Department of Electrical, Computer, and Software Engineering

Part IV Research Project

Project Report

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Using games to teach Robo-Ethics

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Declaration of Originality

This report is my own unaided work and was not copied from nor written in collaboration with any other person.

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ABSTRACT: Care robo-ethics is an emerging academic field that investigates the social and ethical consequences of the adoption of care robots in society. Current literature outlines the need to spread awareness in this field among future roboticists to mitigate future damage from care robots. Board games are a proposed medium to help spread awareness in this field as they provide an engaging, collaborative and empathising atmosphere for ethical discussions. This study then aimed to uncover if a board game device could be used to generate constructive in-depth discussions around the topic of care robo-ethics. Through an iterative game design process, the board game device Bot-Makers was created, with the primary aim of the game being to generate constructive inter-player discussions around the care robo-ethics subject. Bot-Makers was formally evaluated with university student participants in a time-constrained environment, and video recordings, observational data and participant questionnaire data were collected from this evaluation session. The evaluation results showed that the board game device was engaging, collaborative and created a healthy environment for ethical discussions and conflicts. Analyses of the data collected found that on-topic discussions were a major component of the gameplay and that the majority of these discussions were deemed sufficiently in-depth to allow players to further their understanding of care robo-ethics. However, due to the small sample size during the evaluation of this study, further testing should be performed with the Bot-Makers game to gain more confidence in its ability to generate constructive in-depth discussions around the care robo-ethics topic area.

Contents

1. Introduction

This report considers the emerging field of robo-ethics and particularly focuses on the ethical implications that arise due to the adaptation of care robots in society. The technological advancements in the field of robotics, coupled with the lack of ethical frameworks around the development of robots, have created a need to raise awareness around this topic among future roboticists. Care robots are the main focus of this study since the users of such devices are often vulnerable persons (children, the elderly and those with cognitive or physical disabilities) that will be more susceptible to the consequences of unethical practices. Existing studies around ethics based board games show the strong pedagogical promise of this domain, with some of the main benefits coming through the collaboration and discussions that arise during games. However, current literature also suggests that there are no existing studies that concentrate on how board games can be used as discussion devices to allow players to experience ethical decision making and its consequences in a care robotics context. Therefore our study hopes to fill this gap of game-based teaching in the topic of care robo-ethics while also investigating the potential of discussion based board games in furthering a student's understanding of this field.

1.1. Research Question

Can board games stimulate constructive in-depth discussions between students regarding robo-ethics in a care robotics context?

- Design a board game to teach robo-ethics, in the context of care robots, in a university classroom setting.
- Evaluate the ability of the prototype board game to stimulate discussion in robo-ethics, in the context of care robots, among the participants.

1.2. Report Layout

This report first starts with the related work section consisting of the current academic outlook in the field of care robo-ethics and puts forward existing studies that analyse the pedagogical potential of board games. After exploring existing literature in these fields, the research question posed in this study is established. The research method section then outlines the procedure followed for this investigation,

with a particular focus on how the board game device used during the evaluation phase was designed. The next section of the report is the experiments and results section which describes how the evaluation of the game was conducted and presents the key findings that resulted from this evaluation. The discussion section then analyses the results achieved in this study and explores how these results compare to other academic work on care robo-ethics and game based learning. The last part of the report is the conclusion section which addresses if this study has sufficiently answered the research question. The conclusion also summarises the future lines of development emerging from this study.

2. Related Work

2.1. Literature Review

2.1.1. Robo-Ethics

Robo-ethics is a multidisciplinary field which studies the ethical and social challenges that arise from the adaptation of robotics in society [1]. The complexity of robots today has led to concerns around job security, software reliability, the destructive potential of robots, over-reliance on robots, loss of privacy, and the degradation of interpersonal relationships in society [2], [3]. Additionally, the general consensus among researchers is that current ethical frameworks built around robots are too simple to prevent robots from causing harm to humans or the environment [4], [5]. Hence, there is a need to spread awareness around the field of robo-ethics which will aid in the progress of developing more ethical robots in the future [5], [6], [7].

2.1.2. Care Robo-Ethics

The study of care robot ethics investigates the consequences of interactions and emotional connections between care robots and humans. This will be the area of focus for this study.

Care robots are robots utilised in hospitals and homes to provide physical and emotional care to vulnerable persons such as the elderly, children and those suffering from physical and mental disabilities [8]. Care robots are used to alleviate pressure from human caregivers (through assistance with manual, repetitive tasks and the monitoring of users' needs) and also provide a safe medium for vulnerable users to seek physical and emotional help [8], [9], [10]. The primary applications of care robots today are healthcare robots, robots for children with learning difficulties, tele-robotics, physical assistance robots

and therapeutic robots [11], [12]. Despite the abundant applications, the introduction of care robots to society also introduces a host of ethical challenges due to the disruptive potential of human-robot interactions [13]. Care robots are particularly dangerous from an ethical point of view compared to other types of robots because their primary users are vulnerable persons that will be less likely to recognise unethical practices employed by the robots [14]-[15].

Research in human-robot interaction already shows that robot artefacts can incite feelings of mutual friendship for the human user; therefore, adding the ability for care robots to stimulate emotional connection could lead to vulnerable users forming unreciprocated emotional attachments with their robot carers [16]. Graaf touches on how humans can form emotional attachments with social robots, especially common in the case of children and older people, and the psychological damage that this may have on the user's ability to form interpersonal relationships [16].

Care robots also create issues around the privacy of sensitive data collected from the user [11]. To allow for their perceptive ability, care robots are given the ability to record, store and analyse sensitive data about their environment and the personal data of their human user [8], [17]. The ability of care robots to form social connections may also lead to the collection of sensitive data becoming imperceptible to the human user under the façade of care maintained by the robot [17]. This leads us to the concept of trust and over-trust in the human-robot relationship [11]. The role, function and appearance of care robots can cause human users to over-trust the intentions of the care robot [8]. Unfortunately, the lack of regulation around the collection of sensitive data from care robots means that the ethical agency of protecting the user's privacy is placed completely on the engineers and designers of care robots [17].

Another important area of ethics that roboticists must respect during the development and implementation of care robots is sustainability. Hoxha *et al*. highlight the necessity of applying sustainability principles to the entire lifecycle of a robot, including its production, maintenance and disposal [18]. Using the triple bottom line definition, sustainability can be split into three lines: environmental, social and economic sustainability [19]. The environmental line is about not compromising the environmental resources of future generations, the social line is about providing value back to the community (both internally through employees and externally through the user base and

society at large), and the economic line adheres to the financial viability and economic contributions of the venture [19]. Roboticists must evaluate how their care robot impacts all of these three lines of sustainability to ensure that they can provide sustained value to society through their robot implementations. Recent studies such as the self-sustainable robot, Scrapino, and the sustainable behaviour robot, GreenLife, are two instances of roboticists strongly advocating sustainability principles through their robot implementations [18], [20].

There are many diverse ethical issues we must consider when designing and utilising care robots in society; however, these issues are disordered, making it difficult to address these challenges [13]. The lack of principles and legal frameworks around the design of care robots has led the ethical agency of care robots to be put entirely on the shoulder of roboticists [8], [9], [13]. Thus far, the lack of accepted frameworks in social robo-ethics, has unfortunately also led to a lack of awareness of the ethical implications of care robots in society, especially compared to the strong surge in use of care robots [5]. Therefore, it would be beneficial to communicate the principles of care robot ethics in a more accessible medium to increase the awareness of this field among future engineers, designers and roboticists.

2.1.3. Game-based learning

Most contemporary approaches to ethics education have a theoretical focus and do not provide practical, context-sensitive ethical reasoning scenarios to students [21]. Games present a medium through which players can explore their internal decision making or empathise with an external role, lending to ethical conundrums naturally arising in gameplay scenarios [22]. Using board games for ethics education can situate students at the centre of an ethical scenario, develop their high-order problem solving skills and allow them to witness the consequences of ethical decision-making in a safe environment [21]. Schrier [22] further adds that board games for ethics education enhance collaborative learning between students and are also highly motivating teaching devices. Therefore, board games are natural vehicles to stimulate ethical conversations between players and can also help establish the importance of ethical behaviour among students [23]. To further the development of board games for education Cardinot *et al*. [24] also present a framework for designing such games.

2.1.4. Case studies for Ethics games

Due to the pedagogical promise of games to teach ethics, there have been a few case studies around the design of games for ethical education in diverse fields [22]. Privacy by Design, a game to teach computer ethics, used a team discussion style game where each player is given a role to fulfil in the design of a privacy policy [25]. Evaluation of the game found that the majority of students found it interesting and a large proportion of students expressed interest in further learning the practical side of ethics relevant to their field [25]. Through their Delta Design game, another team discussion based roleplay game based on industrial design ethics, Lloyd and Poel [26] found that the inter-player discussions and reflections were essential in helping players feel the ethical responsibility in the roles they partook during the game. Hence, current research highlights how the scenario based environments of board games are great vehicles for generating practical ethical reasoning among students. The Grants and Researchers game, a card game to promote research ethics where the goal of players is to earn reputation points, used a more competitive gameplay, where players were constantly tempted with making unethical moves to gain more reputation points [21]. Despite being highly engaging for players, Briggle *et al.* [21] found that due to the black and white nature of the ethical decisions players were required to make, the game's design wasn't sufficiently complex enough to simulate ethical discussions among participants. Therefore, while previous case studies have achieved some of the pedagogical potential of games, researchers also point out the uncertainties of designing games for ethics education, emphasising the challenge of balancing the learning component with the enjoyment component in educational games [24], [27].

2.2. Gaps in Research

The literature review above outlined the importance of the field of care robo-ethics and the main areas of ethical concerns for this topic [9]. Researchers also note the lack of any widely accepted ethical frameworks for developing care robots and the need to raise awareness for care robot ethics among future roboticists [5], [8]. Designing a board game for ethics could be an efficient medium to instigate discussion around care robot ethics in a practical and collaborative environment [23]. Due to the pedagogical potential of board games, few case studies around the effectiveness of ethics games have already been undertaken. The games in these case studies (Privacy by Design, Delta Design and Grants

and Researchers) were each able to stimulate conversations around a particular domain of ethics while also creating an engaging atmosphere for learning [21], [22], [25]. The case studies for all three of the games, however, also pointed out flaws in their game's design, hinting at the uncertainties around the design of ethics education games [21], [22], [25]. Hence, there is value in further investigating the pedagogical potential of ethics-based board games when applied to different subject domains [22]. There have been no studies yet investigating the effectiveness of a board game in promoting care robot ethics principles. Hence, bearing in mind the potential of board games in creating discussions around ethics, the inquisition naturally arises about how effectively a board game could be designed and utilised to increase awareness and generate discussions around care robot ethics.

3. Research Methods

3.1. Procedure and constraints

The project was split into the *research phase*, the *design phase* and the *evaluation phase*, performed roughly linearly.

Regarding resource constraints, this project required access to academic research databases, existing physical board games, and equipment and materials for constructing a prototype board game. Additionally, as the board game was to be evaluated during a university lecture session, the play time for an entire game session was restricted to below one hour.

3.2. Research Phase

Two distinct research activities had to be undertaken to create a board game solution to incite discussions around the topic of care robot ethics. The first component was investigating the key ethical concerns that arise from the use of care robots in society. These ethical concepts would form the backbone for the discussions between players during gameplay. The second component of research was to look at existing discussion/collaboration games to identify the traits of these board games that are important in inciting discussions among players.

3.2.1. Care robot ethics – Game learning outcomes

This phase consisted of a deeper investigation into the most relevant concerns of care robot ethics that were considered briefly during the literature review. After the collection of a wide range of ethical concerns regarding care robots, these concerns were categorised into three fundamental topics that players must pay attention to during gameplay: privacy/security, human robot interaction/aesthetics, and sustainability. There were other ethical issues such as the treatment of robots that were considered but not shortlisted as they had a smaller scope than the three fundamental groups above. The game was then designed to create as much inter-player conversation around the three fundamental groups of care robo-ethics principles as possible.

3.2.2. Existing discussion/collaborative games

During this part of the project, five existing commercial discussion-based games were played to understand how board games create discussions among players. The fundamental characteristics found in these discussion based games are outlined in Appendix A.

An element present in the majority of discussion games was a strong storyline that was based on a real-life scenario, which allowed players to empathise with their role in the game. All games also contained at least some element of collaboration to survive or win the game, with the majority of the games having both an individual and a team win condition. One observed shortcoming that would make these games inapplicable in an educational environment would be their high game complexity. A new player requires a lot of time to get accustomed to the complex game mechanics, with game setup and learnability being significant challenges in these games. Furthermore, most games had a duration of more than two hours which meant that the gameplay would not fit within the time constraints of a typical lecture/tutorial session.

3.3. Design Phase

For this project, the five-step iterative game design guide, presented by Cardinot *et al*. [24], was employed to create and playtest the board game. There are were five distinctive steps to design the board game device: empathise, define, ideate, prototype and playtest [24]. The playtest step was done in three

iterations, where the game was evaluated and refined in between each of these iterations to help create a game device better suited to inciting discussions in the context of care robo-ethics.

3.3.1. Empathise step

The empathise step consisted of understanding the target audience and their needs from the game [24]. In our context, this was understanding how the board game could help answer the question posed for this study. With respect to time logistics, the game was to be restricted to an hour of gameplay at most. This was to ensure that a complete game session fits within the time limit of a university lecture or tutorial. The intended audience was university students with a basic understanding of robo-ethics. We opted to keep the prior knowledge required of the care robo-ethics topic minimal for players to increase the accessibility of the game. The primary aim of the game was to create constructive in-depth discussions around the topic of care-robot ethics, which would allow us to answer the question posed in this study sufficiently.

3.3.2. Define step

The design step was where the game's learning goals were finalised, and the over-arching style of the game mechanics were considered [24]. As discussed in section 3.2.1. above, the main concepts of care robo-ethics were categorised under the three fundamental groups of privacy/security, human robot interactions/aesthetics and sustainability. These categories would be the fundamental areas of discussions in the game. A fourth category, called project resources, was also added to create more ethical tension in the game as often pressure on project resources, such as time, budget and staff, are what create an atmosphere for unethical behaviour [17]. The motivation of the game would be to stimulate discussions around these four topics to help players identify how these ethical topics may be relevant in the context of care robo-ethics.

To settle on the style of the board game, the properties from the existing games played that worked best to stimulate discussions were incorporated. The game was to have a collaboration element with both a team based and an individual based goal. This would allow more balance between the competitive and collaborative components of the game. The main task of the game would be maintaining balance between the four care robo-ethics topics. The balance would ideally be achieved through collaborative discussions

among players. Additionally, since the board game would be restricted to a playtime of one hour, the game mechanics would need to be simple enough to allow new players to partake in the game with minimal prior understanding of the game rules. Another strategy that was considered for decreasing the playtime was reducing the underlying story of the game but this strategy wasn't employed at this stage.

3.3.3. Ideate step

The ideate step consisted of creating board game ideas based on the learning outcomes, mechanics and constraints of the game laid out in the empathise and define steps prior [24]. During the ideation step, seven game concepts (see Appendix B) were created, with existing board games used to inspire the mechanics of these games. After assessing how viable each of these game concepts would be in generating discussions around the topic of care robo-ethics, concept two was chosen for the final game solution.

Game concept 2 [Bot Makers]: The theme of the game was that players are a team of roboticists that are tasked with designing a care robot for their company. Each player would be exclusively responsible for a unique care robo-ethics topic from the set of privacy/security, human robot interaction/aesthetics, sustainability, and project resources categories, which they would advocate for during the development of the company's care robot. The game consists of decision cards which allow players to make an A or B decision regarding the care robot and event cards which stimulate random events related to the care robot development process. During the game, based on decisions and events, players will earn or lose score tokens in each of the four ethics topics. At the end of the game, each player's ethical topic must have the minimum number of score tokens to make sure the project passes and the team wins. Hence, players must work together to create an ethically sound care robot that passes the company's expectations (see Appendix C for detailed game instructions).

3.3.4. Prototype and playtest step

During the prototype step, a digital version of the game was created. This digital prototype was used as the base to create the subsequent iterations of the game (see Appendix D). Each game design iteration consisted of creating an updated physical copy of the game, play testing the game with participants and making changes to the game based on feedback from participants.

Bot Makers - Iteration 1: Iteration 1 of playtesting was performed on a paper prototype of the game with a limited selection of decision and event cards for the players. This version of the game did not have an individual win condition for players and players either won or lost the game as a team depending on the overall number of score tokens in the four topics, at the end of the game. The more points that the weakest performing ethical topic had, the higher the chance that the players, as a team, would win the game.

Bot Makers – Iteration 2: Based on the results from play testing in iteration 1, the game design was modified to be a better discussion device for the players. Firstly, the description of the different ethics topics on the player role cards was refined to be more in-depth about what each of the ethics categories mean. Next an individual win condition was added such that players would have a chance to win individually as well, which would be a bonus unlocked only if the team won overall. This was to invest players more into their particular topic of interest rather than having players always advocating for the team the entire game. The threshold of win condition was also made static such that if a player gets above a certain number of score tokens, they win, and if they do not meet this requirement, they lose. Hence there is no longer an element of luck to winning or losing the game either as a team or individually. Lastly, a higher volume of decision and event cards was added to reduce the chance of getting the same cards.

Bot Makers - Iteration 3: For this iteration, a polished final version of the game, shown in Figure 1, was created that would be used during the formal evaluation of the study. The only significant change to the game from iteration 2 was that the instruction manual was modified to include a quick start guide to help navigate players through game instructions more efficiently. Additionally, due to the results of playtesting in iteration 2, minor changes were made to how the formal evaluation would be

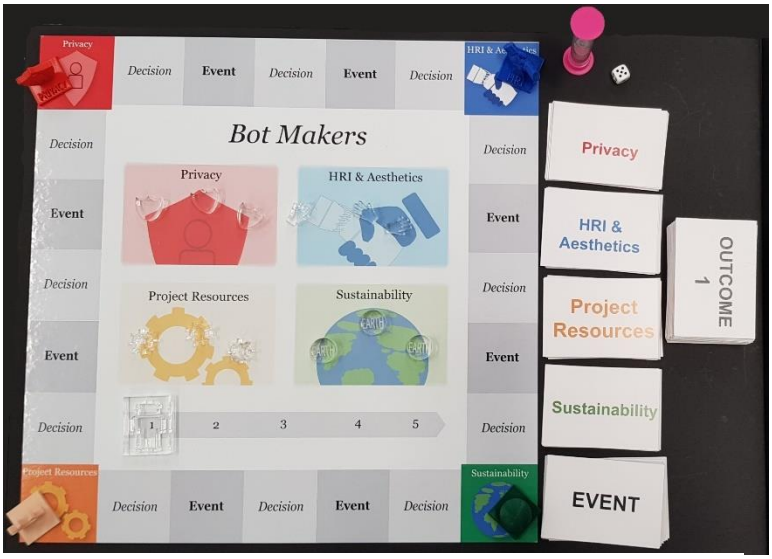

Figure 1: Bot-Makers final version

conducted. The evaluation session of iteration 2 exceeded the one hour time constraint. Hence, to keep the formal evaluation session within the one hour time constraint, it was decided that the board game would now already be set up for the participants, and the researchers would also give a brief explanation of the rules of the game at the start of the session. Additionally, the background story of the game would have to also be cut to reduce the total runtime of the game. These three changes would ensure that the evaluation session could be completed within the one hour time constraint.

3.4. Evaluation Phase

The evaluation phase consisted of developing a verification procedure to answer the posed research question. Since the evaluation was to be done with human participants, particularly students from the University of Auckland, ethics approval for the study had to be obtained from the UAHPEC.

3.4.1. Verification Procedure

The verification of the game device, for the purposes of this study, was to be conducted during a one hour session with students of the Design 302 course at the University of Auckland. Two copies of the board game would be set up prior to the session, after which participants would be recruited and informed about the nature of the study through the participant information sheet (PIS). After participants have read the PIS and provided their informed consent, the rules of the game would be explained to them. When participants are ready they would be split randomly among the two games and would be asked to play the game to completion. The data collected during the session would be video recordings of the entire gameplay of the two games, observations made by the researchers about the two games during gameplay as well as a post-game questionnaire that would be completed by the participants. The questionnaire contained both quantitative and qualitative questions.

4. Experiments and Results

4.1. Experiment Setup

Prior to the game session, two sets of the Bot-Maker game were set up to the initial arrangement of a four player game (also shown in Figure 1 above). Physical copies of the Participant Information Sheet (PIS), Consent Forms and Questionnaire forms were also present at the location. A tripod and video camera were set up to record each of the two game sets, and an audio recorder was also set up to record game one. Figures 2 and 3 below are screenshots from the two game sets during the evaluation session.

Figure 2: Evaluation session - Game one

Figure 3: Evaluation session - Game two

4.2. Activities Undertaken

After six interested participants were gathered, PIS forms were distributed to each of the participants. When the PIS forms had been read, the consent forms were provided to the participants to receive informed consent for the evaluation. Then, each participant was given a unique code identifier that corresponded to a seating allocation on one of the game sets. Since there were six players, the participants were split evenly into two games with three players each to ensure all participants had a similar gameplay experience. Participants were then explained the basic rules of the gameplay and how to win the game. Participants were also told that the researchers would be at hand to answer questions during the gameplay. With the two games ready to start, the recorders were started for both game sets and participants were told to commence the game. During the gameplay, researchers made observations regarding the behaviour of participants in the two game sets and answered questions posed by the participants, not interfering with the gameplay otherwise. After the gameplay was completed, questionnaires were distributed to the participants to fill in. The evaluation session was concluded after both games had finished and all participants had completed the questionnaire forms. The physical forms

completed by participants were then stored at a secure location, and all the collected data (questionnaires, observations and recordings) was digitalised.

4.3. Experiment Results

4.3.1. Participant Demographic

There were six participants for the evaluation phase of this study. Out of the six participants, four participants identified as male and two participants identified as females. With respect to ethnicity, two participants identified as Asian, two participants identified as New Zealand European, one participant identified as Pacific Islander and one participant identified as Asian/Pacific Islander. Five of the participants were aged between 20 to 24 years of age, and one of the participants was aged between 25 to 30 years of age. Despite the relatively low number of participants in the study, the demographics of participants were sufficiently spread to be a good representation of the university student target group of this study.

4.3.2. Quantitative results

There were two types of quantitative data collected during the evaluation: the quantitative results from the questionnaires completed by participants (summarised in Figure 4 below) and the breakdown chart of how much time, on average, was spent on on-topic discussions during the two games (shown in Figure 5 below).

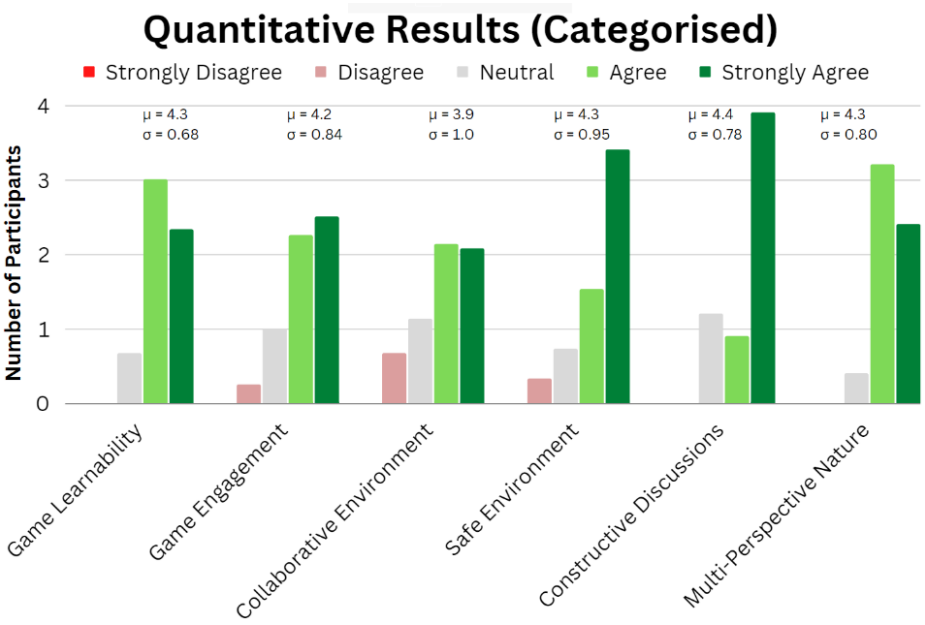

Figure 4: Quantitative (questionnaire) results

The quantitative results were based on the Likert scale, where a statement regarding the game was given and participants rated, from one to five, how strongly they disagreed or agreed with the statement. The full results of the quantitative questionnaire data are provided in Appendix E. To summarise this data, the quantitative questions were categorised into six major characteristics of the game, as shown in Figure 4. Each category represents the overall results of the set of questions related to that characteristic of the game.

As shown in Figure 4 above, the mean score for game learnability was 4.3/SD = 0.68. This means most participants agreed that setting up the game and learning the mechanics of the game was easy. It should be noted, however that since the game was facilitated, it was easier to learn for new players relative to if the game session was unfacilitated. The players also found the game experience to be fun and motivating for their learning, with game engagement having a mean score of 4.2/SD = 0.84. However, it was noticed that the story component of the game engagement characteristic was rated relatively low, with a mean score of 3.4/SD = 1. This indicates that despite the high playability of the game's mechanics, participants would have liked being more immersed in the game's story. Opinions on the collaborative characteristic of the game were generally positive but more diverse, with a mean score of 3.9/SD = 1. Lastly, most participants agreed that the game provided a safe and judgement-free environment for discussions, with the mean score for this game characteristic being 4.3/SD = 0.95. Therefore, the quantitative data suggests that the board game was easy to learn, engaging and provided a safe and collaborative environment that was inducive to ethical discussions between players.

The ability of the game to generate constructive discussions was the most vital characteristic of the game, with a mean score of 4.4/SD = 0.78. In particular, most participants strongly agreed that the game was able to prompt discussions focussed on the topic of robo-ethics and that these discussions were constructive in nature. There was a weaker agreement between participants regarding if discussions were in-depth or not and if discussions were heavily prompted by the game mechanics. Lastly, another strong characteristic of the game was its ability to help players consider and empathise with different perspectives when it comes to robo-ethics principles, with the mean score of this category being 4.3/SD = 0.8. Hence, the quantitative data suggests that the game was able to generate constructive discussions

around care robo-ethics and help players empathise with different perspectives, but the discussions could have potentially been deeper in nature.

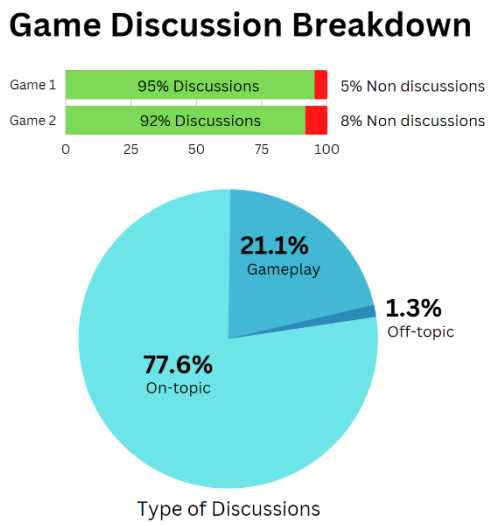

Figure 5: Discussion Breakdown chart

To further investigate the nature of discussions that occurred in the two game sets, Figure 5 was created which categorises the duration of the different types of discussions observed during the games. Discussions occupied the majority of time for both games, accounting for 95% and 92% of the games' duration, respectively. Furthermore, between the two games, on average, 77.6% of the discussions between players focussed on the topic of robo-ethics, 21.1% focused on gameplay, and only 1.3% of discussions were off-topic. Hence, this is further quantitative evidence that the majority of the game time was spent on constructive inter-player discussions based on the robo-ethics principles introduced through the game.

4.3.3. Qualitative results

The qualitative data collected from the evaluation consisted of the participant answers to the open-ended question of the questionnaire and the observations made by the researchers during the two gameplays. A thematic analysis (shown in Figure 6 below) was performed on both the qualitative questionnaire data and the observational data to identify the major trends and themes in the qualitative data.

Figure 6: Thematic analysis

A recurring theme noticed in the qualitative data was that the game provided a "fun and engaging" experience for players. Participants also showed strong unanimous agreement when queried if the discussions through the game were more engaging than the typical discussions in lectures/tutorials. This is consistent with the strong game engagement characteristic indicated by the quantitative data. Another theme observed was that players said the game was quite collaborative and that they "felt a social connection with other players". The collaborative aspect of the game was more

positively represented in the qualitative data compared to the quantitative data and helped provide more indication that the game created a rich environment for collaboration.

A negative theme observed was that participants would have liked more context to the decision making of the game with some participants even mentioning that they didn't know what type of robot they were building. This theme was uncovered slightly by the shortcomings of the game's story immersion characteristics, as shown by the quantitative data. A weaker narrative meant that the underlying context behind all the ethical decisions players had to make during the game was limited. The lack of context to decision making can also be linked to some of the perceived shortcomings in the depth of the discussions around the topic of care robo-ethics. Another theme noticed with respect to the in-game discussions was that players would have liked even more morally ambiguous discussions prompted by the game. The discussion component was one of the most enjoyable parts of the game, and participants appreciated how the in-game discussions helped them consider other perspectives when thinking about care robo-ethics principles. A particular instance of conflict was observed during a decision in game two where one player advocated for building the most ethically sound robot while another player advocated for taking the decision that better helped win the game. However, this clash of ideas was resolved in a collaborative way via the team discussion. Hence, the discussions in the game were able to provide a medium for healthy conflicts between diverse player perspectives.

Therefore, overall, the qualitative data provides further evidence that the game was found to be engaging, socially collaborative and that the game discussions were helpful to in communicating the principles of care robo-ethics. The qualitative data also helped identify the weak storyline part of the game as a factor for why the discussions between players were not as in-depth on the topic of care robo-ethics as anticipated.

5. Discussion

5.1. Time logistics

With respect to the time logistics required of the game, players felt that the game was easy to learn and play, and the run time of both the games was within between 15 to 35 minutes. Additionally, time to set

up the game and give a run-through of how it works took 10 minutes in total. Hence, the board game designed for this study could be set up, explained and played to completion well within a one hour university tutorial or lecture session. Therefore, Bot-Makers was within the time constraints set by this study.

5.2. Overall game experience

The general consensus among participants was that the board game was engaging, motivated their learning and that they enjoyed the experience. All participants also showed strong agreement that the game provided a better discussion environment compared to a standard lecture setting. This is consistent with previous studies that suggest that games are highly motivating teaching devices for students [22].

On the negative side, the weakest part of the overall gameplay was the story immersion. Some participants were also unclear that the type of robot they were working with during the game was a care robot. This indicates that while the participants were implicitly making ethical decisions in the domain of care robo-ethics, they did not have explicit knowledge about what the particular subject area was. The lack of story immersion was because the narrative behind Bot-Makers was cut before the final evaluation session to reduce the duration of gameplay. In hindsight, the story should have been retained as it would have added a care robo-ethics backdrop to all of the game activities. This would provide more context to the decision making during the game, leading to a deeper level of discussions on the topic of care robo-ethics. The importance of an immersive story in creating ethical discussions is an interesting observation. While game design frameworks consistently advocate for a strong storyline in board games, previous ethics education games, such as the Delta Design game, understate this aspect in the case of ethics education games [26], [28]. The results achieved in this study suggest that a solid underlying story in a board game could lead to a deeper level of discussions around the targeted subject domain, in this case, care robo-ethics.

5.3. Collaboration Environment

The data collected by the evaluation of the care robo-ethics board game also generated some interesting perspectives on the collaborative environment created by board games. Participants found that the game device was a great mechanism to socialise in a new team environment in a safe and comfortable manner.

The board game was able to create healthy and light-hearted conflicts/debates among players, and most participants enjoyed the challenge posed to their way of thinking. An interesting conversation that came up after game one was completed was regarding discussion-style games in general and how they are an innovative method to create discussion about an ethically challenging topic or social issue. A participant also further commented how games give you the opportunity to don another character and in a socially acceptable manner present your diverse thoughts to a group without judgement. Previous research has highlighted the socialisation benefits of board games and how they can "decomplexify complexity" [29]. The results of this study further advocate for game-based socialisation due to the safe, comfortable and diverse thinking atmosphere that they present [22].

5.4. Discussion stimulated through board game

Overall, participants thought that discussions were sufficiently prompted by the board game and strongly agreed that the discussions were on-topic and constructive. Inter-player discussions occupied almost the entire duration of the game instances during the evaluation session and a breakdown of the game discussions found that the majority of these discussions were related to the topic of care robo-ethics. The board game, primarily through its discussions, also stimulated multi-perspective decision making and helped the participants understand the ethical challenges faced by roboticists when designing a care robot. This is similar to what was observed through the Delta Design game study, which found that inter-player discussions were integral in helping students empathise with ethical principles from diverse perspectives [26]. Therefore, the board game was able to generate constructive in-depth discussion around the topic of care robo-ethics.

However, some reservations must be made regarding the depth of discussion stimulated through the game. Evaluation data shows weaker agreement among participants that the discussions stimulated were in-depth. Section 5.2. above mentioned that the lack of story immersion in Bot-Makers lends to a weaker backdrop to the ethical decision making in the game, which in turn leads to shallower discussions around the topic of care robo-ethics. This is because when a board game lacks context players cannot empathise with their in-game role and hence are not emotionally invested in the ethical consequences of their in-game actions [22]. With discussions lacking depth, the context of the game becomes about winning by

getting a certain amount of score tokens rather than about players advocating their stances about certain care robo-ethics issues. This conflict is best exemplified by an instance of conflict that came up during game two between two players where one advocated for building the most ethically robust robot while the other player advocated for purely winning the game. Despite best efforts during the design phase of the board game, the conflict among players between winning and behaving ethically, also experienced in previous case studies such as the Grants and Researchers game study [21], could not be avoided. Extending this board game by designing a mechanism to tackle this eternal conflict between winning and behaving ethically could create an exemplary game device that could inspire a lot of future ethics education games. However, this was considered out of scope, since, overall the inter-player discussions among players were deemed sufficiently in-depth to help students experience the ethical dilemmas faced by care robot engineers and designers.

5.5. Limitations

The major limitation of this study was the relatively small sample size of participants. The participant demographics being sufficiently spread proved a good representation of the sample of university students; however, a sample size of 20 or more participants would have helped provide more confidence in the results achieved of this study. Another limitation was the quality of the game device used for the evaluation of this study. A few more iterations of game development had time permitted, would have created an overall better board game device that would have been more likely to stimulate on-topic and in-depth discussions around the topic of care robo-ethics.

5.6. Future Works

The primary extension of this study would be to evaluate the game with more participants and observe if the results of further testing are consistent with the observations made here. Another line of development could be to make changes to the Bot-Makers game based on the feedback collected during the evaluation. These changes would address the weaknesses of the game, such as the story immersion component and the lack of context behind the in-game decision making. Then the new version of Bot-Makers could be formally evaluated with a larger number of participants to assess if these changes allow the game to generate more in-depth discussions around the topic of care robo-ethics.

6. Conclusion

This report first looked at the relevant literature around robo-ethics and the particular importance of teaching robo-ethics in the context of care robots to future engineers and designers of robots. There is a lack of accessibility to the field of care robot ethics and board games could prove a highly effective tool for helping students understand the ethical impacts that care robots have on society. This report then looked at how the research, design and evaluation phases were carried out to create the care robo-ethics board game device used in this study. The experiments and results part of this report summarised the findings during the evaluation. Analyses of the data found that, overall, the game was engaging and adhered to the time constraints of the study.

The first research objective was achieved as, through this study, the research team was able to create a care robo-ethics game that was sufficiently engaging and could be used in a university classroom setting within the time confines posed at the start of this study. The second research objective was also achieved as, through the evaluation of the game, it was found that the designed board game was able to simulate discussions around the topic of care robo-ethics that were sufficiently constructive and in-depth. Some reservations about the depth of the discussions and how well they adhered to care robots in particular must be made as it was observed that the board game discussions were not as deep into the topic of care robo-ethics as anticipated. It must also be noted that the results of this study are limited by the small sample size, and therefore further testing is recommended to gain more confidence in the results. Holistically, however, the board game was able to provide players with an understanding of the ethical issues that affect roboticists during the development of a robot. Hence, in light of the findings in this study, a board game device was found to be able to generate constructive and in-depth discussions around the topic of care robo-ethics and proved a great medium to communicate these ethical concepts in a collaborative, engaging and comfortable environment, to university students.

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8. Appendices

Appendix A

Game research – Playing existing collaborative board games

During this part of the project five commercial games were play tested to investigate how effective each of these games was in generating discussion among players and identify the particular game mechanics that were the most helpful in inciting discussions among players. The games that were play tested were: CO_2, Nemesis, Dead of Winter, The Volcanic Island and The Dungeon. These games were chosen as they all contained a collaborative element that naturally engaged players in discussion through the mechanics of the game.

	CO_2	**Nemesis**	**Dead of Winter**	**The Volcanic Island**	**The dungeon**	**Overall Tendencies**
Positives	Instruction manual Game tokens Representation of reality Flexibility meaning Collaborative	Game tokens Storyline Player characters	Element of chance Board design Story telling	Gameplay was easy to understand Storyline Game tokens	Game cards and tokens Storyline Game hints Very collaborative	Storyline Game tokens Collaborative Element of chance
Negatives	Complex rules Disconnect between tokens and meaning Game setup	Game setup Competitive	Complex rules Lots of actions during player turns	One time play Lots of reading	Game instructions Game complexity Slow progression	Complex rules Game setup
Observations	Weak story Not always a winner Team and individual goals 3 hours	Team and individual motivations Challenging Luck based 3 hours	Multiple level of goals Not always a winner 3 hours	Hard to remember everything No element of randomness 2 hours	Long gameplay No luck element Only team goal 4 hours	Team and individual goals >= 2 hours

Table 1: Existing games - Summary

Appendix B

Ideation – Game concepts

During this part of the project, seven game concepts were created which were each inspired an existing game's design. The table below provides details about each of the seven game concepts and specifies if the concept was chosen for the final board game design or not.

	Concept 1	**Concept 2**	**Concept 3**	**Concept 4**	**Concept 5**	**Concept 6**	**Concept 7**
Inspiration	*Mafia*	*Monopoly*	*Cluedo/Similar to the Delta Design game study*	*Scrabble*	*Snakes and Ladders*	*The Dungeon (Adventure games)*	*Dead of Winter*
Description	Players are randomly assigned roles, with all players being ethical engineers and one secret player being a budget centric engineer. Budget engineer tries to reduce robot features while other players try and increase the ethical attributes of the care robot.	Players are working together to build a care robot. Players are randomly assigned roles from the four ethical topics. Each player advocates for their specific ethical topic as the team decides on which feature they would like to have in their robot. The players must also ensure that the lowest scoring topic stays above a certain number.	Players represent a team of robot engineers. An accident has happened in relation to their robot and the team must work through their previous decisions to find where their project went wrong.	Players work as a team to navigate the board from start to finish. Players will make ethical decisions to decide which direction they move during the game. There is a shortest path which players will try and get as close as possible to.	Players play as individuals that are trying to get to the destination. They will make ethical decisions along the way which will be rated by the other players to see how quickly they move through the board.	A narration based game where players work together to progress through a care robo ethics story. Players will have to collaborate to make progress. There will be a book to provide players with context for the ethical decision making.	A story heavy game where players work to solve a host of ethical challenges related to a care robot within a certain number of rounds. Players will have to move around the board to fix different issues.
Positives	Simple board design Unpredictable	Ethical topics are directly used Ethical decision making Team and individual goals Shorter duration	Fixed number of events Reflection phase at the end of the game	Engaging board design and mechanics	Familiar concept	Rich storyline Strong collaborative component	Rich storyline Engaging game mechanics
Negatives	Ethics may not always win Complex win conditions	Individual topic is more important	Will generate discussions similar to lectures rather than board games	Game will become very easy after a few run throughs Game will have right and wrong answers – not representative of care robot ethics	Individual and not collaborative Won't generate too many discussions	Long game duration Complex for new players	Difficult for new players Long game duration
Continued?	No	**Yes**	No	No	No	No	No

Table 2: Game Concepts - Summary

Appendix C

Bot-Makers: Game instructions

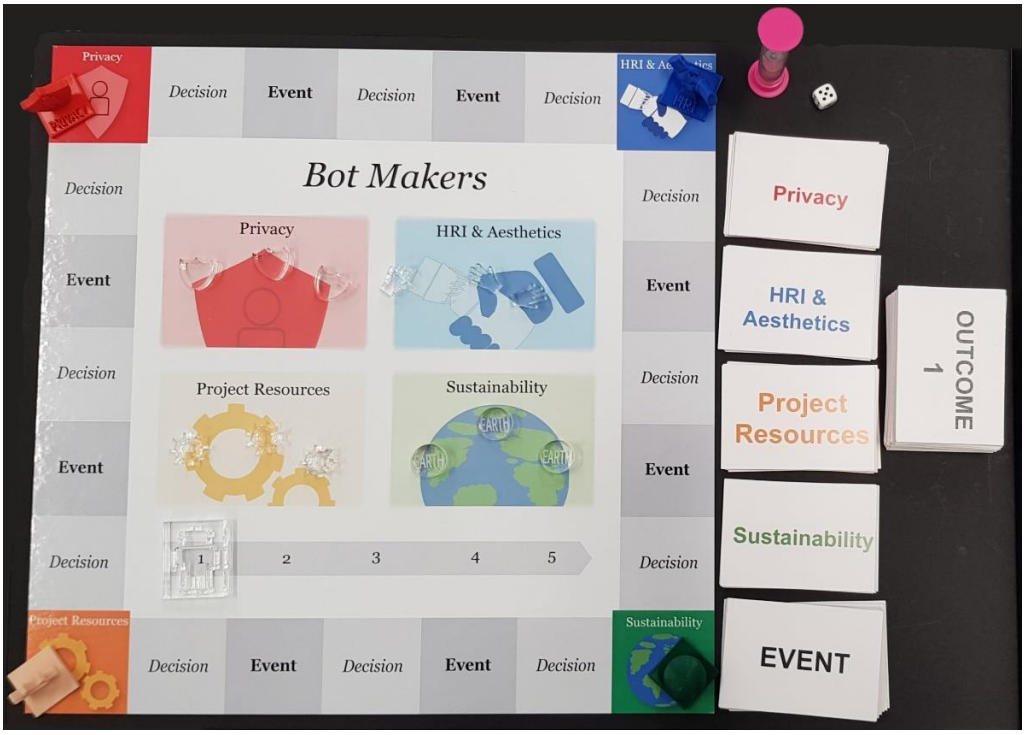


Figure 7: Initial game prototype (digital)

As Figure 7 above shows, the game is centred around the four robo-ethics topics of Privacy, HRI/Aesthetics, Sustainability and Project Resources. The game should be played with four players if possible but can also be played successfully with two or three players. At the start of a game each player takes a role card at random and this role card defines the ethical topic they will be responsible for during the game. In the case of two players, each player takes two role cards instead of one and is responsible for two different topics rather than one. In a game of three players, each player takes a single role card and the remaining topic is removed from the game for simplicity.

The game itself is composed of five rounds where every player must play one turn in each round. At the end of a round, if a topic's score is less than zero then the entire team loses the game. Players initially start at the corner squares for the topic that they are responsible for. During their turn players roll the die and move clockwise around the board based on the number they rolled. During their turn a player can land on either a decision square, an event square or a corner square which all have a different mechanism.

If a player lands on a decision square: they must pick the top decision card from their ethics topic. They then start the two minute timer and read out the scenario in the decision card. Then within the two minutes, after consultation with the rest of team, the player makes a decision on whether they would like to choose either option A or option B. Based on their choice they unveil an outcome card which tells them the outcome of their decision and any tokens they earned or lost in the four ethics topics.

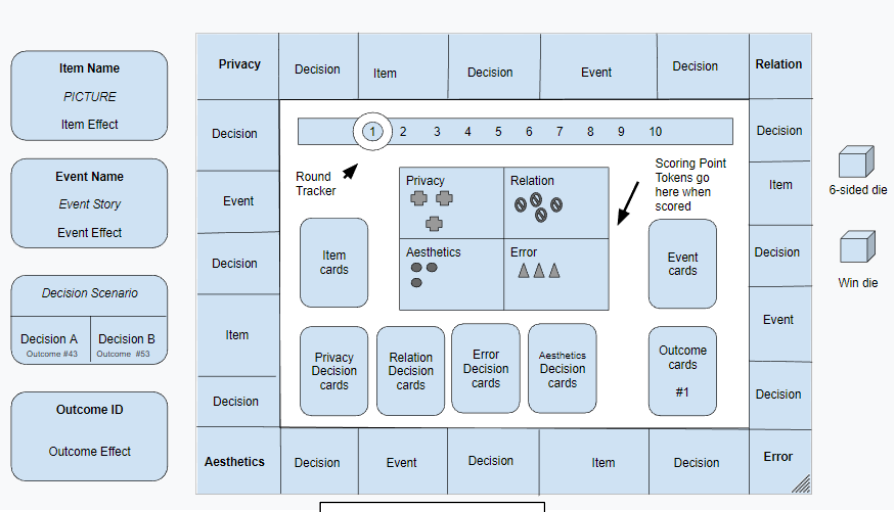
If a player lands on an event square: they must pick the top card from the Event card deck and read it out to the team. An event is a random occurrence that can either positively or negatively impact the team's project and hence their score tally for the four ethics topics. An event card can also give an item to the controlling player which they can use to their benefit later in the game.

If a player lands on a corner square: they earn a free token for their ethics topics and also another free token for the ethics topic corner they landed on.

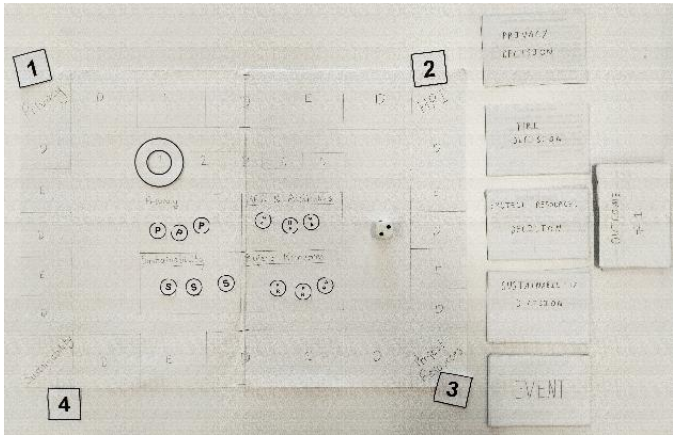
When the five rounds are completed the game ends and the players check if each of the playing topics contains the minimum number of score tokens to make the project pass (set to six during the final evaluation session). If this is the case then the team has passed and players can check if they have enough tokens for their character to get a promotion. If this is not the case then the team has failed and every player has lost. For a player's character to earn promotion, the team's project must have passed as well the player's topic must have the minimum number of tokens to get a promotion (set to eight during the final evaluation session). This would be the perfect outcome for a player in this game.

Appendix D

Game Development – Design iterations

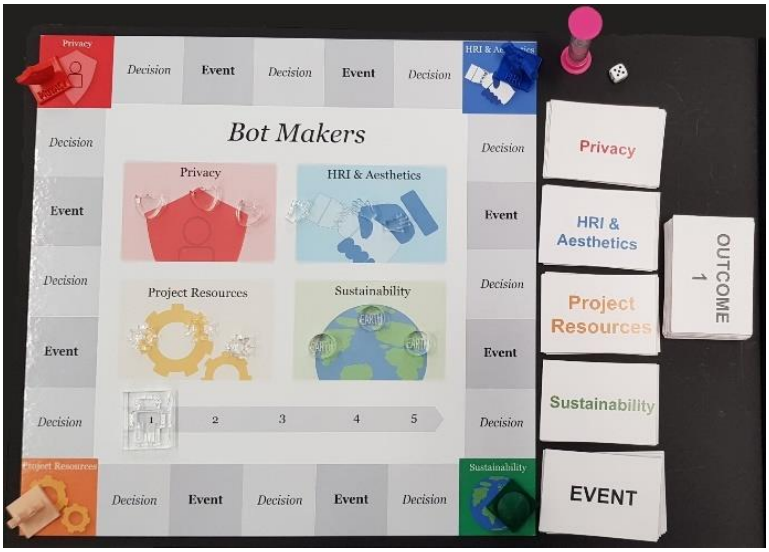


Digital prototype



Iteration 1: Low-Fidelity prototype

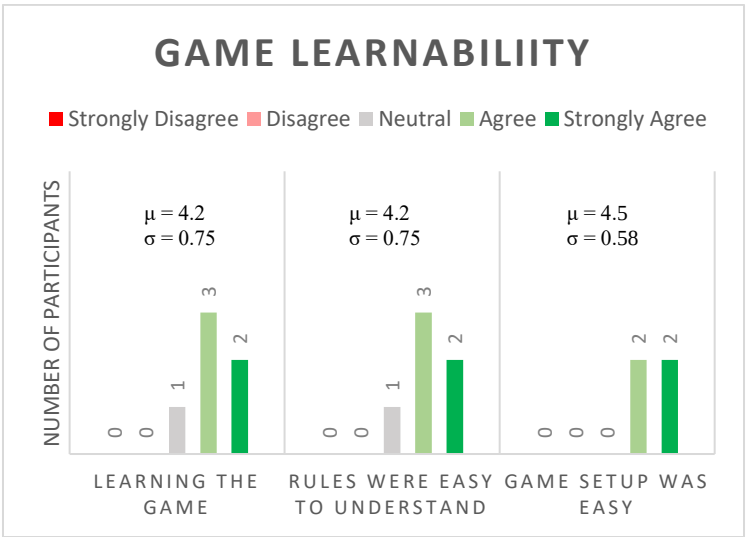
Iteration 2: High-Fidelity prototype

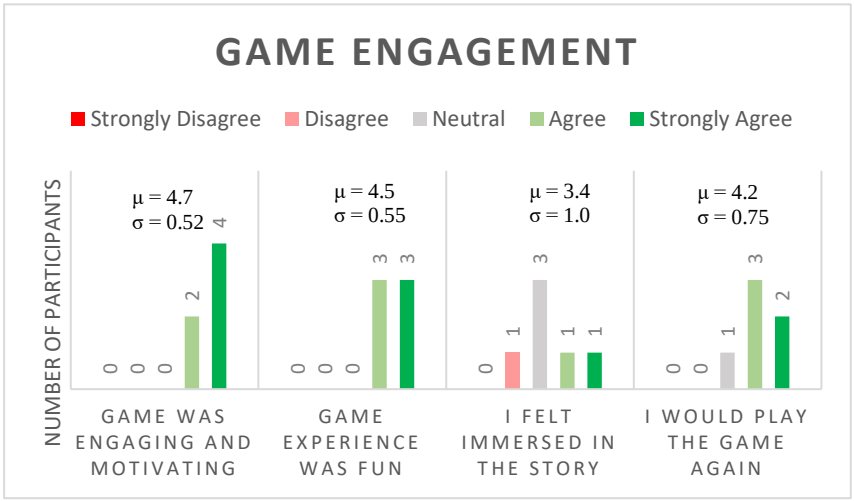


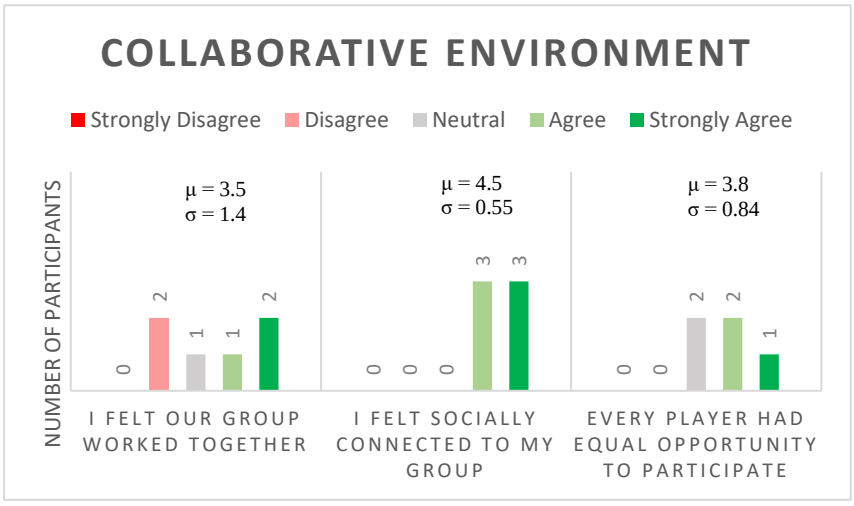
Iteration 3: Final game

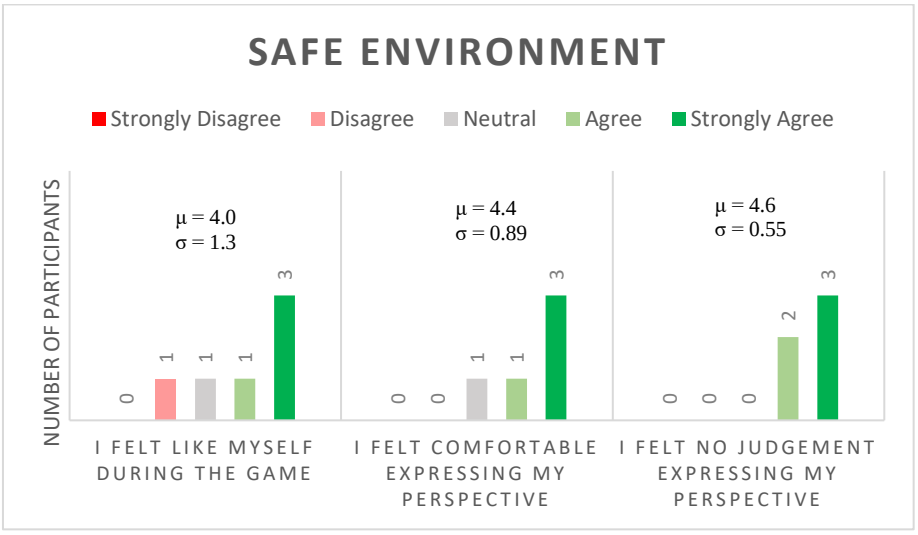
Appendix E

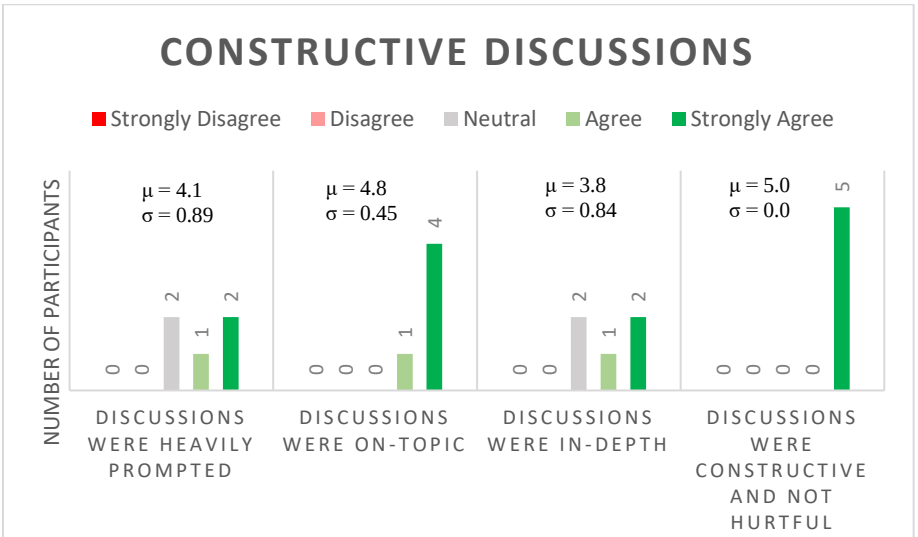
Quantitative results - Figures








SAFE ENVIRONMENT
Strongly Disagree
Disagree
Neutral
Agree
Strongly Agree
NUMBER OF PARTICIPANTS
μ = 4.0
σ = 1.3
0
1
1
1
3
μ = 4.4
σ = 0.89
0
0
1
1
3
μ = 4.6
σ = 0.55
0
0
0
2
3
I FELT LIKE MYSELF DURING THE GAME
I FELT COMFORTABLE EXPRESSING MY PERSPECTIVE
I FELT NO JUDGEMENT EXPRESSING MY PERSPECTIVE


CONSTRUCTIVE DISCUSSIONS
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Disagree
Neutral
Agree
Strongly Agree
NUMBER OF PARTICIPANTS
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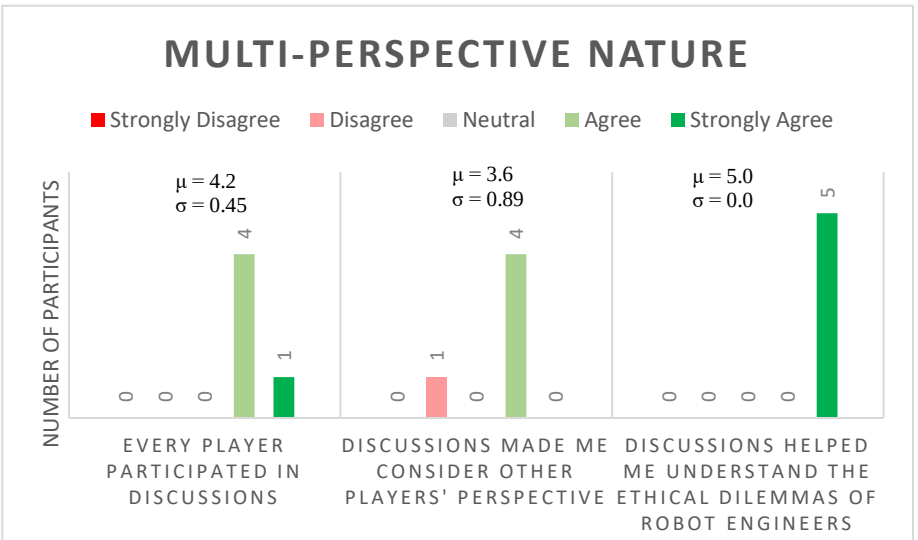
0
0
2
1
2
μ = 4.8
σ = 0.45
0
0
0
1
4
μ = 3.8
σ = 0.84
0
0
2
1
2
μ = 5.0
σ = 0.0
0
0
0
0
5
DISCUSSIONS WERE HEAVILY PROMPTED
DISCUSSIONS WERE ON-TOPIC
DISCUSSIONS WERE IN-DEPTH
DISCUSSIONS WERE CONSTRUCTIVE AND NOT HURTFUL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Disagree
Neutral
Agree
Strongly Agree
NUMBER OF PARTICIPANTS
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0
0
0
4
1
μ = 3.6
σ = 0.89
0
1
0
4
0
μ = 5.0
σ = 0.0
0
0
0
0
5
EVERY PLAYER PARTICIPATED IN DISCUSSIONS
DISCUSSIONS MADE ME CONSIDER OTHER PLAYERS' PERSPECTIVE
DISCUSSIONS HELPED ME UNDERSTAND THE ETHICAL DILEMMAS OF ROBOT ENGINEERS