Department of Electrical, Computer, and Software Engineering

Part IV Research Project

Final Report

Project Number: 3

Effect of Storyline Integration to Educational Boardgame

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13/10/2023

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: Board games are recognised as effective educational tools, particularly for teaching ethical concepts, as they allow students to engage in ethical reasoning without real-life consequences. The previous year's research conducted by Bot Makers indicated the potential of board games to facilitate in-depth discussions on robo-ethics concepts. Subsequently, a board game called "Ethixplorer" was designed, making improvements and introducing a version with an integrated, realistic storyline. University of Auckland students participated in board game evaluation sessions, involving both non-storyline and storyline versions. The analysis of quantitative and qualitative data provided insights into the effectiveness of the board game in stimulating in-depth discussions about robo-ethics. However, the differences in engagement and the depth of discussion between the two versions were not significant enough to definitively establish the positive impact of the storyline in ethics education. Nevertheless, there were notable observations about the storyline, such as its ability to provide a shared goal and enhance team collaboration. This suggests the potential for future development of this board game as an effective educational tool to raise awareness about robo-ethics education and keep pace with the rapid development of robotics.

Acknowledgements: I would like to express my gratitude to my research partner, Min Sun, for their invaluable collaboration and to my supervisor, Craig, and co-supervisor, Allan, for their guidance and support throughout this research project.

1. Introduction

While the significance of educating university students on robot ethics is being increasingly emphasised with the rapid advancement of robotics technology, researchers and educators considers the potential of board games as a novel and engaging educational tool. Using board games to teach robot ethics enables students to safely delve into various ethical considerations and encourages them to engage in ethical reasoning. Building upon the research conducted by Nivran and Calvin in the preceding year, which focused on the development of an educational board game to facilitate constructive discussions among students on robo-ethics in the context of care robotics, this project aims to explore the impact of incorporating a narrative storyline into the board game on student engagement in these discussions, applying to more generic type of robotics [1][2]. To achieve this objective, we plan to apply board game design principles, particularly the ideation phase, to create engaging content and a compelling storyline that elicits profound discussions from students through multiple iterations. Therefore, our research question is as follows:

1.1.Research Question

Does adding a storyline to a board game generate more in-depth discussion between university students regarding robo-ethics principles?

- Design a board game with an embedded storyline to teach robo-ethics within a university classroom setting.
- Evaluate the influence of storylines in board games in stimulating more profound discussions on robo-ethics among the participants.

1.2.Report Overview

This report commences with a literature review conducted before formulating the research question, providing insights into existing work in this field that underpin our background knowledge and

motivation. The subsequent research methods section outlines the board game development process, and the design of our evaluation. Experiment and results section then offers an overview of the experiment sessions' setup, activities undertaken, and the results. These results are subsequently analysed in the discussion section, delving into the significant insights about the effectiveness of storyline integration in board game education revealed by this research. The report concludes by revisiting the research question and summarising potential future directions stemming from this research.

2. Literature Review

2.1.Robo-ethics

2.1.1. Future of Robot Technology and Robo-ethics

Robo-ethics is a branch of applied ethics that examines ethical issues related to the present and prospective uses of robots [3]. It is an offshoot of computer ethics, with modifications necessary when we give computer mobility and direct interaction in the human environment [4]. Robo-ethics is a growing topic since robots now require increased level of control than basic functionality [5]. Ethical perspective towards robots is approached in two ways: robo-ethics itself and machine morality [6][7]. Robo-ethics addresses how humans should design, deploy and treat robots, being aware of possible ethical challenges, including avoiding misuse and allowing for human inspection of functionality of the algorithms and systems [4][6].

In this context, “robots’ are initially developed to provide services for people, by substituting for humans or collaborating with humans to complete tasks that are dull, dirty or dangerous [8][9]. The meaning of robots is evolving, where future generations of robots should be able to gradually acquire most of the characteristics of the human brain [9][10]. The characteristics of robots, such as

computational intelligence with the ability to achieve goal-oriented adaptive behaviours, mobility, interactivity, communication and autonomy, raises ethical questions [3][9][10].

Autonomous robots are expected to operate in the real-world environment without any form of external control once the machine is activated, for extended periods of time [5][8]. Cognitive robots are being developed and are expected to become part of our everyday lives in future, making it crucial to ensure that their behaviour is adequate [11]. This increased capacity makes robots a target of people's moral expectations and evaluations, and they must share moral competence like of what human has [6]. Therefore, the development of autonomous robots with built-in machine ethics is the prospect of deeper understanding of the mechanisms of ethical behaviour in humans [11].

However, as fully autonomous robots are far from development, the focus of robo-ethics should be on those robot systems under development or already in use, such as telerobots where human intervention is crucial [4][12]. In discussions of future of robotics, it is important to emphasise the training roboticists in ethics, focusing on how telerobots alter ethical thinking of their users, rather than on the theoretical possibility of machines making autonomous ethical decisions themselves [4][6].

Overall, the growth of robotics industry is comparable to that of the computer business, and its impact on society is already significant and expected to expand further in the future [8]. Robots' applications span various fields such as labour and services, military and security, research and education, entertainment, medical and healthcare, personal care and companions, and environment [3][4][8][10]. As the benefit from these highly intelligent agents increase, without ethical considerations, this may lead to unscrupulous and harmful behaviours, as history has shown. Therefore, many researchers call out that it is crucial to integrate ethics into the design of robots, to mitigate negative consequences [8][10][11].

2.1.2. Discussion of Ethical issues with Robots

The ethical concerns that arise from the increasing use of robots and AI technology in society are often slow to catch up with technological evolution [6][8]. Social concerns are raised as robots are playing an increasingly significant role in the society, leading to fear of human unemployment, and technological risks [9][10]. These concerns are initiated by media, such as movies and books that portrays dystopian future as complexity of robotics and AI systems progresses further [10]. This has led to the development of robo-ethics policies, such as the rules from Asimov, where some argue that these rules are too simple prevent all potential human harm caused by robots [10], leading to suggestion of overviewing rule: "A robot cannot harm humanity, nor, by remaining passive, allow humanity to be exposed to danger" [9]. Furthermore, as robots are getting autonomous and exhibit "free will", the boundaries between human and robots become increasingly blurred, leading to discussions about robot rights and duties [8][9]. These discussions are further complicated by the fact that development of robots with high degree of autonomy makes it difficult to trace responsibility for any consequential harm they may make [9]. Additionally, the increasing use of robots in social interactions with humans raises questions about the impact on human moral standards and relationships [13]. The vulnerabilities of robots to hacking and the potential infringement on human rights of privacy and physical safety must be considered as robots become more closely integrated into our everyday lives [12].

The challenge in ethics and law regarding robotics lies in determining whose standards should be used. Without clear moral standards, international policy challenges could arise, making it important to consider which ethical theory is appropriate for robot-ethics application [6][8]? Hence Malle suggests that open discussion is needed to determine the various capacities that make up human moral competence to serve as an orienting framework for robot ethics [7]. Ketih W. Miller's first rule in "The Rules, Moral Responsibility for Computing Artifacts" asserts that "those who design, develop,

or deploy a computing artifact are morally responsible for that artifact, and for the foreseeable effects of that artifact [11].” Like so, several articles emphasise the importance of ethical design for robots and highlight the ethical issues that may arise from robot technology evolving. However, Winfield and Jirotka suggests that more evidence is needed to demonstrate that these principles are being translated into practice, as effective and transparent ethical governance of current developments of robots [14].

2.2.Boardgame-based education

2.2.1. Board game to learn ethics

Previous methods of teaching ethics have been found inadequate in developing core ethical skills and connecting ethical theory to scientific practice [15]. Board games offer an immersive approach to teaching ethics by simulating real-life scenarios, allowing students to apply their theoretical knowledge and reflect on their behavioural changes, thus bridging the gap between bare theory and practice [16][17]. Through board games, students are exposed to complex situations with multiple perspectives and uncertainties, that require context-sensitive reasoning, moral reflection, and evaluation of their own ethics and ethical issues [15][17][18]. This is especially a good approach to ethics as participants can learn in 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 [16][18]. Furthermore, boardgames are entertaining and enjoyable that they reduce anxiety, enhance engagement, and facilitate peer teaching and teamwork through discussions [16][17]. The visual, elements, subtle repetitions, and overall discussions help increase retention, hence quality of understanding. [17] The multidisciplinary nature and the practical environment of board games makes them natural tools for teaching ethics and instigate ethical behaviour in their external role [18][19].

“Privacy by Design” is a successful application of board games to teach computer ethics. This team discussion style game requires each player is fulfil a role in the design of a privacy policy, and evaluation of the game found that most students found it engaging and expressed interest in further learning practical ethics relevant to their field [20].

However, some challenges arise in designing effective board game to teach ethics, such as balancing the learning and enjoyment factors [17][21]. In "Grants and Researchers game" players identified making unethical decisions led to earning more points and were more invested in winning the game [15]. Furthermore, the distinct ethical decision options coming from board game nature may restrict participants to discuss for deeper potential of ethical thoughts, which raises the need of covering wider range of ethical decisions in board game design [15]. The lack of design frameworks and evaluation tools also presents obstacles in designing effective ethics games [15][16][21].

2.2.2. Suggested Game Design Principles

The most widely accepted framework for game design is the MDA framework, which divides game design into three components: mechanics (rules and components of the game), dynamics (player interactions with peer and the game), and aesthetics (emotional responses and experience of player) [22]. However, this linear design process may not be suitable for designing educational games that require delicate balance between learning and enjoyment [23]. To address this, Cardinot, McCauley, and Fairfield proposed a new five step iterative approach to board game design: empathise, define, ideate, prototype and playtest [21]. These steps involve understanding the needs of target audience, focusing on learning outcomes, ideate to create rules, and playtest to iterate so effective educational games can be designed [21].

3. Research Methods

3.1.Boardgame Development

3.1.1. Research Phase

We gathered research through two primary methods. First, we played various existing board games to acquaint ourselves with different gameplay experiences, mechanics, and effective elements that make games engaging. Our observations revealed that aesthetics played a significant role in engagement, emphasising the importance of board game design. Additionally, clear instructions and visible headings or actions were crucial, as unclear instructions led to disruptions and gameplay delays. Moreover, collaborative games sparked more extensive discussions compared to individual play, where players tended to be more secretive about their strategies.

Valuable insights were also derived from the previous year's project board game, Bot Makers [1][2]. The rules for collaborative gameplay, which involved discussion cards prompting players to explore ethical scenarios and make choices as a team effectively fostered discussions about ethical concepts. However, the game's mixed focus on both group and individual wins led to unnecessary competition among participants. Frequent occurrences of "Events" squares didn't contribute significantly to discussions, as event cards offered direct outcomes without encouraging player interactions. Furthermore, the board game's basic aesthetic design may have contributed to low participant engagement. We proposed incorporating more gamified elements and design to make players feel like they're actively playing a game rather than simply learning.

We documented the findings from existing board games and Bot Maker in Appendix A.

3.1.2. Design Phase

In response to our research question, we created two versions of the board game, one with a storyline and one without, for comparative analysis.

We developed a storyline rooted in robo-ethics concepts to engage the user. Initially, we considered a more narrative-dystopian approach, but based on feedback from our supervisor, we shifted our focus to enhance learning and concept relevance. We crafted a storyline centered around a robot development project group, where players are given to design an educational robot for classroom use. Their objective is to earn tokens to gain approval from the ethics committee to launch the robot within a specified timeframe. This storyline was integrated into Bot Makers which already featured high-quality decision questions covering the four key robo-ethics categories: human-computer interaction, resources, privacy and security, and sustainability [1][2]. Key improvements included enhancements to the design aesthetics and rule clarity. These improvements were implemented across both versions of the board game, with the sole distinction being the presence or absence of a storyline. The immersive storyline provided a more realistic and detailed context for robot development, potentially increasing player empathy with the concept. Figure 1 below is an example of a discussion card with and without storyline integration.

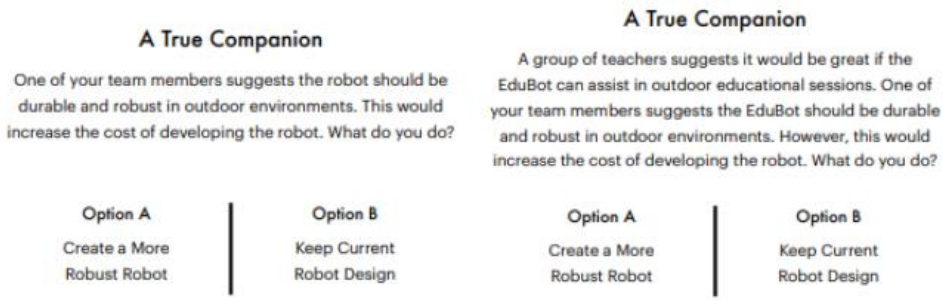

Figure 1. Non-Storyline version and Storyline version discussion card

To streamline the process and conserve resources, we retained the tokens and ethics category scores from the previous game while revamping the overall board design. The board now features a vibrant and engaging colour scheme with pink, beige, and navy. Additionally, we reduced the number of Events squares and increased the number of Decision squares, creating more discussion scenarios for players. In terms of rules, we eliminated individual player tokens to reinforce the collaborative nature

of the game. The board was also made more compact, and the number of cards was reduced by combining decision and results cards into one, allowing players to read a question and then unfold the card to check the results of their choice. These changes resulted in a more well-defined and visually pleasing board game.

3.1.3. Implementation Phase

Following the approved design changes, we initiated the development of an initial low-fidelity prototype for playtesting, in accordance with Cardinot's five-step board game design iteration process [19]. During the playtest session, we identified that the game's original requirement for victory made it overly challenging, leading players to prioritise winning over engaging in discussions about ethical concepts. Consequently, we refined the game rules to reduce the number of tokens required for victory and limited the number of turns, ensuring the game could be completed within 40 minutes to accommodate students' availability in lecture and tutorial sessions. We also recognised the need for clearer differentiation between the non-storyline and storyline versions, prompting us to further integrate storyline concepts into the rulebook.

Our final board game implementation, 'Ethixplorer,' is an educational board game that enables players to explore various facets of robo-ethics, including sustainability, security, resources, and

human-robot interaction (HRI). The final version of the board game is depicted in Figure 2 below, with the prototype versions included in Appendix B.

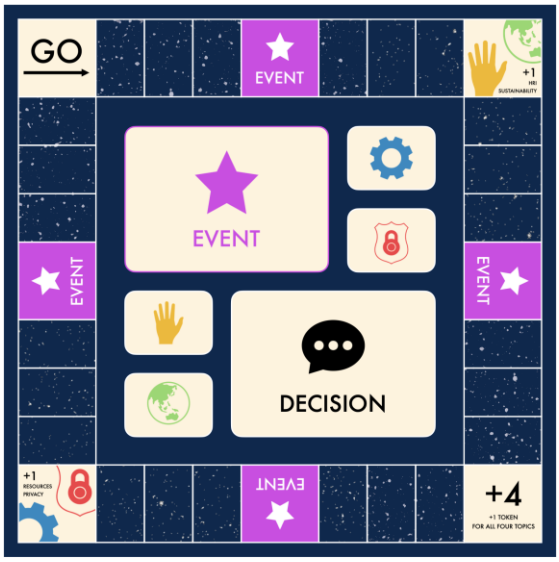

Figure 2. Final Ethixplorer Boardgame Design

The board game comprises a board, a die, team tokens, event cards, discussion cards, character cards, and score tokens for each ethics category. Players select a character card related to a role in robot development and may choose to play as that character. The team starts with four tokens for each ethics category. Players roll the die and move across the board based on their roll. Upon landing on a square, which can be a decision, event, or special square, they either pick a discussion card and discuss it as a team, or select an events card containing realistic events that could occur in robot development projects or the market. One round concludes after each player has rolled the die, and after five rounds, if the team has a minimum of six tokens for each ethics category, they win.

In the storyline version, the team functions as a project team working on "Edubot," an educational robot for use at Ethix High School. The robot must be reviewed by the ethics committee within five weeks for approval and launch. If the team can maintain and enhance ethical qualities by

accumulating more than six tokens, they successfully launch the robot and go on holiday; otherwise, they fail to launch it. Detailed rulebooks for both versions can be found in Appendix C.

3.2.Evaluation Design

The Evaluation phase involved defining the participant criteria, data collection requirements, and the methodology for obtaining valid results to address our problem statement. Ethics approval was secured early in the project from the UAHPEC to conduct a study involving human participants, primarily from the University of Auckland(UoA). Given our study's goal of developing an educational tool, we chose UoA students as our participant group. To ensure a diverse pool, we sought participants from various ethnicities, genders, and age, aiming to glean insights into how different characteristics might impact student engagement with learning through board games.

Pre-designed recruitment materials such as posters and emails approved by the UAHPEC, facilitated the recruitment process and attracted participants. We provided four sets of board games, with two featuring a storyline and the other two without, allowing for a comparison of the effects of storylines on stimulating more in-depth discussions. Different participants were assigned to play different versions of the board games to ensure they remained unaware of the differences in the versions they were given. This approach mitigated concept-building biases and the potential impact of repetition on participants who played the game multiple times. To minimise bias, we randomly assigned groups to either version of the board game and aimed to include as many participant groups as possible to reduce the influence of outliers.

Participants were furnished with a participant information sheet detailing the project's specifics and the purpose of the research session. This ensured that they had all the necessary information.

Additionally, for ethical reasons, participants received a consent form allowing them to sign their agreement for evaluation session and data collection.

Given our research's focus on measuring student engagement during board game discussions, we opted for various data collection methods, including video recordings and observation notes from the board game sessions. A post-play session questionnaire was also employed. These methods allowed us to observe their engagement and focus within the board game context. The questionnaire was carefully structured to encompass both qualitative and quantitative sections, providing a broad spectrum of responses related to the board game context, design, experiences, and the educational insights gained.

4. Experiments and Results

The board game experiment comprised three distinct sessions. The first session involved part four robotics students, with a total of fifteen participants divided into four groups. Two groups each played each version of boardgame. The second session included three voluntary participants, where they played the storyline version of the board game. The final session featured part one and two design students, with sixteen participants organised into four groups, where two groups played storyline version, and the remaining played the other version. In total, eighteen participants engaged in the storyline version, while sixteen participated in the non-storyline version.

4.1.Experiment Setup

During the initial session, we did not arrange the board game setup for the participants, allowing them to initiate the game by reading the rulebook independently. However, we found that this setup approach was unnecessary and redundant. Hence, starting from the second session, we prearranged the game setup before the play session, as illustrated in Figure 3.

Figure 3. Initial Boardgame setup for playing

Physical copies of the participant information sheet and consent forms were conveniently positioned at each station based on participant numbers. Additionally, video recording equipment, such as phones, laptops, or cameras, was prepared and set up at each station to capture the participants' gameplay.

4.2.Activities Undertaken

At the start of each session, the researchers delivered a concise introduction, which included introducing themselves as part four engineering researchers and outlining the session's purpose. Participants were informed that the session aimed to evaluate their board game play, and they were instructed to read the participant information sheet and sign the consent form, have 40 minutes of gameplay, and complete the questionnaire over this evaluation session.

Once all consent forms were collected, video recording commenced, and the participants were given the freedom to engage with the game. Subsequent to this, screenshots from two board game play sessions, as indicated in Figure 4 and Figure 5, were captured through video recording.

Figure 4. 5. Screenshots from Recording of Boardgame play sessions

Researchers maintained a hands-off approach during gameplay, intervening only when participants had questions about rule clarification. Primarily, the researchers observed the participants' gameplay. After completing a full game of the board game, the board games were packed, video recording was halted, and participants were provided with questionnaires to complete individually without discussing with each other. Once all participants in the session had finished the questionnaires, the session concluded.

4.3.Results

A total of thirty-four participants took part in this study, evenly distributed between genders with seventeen males and seventeen females. In terms of ethnicity, twenty-six participants identified as Asian, five as New Zealand European, two as European, and one as American. Age distribution included ten participants under 20, seventeen between 20 and 24 years, four between 25 and 30 years,

and three over 30. This diverse demographic representation accurately reflects the target group for this study.

4.3.1. Quantitative Results

Two types of quantitative data were collected for the research. First, participants completed a Likert scale rating in the post-gameplay questionnaire (Figure 6), and second, the duration of game sessions was categorised based on conversation topics (Figure 7).

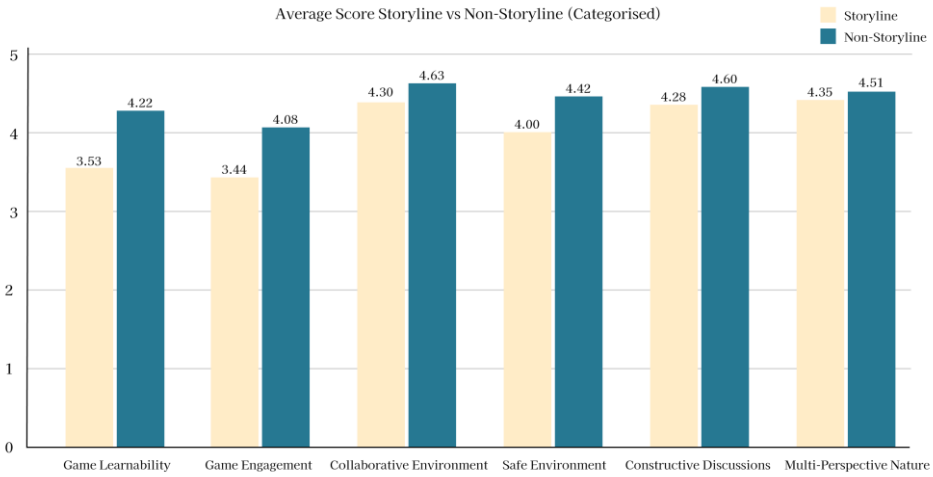

Figure 6. Average Likert Score for Categorised Statements

In the questionnaire, participants rated statements related to gameplay on a scale from one (Strongly Disagree) to five (Strongly Agree). Ratings from participants of both versions were each averaged for the statements. To facilitate comparison, these statements were categorised, and the Likert scores for statements within the same category were averaged, as shown in the Figure 6. The categories encompassed game learnability, game engagement, collaborative environment, safe environment, constructive discussions, and multi-perspective nature. These statements broadly addressed overall game experience and collaboration during discussions. Notably, the mean ratings for each category were lower for the storyline version than for the non-storyline version in all categories. A more

detailed breakdown of the mean scores for each statement within each category is provided in Appendix D.

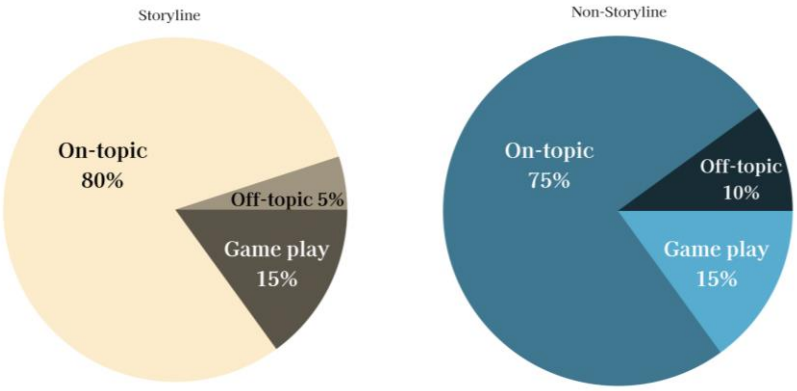

Figure 7. Game Discussion breakdown for Storyline and Non-Storyline Groups

The timely breakdown of discussions was extracted from video recordings of participant gameplay sessions. Researchers measured time based on their interpretation of participant conversations, classifying them into three categories: On-topic, Off-topic, and Game Play. While this representation may not offer precise statistics, it provides an overview of the discussion topics within each group. "On-topic" discussions pertained to robo-ethics context, the storyline, or game concepts. "Game Play" included conversations about the game itself, including understanding and discussing rules, components, and unrelated topics like score acquisition or winning. "Off-topic" conversations encompassed any other topics that arose during the gameplay session unrelated to the core activity. The breakdown of time for all storyline and non-storyline groups was averaged and displayed in Figure 7 above as percentages. On average, storyline groups spent 80% of their discussion time on-topic, 15% on game play, and 5% off-topic. In contrast, non-storyline groups averaged 75% on-topic,

15% on game play, and 10% off-topic. On-topic discussions predominated among all participants during the board game sessions.

4.3.2. Qualitative Results

Qualitative data were gathered through participants' responses to open-ended questions in the questionnaire. The questionnaire consisted of multiple sections, with section 2 focusing on the overall game experience, and section 3 focusing on scenario discussions. In section 2, the question "What did you like most about the game?" aimed to gauge participants' perceptions of the overall game experience and what aspects stood out to them. Figure 8 provides an overview of the responses categorised into the most frequently mentioned themes: storyline, discussion, game components, and collaboration.

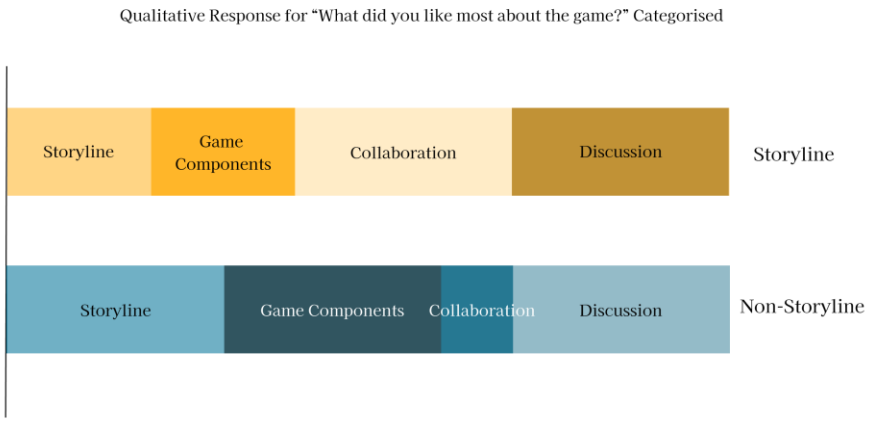

Figure 8. Qualitative Response Categorised to Themes

In the storyline group, responses were fairly evenly distributed among the four categories, suggesting that all four elements held nearly equal significance and contributed positively to the storyline game participants' experiences. On the other hand, the non-storyline group exhibited a more uneven distribution, with storyline and discussion each comprising roughly one-third of the responses, while game components and collaboration accounted for the remaining third.

Regarding questions related to scenario discussions in section 3 of the questionnaire, a thematic analysis was conducted to identify major trends and themes within the qualitative data. Figure 9 presents the key themes and trends for both storyline and non-storyline participant groups.

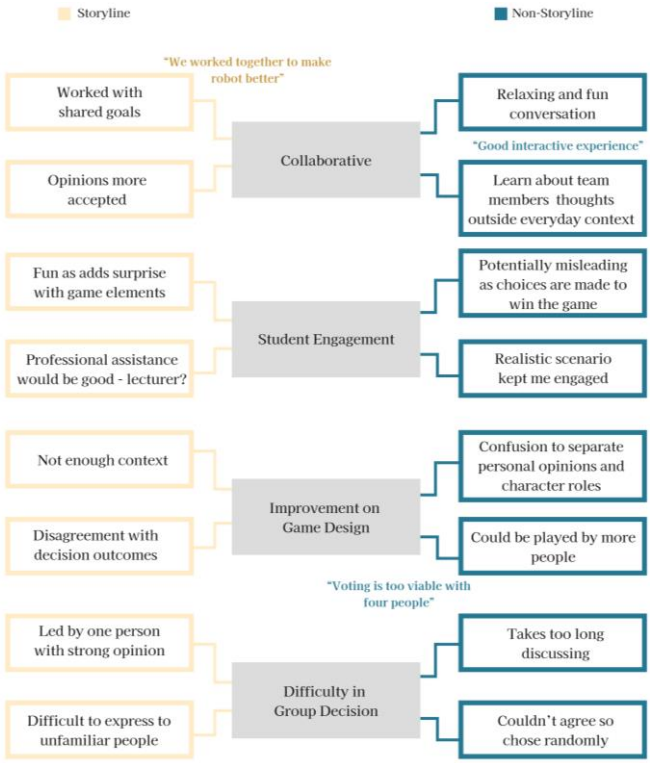

Figure 9. Thematic Analysis of Qualitative Data

Both groups consistently highlighted themes related to the collaborative experience, student engagement, game design improvements, and challenges encountered during group decision-making. Positive feedback centred on the collaborative experiences provided by the board game activity, with the storyline group emphasising the importance of shared goals as a team, while the non-storyline group found the activity enjoyable and a means to get to know one another. Mixed positive and negative themes emerged in discussions of engagement, with both groups acknowledging the fun elements and scenarios of the game but also pointing out limitations, such as a lack of professional attention to learning and heightened competitiveness. Feedback on board game design included comments about the need for clearer context explanations, confusion about character role cards, and

suggestions to increase group size for more extensive discussions. Lastly, participants highlighted difficulties encountered during group discussions, with the storyline group expressing challenges in expressing opinions to unfamiliar team members, particularly when there was a dominant member in the group. The non-storyline group discussed challenges related to arriving at group decisions and the length of discussions, which sometimes led to random decision-making.

5. Discussion

5.1.Game Engagement

In general, the participants found the game experience to be positive, with the majority noting that it was engaging, fun, and provided motivation for discussions. In the questionnaire, most participants answered affirmatively, indicating that the board game was more effective and engaging than traditional lecture or tutorial-based learning methods. This observation aligns with existing study, that boardgames are entertaining and enhance engagement, and facilitate peer teaching and teamwork through discussions [14]. When using a Likert scale, it was found that game learnability and game engagement were better in the non-storyline group, differing by 0.69 and 0.64, respectively. This difference could be attributed to the longer rulebook associated with the storyline integration. However, it was evident from the qualitative feedback that the context of decision and outcome cards was often insufficient, and the rules were considered confusing. Therefore, reducing the length of these components did not seem to be a suitable solution. It became apparent that an improved board game design was necessary to enhance the overall participant experience.

The data suggested that students were primarily drawn to the board game elements, such as designs and the acquisition of tokens, which contributed to keeping them engaged. However, there were numerous comments about becoming too invested in winning the game, indicating the unresolved

problem of using a board game for learning that was identified in previous studies with "Grants and Researchers game" where players made unethical decisions led to earning more points to win the game [13]. Overall, it was evident that the non-storyline group had a more profound engagement with the board game itself, as evidenced by their significantly higher Likert ratings. Their questionnaire responses mostly centred on key themes of having fun, relaxation, and building relationships with team members. This group seemed to enjoy the gameplay aspect and was more attracted to the gaming nature of the activity than the ethical content.

In contrast, the storyline group mainly commented on their challenges in expressing themselves, with their comments focused on discussions becoming excessively lengthy. This contrast between the two groups suggests that the non-storyline participants were more attracted to the gameplay, while the storyline group may have been more focused on the ethical aspects.

5.2.In-depth Team Discussions on Ethical Topic

In terms of time spent On-topic discussions, it was observed that the storyline team tended to have slightly longer discussions, although the difference was relatively minimal. Qualitative responses suggested that successful collaboration played a significant role in keeping these groups consistently engaged within their contextual framework. Consequently, the storyline team appeared to be more cohesive as a team, emphasising the importance of shared goals. While this cohesion didn't necessarily translate into a stark statistical difference in Likert ratings, when compared to the non-storyline group, who provided significantly fewer responses about collaboration, it can be inferred that the inclusion of a storyline and the establishment of players as a team with a detailed goal, such as developing an educational robot for ethical committee approval, contributed to improved teamwork and motivation within the storyline context.

In contrast to the noticeable difference in Likert scores for game learnability and engagement categories, the variance between the two groups was considerably lower in other categories. The

difference in the collaborative environment was 0.33, the safe environment was 0.42, constructive discussions had a difference of 0.32, and the multi-perspective nature showed a difference of 0.16. This suggests that while the storyline team might have been less engaged in the game itself, they had a notably positive experience when it came to collaboration, discussions, and exploring diverse perspectives within the team.

Furthermore, it's particularly noteworthy that Likert statements such as "Group worked together to achieve the goal of the game" with a difference of 0.11, "Group discussions were on-topic" with a difference of 0.19, "Group discussions were constructive and not hurtful" with a difference of 0.07, and "Groups discussions made me think about different perspectives" with a difference of 0.01 displayed significantly smaller differences in the storyline group compared to the non-storyline group's Likert scale. Given that other statement differences were considerably larger, some even reaching 0.6, and considering the overall lower average score for the storyline group, this indicates that the storyline group was particularly satisfied with their collaboration toward a unified goal, maintaining on-topic and constructive discussions, and the experience of sharing different perspectives about ethical concepts.

5.3.Limitations

In response to our research question, we conducted a controlled experiment in which two different groups were provided with distinct versions of board games. This approach was necessary because the design of the game indicated that a single prior exposure to the context would significantly influence a player's subsequent gameplay. Consequently, we ensured that all participants were encountering the game for the first time to obtain unbiased results. However, a limitation of this study is the potential for selection bias, as it is challenging to guarantee perfectly matched participant

characteristics between the groups. This bias could arise from personal traits, preferences, or the influence of social desirability.

For instance, it was observed that the Likert scale ratings provided by non-storyline participants were higher across all categories compared to the storyline group's ratings. While this might reflect the actual impact of the storyline in the board game, the uniformity in higher ratings for all categories also raises concerns about the reliability of the results. It could suggest that participants in the storyline group tended to rate items more favourably. To mitigate this potential issue, future Likert scale statements could be designed as a mixture of negative and positive statements to reduce the likelihood of participants consistently rating everything highly. This would help ensure a more robust assessment of the game's impact.

5.4.Future Works

The next steps in enhancing the current version of the board game and making it more engaging and educational for the context of robo-ethics would involve additional iterations based on participant feedback. Improvements to the game rules and rulebook are essential to reduce player confusion, allowing them to focus more on discussions. Further ideation and development of the storyline are also necessary to create a deeper and more engaging narrative that is seamlessly integrated into the board game. This distinction from versions without the storyline will help clarify the impact of the storyline on discussions. With these more distinguished versions, additional participant play sessions can be organised to conduct further research on the effects of the storyline on discussions.

6. Conclusions

The report delves into the utilisation of board games as a highly effective tool for imparting an understanding of the ethical dimensions inherent in the development of robots. The integration of a compelling storyline within the board game was anticipated to facilitate more profound discussions

among students about the ethical scenarios encountered, thereby enhancing their educational experience. This gave rise to the central question of whether the inclusion of storylines in board games can indeed foster more in-depth discussions among students studying robo-ethics.

To address this question, we embarked on a comprehensive research, design, and evaluation process, creating a new version of the robo-ethics board game, complete with an integrated storyline. This successfully fulfilled our initial research objective of designing a board game with an embedded storyline for teaching robo-ethics within a university classroom setting. The second objective was realised as university students participated in both the storyline and non-storyline versions of the board games during the subsequent evaluation session, allowing us to compare the impact of the storyline on board game discussions.

In sum, the study revealed that board games served as engaging and motivational tools for students to explore ethical scenarios and gain insights into robo-ethics concepts. However, the differences in the resulting data between the storyline and non-storyline versions were not substantial enough to conclusively assert that storylines significantly stimulate more profound discussions on robo-ethics among the participants. This may be attributed to the lack of clear distinctions between the two versions. To extract more valuable insights, enhancements must be made to the board games, rendering the two versions more distinct. An interesting observation, however, is that participants engaging with the storyline version reported significantly more positive experiences concerning team collaboration, the discussion environment, and the exploration of different perspectives.

It is worth acknowledging that the findings of this research may be influenced by individual participant biases, yet this presents a promising avenue for future exploration – whether storyline integration provides a unifying goal for board game players and, in the long term, bolsters students' focus and immersion in robo-ethics concepts. Additionally, it is essential to recognise that the depth of discussions may have been impacted by confusion related to game mechanics and rules.

Consequently, future iterations of the board game design should aim to minimise these sources of confusion.

Considering the findings of this study, it is apparent that the integration of storylines into board games may not result in significant differences in the depth of discussions among university students on the subject of robo-ethics principles. However, it does suggest the potential to enhance collaborative and multi-perspective experiences during discussions.

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Appendix A: Game Development Research Table

	Monopoly	Castle Panic	The Game of Life	Cluedo	Uno	Bot Makers
Positive	Clear rulebook, engaging story concept	Storyline is very immersive; component designs match the story well. Collaborative game aids discussion.	Clear, relatable realistic storyline. The token designs resembling actual car and human is good.	Storyline engagement is the best, the design matches storyline well	Simple rules, short gameplay time, little resources need to develop.	Context is good: engaging discussion cards, event cards are good twisters
Negative	No discussion between players	Too many components to the game – monsters, items, soldier cards	Too many phases in game makes it confusing and gameplay too long	Rule a little bit difficult to understand from first time play.	Fast paced game, cannot move into discussions	The rule book is bit too long and boring. The design is plain.
Notes	Monopoly board gameplay rules are most basic and familiar – refer to rulebook	Collaboration game – good discussion on strategies	Game play should finish in 40-50 minutes	Important that aesthetic theme is consistent throughout board, characters, rulebook	N/A	Keep context but improve design aesthetic.

Table 1. Existing Games Summary

Appendix B: Boardgame Iteration Design Versions

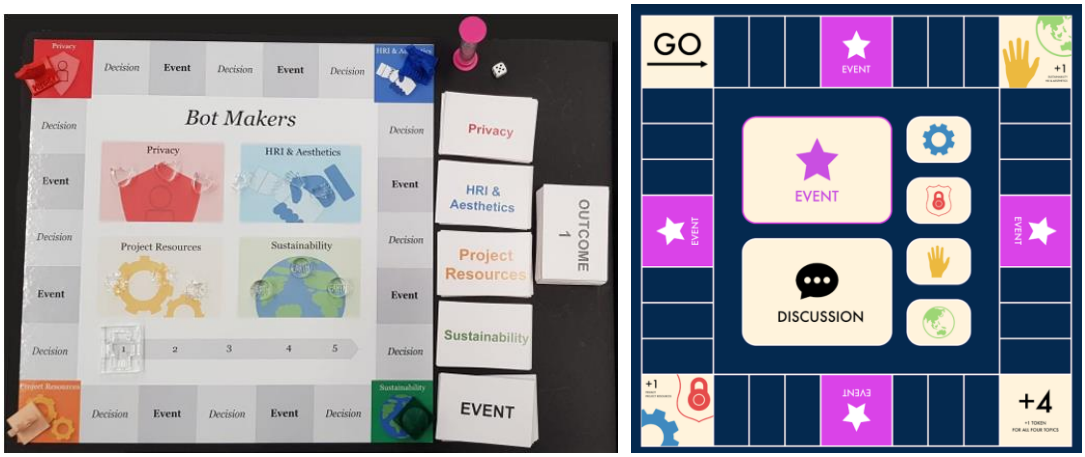


Figure B.1. Bot Makers Boardgame from last year / Figure B.2. High Fidelity Prototype of Ethixplorer

Figure B.3. Final Implementation of Ethixplorer

Appendix C: Ethixplorer Rule Book

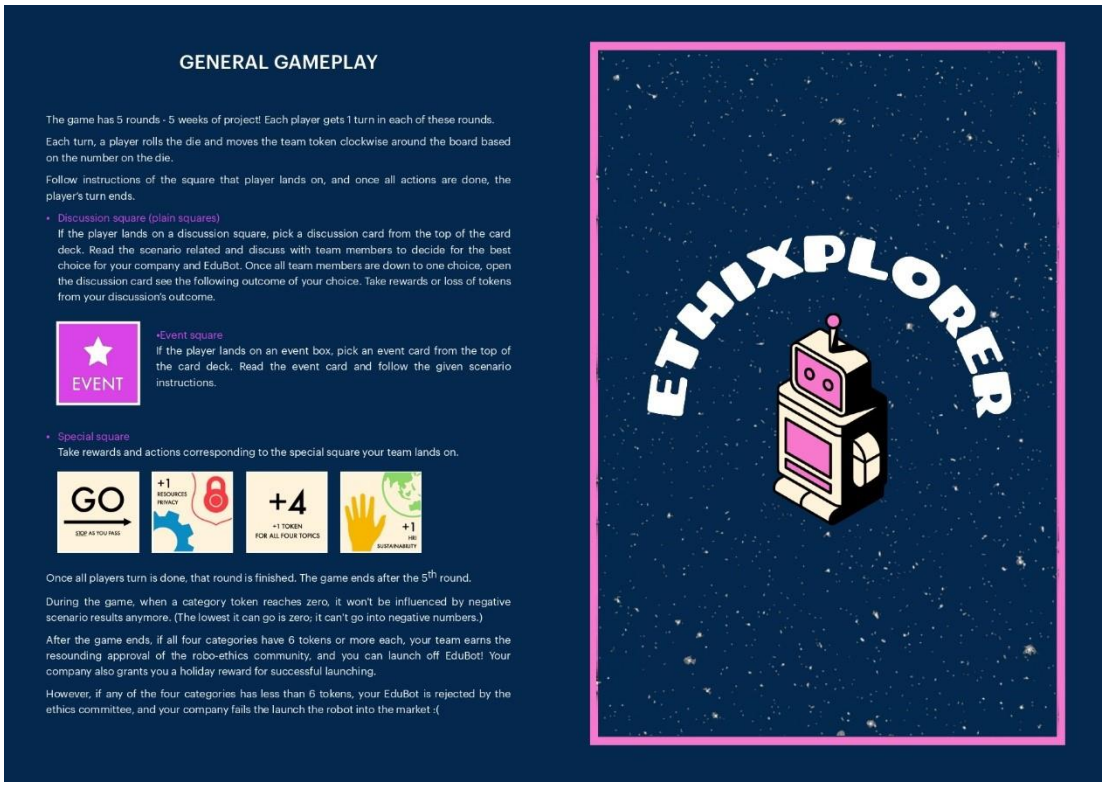


Figure C.1: Storyline Version Rule Book - General Gameplay

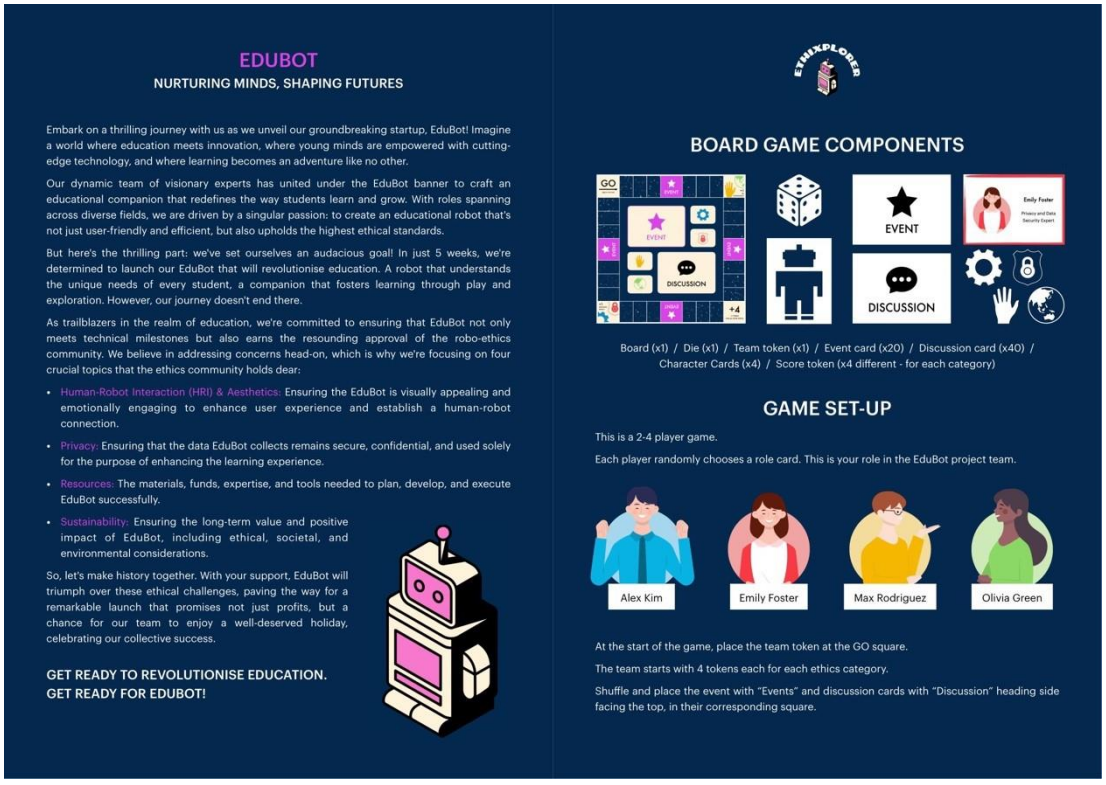


Figure C.2: Storyline Version Rule Book - Background and Board Game Components

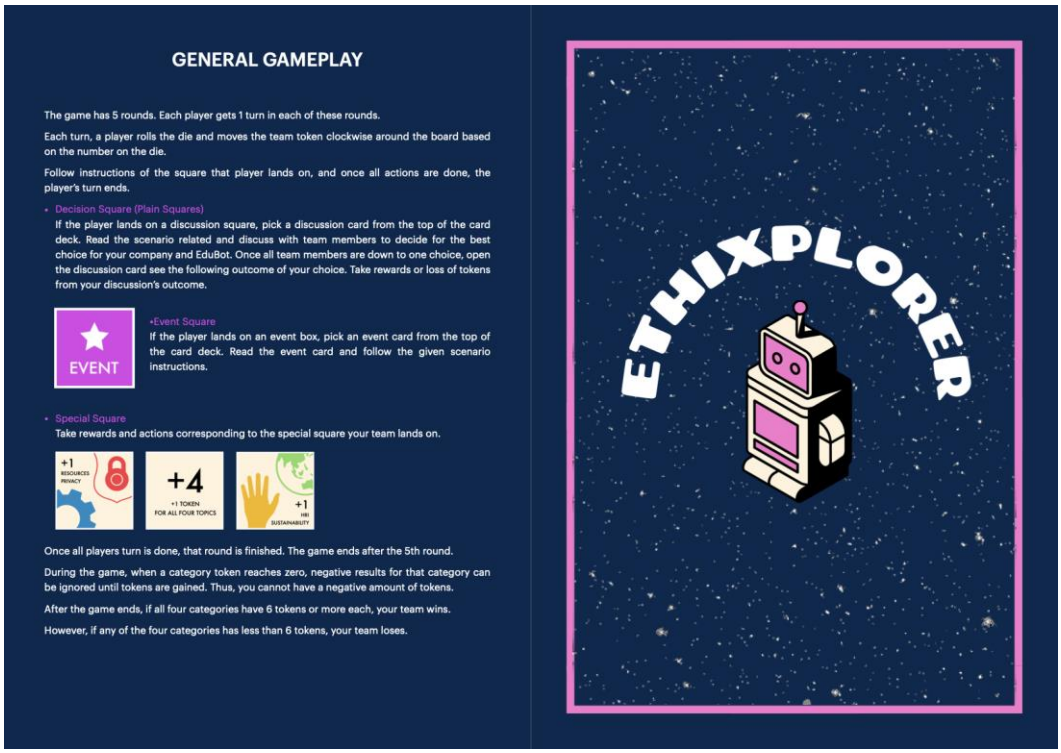
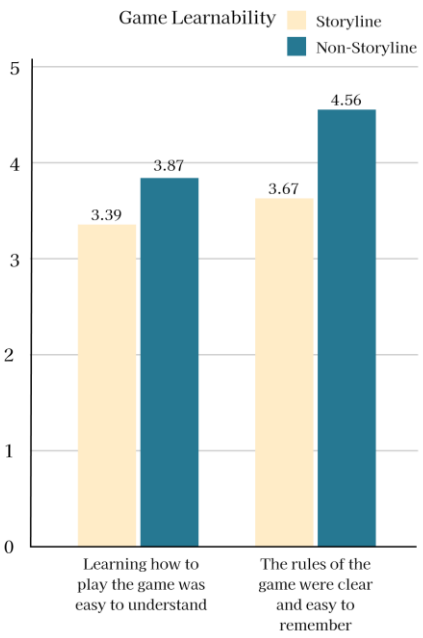


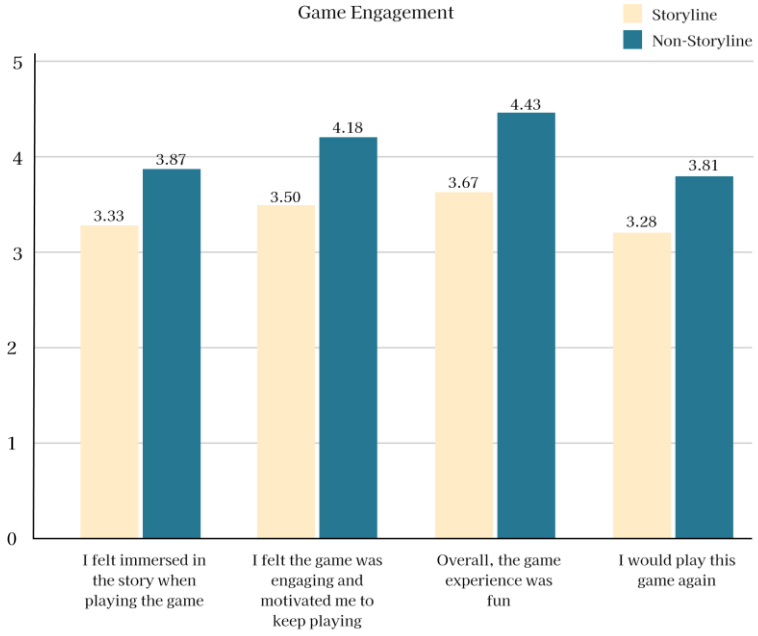
Figure C.3: Non-storyline Version Rule Book - General Gameplay

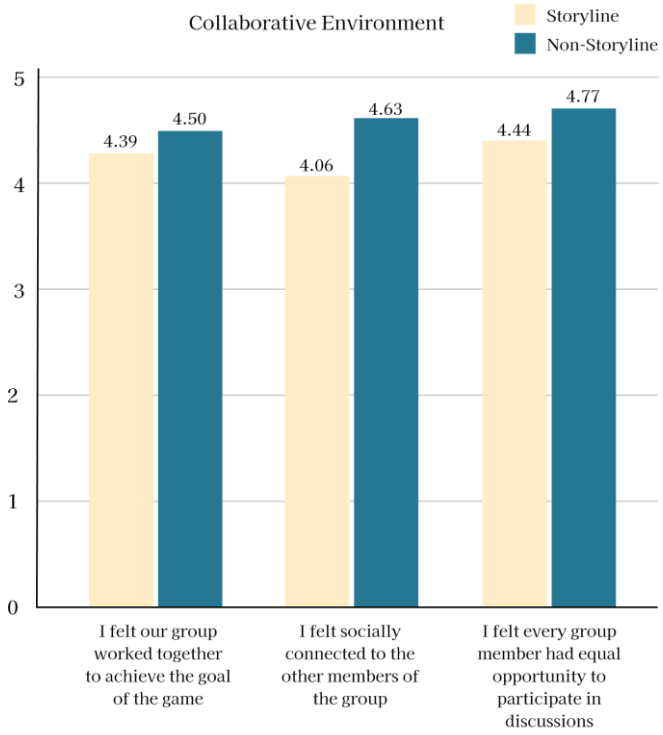
Figure C.4: Non-storyline Version Rule Book - Background and Board Game Components

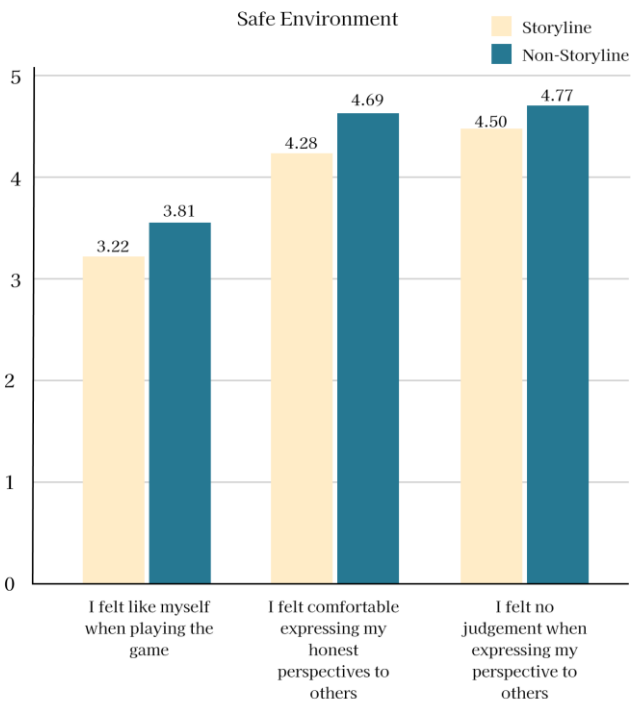
Appendix D: Quantitative Results from Questionnaire

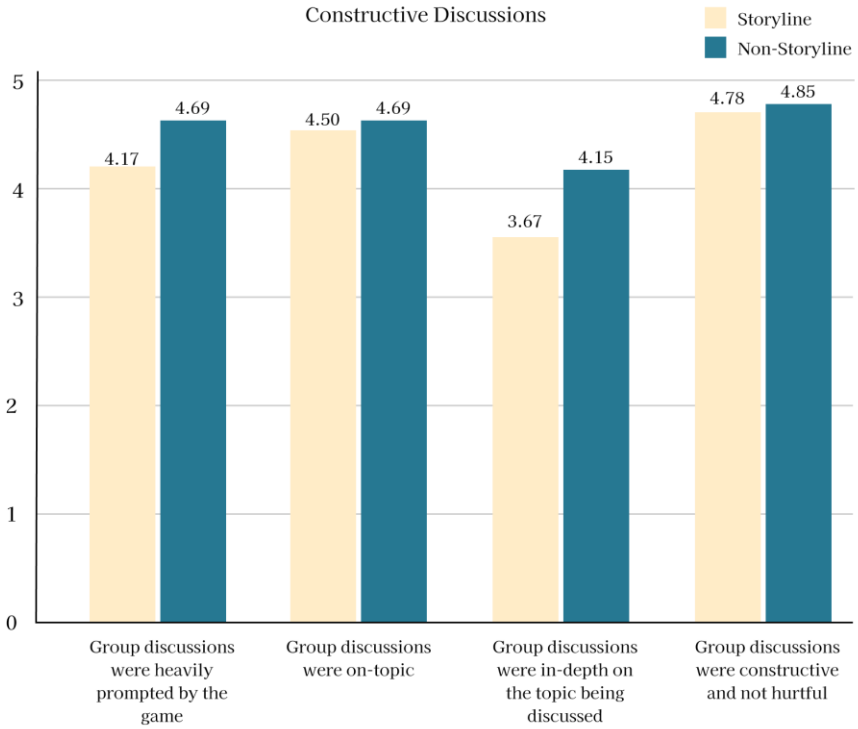
These figures are the Likert scale average score calculated for each version groups, data taken from the questionnaire.

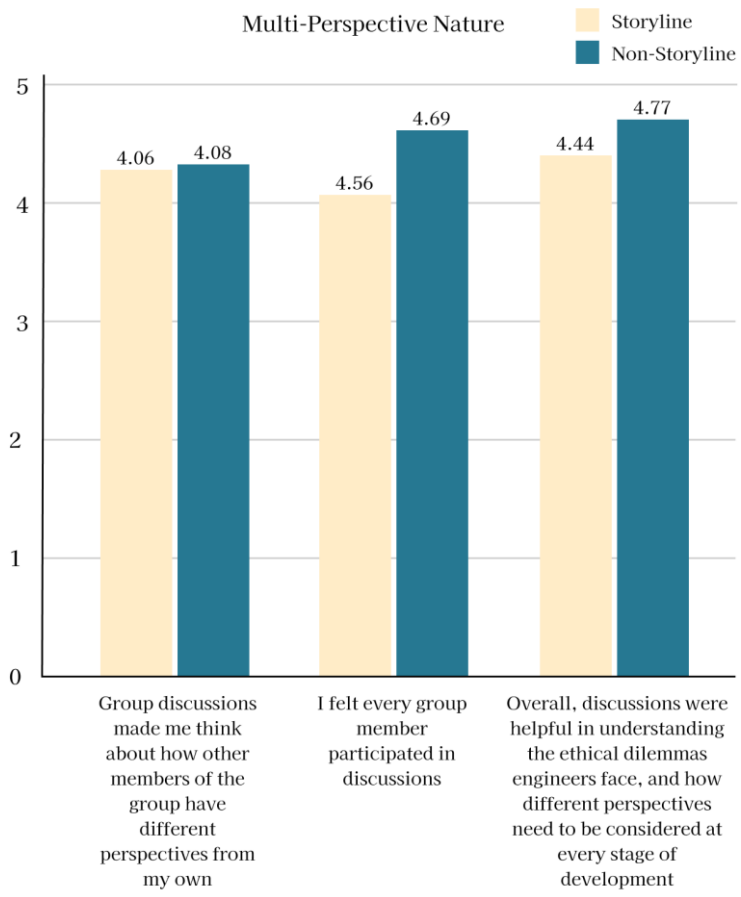







Safe Environment
Storyline
Non-Storyline
5
4
3
2
1
0
3.22
3.81
4.28
4.69
4.50
4.77
I felt like myself when playing the game
I felt comfortable expressing my honest perspectives to others
I felt no judgement when expressing my perspective to others


Constructive Discussions
Storyline
Non-Storyline
5
4
3
2
1
0
4.17
4.69
4.50
4.69
3.67
4.15
4.78
4.85
Group discussions were heavily prompted by the game
Group discussions were on-topic
Group discussions were in-depth on the topic being discussed
Group discussions were constructive and not hurtful


Multi-Perspective Nature
Storyline
Non-Storyline
5
4
3
2
1
0
4.06
4.08
4.56
4.69
4.44
4.77
Group discussions made me think about how other members of the group have different perspectives from my own
I felt every group member participated in discussions
Overall, discussions were helpful in understanding the ethical dilemmas engineers face, and how different perspectives need to be considered at every stage of development