_data, aes(group, y=leading_edge.usual)) + geom_boxplot()
results <- aov(leading_edge.usual ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(leading_edge.usual),sd=sd(leading_edge.usual))


ggplot(ice_data, aes(group, y=part_of_experience.experience_was_external)) + geom_violin()
ggplot(ice_data, aes(group, y=part_of_experience.experience_was_external)) + geom_boxplot()
results <- aov(part_of_experience.experience_was_external ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(part_of_experience.experience_was_external),sd=sd(part_of_experience.experience_wa
s_external))

ggplot(ice_data, aes(group, y=belong_in_experience.not_part_of_experience)) + geom_boxplot()
results <- aov(belong_in_experience.not_part_of_experience ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(belong_in_experience.not_part_of_experience),sd=sd(belong_in_experience.not_part_o
f_experience))

ggplot(ice_data, aes(group, y=embraced_being_member.remained_bystander)) + geom_boxplot()
results <- aov(embraced_being_member.remained_bystander ~ group, data=ice_data)
summary(results)
```

```
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(embraced_being_member.remained_bystander),sd=sd(embraced_being_member.remained_bys
tander))

ggplot(ice_data, aes(group, y=welcomed_becoming_character.merely_controlling_character)) +
geom_boxplot()
results <- aov(welcomed_becoming_character.merely_controlling_character ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%

summarise(mean=mean(welcomed_becoming_character.merely_controlling_character),sd=sd(welcomed_becoming_
character.merely_controlling_character))

ggplot(ice_data, aes(group, y=recognized_characters_as_real_people.treated_characters_as_fictional)) +
geom_boxplot()
results <- aov(recognized_characters_as_real_people.treated_characters_as_fictional ~ group,
data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(recognized_characters_as_real_people.treated_characters_as_fictional),sd=sd(recogn
ized_characters_as_real_people.treated_characters_as_fictional))

ggplot(ice_data, aes(group, y=actions_part_of_experience.kept_actions_external_to_experience)) +
geom_boxplot()
results <- aov(actions_part_of_experience.kept_actions_external_to_experience ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(actions_part_of_experience.kept_actions_external_to_experience),sd=sd(actions_part
_of_experience.kept_actions_external_to_experience))

ggplot(ice_data, aes(group, y=feel_responsible_for_tasks.felt_no_obligation_to_tasks)) +
geom_boxplot()
results <- aov(feel_responsible_for_tasks.felt_no_obligation_to_tasks ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(feel_responsible_for_tasks.felt_no_obligation_to_tasks),sd=sd(feel_responsible_for
_tasks.felt_no_obligation_to_tasks))


ggplot(ice_data, aes(group, y=believe_was_part_of_story.did_not_feel_part_of_story)) + geom_boxplot()
results <- aov(believe_was_part_of_story.did_not_feel_part_of_story ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(believe_was_part_of_story.did_not_feel_part_of_story),sd=sd(believe_was_part_of_st
ory.did_not_feel_part_of_story))

ggplot(ice_data, aes(group, y=empowered_myself_to_make_believe.did_not_suspend_reality)) +
geom_boxplot()
results <- aov(empowered_myself_to_make_believe.did_not_suspend_reality ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(empowered_myself_to_make_believe.did_not_suspend_reality),sd=sd(empowered_myself_t
o_make_believe.did_not_suspend_reality))

ggplot(ice_data, aes(group, y=let_experience_become_part_of_me.kept_experience_separate)) +
geom_boxplot()
results <- aov(let_experience_become_part_of_me.kept_experience_separate ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
```

```
summarise(mean=mean(let_experience_become_part_of_me.kept_experience_separate),sd=sd(let_experience_be
come_part_of_me.kept_experience_separate))

ggplot(ice_data, aes(group, y=played_pretend.did_not_play_pretend)) + geom_boxplot()
results <- aov(played_pretend.did_not_play_pretend ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(played_pretend.did_not_play_pretend),sd=sd(played_pretend.did_not_play_pretend))

ggplot(ice_data, aes(group,
y=interfaces_helped_believe_experience.interfaces_feel_outside_looking_into_experience)) +
geom_boxplot()
results <- aov(interfaces_helped_believe_experience.interfaces_feel_outside_looking_into_experience ~
group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(interfaces_helped_believe_experience.interfaces_feel_outside_looking_into_experien
ce),sd=sd(interfaces_helped_believe_experience.interfaces_feel_outside_looking_into_experience))

ggplot(ice_data, aes(group, y=easy_to_believe_experience.hard_to_believe_experience)) + geom_boxplot()
results <- aov(easy_to_believe_experience.hard_to_believe_experience ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(easy_to_believe_experience.hard_to_believe_experience),sd=sd(easy_to_believe_exper
ience.hard_to_believe_experience))

ggplot(ice_data, aes(group, y=part_of_life.make_believe)) + geom_boxplot()
results <- aov(part_of_life.make_believe ~ group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$part_of_life.make_believe, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(part_of_life.make_believe),sd=sd(part_of_life.make_believe))

ggplot(ice_data, aes(group, y=believed_veracity_of_story.story_was_imaginary)) + geom_boxplot()
results <- aov(believed_veracity_of_story.story_was_imaginary ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(believed_veracity_of_story.story_was_imaginary),sd=sd(believed_veracity_of_story.s
tory_was_imaginary))

ggplot(ice_data, aes(group, y=characters_were_other_people.characters_were_computer_generated)) +
geom_boxplot()
results <- aov(characters_were_other_people.characters_were_computer_generated ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(characters_were_other_people.characters_were_computer_generated),sd=sd(characters_
were_other_people.characters_were_computer_generated))

ggplot(ice_data, aes(group, y=tasks_affected_people.tasks_did_not_affect_others)) + geom_boxplot()
results <- aov(tasks_affected_people.tasks_did_not_affect_others ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(tasks_affected_people.tasks_did_not_affect_others),sd=sd(tasks_affected_people.tas
ks_did_not_affect_others))

ggplot(ice_data, aes(group, y=environment_was_extension_of_life.environment_was_contained_in_game)) +
geom_boxplot()
results <- aov(environment_was_extension_of_life.environment_was_contained_in_game ~ group,
data=ice_data)
summary(results)
```

```
pairwise.t.test(ice_data$environment_was_extension_of_life.environment_was_contained_in_game,
ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%

summarise(mean=mean(environment_was_extension_of_life.environment_was_contained_in_game),sd=sd(environ
ment_was_extension_of_life.environment_was_contained_in_game))

ggplot(ice_data, aes(group, y=interfaces_connected_me_to_systems.interfaces_were_simulated)) +
geom_boxplot()
results <- aov(interfaces_connected_me_to_systems.interfaces_were_simulated ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(interfaces_connected_me_to_systems.interfaces_were_simulated),sd=sd(interfaces_con
nected_me_to_systems.interfaces_were_simulated))

ggplot(ice_data, aes(group, y=illusion.factual)) + geom_boxplot()
results <- aov(illusion.factual ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(illusion.factual),sd=sd(illusion.factual))

ggplot(ice_data, aes(group, y=non_fiction.fiction)) + geom_boxplot()
results <- aov(non_fiction.fiction ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(non_fiction.fiction),sd=sd(non_fiction.fiction))

ggplot(ice_data, aes(group,
y=blurred_reality_make_believe.distinct_separation_between_reality_and_make_believe)) + geom_boxplot()
results <- aov(blurred_reality_make_believe.distinct_separation_between_reality_and_make_believe ~
group, data=ice_data)
summary(results)
pairwise.t.test(ice_data$blurred_reality_make_believe.distinct_separation_between_reality_and_make_bel
ieve, ice_data$group, p.adj = "bonf")
ice_data %>%
  group_by(group) %>%

summarise(mean=mean(blurred_reality_make_believe.distinct_separation_between_reality_and_make_believe)
,sd=sd(blurred_reality_make_believe.distinct_separation_between_reality_and_make_believe))

ggplot(ice_data, aes(group, y=tasks_were_consequential.tasks_were_inconsequential)) + geom_boxplot()
results <- aov(tasks_were_consequential.tasks_were_inconsequential ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(tasks_were_consequential.tasks_were_inconsequential),sd=sd(tasks_were_consequentia
l.tasks_were_inconsequential))

ggplot(ice_data, aes(group, y=contributor.observer)) + geom_boxplot()
results <- aov(contributor.observer ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(contributor.observer),sd=sd(contributor.observer))

ggplot(ice_data, aes(group, y=many_choices.few_choices)) + geom_boxplot()
results <- aov(many_choices.few_choices ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(many_choices.few_choices),sd=sd(many_choices.few_choices))

ggplot(ice_data, aes(group, y=actions_were_goal_oriented.actions_did_not_have_direction)) +
geom_boxplot()
```

```
results <- aov(actions_were_goal_oriented.actions_did_not_have_direction ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%

summarise(mean=mean(actions_were_goal_oriented.actions_did_not_have_direction),sd=sd(actions_were_goal
_oriented.actions_did_not_have_direction))


ggplot(ice_data, aes(group, y=open_ended.scripted)) + geom_boxplot()
results <- aov(open_ended.scripted ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
  summarise(mean=mean(open_ended.scripted),sd=sd(open_ended.scripted))

ggplot(ice_data, aes(group, y=complete_freedom.narrow_path)) + geom_boxplot()
results <- aov(complete_freedom.narrow_path ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(complete_freedom.narrow_path),sd=sd(complete_freedom.narrow_path))

ggplot(ice_data, aes(group, y=could_change_what_occurred.things_just_happened)) + geom_boxplot()
results <- aov(could_change_what_occurred.things_just_happened ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(could_change_what_occurred.things_just_happened),sd=sd(could_change_what_occurred.
things_just_happened))

ggplot(ice_data, aes(group, y=characters_reacted_to_what_I_did.characters_unaware_of_my_actions)) +
geom_boxplot()
results <- aov(characters_reacted_to_what_I_did.characters_unaware_of_my_actions ~ group,
data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(characters_reacted_to_what_I_did.characters_unaware_of_my_actions),sd=sd(character
s_reacted_to_what_I_did.characters_unaware_of_my_actions))

ggplot(ice_data, aes(group, y=tasks_altered_story.tasks_were_just_to_complete)) + geom_boxplot()
results <- aov(tasks_altered_story.tasks_were_just_to_complete ~ group, data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(tasks_altered_story.tasks_were_just_to_complete),sd=sd(tasks_altered_story.tasks_w
ere_just_to_complete))

ggplot(ice_data, aes(group,
y=interface_allowed_me_to_modify_circumstances.interface_acted_like_television)) + geom_boxplot()
results <- aov(interface_allowed_me_to_modify_circumstances.interface_acted_like_television ~ group,
data=ice_data)
summary(results)
ice_data %>%
  group_by(group) %>%
summarise(mean=mean(interface_allowed_me_to_modify_circumstances.interface_acted_like_television),sd=s
d(interface_allowed_me_to_modify_circumstances.interface_acted_like_television))
```