A **REPORT** ON **PILOT EVALUATION** OF **GREEN THEMED SERIOUS GAMES**

Prepared by:

PLAY2GREEN

Serious Gaming for Universal Access to Green Education

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A REPORT ON PILOT EVALUATION OF GREEN-THEMED SERIOUS GAMES

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Executive summary

Climate change has become one of the most pressing challenges of recent decades. Issues such as marine pollution, air pollution, deforestation, and greenhouse gas emissions have heightened the urgency for action. Inspired by the work of Greta Thunberg and other environmental activists, the Play2Green project was created with the overarching objective of raising awareness of environmental challenges among university students and the wider community.

Education is one of the most powerful tools in addressing environmental issues. By informing and engaging the general public, individuals become more aware of the problems and the actions that can mitigate them. To reach the broadest possible audience, it is essential to design solutions that are universally accessible. Leveraging Emerging Technologies (ET) and aligning development with Universal Design for Learning (UDL) principles significantly increases inclusivity and ensures that more users can benefit from the solutions.

The project focuses on developing socially innovative solutions based on ET to improve knowledge of green topics, particularly recycling and waste management. For such solutions to have an impact, they must be both accessible and widely available. By integrating UDL principles with ET, Play2Green enhances the feasibility and scalability of these goals. This report contributes to disseminating these achievements by showcasing the visibility and acceptance of the developed green-themed serious games, especially among high school students and higher education learners.

Chapter one – Introduction

The "green agenda," encompassing the broad spectrum of environmental challenges, can and should be integrated into higher education curricula. Embedding such themes into education enhances the likelihood that younger generations will adopt sustainable practices in their daily lives. Even seemingly small, individual contributions can have a meaningful impact on addressing today's environmental crises. The introduction chapter outlines the key actors in this project: green education, the application of UDL principles, the role of serious games, and the importance of systematic user testing and evaluation of developed solutions.

Chapter two – Green themed serious games

This chapter presents the green-themed serious games developed within the Play2Green project. Out of a dozen prototypes, three games were selected, refined, and fully developed. Each game leverages a different emerging technology, chosen to align with its educational objectives and gameplay mechanics. Green Siesta employs Artificial Intelligence. Green Siesta Quiz integrates Augmented Reality. HoloZoo explores the potential of holography. These games combine educational content with engaging interaction, aiming to foster awareness and knowledge of environmental issues through play.

Chapter 3 – Experiment setup

The third chapter, experiment setup, describes the methodology used to evaluate the games. Each of the three serious games was accompanied by a structured questionnaire. These questionnaires collected demographic data, user experience feedback, perceptions of the ET employed in each game, assessments of the UDL features, and overall satisfaction with the solutions. Overall 360 users participated in this evaluation, including high school students, university students, PhD students, postdoctoral fellows, university professors and others. To gather sufficient data, dissemination events were organized across partner countries. These events included plenary presentations, hands-on gaming sessions, and subsequent completion of the questionnaires by participants.

Chapter 4 – Results and discussion

The results and discussion chapter presents and interprets the results obtained from the dissemination events. Findings are illustrated with graphs and are analysed separately for each of the three games. Overall, participant feedback was highly positive, with the vast majority of participants achieving their learning outcomes. The games were well received, and user experience did not differ significantly across groups divided by gender, age, gaming experience, or disability status. The biggest differences were noted by comparing participants with previous gaming experience to those without. Importantly, most participants indicated they would recommend the games as educational tools for learning about waste management and recycling. Many also noted that the game design appeared particularly suitable for younger audiences, which reinforces their potential as tools for early environmental education.

Chapter 5 – Conclusions

The concluding chapter synthesizes the insights drawn from the analysis. The primary aim of the Play2Green project was to develop accessible solutions that bring green education closer to students, including those with disabilities. The findings confirm the value of integrating UDL principles in the development process, as these guidelines support personalized learning pathways and enable students to engage with the content according to their own preferences. Furthermore, the analysis suggests that the developed solutions were successful in their overarching goal, which was to make green education more accessible by combining emerging technologies with inclusive design. This approach shows great promise by interpreting the results, by not only enabling broader engagement but also lays the foundation for future innovations in green education.

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1 Introduction

Chapter 1

Introduction

Green topics have gained increasing attention from companies, organizations and educational institutions worldwide. Their relevance extends beyond environmental protection to include sustainability, climate action and the responsible management of natural resources[1]. These topics emphasize not only preserving the environment but also promoting long-term social and economic well-being. As global challenges such as climate change, resource depletion and pollution, the integration of green principles into policies, business practices and educational initiatives has become essential[2].

Education plays a central role in fostering awareness and understanding of these issues[3]. By equipping individuals with knowledge and skills related to sustainability, education helps shape responsible behaviors and informed decision-making. Despite its critical importance, many educational systems face challenges in fully integrating sustainability concepts into their curricula[4]. Limited resources, rigid program structures and a lack of teacher training often hinder the effective delivery of environmental education, making it difficult to motivate and prepare future generations to act responsibly toward the planet.

To enhance learner engagement and promote active learning, it is crucial to adopt approaches that resonate with learners' experiences and preferences. Education institutions can foster more inclusive and engaging learning environments by effectively leveraging and integrating technologies[5]. Serious games, in particular, have emerged as an innovative educational tool[6]. Defined as games whose primary purpose is to develop user skills rather than provide entertainment, serious games use simulation, interactive learning and scenario-based challenges to facilitate understanding. In environmental education, serious games can increase awareness of ecological issues, foster pro-environmental behaviors and support sustainable decision-making.

When designing educational materials, whether serious games, interactive simulations, or traditional resources, applying the principles of Universal Design for Learning (UDL) is essential[7]. UDL provides a framework for creating inclusive and equitable learning environments, accommodating the wide range of abilities, motivations, backgrounds, and learning preferences among students. By ensuring accessibility and flexibility in learning experiences, UDL addresses the limitations of one-size-fits-all approaches, making sustainability education more effective and engaging for diverse audiences.

The three main areas highlighted (green education, serious gaming and universal design for learning)

[1] L. Zhang, M. Xu, H. Chen, Y. Li, and S. Chen, "Globalization, green economy and environmental challenges: state of the art review for practical implications," Frontiers in Environmental Science, vol. 10, p. 870271, 2022.

[2] J. Awewomom, F. Dzeble, Y. D. Takyi, W. B. Ashie, E. N. Y. O. Ettey, P. E. Afua, L. N. A. Sackey, F. Opoku, and O. Akoto, "Addressing global environmental pollution using environmental control techniques: a focus on environmental policy and preventive environmental management," Discover Environment, vol. 2, no. 1, art. no. 8, 2024.

[3] European Commission, "Green education initiatives," European Education Area, European Union, Focus Topics – Green Education, "About Green Education," updated 21 August 2025. [Online]. Available: https://education.ec.europa.eu/focus-topics/green-education/about-green-education. [Accessed: 25-Aug-2025]

[4] Y. Chavula, E. Abdi, A. Uwimbabazi, C. Habowa, G. Mensah, L. Amanzi, et al., "Bridging environmental education and sustainable development: An integrated approach for a greener future," 2024.

[5] I. Zekic, J. Babic, and I. Slosic, "Inclusion of Green-themed Serious Games based on Emerging Technologies into Non-green-themed Higher Education Courses," in 17th International Conference on Telecommunications, ConTEL 2023, Institute of Electrical and Electronics Engineers Inc., 2023. doi: 10.1109/ConTEL58387.2023.10198981.

[6] F. Bajraktari et al., "A serious gaming approach for teaching environmental entrepreneurship," in IEEE Global Engineering Education Conference, EDUCON, IEEE Computer Society, Apr. 2021, pp. 1310–1317. doi: 10.1109/EDUCON46332.2021.9454148.

[7] M. Yang, M. S. U. Duha, B. A. Kirsch, N. Glaser, H. Crompton, and T. Luo, "Universal design in online education: A systematic review," Distance Education, vol. 45, no. 1, pp. 23–59, 2024.

constitute the primary focus of the **Play2Green, P2G** project with the full title: **Serious Gaming for Universal Access to Green Education**[8]. The P2G project (identifier: 2022-1-HR01-KA220-HED-000088675) kicked off on September 1, 2022, and is set to wrap up on August 31, 2025, after three years (36 months) of work. The Play2Green project is carried out by an international consortium composed of five higher education institutions (HEIs) and one non-governmental organization (NGO). The HEIs are universities representing four EU member states: University of Zagreb Faculty of Electrical Engineering and Computing (Croatia), University of Debrecen (Hungary), Universitat Politècnica de València (Spain), IMT Atlantique Bretagne Pays de la Loire (France), and University of Dubrovnik (Croatia). The NGO partner is ASPAS (Asociación de Familias y Personas Sordas de Valencia) from Valencia , an organization established by parents to provide a common framework of reference and support aimed at improving the quality of life of hearing-impaired children and their families. The inclusion of the non-governmental organization in the consortium further emphasizes the importance of Universal Design for Learning (UDL) and the provision of universal access to education for all.

The project aims to raise awareness of green topics through serious games and to ensure universal access to education for all learners, with a particular focus on higher education students and lecturers, as well as high school students. As part of the P2G project, three green-themed serious games have been developed:

- **Green Siesta – an artificial intelligence-based serious game** designed to teach players about sustainable waste management practices and environmental decision-making through interactive scenarios and personalized feedback.
- **HoloZoo – a hologram-based serious game** that introduces players to biodiversity and wildlife conservation using immersive 3D holographic representations of animals and ecosystems.
- **Green Siesta Quiz – an augmented reality-based serious game** that reinforces knowledge from Green Siesta, allowing players to engage with waste management and other sustainability challenges in a real-world environment using AR technology.

Evaluation and piloting following the development of a serious game are essential to ensure that the game effectively achieves its educational objectives[9]. This process assesses whether the game fosters meaningful learning, skill development and user engagement. Through evaluation, developers obtain valuable feedback on game design, usability and accessibility, enabling them to identify both strengths and areas for improvement. Piloting further verifies whether the game is suitable for the target audience, accommodates diverse learning needs, and translates immersive and interactive experiences into real-world knowledge retention and behavioral change[10]. Ultimately, thorough evaluation and piloting provide validation and credibility for serious games as effective educational tools, while guiding refinements to optimize their learning impact and overall effectiveness.

This document provides an overview of the evaluation of the developed serious games, namely Green Siesta, Green Siesta Quiz and HoloZoo. It details the methodology employed during the pilot evaluation and offers insights into the impact of these games on higher education students and lecturers, as well as on high school students who participated in the pilot. It should be emphasized that more than 300 participants engaged in the evaluation of the developed serious games, producing substantial results and highly positive feedback.

The following chapters provide a detailed description of the developed serious games, including essential information and accompanying screenshots. This is followed by a comprehensive overview of the experimental setup, covering the methodology, a list of events and other relevant details. An extensive discussion of the results, which forms the core of this document, is then presented. Finally, the conclusions summarize and complement the entire pilot evaluation as well as this report.

[8] Official web page: https://sociallab.fer.hr/play2green/

[9] A. Bester, L. R. Mayer, E. Pacheco-Velazquez, and V. Rodes-Paragarino, "What do we evaluate in serious games? A systematic review," in Proc. 17th Eur. Conf. Games Based Learning (ECGBL), Academic Conferences International (ACI), Sep. 2023, pp. 482–489.

[10] L. Rodriguez-Calzada, M. Paredes-Velasco, and J. Urquiza-Fuentes, "The educational impact of a comprehensive serious game within the university setting: Improving learning and fostering motivation," Heliyon, vol. 10, no. 16, 2024.

Green-themed serious games

2

Chapter 2

Green-themed serious games

Serious games, games designed with the primary purpose of enhancing knowledge and/or skills while maintaining an entertaining format, have demonstrated a strong impact in educational contexts. Their strength is in increasing engagement as well as their adaptability, meaning they can be designed by Universal Design for Learning (UDL) principles, making them accessible to a wider audience through personalization and inclusive features. Compared to traditional teaching methods, serious games offer significant advantages. They foster motivation in learners, provide highly interactive and inclusive digital experiences, and can be adapted for a variety of purposes, including rehabilitation, simulation, or education on complex topics[1].

The Play2Green project sought to bring the green agenda closer to the general public, particularly targeting high school and university students. Its main aim was to teach them about waste management and recycling practices, including differences in approaches across countries. An additional innovation of the project was the integration of Emerging Technologies (ET), making the games more engaging and appealing to younger generations who are accustomed to digital innovations.

Three serious games were ultimately developed. Green Siesta is an Artificial Intelligence (AI) based game that integrates UDL principles through multiple personalization options, the inclusion of a virtual sidekick serving as both guide and tutor, and the use of non-playable characters (NPCs). Green Siesta Quiz builds on Augmented Reality, which is used both for object manipulation and for designing a reward system with multiple features. Finally, HoloZoo employs holography to immerse students in learning about endangered species and ecosystems across the globe.

2.1 Green Siesta

Green Siesta[2] is a dialogue-based quest game set in a 3D virtual environment. It follows a student, Kimi, as they navigate a virtual world and learn how to manage different types of waste, including plastic, paper, and organic materials. The game is divided into four levels. The introductory level teaches the

Figure 2.1: Completing quests in the Green Siesta serious game

[1] I. Zekic, J. Babic, and I. Slosic, "Inclusion of Green-themed Serious Games based on Emerging Technologies into Non-green-themed Higher Education Courses," in 17th International Conference on Telecommunications, ConTEL 2023, Institute of Electrical and Electronics Engineers Inc., 2023. doi: 10.1109/ConTEL58387.2023.10198981.

[2] https://sociallab.fer.hr/play2green/games/green-siesta/

player how to navigate and control the game while outlining expected learning outcomes. Subsequent levels focus on completing quests such as collecting waste, managing it properly, or creating new objects from recycled materials, as shown in figure 2.1. Additionally, players can discover "Green Secrets", boxes hidden throughout the environment that provide facts about recycling and waste management relevant to each level's theme.

The integration of educational content is the most critical feature for an educational serious game. Learning materials are embedded into dialogues with NPCs, who also introduce the quests and tasks, shown in figure 2.2, making them more engaging and digestible than traditional text-based methods. The

Figure 2.2: The instroduction to a level in the Green Siesta serious game

"Green Secrets" feature also enriches the experience by rewarding exploration with factual information, as shown in figure 2.3. Ultimately, the overarching goal of Green Siesta is to teach proper waste management and disposal practices for paper, plastic, and organic waste, embedding educational objectives directly into the gameplay and narrative structure.

Figure 2.3: Opening a hidden green secret in the Green Siesta serious game

UDL principles are applied extensively in Green Siesta, ensuring various users can enjoy it[3]. These features include subtitles and voiceovers, the division of learning materials into multiple levels, and the use of NPCs and a virtual sidekick for guidance. The game also implements a tiered hint system, ensuring that players can choose between receiving minimal guidance or detailed support, thus avoiding frustration. Rewards for task completion further reinforce motivation and learning outcomes. All of the features that were designed baring UDL principles in mind are described in the Green Siesta user

[3]A. Radovic, I. Slosic, J. Babic, and A. Boni, "Students Perception and Game Experience Analysis of a Serious Game for Green Education," 2025 17th International Conference on Quality of Multimedia Experience (QoMEX), Madrid, Spain, 2025, to be published

manual[4]. AI was used for implementing some of these features, including generating the Text-to-Speech, enabling the navigation of multiple NPCs as well as designing the virtual sidekick[5].

2.2 Green Siesta Quiz

Green Siesta Quiz[6] extends the storyline of Green Siesta while incorporating Augmented Reality (AR). The game is structured into multiple levels, each focusing on a different waste category: plastic, paper, organic, communal, and glass. Players are challenged through two primary mechanics: quiz-based tasks and sorting challenges, in which they must determine the correct bin for different waste items for facts about waste management they have learned about, as shown in figure 2.4. If they do not answer correctly

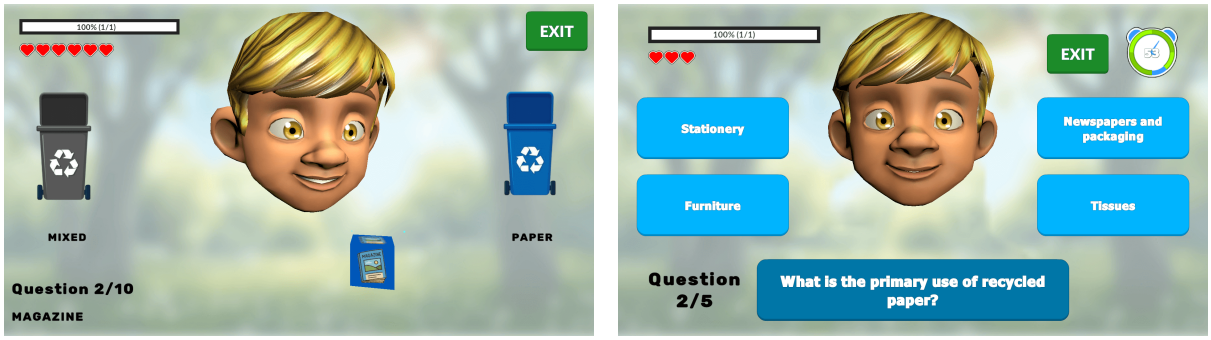

Figure 2.4: Game mechanics in the Green Siesta Quiz serious game

they get an explanation about the correct ways and facts about waste management.

In designing the game, UDL guidelines were again followed. There is an on-boarding portion for the introduction of game mechanics, as shown in figure 2.5. Learning materials are broken into manageable

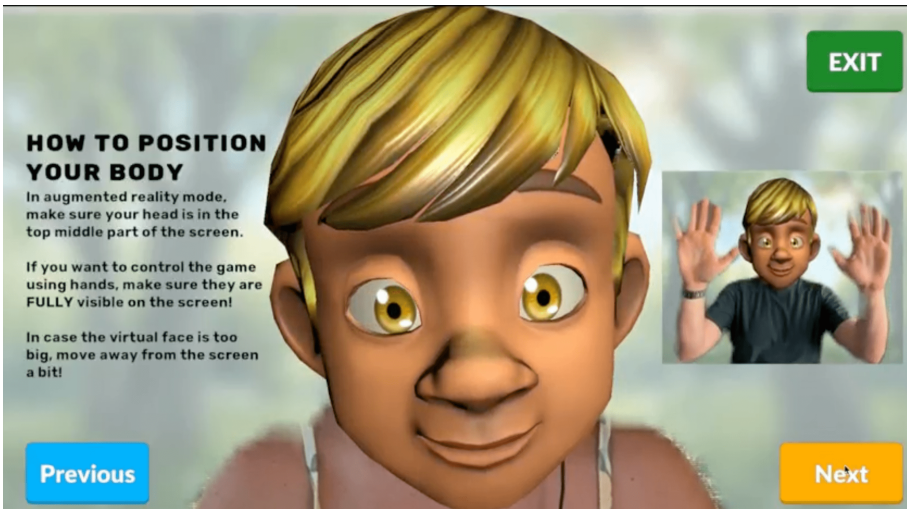

Figure 2.5: A representation of the on-boarding in the Green Siesta Quiz serious game

segments, and the system offers personalization options. Features include voiceovers, subtitles, sequential learning design, and reward mechanisms to encourage progress. The game also provides multiple navigation modes, allowing players to interact using hand gestures, a mouse, or a keyboard. This flexibility ensures accessibility for users with diverse abilities and preferences. All of these UDL festures are further described in the Green Siesta Quiz user manual[7]

[4]http://sociallab.fer.hr/play2green/wp-content/uploads/sites/2/2025/03/P2G-ENG-USER-MANUAL-AI-game-1.pdf

[5]A. Radovic, I. Slosic, J. Babic, and A. Boni, "Application of universal design for learning in serious games: A case study on green education," in EDULEARN25 Proceedings, ser. 17th International Conference on Education and New Learning Technologies. IATED, July 2025, pp. 4374–4382. [Online]. Available: https://doi.org/10.21125/edulearn.2025.1128

[6]https://sociallab.fer.hr/play2green/green-siesta-quiz/

[7]http://sociallab.fer.hr/play2green/wp-content/uploads/sites/2/2025/06/P2G-GSQuiz-EN-UM.pdf

AR was used to implemented some of these features, including the rewarding system, the user unlocks multiple AR features depending on their success in the game. Another way AR was introduced was in introducing various ways of navigating the game, through the pinch gesture as well as with the mouse click[8].

2.3 HoloZoo

HoloZoo[9] is a green serious game which makes use of holography. It is a mobile application that connects

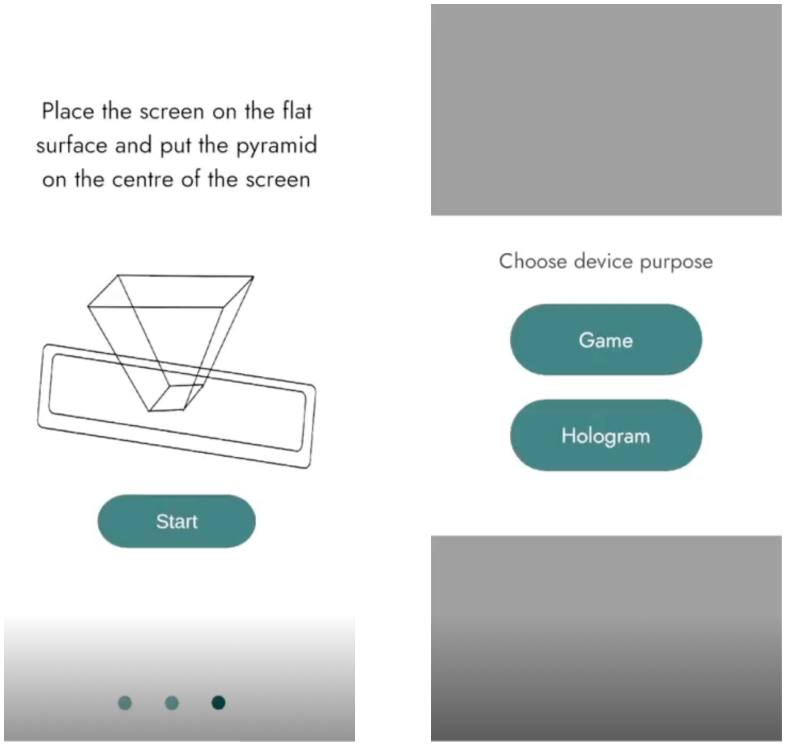

Figure 2.6: Instructions to build a pyramid and choose device purpose in the HoloZoo serious game

via Bluetooth to a secondary device, which serves as the holographic display. To support accessibility, the application includes instructions for creating a simple holographic pyramid at home using a clear plastic sheet, allowing broader use of the technology[10]. These features ensure that HoloZoo is not only innovative but also inclusive, broadening opportunities for environmental education through immersive technology[11].

The game offers two modes: one for holographic display and another for interactive play, as shown in figure 2.6.Within the play mode, users can choose between a quiz and a learn mode. If the learn mode is chosen, users can choose to learn through a list or a globe feature. The globe presents a 3D model of the Earth. By selecting a continent, players can learn about species native to that region, as shown in figure 2.7. Selecting an animal will list the information of the selected species as well as provide a look at the 3D model of the species. The user can turn and enlarge the model and inspect it further using the connected device posing as a hologram, as shown in figure 2.8. Once familiar with the material, users can test their knowledge through quizzes. Successfully completing quizzes unlocks additional levels with new species and ecosystems to explore.

[8] A. Radovic, I. Slosic, J. Babic, and A. Boni, "Using Augmented Reality to advance in Universal Design for Learning in green serious games," in ICERI25 Proceedings, ser. 18th annual International Conference of Education, Research and Innovation. IATED, Seville, Spain, 2025, to be published

[9] https://sociallab.fer.hr/play2green/holozoo/

[10] https://sociallab.fer.hr/play2green/wp-content/uploads/sites/2/2025/04/P2G-HoloZoo-ENG-USER-MANUAL-HOLO-game.pdf

[11] M. Kristić, A. K. Dilberović, Ž. Car and K. Žubrinić, "Research Instrument for Analyzing User Interactions and Accessibility of Holographic Technology in Educational Games for Environmental Awareness," 2024 47th MIPRO ICT and Electronics Convention (MIPRO), Opatija, Croatia, 2024, pp. 1967-1973, doi: 10.1109/MIPRO60963.2024.10569537

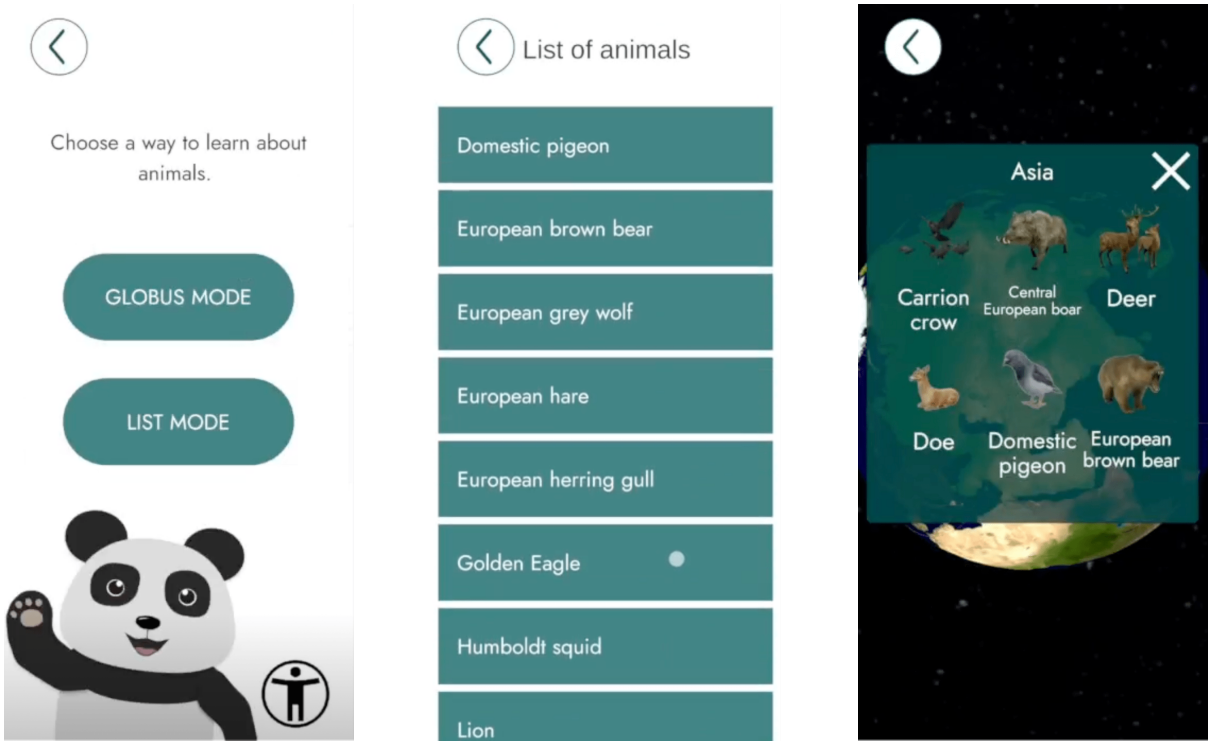

Figure 2.7: Choosing the globe or list mode in the HoloZoo serious game

As with the other two games, UDL principles guided development. Personalization options include language selection, font and color customization, and media management. Learning materials are divided into smaller segments, and content is delivered through multiple channels, including visualizations of 3D species models in holographic form. All of the features implemented following the UDL principles are stated in the user manual.

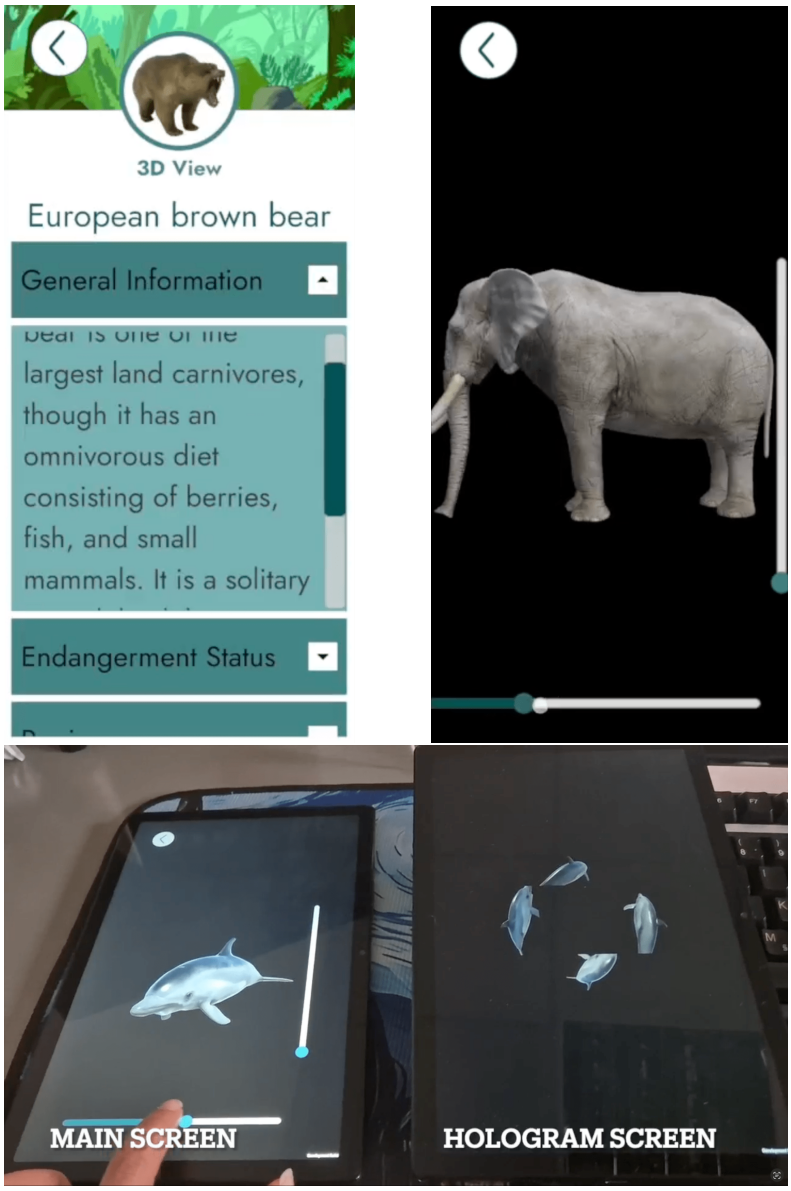

Figure 2.8: Display of the species, animal models and manipulation

3 Experiment setup

Chapter 3

Experiment setup

The following chapter provides a detailed explanation of the experimental setup. The first subsection provides an overview of the methodology applied in conducting the evaluation events. The primary data collection instruments are then presented, followed by an overview of the locations and events where data were gathered. These data will be analyzed in the subsequent chapters.

3.1 Methodology

The evaluation of the games developed in the Play2Green project followed a structured procedure designed to ensure comparability across different events and participant groups. The procedure was consistent, combining gameplay sessions with structured questionnaires.

The process of game evaluation and the implementation of all multiplier events can be grouped into several methodological steps as shown in Figure 3.1. The first step is registration, followed by the plenary part of the event, the evaluation session, and finally, the follow-up session.

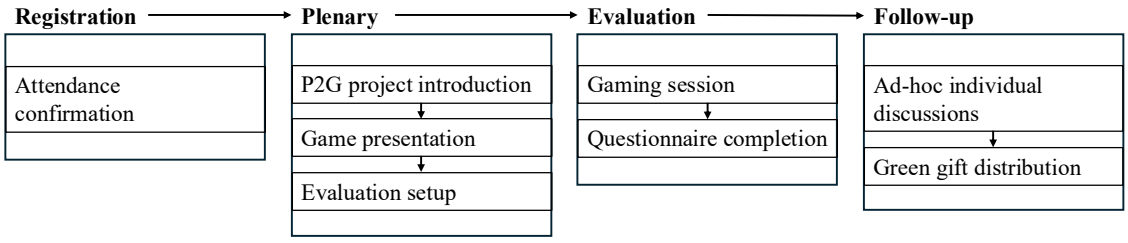

Figure 3.1: Methodological steps for experiment setup

At the beginning of each evaluation, participants recorded their attendance on the participant list. After that, participants were welcomed and introduced to the context of the Play2Green project. They were given a short presentation of the game and an explanation of the evaluation setup and plan. Each participant created a new profile to ensure that the gameplay started from the beginning, after which they were asked to read and accept the terms of participation, including explicit opt-in for data collection.

Participants then played the game for approximately 20–40 minutes, depending on the time available during the specific event. At the end of the session, they completed an evaluation questionnaire distributed via Microsoft Forms, accessible directly through the game.

As a follow-up to the process, some participants engaged in individual discussions regarding the games, after which they received a small green gift along with promotional materials highlighting the Play2Green project and the European Union.

3.2 Data collection instruments

The main source of data was a structured questionnaire that captured several categories of information:

- Demographic characteristics of participants.

- General feedback on the game and its design.
- Feedback on specific inclusive design features (e.g. UDL, AI, AR).
- Self-reported learning outcomes.
- Self-reported player experience.

Additionally, basic gameplay data was recorded internally by the games themselves to provide information on progress and success in completing tasks. These data sources together form the basis of the analysis presented in the results and discussion chapter.

Each player could easily access the questionnaire. On the main page of the game, the player needs to click the star on the right side of the screen, labeled 'Questionnaires,' as shown in the Figure 3.2. The player then selects the desired questionnaire from the list. The selected questionnaire, created using the Microsoft Forms platform, opens in a web browser, as illustrated in Figure 3.3.

Figure 3.2: Accessing the questionnaire in the game

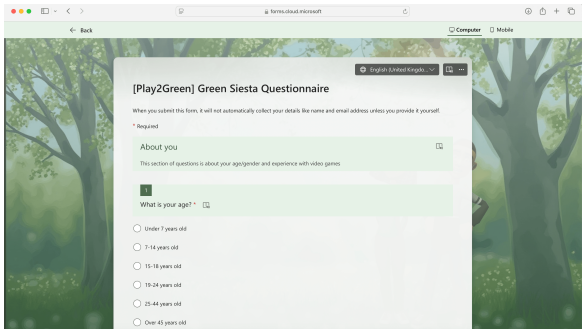

Figure 3.3: Appearance of the questionnaire inside Microsoft Forms

3.3 Evaluation events

The evaluation sessions were conducted in different contexts and time frames, ensuring diversity of perspectives and participant backgrounds.

3.3.1 Pilot locations

The evaluation of the developed solutions was carried out in the project's partner countries. As shown in the Figure 3.4, the evaluation events took place in Valencia (Spain), Zagreb and Dubrovnik (Croatia), and Debrecen (Hungary).

Figure 3.4: Overview of pilot locations

The evaluations reached schools, universities, and public dissemination events across Europe. To provide orientation on the scope of the evaluation, Table 3.1 illustrates the distribution of participants across the pilot events of the Play2Green project. In Debrecen and Valencia, the multiplier event was

conducted on two occasions. The table provides the exact number of participants for each event, as well as the percentage relative to the total number of collected evaluations. These numbers demonstrate the significant reach of the evaluation, with 360 participants taking the full part in the process.

Event	**Date**	**Number of Participants**	**Percentage of Participants**
Debrecen Multipler (part I and II)	13 February and 2 April 2025	25	6.94%
Valencia Multipler (part I and II)	14-15 April and 13 May 2025	83	23.06%
Zagreb Multipler	22 April 2025	115	31.94%
Dubrovnik Multipler	16 May 2025	71	19.72%
University course *Software agents* (Zagreb)	May 2025	33	9.17%
University course *Human factors in computing* (Zagreb)	June 2025	11	3.06%
Higher-education lecturer session (Zagreb)	June - August 2025	22	6.11%

Table 3.1: Evaluation events

The following subsections present all multiplier events in chronological order, accompanied by photographs and additional information. In addition to the evaluations carried out within the multiplier events, the game was also evaluated as part of two university courses in Zagreb and further evaluated by lecturers from higher education institutions.

3.3.2 Multiplier event in Debrecen (part I)

The first Play2Green conference was held on 13 February 2025 in Debrecen (Hungary), where participants tested the Green Siesta game in a public dissemination setting. The most notable parts of the event are shown in Figure 3.5, which depicts the plenary session where participants were introduced to the P2G project and the game, followed by the evaluation session during which they tested the game (Figure 3.6).

Additional photographs and further details about the event are available at the following link: https://sociallab.fer.hr/play2green/play2green-debrecen-2025-multiplier-event/.

Figure 3.5: Plenary session

Figure 3.6: Game evaluation session

3.3.3 Multiplier event in Debrecen (part II)

A second event in Debrecen took place on 2 April 2025 at the Ady Endre Secondary School, providing access to a group of high school students.

The event comprised a plenary session in which the P2G project and the game was presented to high school students (Figure 3.7). This was followed by a game evaluation session (Figure 3.8), dur-

ing which participants engaged with the developed game and completed the corresponding questionnaire. Additional photographs and further details about the event are available at the following link: https://sociallab.fer.hr/play2green/second-play2green-conference-in-debrecen/.

Figure 3.7: Plenary session

Figure 3.8: Game evaluation session

3.3.4 Multiplier event in Valencia (part I)

On 14–15 April 2025, Universitat Politècnica de València hosted the first multiplier event, inviting groups of high school students to engage in a gaming session in a university setting.

At the Valencia multiplier event, the plenary session (Figre 3.9) introduced participants to green topics, the main objectives of the P2G project, and the details of the Green Siesta game. This was followed by the evaluation session (3.10), conducted in a laboratory classroom, where each participant assessed the game and completed the questionnaire.

Additional information about the event is available at the following link: https://sociallab.fer.hr/play2green/multiplier-event-in-valencia-1/.

Figure 3.9: Plenary session

Figure 3.10: Game evaluation session

3.3.5 Multiplier event in Zagreb

On 22 April 2025, the Faculty of Electrical Engineering and Computing (FER) in Zagreb organized an event at the X. Gymnasium Ivan Supek. The event combined STEAM promotion with Play2Green game testing.

The evaluation involved students from several high school classes. As presented in Figure 3.11, the event commenced with a plenary session, which was followed by the evaluation session conducted in multiple laboratory classrooms. Each high school student received a small green gift along with promotional materials highlighting the Play2Green project logo and the European Union, as shown in Figure 3.12.

Further information and photographs from the multiplier event in Zagreb are available at the following link: https://sociallab.fer.hr/play2green/multiplier-event-in-zagreb/.

Figure 3.11: Plenary session

Figure 3.12: Green promotion materials

3.3.6 Multiplier event in Valencia (part II)

The second part of the multiplier event in Valencia was organized on 13 May 2025 at the Escuela Técnica Superior de Ingeniería de Telecomunicación (ETSIT-UPV).

As in all events, the plenary session was followed by a game session, during which participants played the developed game (Figure 3.13). Each participant received a small green gift as a token of appreciation for their participation, as shown in Figure 3.14.

Additional information and photographs related to this event are available at the following link: https://sociallab.fer.hr/play2green/multiplier-event-in-valencia-2/.

Figure 3.13: Game evaluation session

Figure 3.14: Green promotion materials

3.3.7 Multiplier event in Dubrovnik

On 16 May 2025, a conference was held at the Faculty of Electrical Engineering and Applied Computing of the University of Dubrovnik. The event promoted STEAM fields, presented study opportunities at the university, and showcased Play2Green project results.

The multiplier event in Dubrovnik began with a plenary session (Figure 3.15) presenting the objectives of the P2G project and onboarding participants to the developed game. The session was further enhanced by guest speakers from academia and industry, who discussed marine ecology and other environmental topics. Following the plenary session, participants proceeded to laboratory classrooms to evaluate the game and complete the corresponding questionnaire (Figure 3.16).

Additional information regarding this event is available at the following link: https://sociallab.fer.hr/play2green/play2green-conference-in-dubrovnik/.

Figure 3.15: Plenary session

Figure 3.16: Game evaluation session

3.3.8 University course Software agents (Zagreb)

In May 2025, the game *Green Siesta* was tested as part of a laboratory exercise within the course *Software Agents*[1] at University of Zagreb FER. The course covers the fundamentals of software and mobile agents, including their models, management, mobility, and communication. The course also explores semantic agents, agent platforms and applications of game theory in multi-agent systems.

In Green Siesta AI based serious game the AI-powered virtual sidekick acts as a personalized support agent, offering context-sensitive guidance and visual cues for each task. With this in mind, testing with students enrolled in this course was particularly valuable, as they were able to evaluate the developed solution from their own perspective and with the knowledge gained in the course. This allowed them to provide more detailed and expert feedback, especially focused on the AI component.

3.3.9 University course Human Factors in Computing (Zagreb)

In June 2025, the game *Green Siesta Quiz* was tested as part of the course *Human Factors in Computing*[2] at University of Zagreb FER. The course introduces ergonomics with a focus on computer-based workplaces and human–computer interaction, examining user needs, limitations and health risks. It explores universal design, digital accessibility, and the use of assistive technologies such as AR, VR and holography.

In the all developed serious games, we followed the principles of UDL, and students enrolled in this course were able to provide more precise evaluations of the implemented components related to UDL.

3.3.10 Higher-education lecturer session (Zagreb)

Finally, a private testing session of *Green Siesta Quiz* was conducted at the University of Zagreb FER with higher-education lecturers, providing insights from an expert perspective on teaching and learning relevance.

Their expertise enhances the evaluation of the developed solutions, with a greater focus on the Green Siesta Quiz, taking into account their teaching experience and research knowledge. Their constructive feedback and professional insights offer valuable guidance for refining the current work and informing future research efforts.

[1] Official course page: https://www.fer.unizg.hr/en/course/sofage
[2] Official course page: https://www.fer.unizg.hr/en/course/hfic

Results and discussion

4

Chapter 4

Results and discussion

This chapter presents the results of the evaluation of the Play2Green games, with a particular focus on the flagship game *Green Siesta*. The evaluation was designed to capture both quantitative and qualitative insights, allowing for an assessment of how the games supported learning, engagement, and inclusive design principles. In doing so, the chapter also reflects on the wider project objectives and how they were achieved through the pilot activities.

Across all events and pilot locations, the evaluation reached more than three hundred participants, surpassing the planned outreach goal of the project. The diversity of the sample ensured that multiple learner categories were included, while also involving participants with disabilities, thereby reflecting the inclusive character of the Play2Green project. The results further show that the games supported learning on green topics, with a large proportion of learners reporting that they had achieved the intended learning outcomes. Importantly, most participants also expressed that they would recommend serious games as a tool for learning about sustainability and related subjects, which highlights the relevance and transferability of this approach.

To maintain clarity and readability, this chapter primarily presents and discusses results for *Green Siesta*, which was evaluated on the largest scale and provides the most robust dataset. Specific insights related to *Green Siesta Quiz* and *HoloZoo* are discussed in the subsections on augmented reality and holographic features, respectively, with further detailed findings provided in the appendix.

4.1 Demographics

Age group

Figure 4.1 presents the age distribution of participants who engaged with the Green Siesta game during the evaluation activities. Understanding the demographic profile of respondents is a useful starting point, as it helps situate the feedback in the context of who the game has reached. Age is particularly relevant in this case since the project placed emphasis on involving younger players, with the idea that Green Siesta could provide both an engaging experience and an educational tool for this audience. By looking at the spread of different age categories, one can see whether the outreach was successful in attracting the groups that were originally intended to take part.

The results shown in the figure highlight that a large proportion of the respondents were high school pupils. This strong presence of the adolescent group fits well with the project's dissemination strategy, as many of the evaluation sessions were organised in the form of multiplier events directly targeting schools. Having this alignment between intended and actual audiences is an encouraging sign, since it means that the experiences and opinions gathered through the survey reflect the group the game was primarily designed for. It also indicates that the findings in later sections can be interpreted with confidence as being relevant to the central target group, while responses from older participants, though smaller in number, can still provide complementary insights on how the game may be perceived outside of its main audience.

Gender

Figure 4.2 provides an overview of the gender distribution among participants who took part in the Green Siesta evaluation. Recording gender characteristics is part of describing the respondent group and helps to better understand the perspectives represented in the study. Although the game was not developed

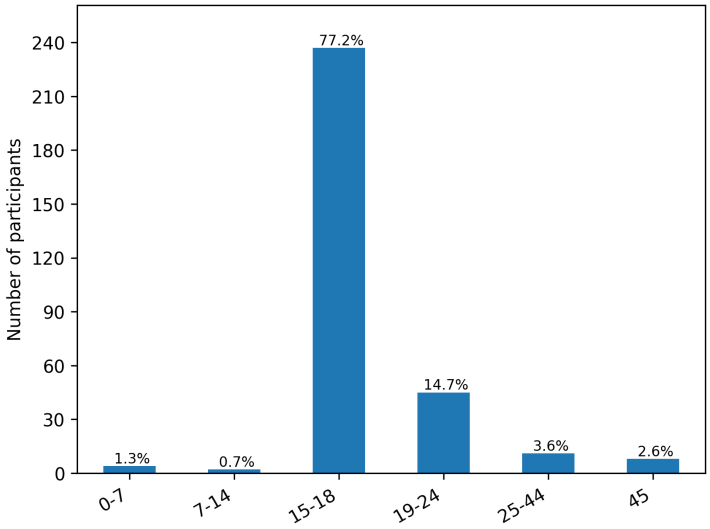

Figure 4.1: Age distribution of Green Siesta participants.

with a gender-specific audience in mind, it is useful to note the composition of participants to interpret how broadly the findings can be generalized.

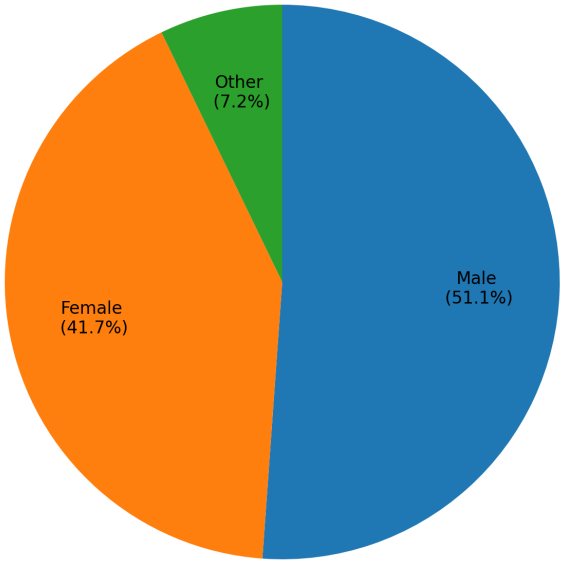

Figure 4.2: Gender distribution of Green Siesta participants.

The figure shows a relatively balanced distribution between genders, with a slight majority of male participants. This outcome can be understood in light of the setting of the multiplier events, many of which were held at technical faculties that actively promote STEAM studies, fields that tend to attract more male students. The balance nonetheless indicates that feedback is not strongly dominated by one gender, which is reassuring for the reliability of the results. At the same time, recognizing the small skew toward male participants provides context for later sections, where perceptions of the game's mechanics and content may be shaped by the backgrounds of those who took part.

Highest achieved education

Figure 4.3 shows how participants reported their highest level of education in the Green Siesta evaluation. At first sight, the distribution seems to confirm that most respondents were high school pupils, which would match the expected target group. However, it is important to note that this question was not always understood as intended, especially among younger participants with limited English proficiency. Instead of indicating the level they were currently attending, some high school pupils responded as if the question asked about the level they had already achieved.

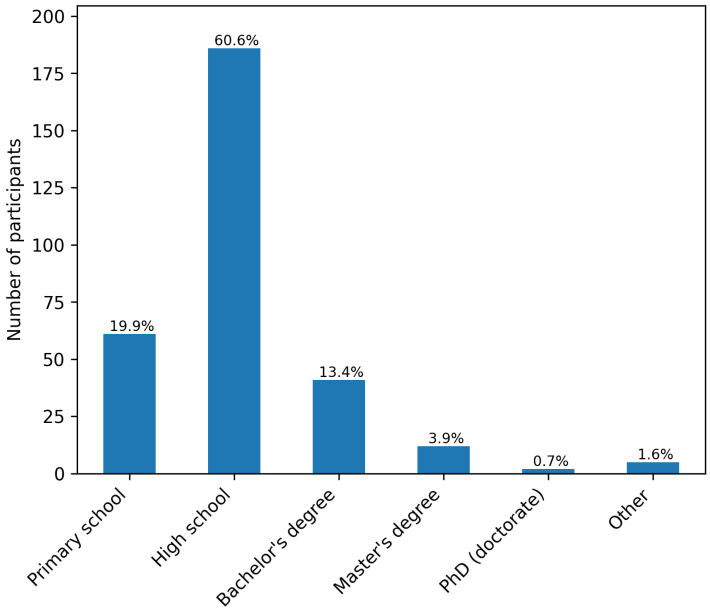

Figure 4.3: Reported highest education among Green Siesta participants.

This misunderstanding explains why the majority of answers fall into the high school category, even though many respondents had not yet completed that level of education. The smaller shares of bachelor's and master's degrees mostly come from piloting sessions with university students, particularly those from Zagreb. While the distribution therefore needs to be read with caution, it still indicates the presence of both the intended adolescent group and a smaller number of older students whose perspectives provide additional insight. The following figure offers a clearer picture of participants' actual educational stage.

Current status

Figure 4.4 provides a more reliable view of participants' educational stage by asking about their current status. Unlike the previous question on highest education, this wording was easier for respondents to interpret and avoids the confusion that some high school pupils had when asked about completed levels. As a result, the distribution here gives a more accurate representation of the participant group.

The figure confirms that the majority of participants were currently enrolled in high school, which aligns well with the main target audience of the project. Smaller groups of university students also appear, reflecting the involvement of piloting groups from partner organisations, most prominently from Zagreb. This result provides confidence that the evaluation reached the intended demographic focus, while also including contributions from older learners who could reflect on the game with a different educational perspective.

Prior experience playing video games

Figure 4.5 presents the distribution of participants according to whether they had any prior experience playing video games. This question is relevant in the context of Green Siesta, as the game combines playful interaction with educational goals. Knowing how familiar participants are with video games in general helps to understand the baseline from which they approached the activity and to anticipate possible differences in how easily they could engage with the mechanics.

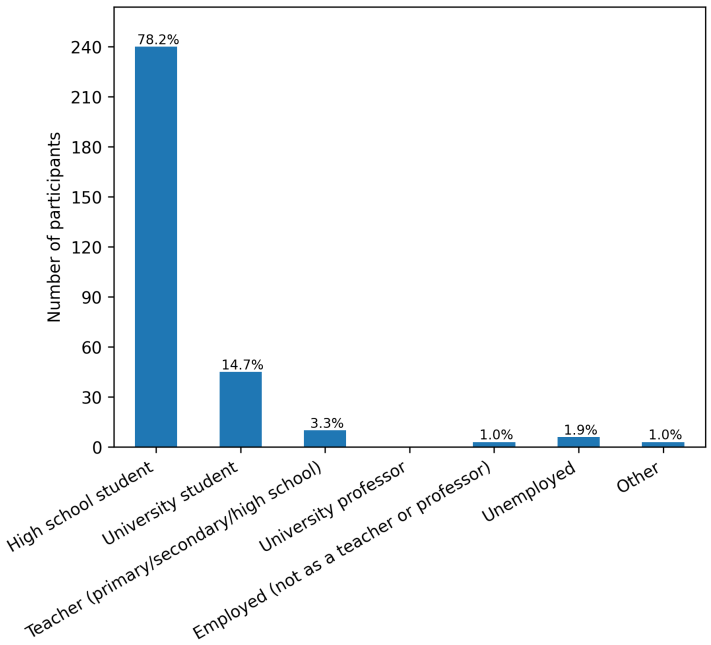

Figure 4.4: Current educational status of Green Siesta participants.

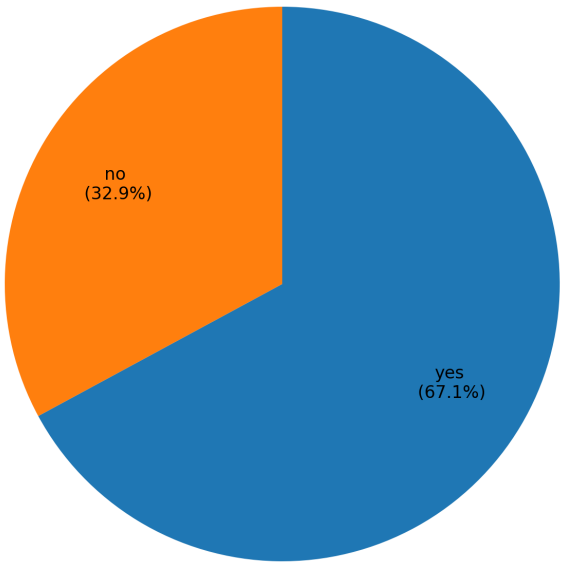

Figure 4.5: Previous experience with video games among Green Siesta participants.

The figure shows that a clear majority of respondents had played video games before, which is expected given the age group and the popularity of gaming among young people. At the same time, roughly three out of ten participants reported no prior gaming experience. This outcome is noteworthy because it highlights the inclusiveness of the evaluation: the game did not only attract regular gamers, but also reached participants who would not usually engage with digital games. This reflects the educational setting in which Green Siesta was introduced, where participation was encouraged through multiplier events and not limited to those already familiar with gaming. As such, the responses of non-gamers provide valuable insights into how accessible and welcoming the game design is for newcomers, and

whether it can serve as an inclusive tool for broader learning contexts.

Video game playing frequency

Figure 4.6 presents the frequency with which participants reported playing video games, considering only those who indicated prior experience. This question complements the previous one by offering more detail on the diversity of gaming backgrounds within the sample. It allows us to see not only who had played before, but also how regularly they engaged in gaming, which can influence their familiarity with common mechanics and expectations of gameplay.

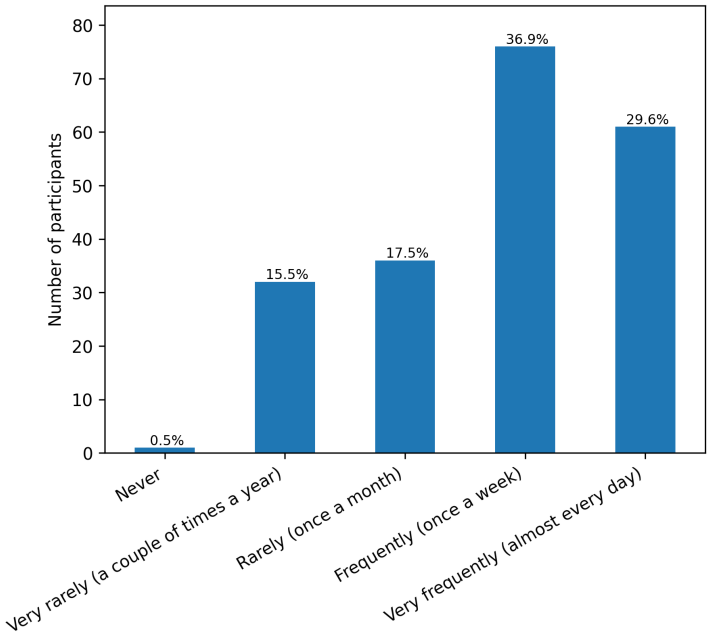

Figure 4.6: Frequency of video game play among Green Siesta participants with prior experience.

The responses show a fine balance across different levels of gaming frequency, with a tilt toward more experienced players. About one third of respondents reported playing daily, and another fifth indicated playing several times a week, together forming a substantial group of regular gamers. At the same time, smaller shares described playing only once a week or once a month, while roughly another third reported playing less often. This spread highlights the diversity of the sample, from highly active gamers to more occasional players. The mix is valuable because it ensures that feedback reflects both perspectives: those deeply accustomed to gaming and those engaging more casually. It also shows that Green Siesta reached a broad spectrum of participants, providing insight into how well the game appeals to both experienced and less frequent players.

Familiarity with the serious game term

Figure 4.7 shows whether participants were familiar with the term "serious game" before engaging with Green Siesta. This background question is important as it gives insight into how much prior knowledge respondents had of the concept that underpins the project. Familiarity with the term can indicate whether participants were already exposed to discussions of games as learning tools, or whether they approached Green Siesta without such context.

The figure shows that roughly six out of ten participants knew the term beforehand, while the remaining four out of ten did not. This finding can be partly explained by the context in which the multiplier events were organised: some teachers and facilitators introduced the term to students as part of the workshops, which increased awareness among those groups. At the same time, the presence of a sizeable minority who had never encountered the concept illustrates that the project also reached participants without prior exposure to the idea of games for learning. This mix is useful, as it confirms that Green Siesta was evaluated by both students who could position it within an existing understanding of serious games and those for whom the project offered a first introduction to the concept.

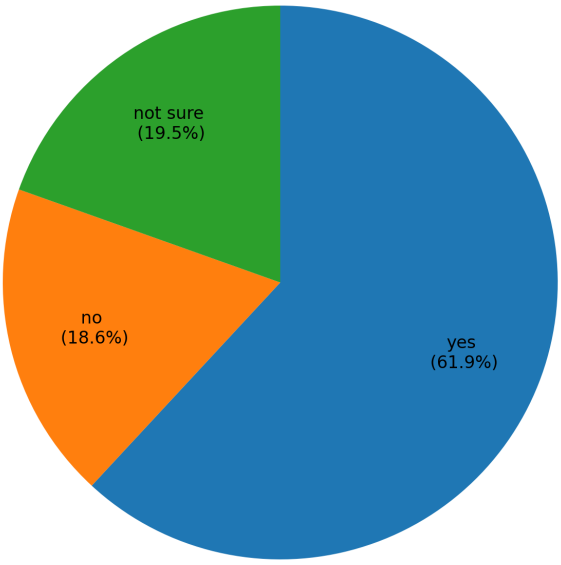

Figure 4.7: Familiarity with the term “serious game” among Green Siesta participants.

Prior experience playing educational/serious games

Figure 4.8 illustrates whether participants had prior experience playing an educational or serious game before engaging with Green Siesta. This question helps to understand the extent to which respondents were already familiar with games designed for purposes beyond entertainment, such as learning or training. Establishing this background is useful for interpreting how participants positioned Green Siesta within their own experiences.

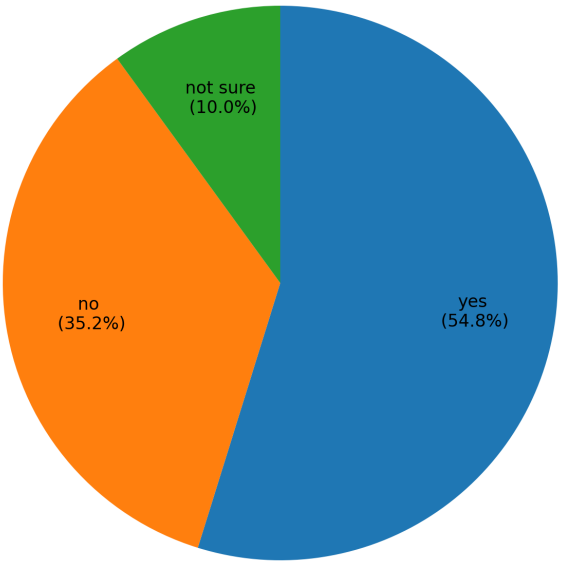

Figure 4.8: Prior experience with educational or serious games among Green Siesta participants.

The results show that slightly more than half of the participants had already played an educational or serious game before, while a substantial share had not. This outcome is logical given the broad range of applications such games have, many of which students are likely to encounter during school years or leisure activities. Common examples might include educational apps for learning programming concepts, simulation games such as flight simulators, or other digital tools designed with a learning component. The fact that prior experience was present in a majority of respondents means that many players could situate Green Siesta within a wider frame of reference, while those without such experience evaluated it as a new type of game. Together, these perspectives provide complementary insights into both the accessibility of the game for first-time serious game players and its perceived quality when compared with other educational games.

Participants with disabilities

Figure 4.9 shows that nearly one fifth of Green Siesta participants reported having at least one disability. This is a substantial share and it reinforces why accessibility should be a baseline consideration in serious game design rather than an afterthought. In line with Universal Design for Learning, the game must anticipate varied needs so that players can access, process, and act on information through multiple routes.

Building on that, Figure 4.10 indicates that, among participants with disabilities, most reported a single difficulty while roughly fifteen percent reported multiple difficulties. This points to the importance of flexible, adaptable mechanics that can be combined to suit different profiles. Figure 4.11 provides further detail: the most prevalent category was visual impairment (about 11.4 percent), followed by hearing impairment (3.6 percent), mental health conditions (2.9 percent), cognitive or learning difficulties (2.6 percent), neurodivergent conditions (2.3 percent), and several smaller categories. In total, at least nine categories were represented, underscoring the need for multiple means of Representation, Engagement, and Action and Expression so learners with diverse abilities can benefit fully from the game.

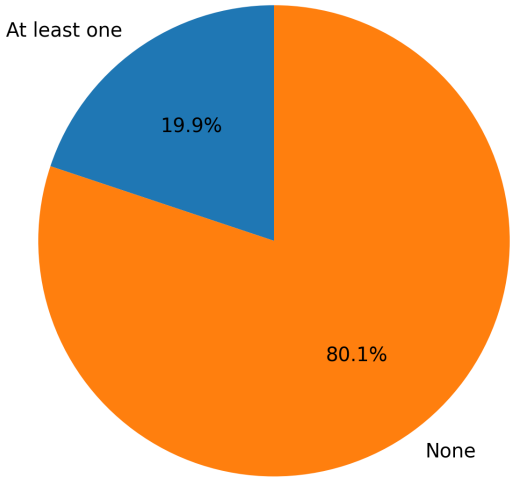

Figure 4.9: Participants reporting at least one disability in Green Siesta.

4.2 Feedback

4.2.1 General

Visual appeal

Figure 4.12 presents participants' opinions on the visual appeal of Green Siesta. The game was designed with playful, animated, and interactive 3D graphics to create an engaging environment that would appeal to younger audiences while also supporting immersion in the educational narrative. Visual design is an important component of serious games, as it can influence not only enjoyment but also motivation to persist with the learning experience.

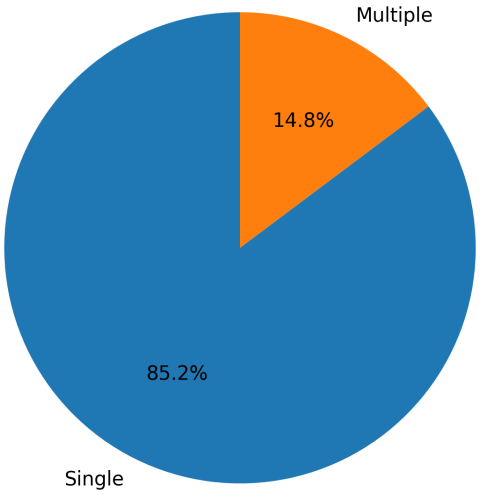

Figure 4.10: Among participants with disabilities, single versus multiple difficulties.

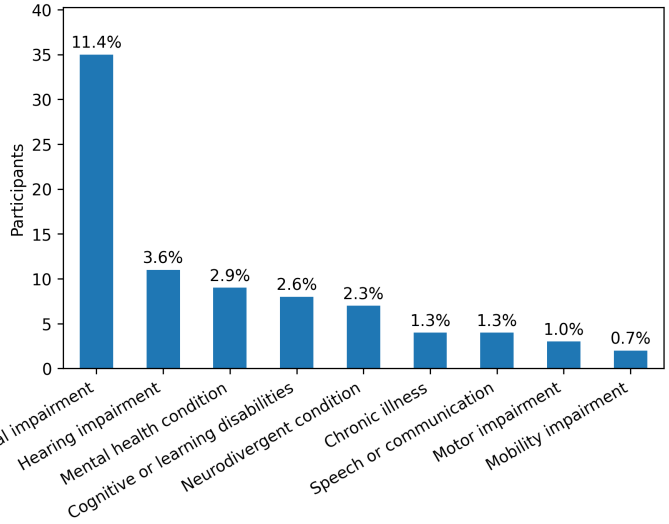

Figure 4.11: Prevalence of reported disability categories among participants.

The figure shows that more than half of the participants found the visuals appealing, confirming that the style and presentation of the game resonated with the majority of players. However, a portion of respondents expressed lower satisfaction with the visuals. The main reason for this can be traced back to the technical conditions under which the game was played: in several cases, older school or faculty computers automatically adjusted the game to a lower graphical fidelity in order to run smoothly. While this may have reduced the visual quality for some players, it also demonstrates a deliberate adaptability feature in the game design. In line with principles of Universal Design for Learning (UDL), the ability to adjust performance settings ensured that the game remained accessible across different hardware setups, prioritising inclusion and functionality over purely aesthetic considerations.

Clarity of narration

Figure 4.13 illustrates participants' views on the clarity of the narrative text used in Green Siesta. Since the game relies on story elements to guide players through tasks and to frame the educational content, clear and accessible narration is central to the overall experience. If players struggle to follow the storyline, both engagement and learning outcomes could be negatively affected, making this an important aspect to evaluate.

The figure shows a very favorable outcome, with around seven out of ten participants agreeing that

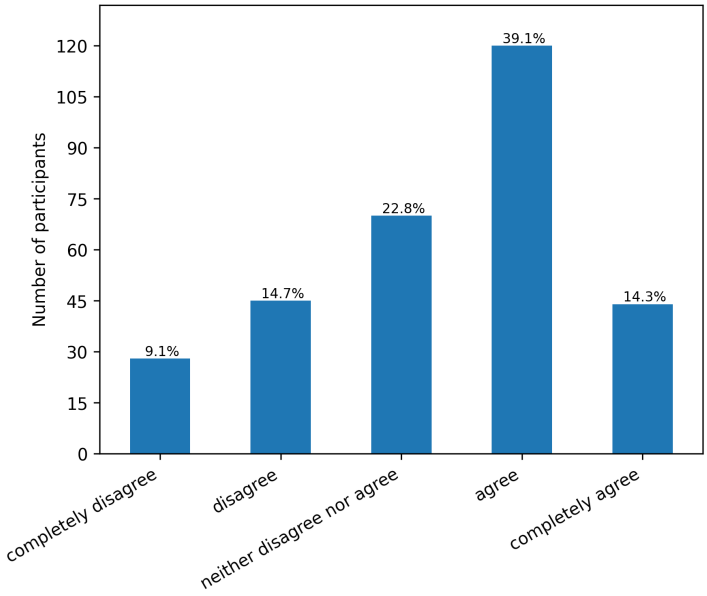

Figure 4.12: Perceived visual attractiveness of Green Siesta.

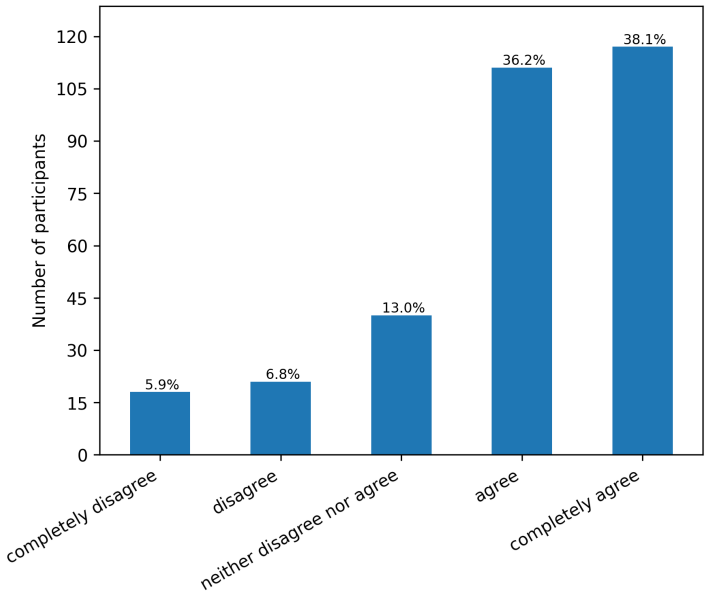

Figure 4.13: Clarity of the narrative text in Green Siesta.

the narrative text was clear and easy to follow. This suggests that the written storyline and guidance were effective for the majority, supporting both comprehension and immersion. For the remaining three out of ten, feedback indicates that the main difficulty stemmed from the game's design choice to present subtitles in the local language while leaving the audio narration in English. While this bilingual approach was intended to support language learning and international transferability, some participants found it challenging and reported it as reducing overall clarity. Taken together, the responses confirm that the narrative text is well designed for most players, while also highlighting the importance of balancing educational design choices with accessibility in multilingual settings.

Goal understanding

Figure 4.14 shows how well participants felt they understood the goals of Green Siesta while playing. Goal clarity is a crucial component of game design, particularly in serious games, as it ensures that players know what is expected of them and how tasks relate to the underlying educational objectives. A lack

of clarity at this stage could result in confusion, reduced motivation, or missed learning opportunities, making it an essential factor to evaluate.

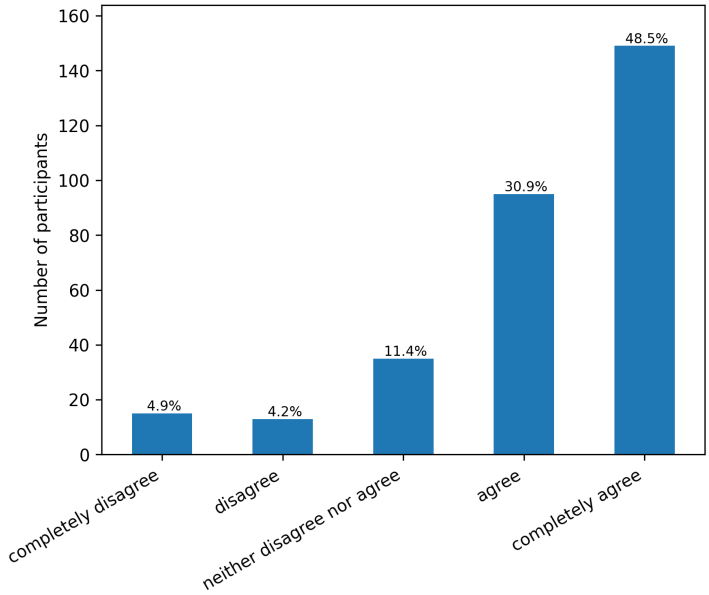

Figure 4.14: Participants' understanding of the goals in Green Siesta.

The results are very favorable, with around eight out of ten participants reporting that they clearly understood the game's goals. This outcome complements earlier findings on narrative clarity, since both aspects together provide the foundation for players to follow the storyline and connect their actions to the intended learning purpose. The smaller group who indicated some difficulty may have been influenced by language-related issues or by unfamiliarity with the conventions of serious games. Overall, the result confirms that Green Siesta performs well in one of the most fundamental aspects of educational game design: giving players a clear sense of purpose that helps sustain engagement and supports meaningful learning.

Intuitive controls

Figure 4.15 presents how participants evaluated the intuitiveness of the game controls. This question refers specifically to the control of the main character, Kimi, whose movement is managed through the keyboard. Controls are an essential element of gameplay experience, as they directly shape how easily players can interact with the environment and focus on the intended learning content. For an educational game such as Green Siesta, smooth and intuitive interaction is particularly important to avoid frustration and maintain immersion.

The results show that most participants gave positive remarks about the controls, suggesting that for the majority, Kimi was easy to navigate and gameplay remained fluid. Among those who rated this aspect lower, a common source of difficulty was the use of the well-established WSAD keyboard scheme (i.e., keys "W", "S", "A" and "D" are mapped to up, down, left and right arrow keys, respectively), which is considered an industry standard in PC gaming. Although the game provides visual prompts when the character is idle, this mechanic was less intuitive for participants with little or no prior gaming experience. This is particularly relevant since many respondents belong to Generation Z, a group that increasingly plays games on mobile devices where touch controls dominate. For these players, keyboard-based navigation may feel less natural. Taken together, the findings highlight both the strength of adopting a widely recognized standard for experienced players and the challenge of ensuring accessibility for those less accustomed to PC controls. As a design implication, offering alternative control options or more customizable input schemes could further enhance inclusivity and make the game accessible to a broader range of players.

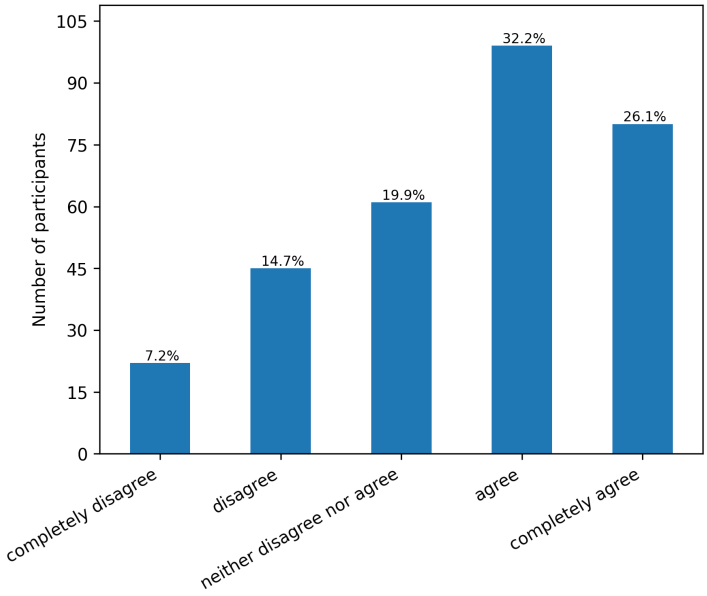

Figure 4.15: Perceived intuitiveness of the controls in Green Siesta.

Sidekick awareness

Figure 4.16 shows whether participants were aware of the AI sidekick that accompanied them during the Green Siesta gameplay. The sidekick was designed to follow the main character and provide assistance when requested, functioning as a supportive feature that players could rely on for guidance. Awareness of this functionality is important, since if players do not notice or recognize the sidekick, its potential as a learning and support tool would be diminished.

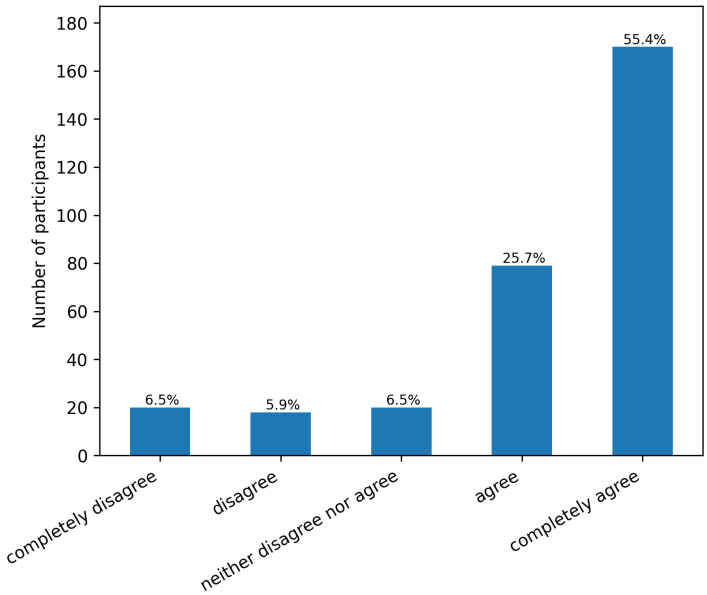

Figure 4.16: Participants' awareness of the AI sidekick in Green Siesta.

The responses are very positive, with about 80 percent of participants reporting awareness of the AI sidekick. This result confirms that the feature was visible and accessible to the vast majority of players, fulfilling its role as an integral support element in the game. A smaller share of respondents did not notice the sidekick, which may reflect differences in how players focused their attention during gameplay. Overall, the finding demonstrates that the sidekick was successfully integrated into the game environment and understood by players as an available resource. From a design perspective, this is an

encouraging result, as it shows that assistive features can be embedded in a way that feels natural and accessible, providing players with the option to seek help without disrupting immersion.

Sidekick usefulness in any game

Figure 4.17 presents participants' views on the usefulness of sidekicks in games more broadly, beyond the specific implementation in Green Siesta. Sidekicks are a familiar feature in many games, where they serve to support the main character, guide the player, or enrich the narrative. In educational games, such features can take on an additional role by scaffolding learning and ensuring that players are not left without help when challenges arise.

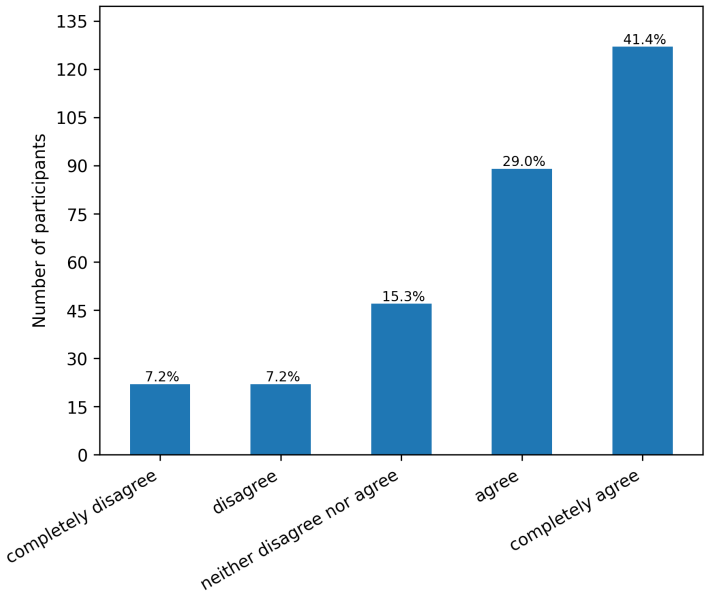

Figure 4.17: Participants' views on the usefulness of sidekicks in games.

The results show that the vast majority of participants regarded sidekicks as a valuable asset in games. This strong endorsement indicates that the design choice to include an AI sidekick in Green Siesta was well aligned with player expectations and gaming conventions. By implementing an AI character in such an impactful and supportive manner, the project ensured that the feature would be perceived as useful rather than distracting. The positive evaluation also reinforces the idea that sidekicks can serve both functional and motivational purposes: they help players overcome obstacles, while at the same time adding variety and engagement to the gameplay experience. From a design perspective, the result validates the integration of AI assistance as a meaningful element that strengthens both playability and learning outcomes.

Educational value of green-themed content

Figure 4.18 shows how participants evaluated the educational value of the green-themed content in Green Siesta. Since one of the central aims of the project was to raise awareness about environmental issues and sustainable practices, it is essential to assess whether players recognized the educational aspects embedded in the game. The evaluation therefore provides a direct measure of how successfully the core objective of the game was achieved.

The results are very encouraging, as the vast majority of participants considered the green-themed content to be educational. This validates the overall design goal of the game and demonstrates that players were able to connect the gameplay with meaningful learning outcomes. A key reason for this positive evaluation lies in the way the content is delivered. Much of the educational material is embedded in practical, interactive tasks, such as collecting trash, reducing non-recyclables, and crafting by repurposing items into new objects. These activities are naturally integrated into the story mode, ensuring that learning takes place in an engaging and hands-on manner. Additional green-themed knowledge is provided by non-player characters (NPCs), who supply relevant information in a conversational format, further reinforcing the messages of the game. Beyond these structured elements, players also enjoyed the

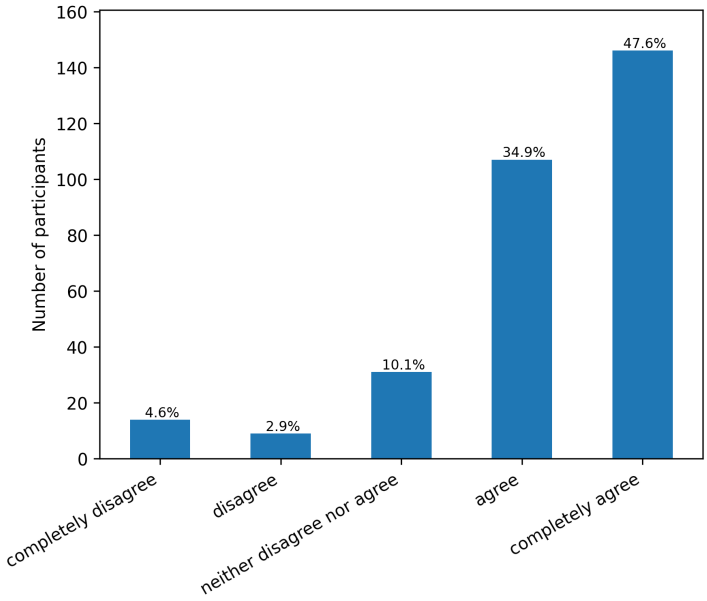

Figure 4.18: Perceived educational value of the green-themed content in Green Siesta.

"green secrets," short fun facts scattered around the map that reward exploration and curiosity. All of this content is supported by a learning journal, available at any time for reviewing progress and revisiting information, making the educational layer both persistent and accessible. Together, these features explain why the majority of participants found the content to be highly educational and engaging.

Raising awareness on environment and climate change

Figure 4.19 presents participants' views on whether Green Siesta contributed to raising awareness about environmental issues and climate change. This dimension is central to the purpose of the game, since the Play2Green project was designed with the explicit aim of using playful approaches to foster sustainability-related learning and reflection. Evaluating this aspect therefore provides a direct measure of how well the game fulfilled its mission.

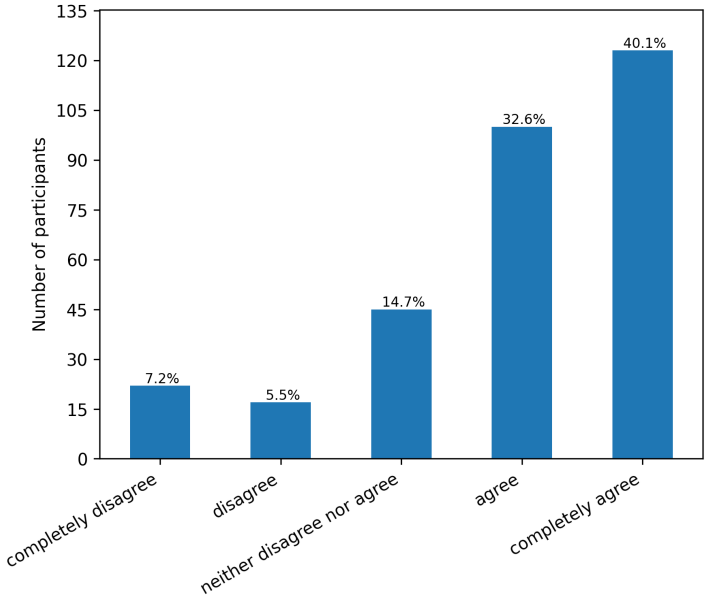

Figure 4.19: Participants' views on whether Green Siesta raises awareness about environment and climate change.

The results show that the majority of participants agreed that serious games in general, and Green Siesta in particular, are effective tools for raising awareness about the environment and climate change. This outcome validates the game's design goals and provides strong support for the broader Play2Green project objective. It also indicates that the combination of interactive tasks, exploratory elements, and green-themed content successfully translated into increased awareness among players. The finding is significant because it confirms not only that players enjoyed the game but also that they recognized its value as an educational and socially relevant tool. Taken together, the responses demonstrate the potential of serious games to contribute meaningfully to climate education and to engage younger audiences in critical sustainability issues.

Willingness to recommend

Figure 4.20 illustrates participants' willingness to recommend Green Siesta to others who might be interested in playing. This measure provides a simple yet powerful indicator of overall satisfaction, as players are more likely to recommend an experience they find valuable, enjoyable, or meaningful. In the context of serious games, willingness to recommend also signals whether participants believe the game holds relevance for peers and other target groups.

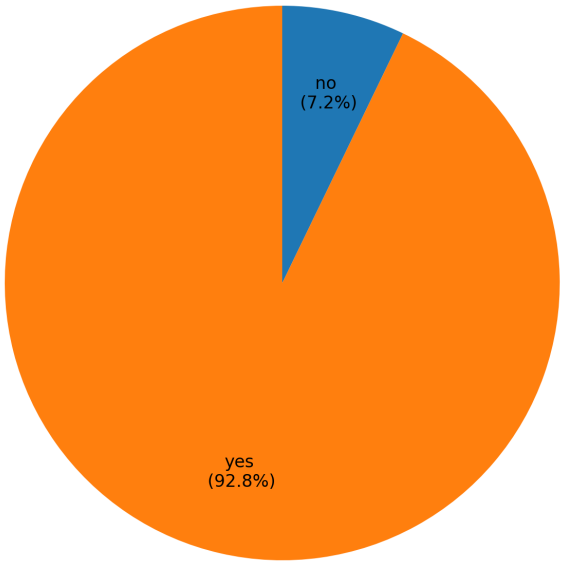

Figure 4.20: Willingness of participants to recommend Green Siesta to others.

The responses are highly encouraging: a large majority of participants, 92.8 percent, indicated that they would recommend Green Siesta to others. This strong endorsement is significant because it not only reflects positive individual experiences but also suggests a potential for organic dissemination beyond the initial evaluation events. In practice, such word-of-mouth recommendations are essential for ensuring the long-term impact of the game and for increasing the visibility of the Play2Green project. The result confirms that participants see the game as both enjoyable and worthwhile, reinforcing its value as a tool for raising awareness and education on environmental topics while also pointing toward its sustainability as an initiative that can grow through community support.

To better understand who participants considered as potential audiences, we also examined the specific target groups to whom they would recommend the game (Figure 4.21).

The largest share of recommendations was directed toward children under 12 years (81.1 percent), followed by teenagers aged 13–19 years (41 percent). This strong emphasis on younger audiences highlights how the playful design, visual style, dreamlike atmosphere, and green-themed content resonated particularly well with children and teenagers, making the game an engaging educational tool for early awareness. Importantly, however, participants also recommended the game for young adults (9.1 per-

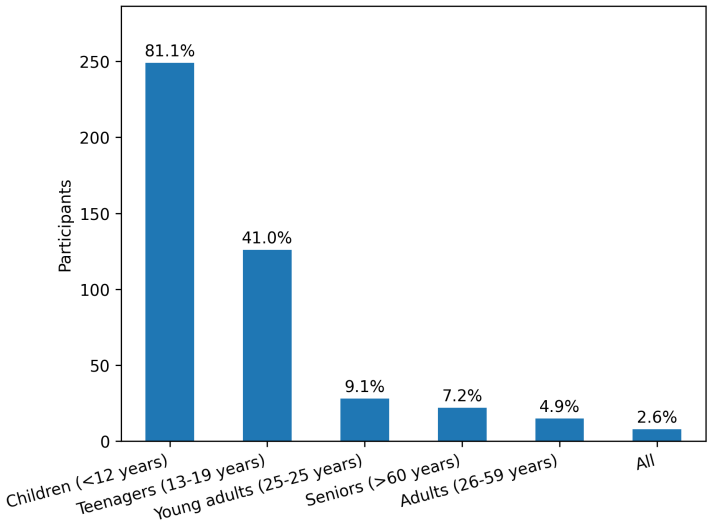

Figure 4.21: Target groups to which participants recommended Green Siesta.

cent), seniors (7.2 percent), adults aged 26–59 (4.9 percent), and even across all age groups (2.6 percent). This broad spread indicates that, while Green Siesta is especially suited for younger generations, its accessibility and layered content make it meaningful for diverse audiences, showcasing the effectiveness of Universal Design for Learning principles in addressing different needs and preferences.

Game rating

Figure 4.22 shows how participants rated Green Siesta overall. This is a key measure of the general impression the game left on players, combining aspects of gameplay, visuals, narrative, and educational content into a single evaluative judgment. While detailed results on individual components provide nuanced insights, the overall rating reflects how these elements come together into a coherent experience.

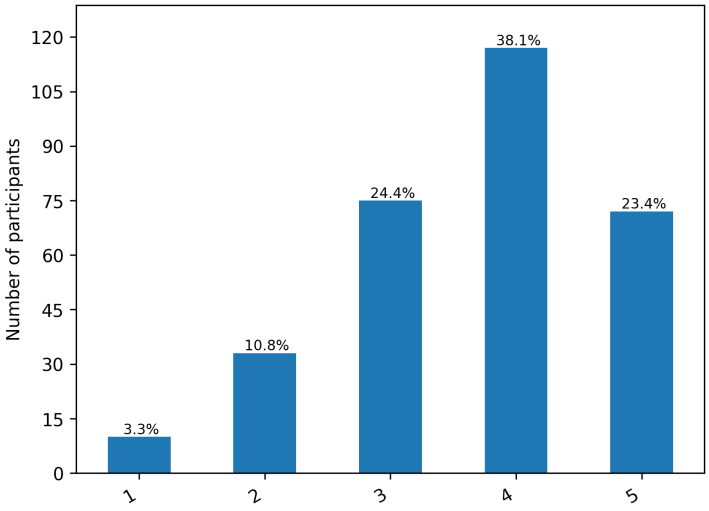

Figure 4.22: Overall rating of Green Siesta by participants.

The results suggest that the game was evaluated as very good by the majority of participants. This outcome is particularly encouraging given the limited testing time of 20–30 minutes during the multiplier events, which allowed only a short exposure to the gameplay and its educational features. It is also noteworthy in light of the game's identity as a serious game, where the primary emphasis is placed on learning and raising awareness rather than solely on entertainment. When considered alongside the high willingness-to-recommend result, where over 90 percent of participants said they would suggest the game to others, this finding reinforces the impression that Green Siesta achieved a rare balance: it was

evaluated as both meaningful in its educational goals and enjoyable as a game experience. Together, these outcomes validate the project's design choices and confirm its relevance for long-term impact.

4.2.2 Design

Well-defined and highlighted goals

Figure 4.23 presents participants' evaluations of whether Green Siesta provided well-defined and clearly highlighted goals during gameplay. As this section shifts focus to design-related elements, the clarity and visibility of goals becomes a cornerstone for effective player guidance. Clear goals are essential in serious games because they allow players to orient themselves in the environment, understand what is expected, and connect their progress to meaningful outcomes.

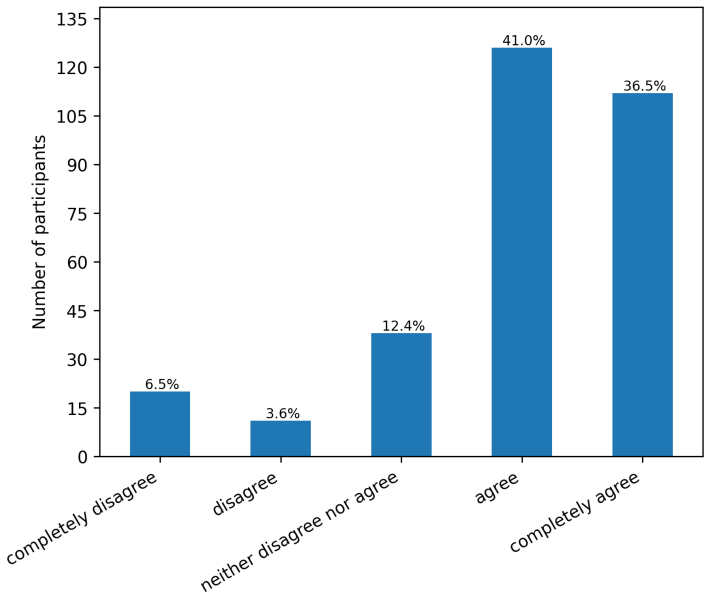

Figure 4.23: Participants' evaluations of the clarity and visibility of goals in Green Siesta.

The results indicate that a majority of participants evaluated the game positively in this regard, confirming that Green Siesta succeeds in defining and highlighting objectives in a way that players can readily follow. This aligns directly with the Universal Design for Learning (UDL) principles implemented in the game, particularly under the pillar of Action and Expression, where players are provided with multiple means of understanding and pursuing goals. For instance, Green Siesta supports clarity through task checklists, progress indicators, and narrative reinforcement by NPCs, ensuring that objectives are communicated in varied ways. The finding is consistent with the earlier result on goal understanding, and together these outcomes underline that the UDL-informed design choices around structuring and presenting objectives were effective, supporting both gameplay flow and educational engagement.

Ability to personalize gaming experience

Figure 4.24 presents participants' evaluations of whether they were able to personalize their gaming experience in Green Siesta. Personalization is an important design feature in serious games, as it allows players to adjust the experience to their preferences and identities, thereby increasing their sense of agency and ownership. In the context of Universal Design for Learning (UDL), this aspect is closely related to the principle of Engagement, which emphasizes offering learners multiple ways to connect with and stay motivated in the learning process.

The results show that even though participants had only a limited amount of time during testing sessions, most reported being able to personalize their gameplay experience. This included elements such as creating or modifying a user profile, naming the main character, and tracking individual progress, which reinforced their connection to the game. Achieving such personalization within short 20–30 minute sessions highlights how well the feature was integrated and how accessible it was for players. From a design perspective, this confirms that personalization functions effectively as a UDL-driven feature: it

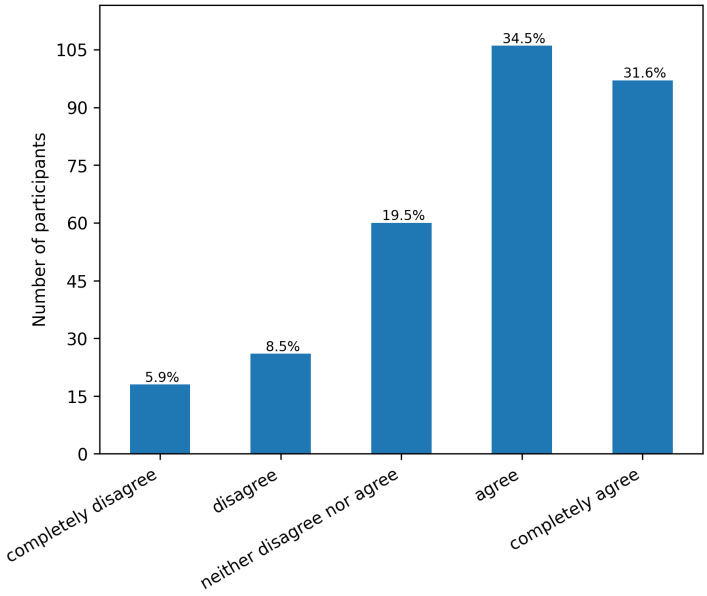

Figure 4.24: Participants' ability to personalize their Green Siesta gameplay experience.

enhances engagement by allowing learners to shape the experience according to their own identity and progress. These findings also anticipate the importance of related features such as progress tracking and the learning journal, which extend personalization by helping players monitor and reflect on their development throughout the game.

Subtitles/voiceover helpfulness

Figure 4.25 shows participants' evaluations of the subtitles and voiceover features in Green Siesta. These elements are central to accessibility and inclusivity, as they ensure that information is conveyed through multiple channels. In line with Universal Design for Learning (UDL), this relates directly to the pillar of Representation, which emphasizes providing learners with multiple means of accessing and processing information. By combining subtitles with voiceovers, the game aims to accommodate players with different preferences and needs.

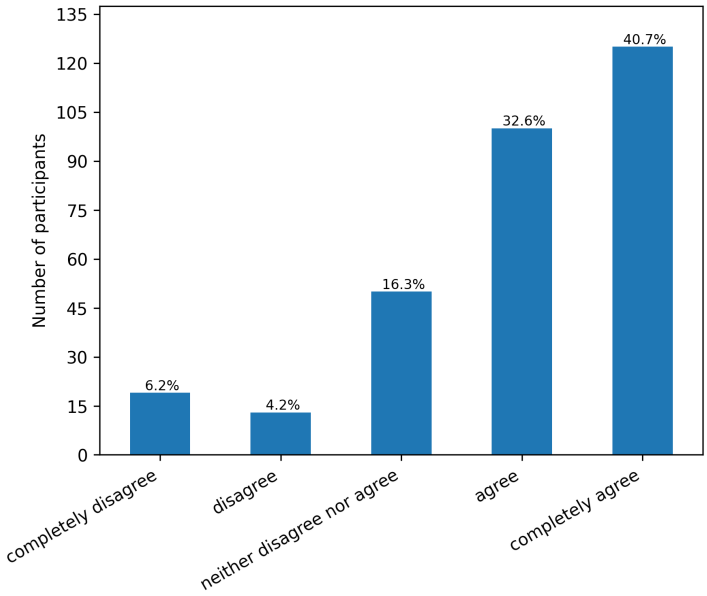

Figure 4.25: Participants' views on the helpfulness of subtitles and voiceovers in Green Siesta.

The results show that participants were very supportive of the subtitle and voiceover features. Many appreciated that subtitles were available in their own language, which made the narrative more accessible. At the same time, a smaller share of participants noted that they expected the voiceover itself to also be in their native, non-English language, rather than English only. While the bilingual design was intentional, both to support international transferability and to reinforce language learning opportunities, it highlights an area for potential refinement. A possible direction for future work could be to provide optional localized voiceovers in addition to the subtitles, thereby further aligning with UDL principles and ensuring that all players feel equally included in the storytelling experience.

Onboarding

Figure 4.26 presents participants' evaluations of the onboarding process in Green Siesta. Onboarding refers to how new players are introduced to the game's controls, objectives, and mechanics. In Green Siesta, this was achieved through a dedicated tutorial level where the basics were explained, including character controls, overall goals, tasks, and the location of green secrets. This design differs from the more common text-heavy onboarding methods used in mobile applications, offering instead an interactive, hands-on approach that better reflects the medium of a 3D educational game.

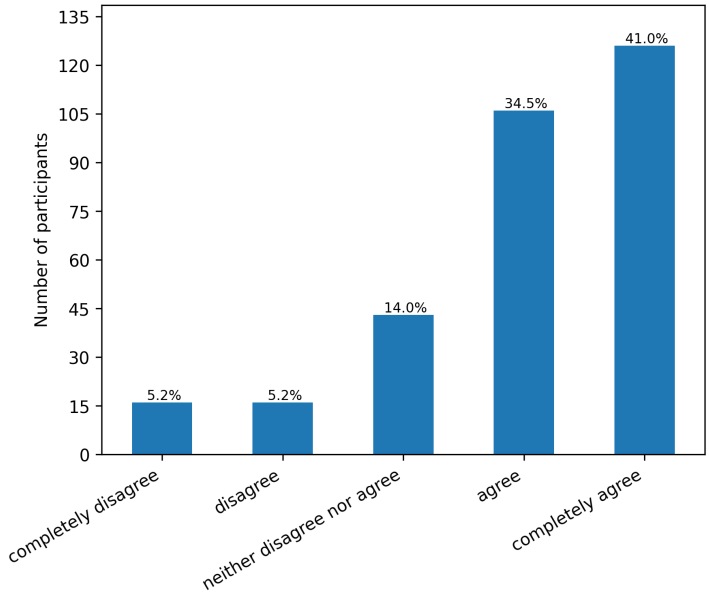

Figure 4.26: Participants' evaluations of the onboarding tutorial in Green Siesta.

The results indicate that the vast majority of participants, over 70 percent, enjoyed the onboarding process. This positive reception highlights the value of interactive tutorials, which allow players to actively practice skills rather than passively read instructions. In terms of Universal Design for Learning (UDL), the onboarding design draws on both Representation, by presenting information in multiple forms such as text prompts, visual cues, and practice opportunities, and Engagement, by immersing players immediately in the story-driven environment. The finding suggests that interactive onboarding is an effective method not only for easing players into the game but also for reinforcing motivation and accessibility. As a design implication, future development could build on this approach by offering adaptive onboarding paths, where more experienced players can skip sections while newcomers receive additional guidance.

Engagement and immersion from non-playable characters

Figure 4.27 presents participants' evaluations of whether non-playable characters (NPCs) contributed to engagement and immersion in Green Siesta. NPCs were included in the game to provide context, deliver green-themed content, and enrich the story environment. While most of the NPCs were static in their animations and positioning, they were designed to make the world feel populated and to guide players toward relevant information and tasks.

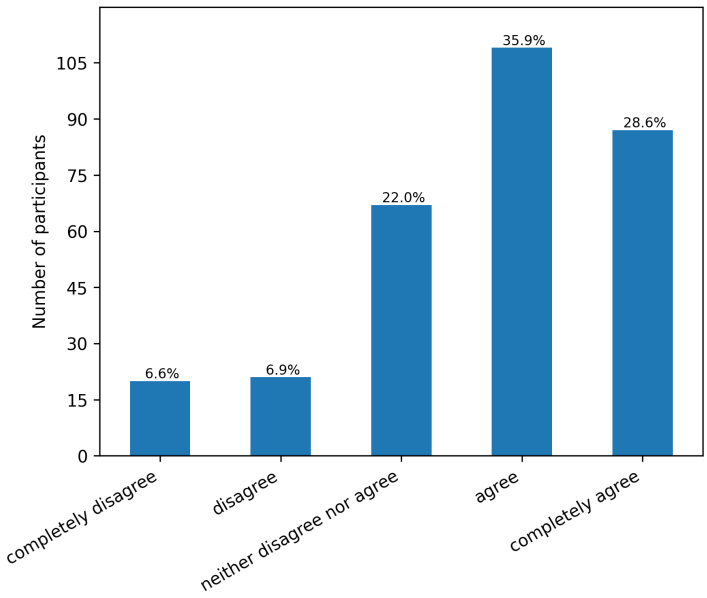

Figure 4.27: Participants' views on the immersive contribution of non-playable characters in Green Siesta.

The results indicate that participants generally felt engaged and immersed thanks to the presence of NPCs. This positive reception is notable because it shows that immersion does not necessarily depend on complex character animation; even static NPCs can significantly enhance the sense of being in a living environment. This finding is not surprising, given that many computer games rely on NPCs, whether static or dynamic, to populate the world and to deepen engagement. From a Universal Design for Learning (UDL) perspective, the use of NPCs aligns with the Engagement pillar by sustaining interest, providing multiple forms of interaction, and supporting narrative immersion. As a design implication, future iterations could explore adding more dynamic or responsive NPC behaviors, further increasing immersion while retaining their core role as accessible carriers of educational content.

Game and learning progress

Figure 4.28 presents participants' evaluations of the game's ability to track and display progress. In Green Siesta, progress tracking was implemented through two complementary mechanisms: an in-game progress bar that shows advancement within the current level, and a learning journal that can be accessed at any time to review unlocked or completed tasks and green-themed knowledge. Together, these features were designed to provide both immediate feedback and a persistent record of learning, helping players to situate themselves in the game environment and to reflect on their progress.

The results show that a strong majority of participants, more than 70 percent, appreciated the ability to monitor their progress. This suggests that players valued having both short-term indicators, such as level progress bars, and long-term records through the learning journal. From a Universal Design for Learning (UDL) perspective, these tools align with the Action and Expression pillar, which emphasizes supporting goal setting, self-regulation, and monitoring of progress. The positive reception also builds on earlier findings about personalization, as progress tracking enables players to connect their individual experience with the broader educational objectives of the game. As a design implication, expanding the learning journal to include more reflective prompts or optional self-assessment tasks could further strengthen its role as a bridge between gameplay and meaningful learning.

Support for multiple languages

Figure 4.29 presents participants' evaluations of the multilingual capability of Green Siesta. The game was made available in several languages (i.e., English, Croatian, Spanish, French, and Hungarian) in order to reflect the diverse backgrounds of the project's partner institutions and target groups. Language accessibility is a critical factor in serious games, as it ensures that content can be understood and appreciated by learners who may not be fully comfortable in English.

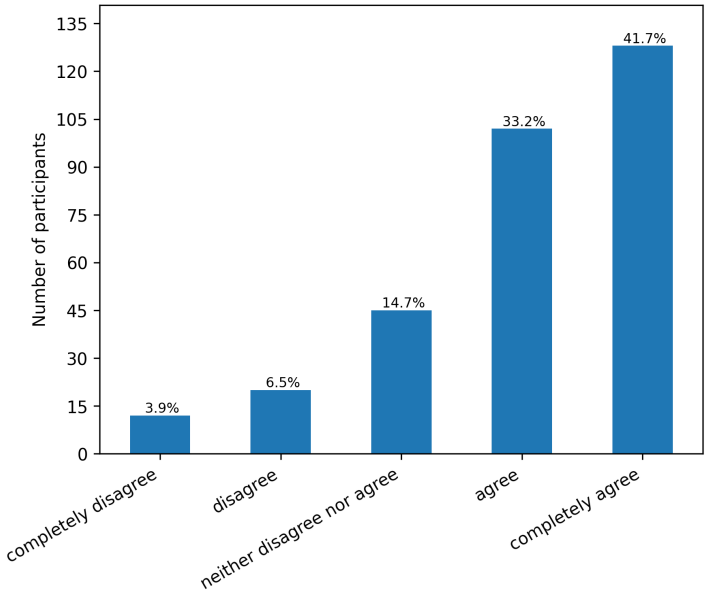

Figure 4.28: Participants' evaluations of progress tracking in Green Siesta.

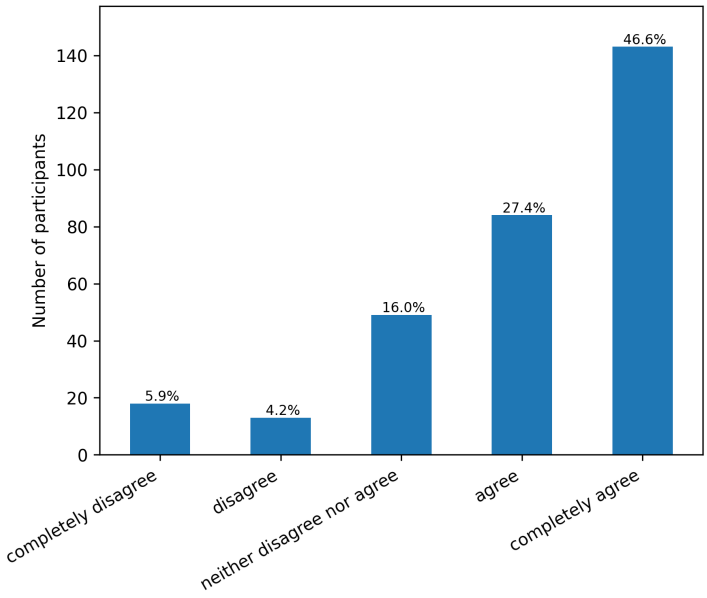

Figure 4.29: Participants' views on the multilingual support provided in Green Siesta.

The results show that the vast majority of participants valued the multilingual feature. This outcome is not surprising, as many high school pupils in particular are still developing their proficiency in English and therefore benefit from being able to access content in their native language. From a Universal Design for Learning (UDL) perspective, this aligns with the Representation pillar, which emphasizes providing multiple means of accessing and comprehending information. The finding confirms that multilingual support enhances inclusivity and makes the game approachable to a wider audience. As a design implication, continuing to expand language options and refining translations could further increase accessibility, ensuring that Green Siesta remains adaptable to new contexts and learners across different regions.

Green-themed content organization and digestibility

Figure 4.30 shows participants' evaluations of the organization of green-themed content in Green Siesta. The game was structured around per-topic levels, with each "dream" focusing on a particular environ-

mental theme. This structure was intended to help players navigate the game more easily while also making complex sustainability concepts more digestible. By combining clear thematic segmentation with a variety of learning tasks, the game aimed to support both understanding and retention of knowledge.

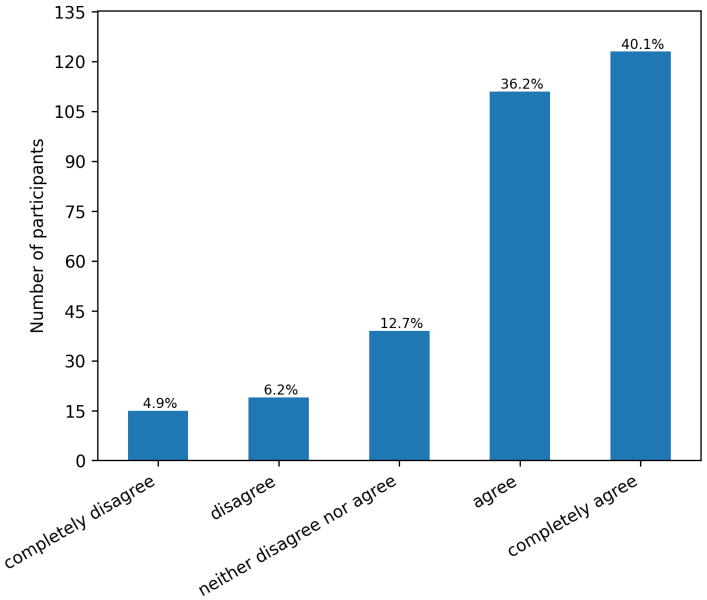

Figure 4.30: Participants' views on the organization and digestibility of green-themed content in Green Siesta.

The results confirm that the majority of participants appreciated this organizational choice. They found that the per-topic levels made it easier to follow the storyline and to connect tasks with the corresponding environmental concepts. The effectiveness of this approach was further strengthened by the combination of theoretical explanations, practical activities such as collecting and recycling, and exploratory elements like green secrets scattered across the map. From a Universal Design for Learning (UDL) perspective, this reflects both the Representation pillar, by providing content through multiple channels, and the Action and Expression pillar, by enabling players to act on knowledge in diverse ways. As a design implication, continuing to expand the variety of tasks and reinforcing thematic coherence could further enhance digestibility, ensuring that players engage with the content in a structured yet engaging manner.

Controls onboarding

Figure 4.31 shows participants' evaluations of the clarity and helpfulness of the control explanations in Green Siesta. Learning how to control the game effectively is a prerequisite for engaging with its educational content, and poorly explained mechanics can create unnecessary barriers. To address this, Green Siesta introduced controls within the interactive onboarding level, where players practiced movement and basic interactions in a guided environment. In addition, if a player remained idle for a period of time, the heads-up display (HUD) presented reminders of the relevant control scheme.

The responses indicate that participants valued these mechanisms, with most evaluating the explanations as clear and effective. The combination of an interactive onboarding level and context-sensitive HUD prompts helped ensure that both newcomers and more experienced players could orient themselves without frustration. From a Universal Design for Learning (UDL) perspective, this reflects the principles of Representation, as information about controls was presented in multiple forms, and Action and Expression, since players were supported in acquiring the skills needed to act within the game. The result demonstrates that control onboarding was a well-implemented feature, lowering barriers to entry and helping maintain focus on the educational objectives rather than on technical difficulties.

Personalization rating

Figure 4.32 presents participants' evaluations of the personalization features in Green Siesta. These features included a wide range of configuration options, such as audio and video settings, language

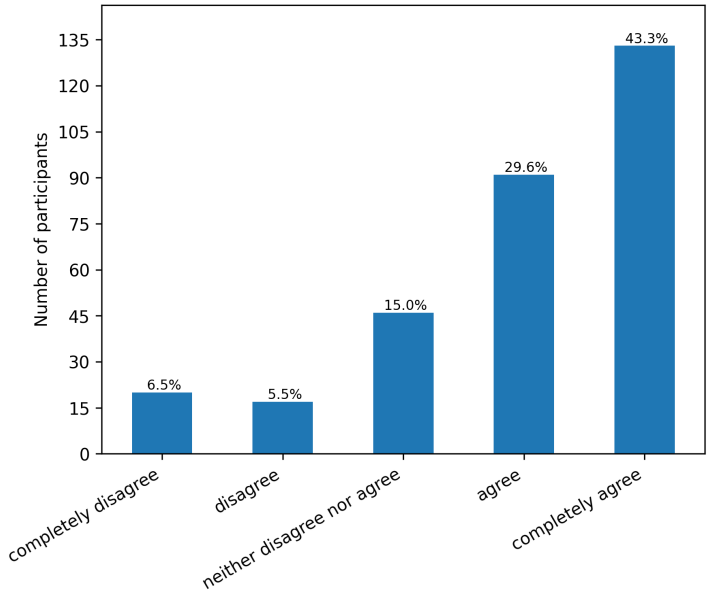

Figure 4.31: Participants' evaluations of the clarity of control explanations in Green Siesta.

selection, and other adjustments that allowed players to tailor the game to their preferences and context. Personalization is a key aspect of user experience design in both entertainment and educational games, as it increases comfort, ownership, and accessibility.

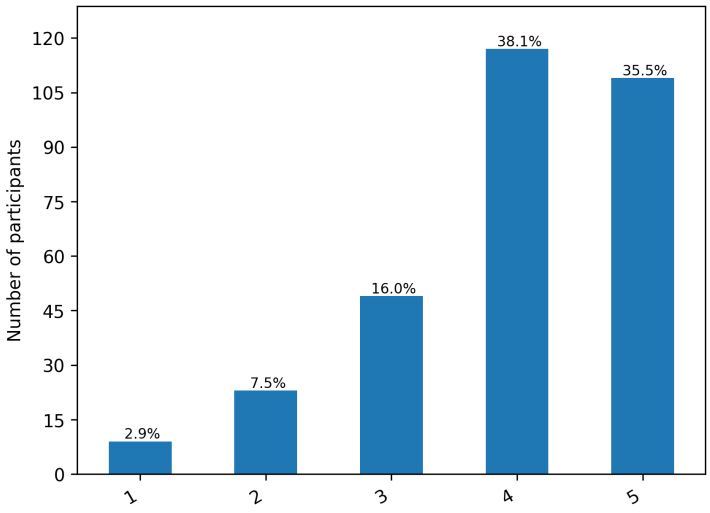

Figure 4.32: Participants' evaluations of the personalization features in Green Siesta.

The results show that participants rated personalization very positively, with the majority assigning good to excellent marks. This outcome indicates that the abundant configuration options were both easy to find and perceived as useful in shaping the game experience. From a Universal Design for Learning (UDL) perspective, this aligns with the Engagement principle, since allowing players to adapt the environment to their needs supports motivation and sustained involvement. When viewed alongside the earlier finding that players were able to personalize their experience even within short testing sessions, the strong ratings here confirm that personalization was a well-integrated design choice. Together, these findings suggest that Green Siesta successfully leveraged personalization to enhance both accessibility and enjoyment, providing players with meaningful control over their gameplay environment.

4.2.3 Artificial intelligence (Green Siesta)

AI usage (i.e. sidekick)

Figure 4.33 shows whether participants made use of the AI sidekick during gameplay. The sidekick was designed as an optional companion that players could turn to for support, rather than as a background algorithm hidden from view. This design decision was intended to make artificial intelligence more approachable and to provide players with a tangible, interactive resource embedded in the game world.

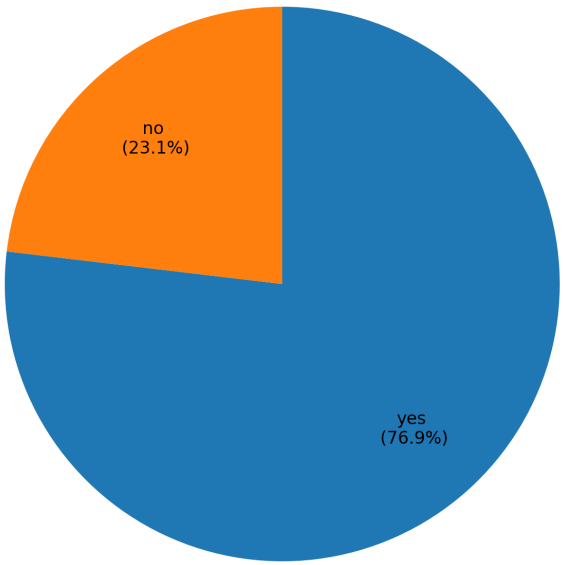

Figure 4.33: Participants' reported use of the AI sidekick in Green Siesta.

The results indicate that the majority of participants chose to use the sidekick, which validates the usefulness and appropriateness of implementing AI as a personalized character. Rather than functioning as a "cold" algorithm working invisibly in the background, the sidekick provided accessible and learner-friendly support. From a Universal Design for Learning (UDL) perspective, this aligns with the Engagement pillar, by sustaining interest and offering choice in how assistance is accessed, as well as with Action and Expression, by giving players a clear mechanism to request support when needed. The high usage confirms that the sidekick was not only a well-integrated design feature but also a practical tool that contributed to accessibility, immersion, and personalization within the game.

Prior experience in using sidekicks in game

Figure 4.34 presents participants' responses on whether they had prior experience with sidekicks in other games. Sidekicks are a common design feature in more complex or "hardcore" gaming environments, where they often function as companions, guides, or combat allies. For Green Siesta, the sidekick Leafy was designed to provide a similar sense of companionship while also serving as an accessible entry point to AI support in an educational context.

The results indicate a roughly 6:4 split in favor of participants who had previously used sidekicks in other games. This suggests that while a significant portion of players brought existing familiarity with the concept, many others encountered a sidekick for the first time in Green Siesta. In this sense, Leafy was not only useful for enhancing gameplay and providing support but also functioned as a novelty factor for those less experienced with the mechanic. From a Universal Design for Learning (UDL) perspective, this aligns with the Engagement pillar, as the sidekick both sustained interest for experienced players and provided new, motivating experiences for others. The finding reinforces that the inclusion of Leafy successfully bridged diverse player backgrounds, making AI-driven assistance approachable for all.

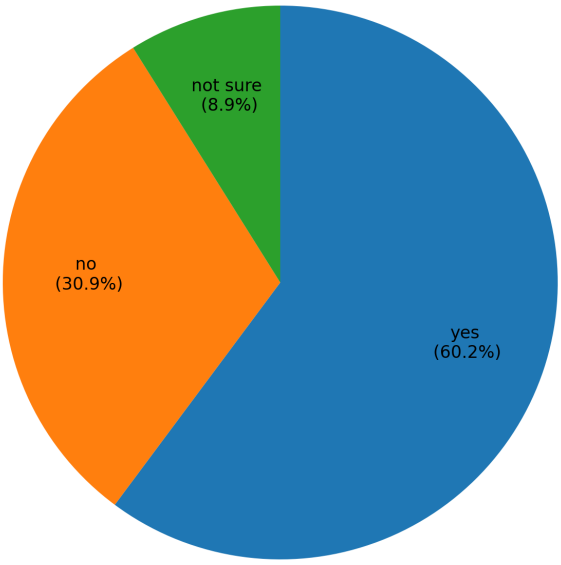

Figure 4.34: Participants' reports on prior experience with sidekicks in other games.

Sidekick helpfulness

Figure 4.35 presents participants' evaluations of how helpful they found Leafy, the AI sidekick in Green Siesta. As noted in the previous figures, Leafy was designed to be an approachable, visible form of artificial intelligence rather than an invisible background process. The aim was to ensure that players of different levels of gaming experience could access support in a way that felt natural and motivating.

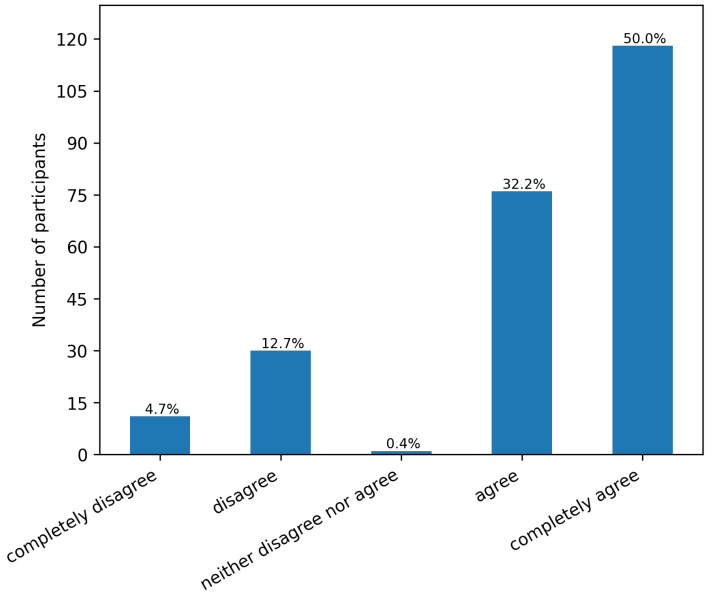

Figure 4.35: Participants' evaluations of the helpfulness of Leafy, the AI sidekick.

The results show that the vast majority of participants considered Leafy to be helpful. This outcome confirms that the AI sidekick was not only well integrated into gameplay but also perceived as a meaningful contributor to the learning process. From a Universal Design for Learning (UDL) perspective, Leafy embodies both Engagement, by sustaining interest and providing optional support, and Action and Ex-

pression, by giving players control over when and how assistance was accessed. The positive evaluations suggest that Green Siesta demonstrates a promising model for the impactful use of AI in educational games: presenting AI not as a hidden mechanism but as an interactive, supportive companion. As a design implication, Leafy's success highlights a pathway for future serious games to adopt AI features that are simultaneously inclusive, motivating, and pedagogically effective.

Gaming experience enhancement

Figure 4.36 presents participants' evaluations of whether the AI sidekick Leafy enhanced their overall gaming experience. This question builds directly on earlier measures of awareness, usefulness, and helpfulness, providing a broader perspective on the perceived value of Leafy as part of the Green Siesta experience.

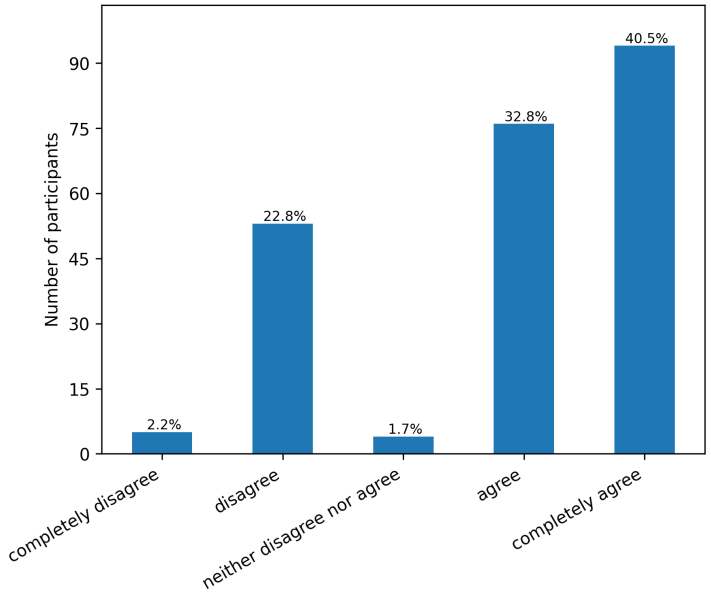

Figure 4.36: Participants' views on whether Leafy enhanced their overall gaming experience.

The results confirm that participants widely agreed that the AI sidekick enhanced their gaming experience. This consistency with earlier findings demonstrates that Leafy was not only functional and supportive but also successful in improving immersion, motivation, and enjoyment. From a Universal Design for Learning (UDL) perspective, Leafy contributed to Engagement by providing an optional yet motivating presence, while also supporting Action and Expression by helping players pursue goals more effectively. Taken together, these findings suggest that Green Siesta's choice to implement AI in the form of an interactive sidekick was highly effective. More broadly, the result highlights how serious games can harness AI not just as a background technology but as a visible, relatable character that enhances both gameplay quality and educational outcomes.

Awareness of AI as a help tool

Figure 4.37 presents participants' evaluations of whether they were aware that the AI sidekick Leafy could provide help with tasks during the game. Awareness of a support feature is a crucial prerequisite for its effective use: if players are not sure what a tool can do, they are far less likely to engage with it. For this reason, Green Siesta's design made Leafy's purpose explicit through narrative cues and visual indicators.

The results show that participants were well aware of Leafy's role as a help tool, suggesting that the AI sidekick was integrated in an intuitive and accessible way. This awareness is an important factor in explaining why Leafy was widely used and positively evaluated in earlier measures. From a Universal Design for Learning (UDL) perspective, the feature reflects the Engagement pillar by ensuring that learners know they can access support when needed, and the Action and Expression pillar by enabling them to choose when and how to request that support. The outcome highlights that the design succeeded

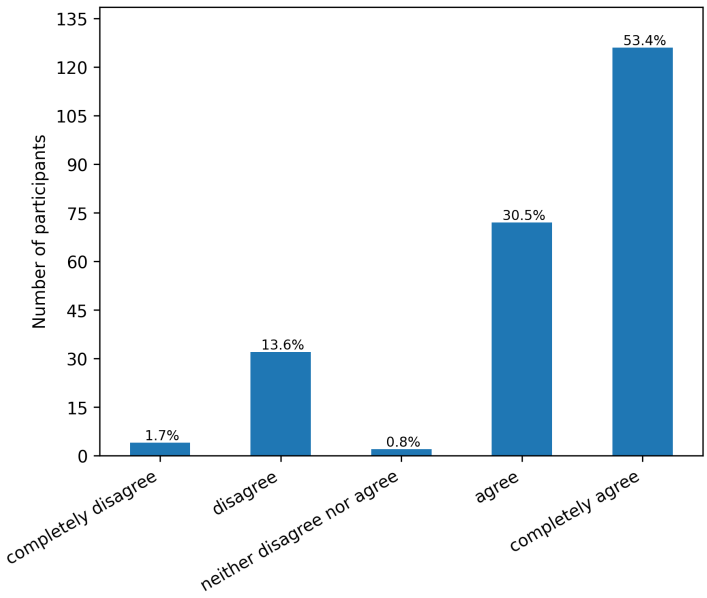

Figure 4.37: Participants' awareness of Leafy as a tool for task support in Green Siesta.

in balancing clarity with optionality: players understood Leafy's role without being forced to rely on it, which is a key element of inclusive and learner-centered design.

The role of AI for enhancing engagement

Figure 4.38 shows participants' evaluations of whether the AI sidekick Leafy contributed to enhancing their engagement with the game. Engagement is a critical factor in serious games, as it directly influences both the enjoyment of gameplay and the effectiveness of learning outcomes. Leafy was designed with this in mind, serving not only as a support tool but also as a motivating presence that sustained attention and interest throughout the game.

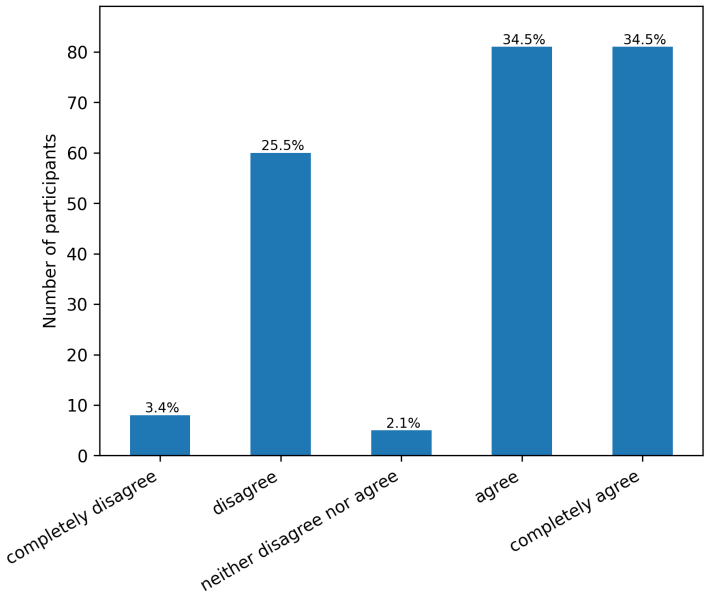

Figure 4.38: Participants' views on Leafy's role in enhancing engagement.

The results confirm that participants favored the inclusion of Leafy and considered the sidekick an effective way to enhance engagement. This finding is consistent with earlier measures of usefulness, helpfulness, and awareness, reinforcing that the AI sidekick was not only functional but also motivational.

From a Universal Design for Learning (UDL) perspective, Leafy directly supported the Engagement pillar by sustaining interest and providing an accessible, interactive element that players could rely on at their own discretion. More broadly, the positive evaluations highlight that visible and interactive AI has strong potential to enrich serious games, suggesting that similar approaches could be adopted in future educational titles to keep learners both motivated and actively involved.

Most valuable AI features

Figure 4.39 presents participants' assessments of the most valuable features provided by the in-game AI sidekick. Nearly half of the respondents (48.2 percent) emphasized the importance of textual and narrative hints for guiding their progress in quests and tasks, while 42.7 percent valued the sidekick's ability to provide visual cues, such as highlighting recyclable trash. These two leading features confirm that players especially appreciated clear, context-sensitive support that allowed them to maintain autonomy while still receiving guidance when needed. At the same time, 17.6 percent of participants highlighted the auto-play option, where the sidekick could complete tasks independently, and 12.4 percent appreciated the motivational role of inspirational messages delivered after successful actions.

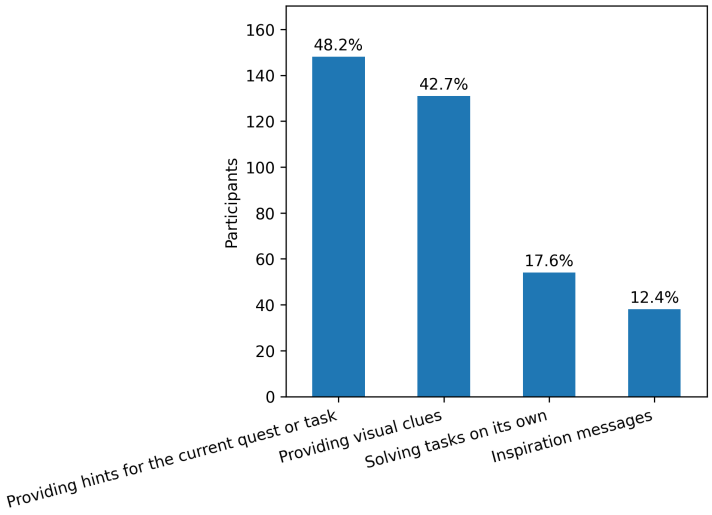

Figure 4.39: Participants' views on the most valuable features of the AI sidekick in Green Siesta.

Taken together, the results illustrate how the AI sidekick served as a flexible scaffolding mechanism, aligning closely with Universal Design for Learning principles. The high value placed on textual and visual guidance indicates that participants benefitted from multiple modes of representation, while the presence of auto-play and inspirational messaging highlights the importance of accessibility and motivational support for different types of players. Importantly, the diversity of preferences shows that the sidekick did not function as a one-size-fits-all tool but rather as a dynamic companion that adapted to various learning styles and levels of engagement. This suggests that AI-driven support systems in serious games can significantly enhance both inclusivity and player satisfaction by providing personalized pathways to success.

4.2.4 Augmented reality (Green Siesta Quiz)

Augmented reality (AR) was implemented in the *Green Siesta Quiz* to extend interactivity, enhance engagement, and experiment with gesture-based controls. The following subsections present participant feedback on prior exposure, usage, interaction quality, and perceived impact.

Prior exposure and feature usage

Figure 4.40 shows whether participants had used AR applications before playing.

As illustrated in Figure 4.41, the majority engaged with the AR features during the quiz session.

These results suggest that the AR features were approachable and encouraged participation, even among players without prior AR experience.

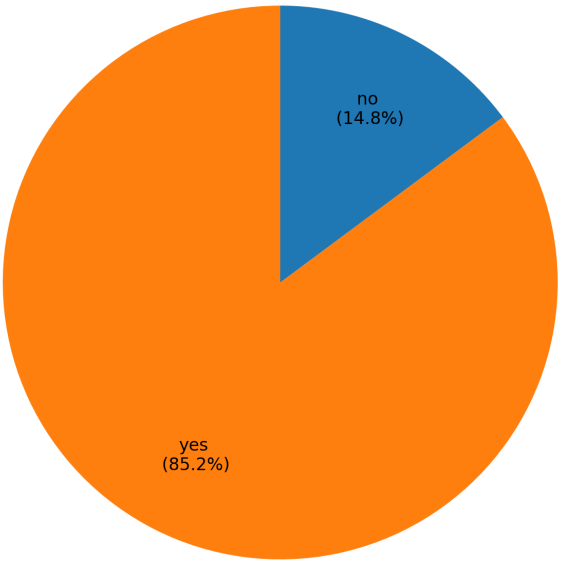

Figure 4.40: Participants' prior experience with AR technologies before playing *Green Siesta Quiz*.

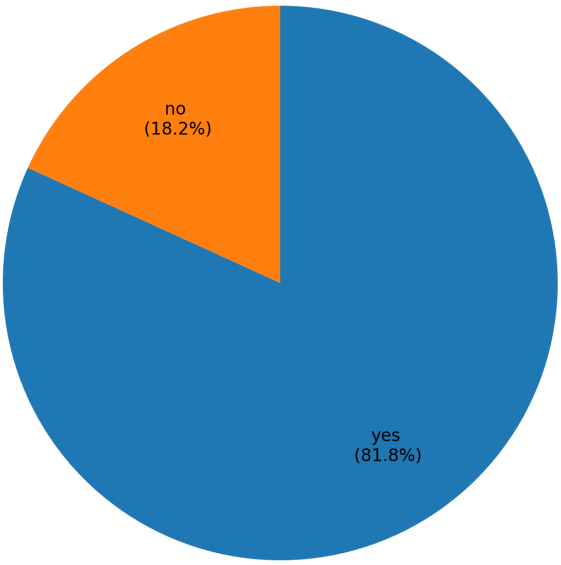

Figure 4.41: Extent of AR feature usage during the *Green Siesta Quiz*.

Gesture-based interaction

Figure 4.42 presents player evaluations of the gesture-based controls.

The feedback indicates that most participants found gestures to be understandable and usable, while also highlighting opportunities to further refine interaction design.

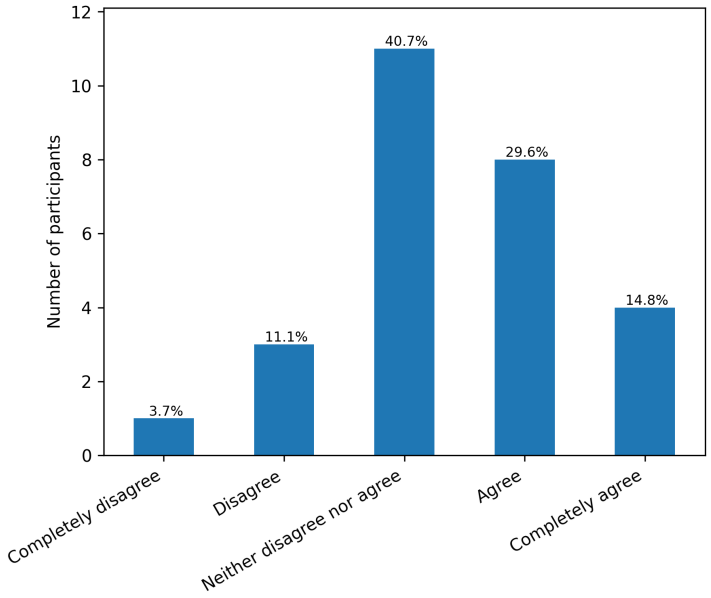

Figure 4.42: Player evaluation of gesture-based controls in the AR mode of *Green Siesta Quiz*.

Perceived usefulness and impact

Figures 4.43–4.45 capture perceptions of the value of AR in the quiz. Players considered AR to be a useful addition, reported that it increased their engagement, and indicated that it improved the overall game experience.

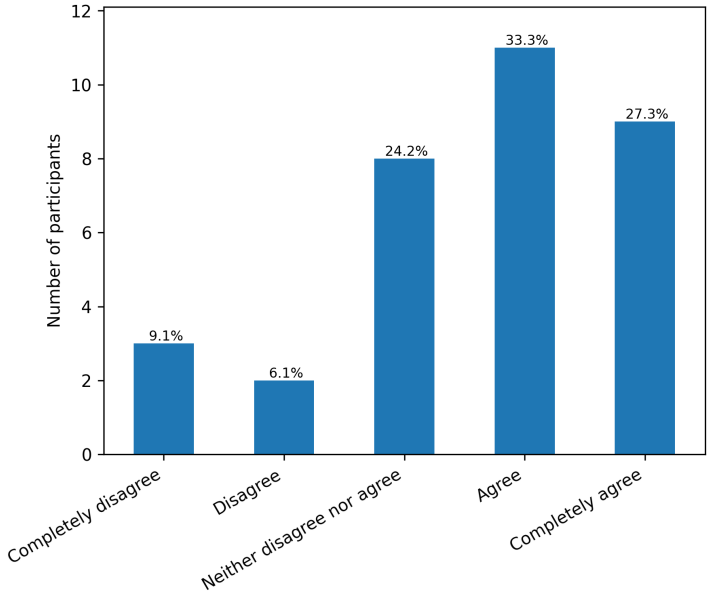

Figure 4.43: Perceived usefulness of the AR functionality in *Green Siesta Quiz*.

Together, these results suggest that AR positively contributed to both motivation and experience quality, reinforcing its role as a meaningful extension of the quiz.

Summary

In summary, the AR features in *Green Siesta Quiz* were widely adopted and well received. They enriched the quiz experience by increasing engagement and supporting interactive gameplay. More detailed results on the quiz can be found in Appendix.

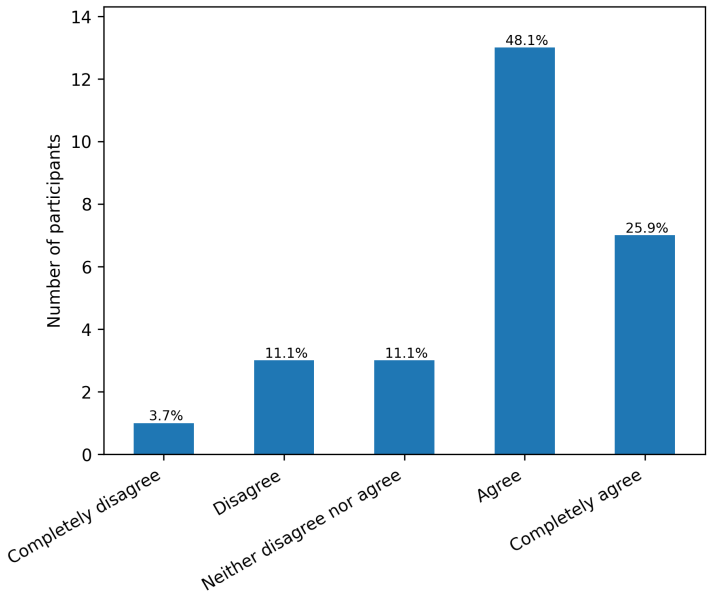

Figure 4.44: Reported increase in player engagement due to AR features in *Green Siesta Quiz*.

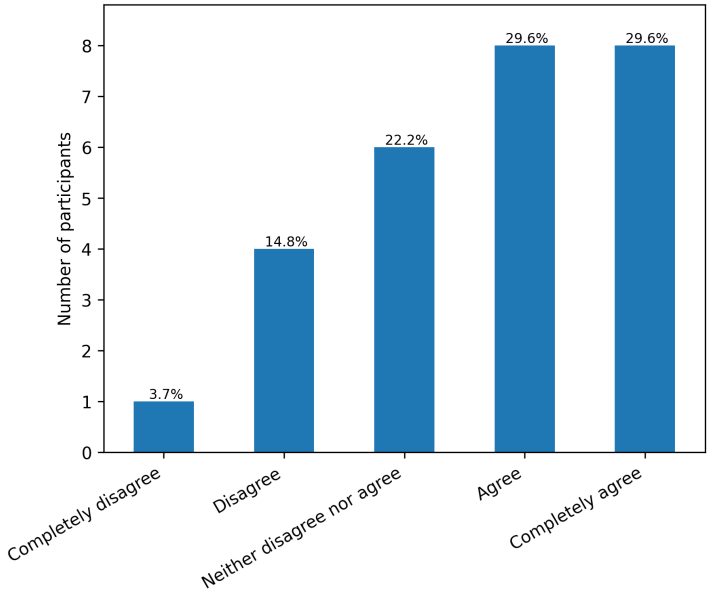

Figure 4.45: Player perception of whether AR features improved the overall experience of *Green Siesta Quiz*.

4.2.5 Holographic features (HoloZoo)

The *HoloZoo* serious game was based on holography. Holography was used to improve engagement and interest in the educational content portrayed in this game by using an emerging technology not commonly used. The following analysis presents the participant information and their perception of using the *HoloZoo* application.

Demographics

The demographic profile (Figures 4.46 and 4.47) of participants provides context for understanding engagement and outcomes in *HoloZoo*.

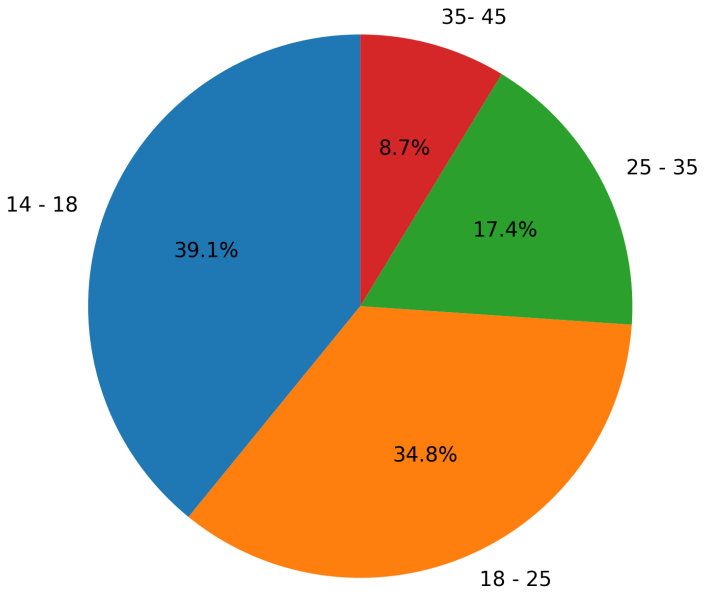

Figure 4.46: Age distribution of participants in *HoloZoo* questionnaire.

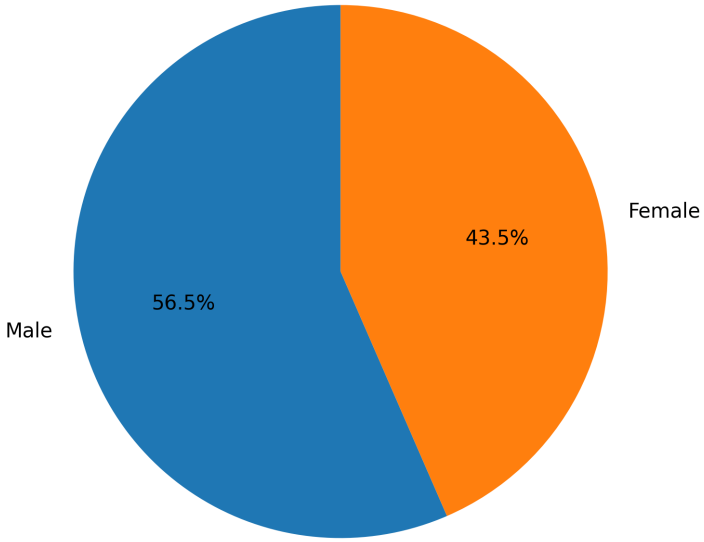

Figure 4.47: Gender distribution of participants in *HoloZoo* questionnaire.

Prior exposure to technology

Figure 4.48 shows whether participants were familiar with holography before using the application.

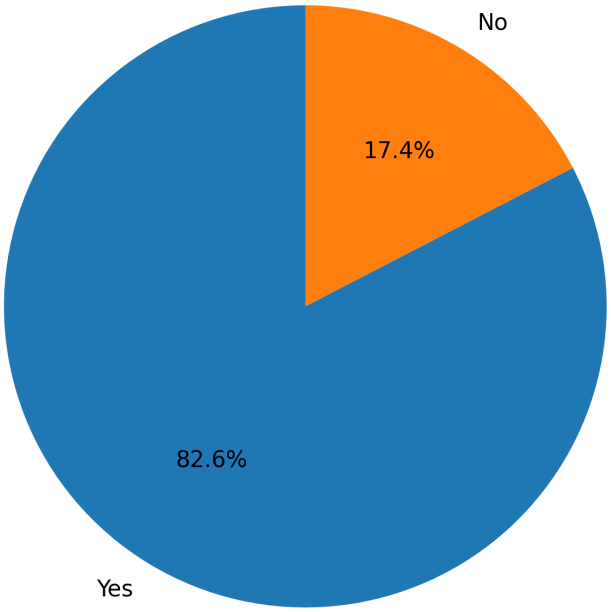

Figure 4.48: Participants' prior experience with holography technologies before playing *HoloZoo*.

As illustrated in Figure 4.48, the majority of participants were familiar with holography.

Accessibility

HoloZoo was developed keeping in mind the accessibility guidelines for building a mobile application[1]. These were examined through the questionnaire, and the results are presented in the following charts.

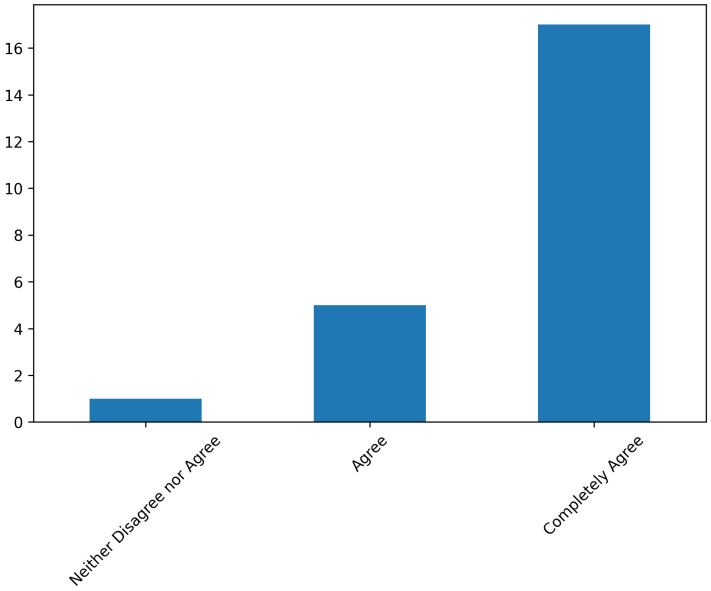

Figure 4.49: Distribution of the ease of using the *HoloZoo* application.

[1] https://www.w3.org/WAI/standards-guidelines/mobile/

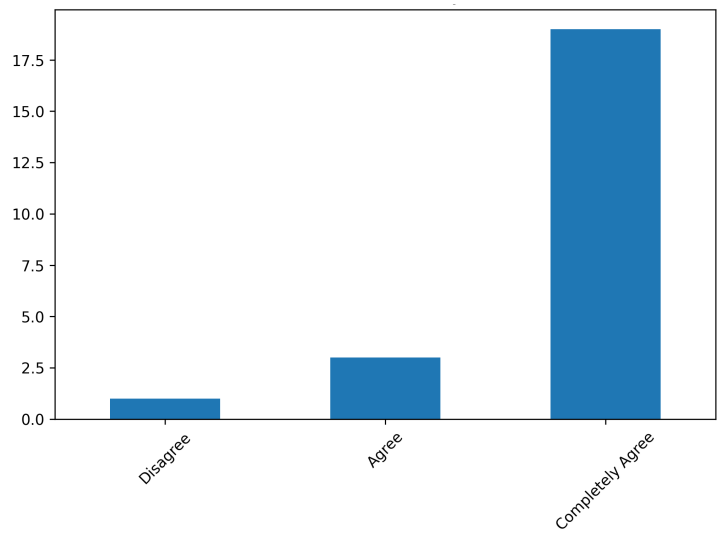

Figure 4.50: Distribution if elements are sufficiently visible in *HoloZoo*.

Figures 4.49 and 4.50 suggest that the application has intuitive design with well positioned elements that are easily accessible.

Perceived usefulness and impact of holography

Figures 4.51 and 4.52 capture perceptions of the value of holography in the application and if the holograms were easily understandable.

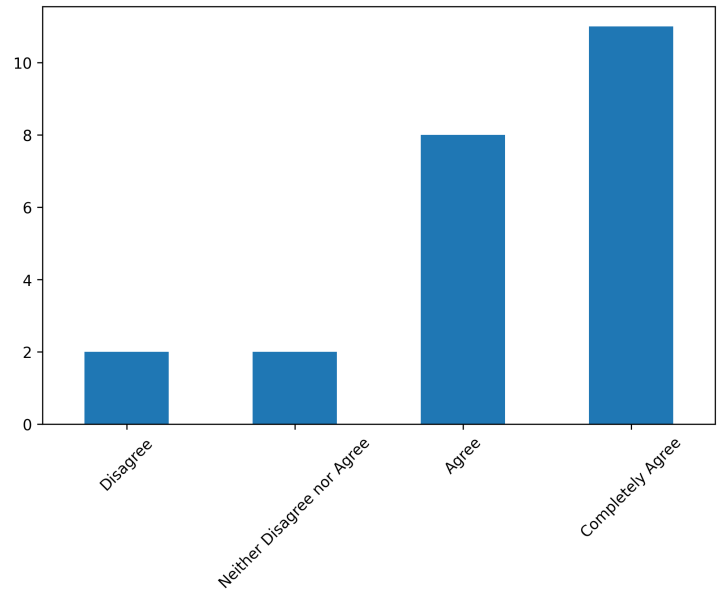

Figure 4.51: Perception of understandability of hologram in *HoloZoo*

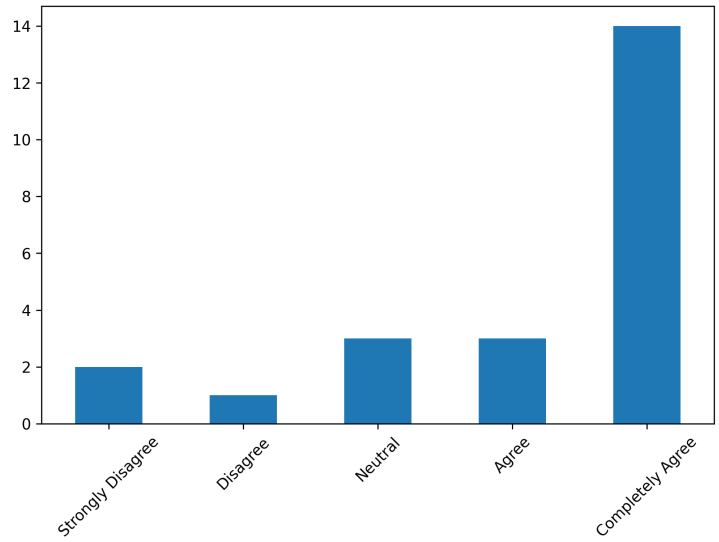

Figure 4.52: Player perception of holograms improving learning experience of *HoloZoo*.

These results suggest that holography was a beneficial technology to use in this educational serious game as the majority of users agree that it improved their learning experience and that the holograms were understandable.

Environmental conditions

The conditions in which the HoloZoo application is tested is of crucial value. The proper setting of lighting, noise and device is very important for the perception of the technology as well as application.

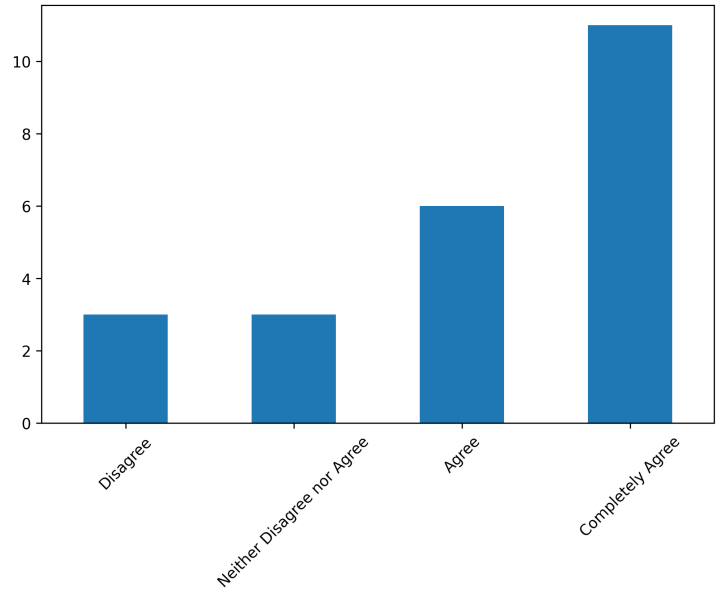

Figure 4.53: Player perception that room lighting was pleasant during testing *HoloZoo*

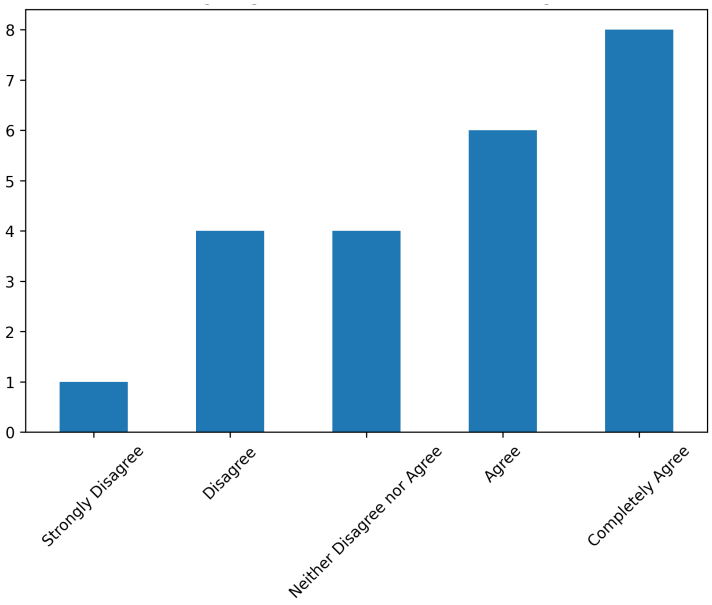

Figure 4.54: Player perception that room lighting did not interfere with the holograms during testing *HoloZoo*

While most participants found the lighting acceptable as shown in figure 4.53, several noted that ambient light had a noticeable effect on the quality of the holographic projection, presented in figure 4.54.

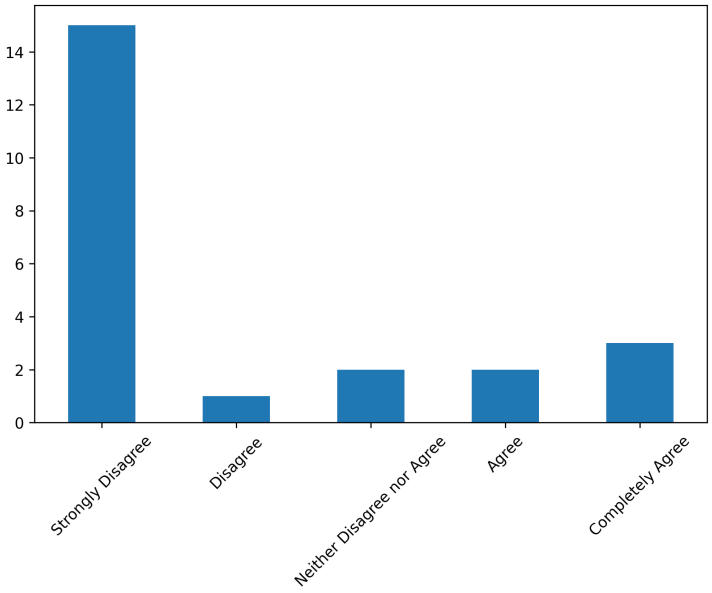

Figure 4.55: Player perception of noise distracting during testing *HoloZoo*

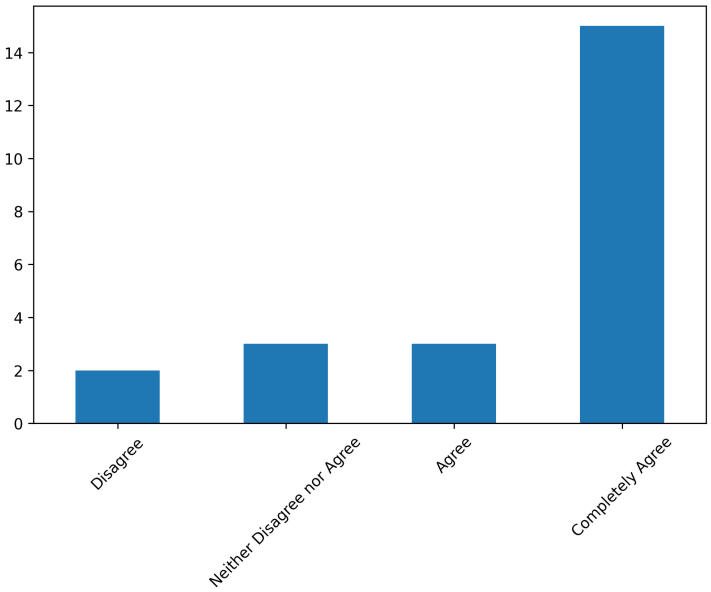

Figure 4.56: Player perception that noise was not disturbing during testing *HoloZoo*

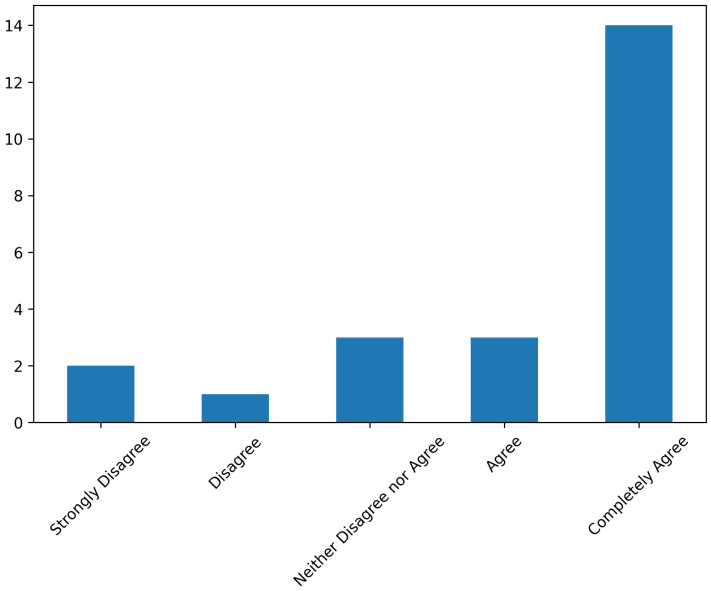

Figure 4.57: Player perception that noise made it difficult to concentrate during testing *HoloZoo*

Most participants indicated that background noise was not significantly distracting, shown in figures 4.55 and 4.56, though a few reported mild difficulties in maintaining concentration due to environmental sounds, seen in figure 4.57.

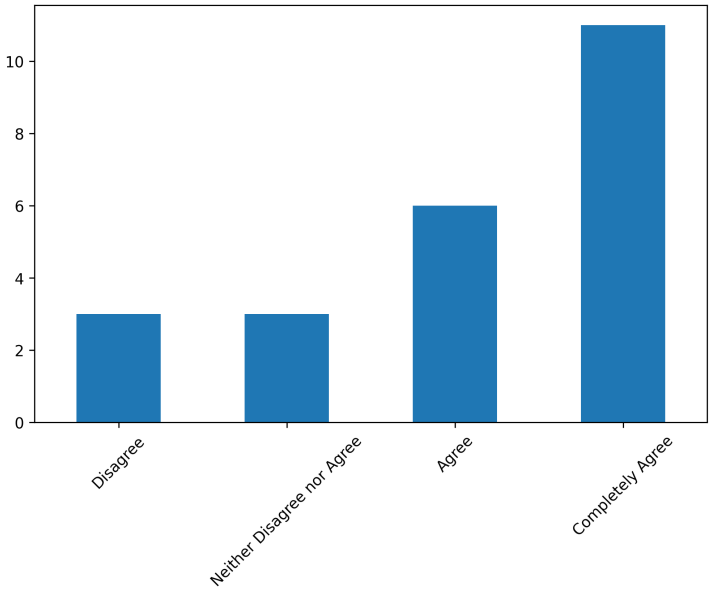

Figure 4.58: Player perception that device movement affected testing *HoloZoo*

Responses indicated that device movement (tilting or rotation) had minimal impact on usability for the majority of participants, which is presented in figure 4.58.

Summary

Conclusively, the holograms used in *HoloZoo* were understandable and have proven to be useful in enhancing engagement and improving learning experiences. This shows that the use of holograms has a clear purpose when used in educational serious games.

4.3 Achieved learning outcomes

This section presents the results related to achieved learning outcomes in Green Siesta. While self-report questions on emotions and engagement capture how the game feels to play, these outcome-focused items address whether players actually absorbed the intended environmental lessons through gameplay. The design of the game relied on practical, symbolic, and exploratory mechanics—, such as collecting recyclables, disposing of non-recyclables, crafting new items, and uncovering green secrets, that map directly onto the project's educational goals. By embedding these actions into the dreamlike narrative and reinforcing them through NPC dialogue and the AI sidekick, the game sought to blend hands-on practice with conceptual understanding.

The results are highly encouraging: in all tasks, well over 90 percent of participants reported success. This suggests that the mechanics were not only accessible and enjoyable but also effective in delivering the intended environmental lessons. From a Universal Design for Learning (UDL) perspective, the activities consistently reflected principles of Engagement, Action and Expression, and Representation, ensuring that knowledge could be approached in multiple ways. Together, these outcomes demonstrate that Green Siesta succeeded in making recycling, waste management, and sustainability concepts memorable, interactive, and motivating for a broad audience.

Collection of recycables

Figure 4.59 presents participants' self-reported success in completing task-collecting activities, specifically gathering recyclable items within Green Siesta. These tasks were central to the gameplay design, providing players with hands-on practice in environmentally responsible behavior. At the same time, they were embedded in a broader educational context: discussions with NPCs, guidance from the AI sidekick, and follow-up feedback ensured that practical actions were reinforced with theoretical knowledge.

The results show that more than 95 percent of participants successfully completed these collecting tasks. This very high level of success indicates that players were not only able to engage with the

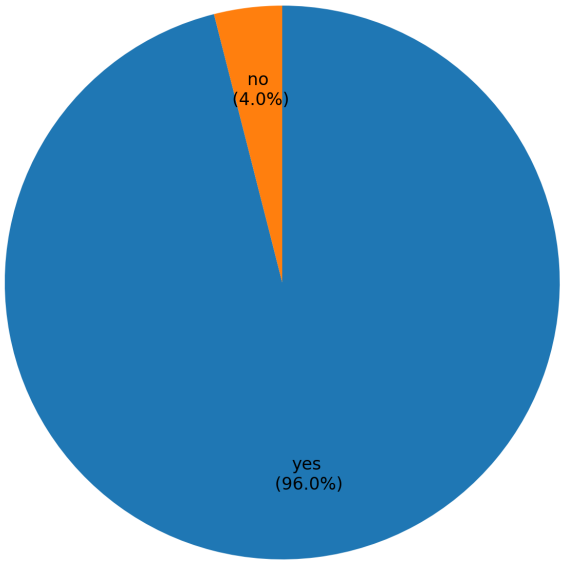

Figure 4.59: Participants' success in collecting recyclable and non-recyclable items in Green Siesta.

mechanics of the activity but also understood its environmental meaning. From a Universal Design for Learning (UDL) perspective, the task design reflects Action and Expression, by allowing players to demonstrate understanding through interactive practice, and Representation, by reinforcing those actions through dialogue and explanatory content. The outcome suggests that Green Siesta effectively combined experiential gameplay with supportive educational structures, ensuring that the learning objectives, awareness of recycling and waste separation, were achieved by nearly all participants.

Disposal of non-recyclables

Figure 4.60 presents participants' success rates in disposing of non-recyclable items within Green Siesta. More than 90 percent reported being able to complete this task successfully. The activity was designed in a playful and symbolic way: since the game is set in a dream-like environment, the main character Kimi disposes of non-recyclables by physically punching them, thereby destroying items that cannot be recycled. This choice was intended to make the action memorable, while still clearly conveying the environmental lesson.

The high success rate confirms that the task was accessible and engaging. The dreamlike design encouraged exploration and play, while the underlying concept connected back to a serious environmental issue: how societies must deal with non-recyclable waste. From a Universal Design for Learning (UDL) perspective, the task aligns with Engagement, by making the challenge playful and motivating, and with Action and Expression, by allowing learners to demonstrate understanding through direct interaction. The outcome suggests that even abstract or symbolic mechanics can serve as powerful tools for reinforcing environmental awareness when they are clearly tied to real-world concerns.

Re-purposing recyclables by creating new items

Figure 4.61 shows participants' success in re-purposing recyclables by creating new items during gameplay. More than 90 percent reported successfully completing this task. In the dreamlike setting of Green Siesta, the character Kimi first collects recyclable items and disposes of non-recyclables. Following this, an orb becomes available for activation, initiating the crafting process. As a result, a new object is generated, often accompanied by a follow-up from an NPC and the completion of the corresponding quest. This design turned the crafting mechanic into a structured yet rewarding learning sequence.

The very high success rate suggests that players not only understood the sequence but also enjoyed the process of transforming collected materials into something new. The orb and quest-completion fram-

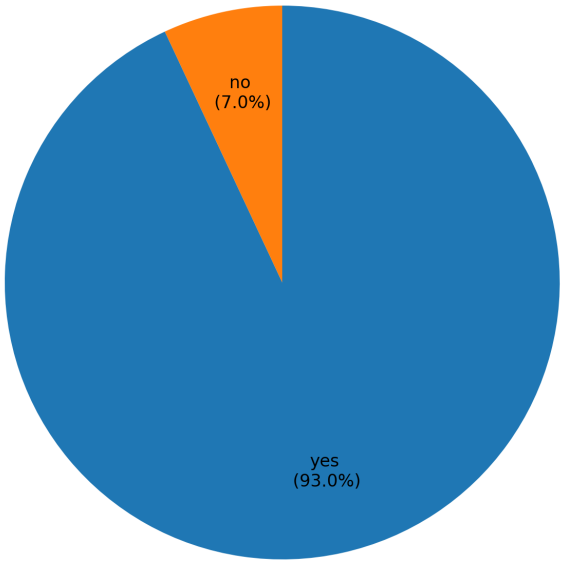

Figure 4.60: Participants' success in managing non-recyclable items in Green Siesta.

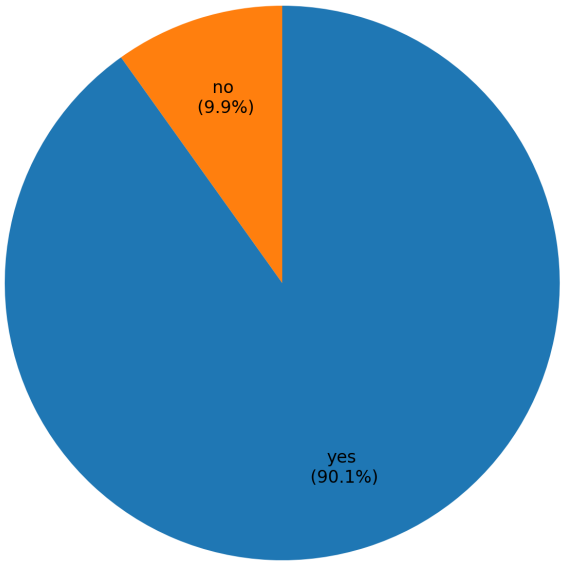

Figure 4.61: Participants' success in re-purposing recyclables by crafting new items in Green Siesta.

ing gave the activity a clear sense of achievement, reinforcing the importance of re-purposing as part of sustainable behavior. From a Universal Design for Learning (UDL) perspective, this task aligns with Engagement, by providing a motivating and playful challenge, and with Action and Expression, by allowing learners to demonstrate knowledge through interactive practice. The combination of symbolic dreamlike mechanics and tangible outcomes illustrates how serious games can make abstract sustainability concepts both memorable and enjoyable.

Acquiring optional green-themed knowledge through exploration

Figure 4.62 presents participants' success in acquiring optional green-themed knowledge through the discovery of so-called green secrets. More than 90 percent of participants reported successfully engaging with this activity. The green secrets were presented as spinning boxes hidden in each level. When discovered and activated, they delivered short fun facts directly to Kimi's in-game phone (i.e., main character), with each fact tied to the topic of the level, such as paper, plastic, or organic waste. This mechanic rewarded curiosity while seamlessly integrating educational content into exploration.

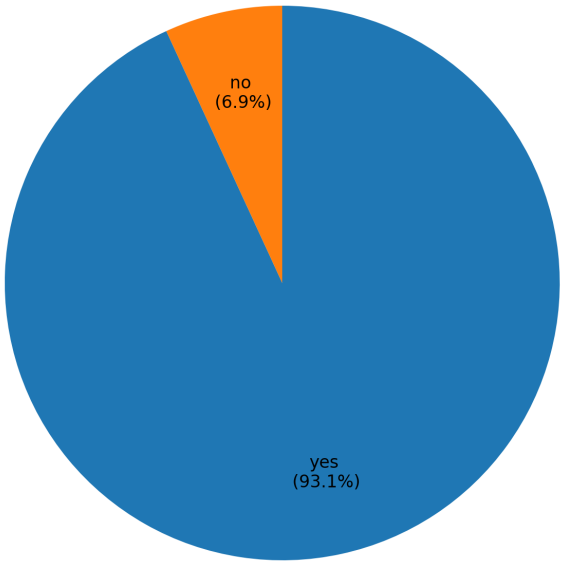

Figure 4.62: Participants' success in acquiring green-themed knowledge through exploration.

The high success rate confirms that participants not only found but also valued these optional knowledge elements. By framing fun facts as optional rewards, the design encouraged players to actively explore the environment rather than passively consume content. From a Universal Design for Learning (UDL) perspective, this approach supports Engagement, as it motivated players to seek additional information voluntarily, and Representation, as the knowledge was presented in short, accessible textual form that complemented practical gameplay. The outcome demonstrates that curiosity-driven mechanics can be highly effective in serious games, turning the search for information into a playful and memorable part of the learning experience.

4.4 Self-report player experience

The following section presents results from the self-report player experience questionnaire which was designed following the standardised *Game Experience Questionnaire*[2]. This analysis gives insights on several categories, whether users were immersed and challenged while playing Green Siesta. If they felt competent, tense or if they felt flow during their gaming session. And finally, the amount of positive and/or negative affect that the game imparts on the player[3]. Unlike objective measures such as task success or completion rates, self-report items capture the subjective side of gameplay: how players felt

[2]Effie L.-C. Law, Florian Brühlmann, and Elisa D. Mekler. 2018. Systematic Review and Validation of the Game Experience Questionnaire (GEQ) - Implications for Citation and Reporting Practice. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '18). Association for Computing Machinery, New York, NY, USA, 257–270. https://doi.org/10.1145/3242671.3242683

[3]A. Radovic, I. Slosic, J. Babic, and A. Boni, "Students Perception and Game Experience Analysis of a Serious Game for Green Education," 2025 17th International Conference on Quality of Multimedia Experience (QoMEX), Madrid, Spain, 2025, to be published

about the game's difficulty, aesthetics, story, and their own sense of competence or success. These aspects are crucial in understanding whether the game was not only educational but also motivating and enjoyable, since positive affect and perceived competence directly support learning outcomes.

The analysis is organised around individual survey items, each accompanied by a figure that shows the distribution of responses. Across the results, a generally positive pattern emerges: most participants reported feeling content, skilful, and successful, while negative responses such as boredom, annoyance, or frustration were minimal. These findings suggest that Green Siesta was able to strike a balance between its role as a serious educational game and its function as an enjoyable experience. Importantly, the results also highlight areas for future refinement, such as providing more narrative depth, longer play sessions, and optional challenges, while confirming that the game's current design aligns well with the Universal Design for Learning (UDL) principles of accessibility, engagement, and inclusivity.

Felt content

Figure 4.63 reports on participants' self-assessment of how content they felt while playing Green Siesta. This type of question is commonly used in self-report instruments that evaluate game experience. It asks players to reflect on their overall emotional state during the game, focusing on whether the experience left them satisfied, at ease, and positively engaged. The answer options followed a five-point scale: not at all, slightly, moderately, fairly, and extremely.

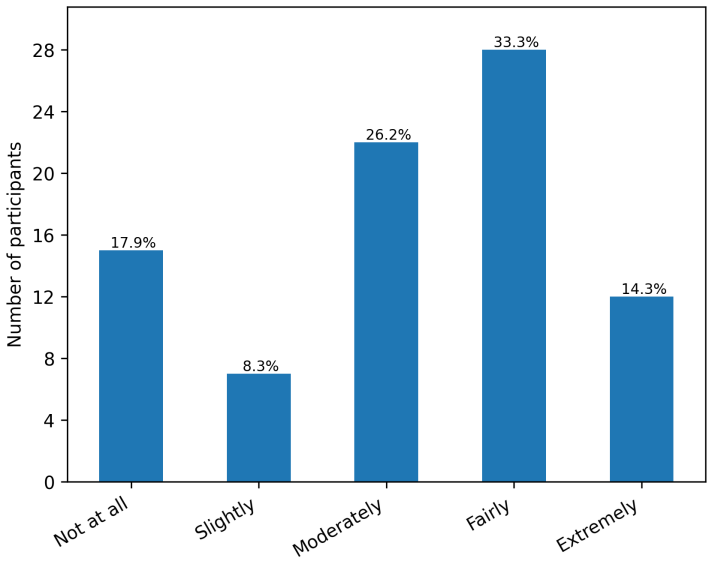

Figure 4.63: Participants' self-reported feeling of contentment during gameplay.

The responses indicate that the majority of participants placed themselves in the middle to higher part of the scale, with most choosing fairly, followed by moderately and extremely. Fewer selected the lowest categories of not at all or slightly. This distribution suggests that players generally felt satisfied with their experience in Green Siesta, confirming that the game was able to create a positive emotional balance for most participants. Such results are encouraging for a serious game, where educational and awareness-raising goals sometimes risk overshadowing enjoyment, yet here the two dimensions were successfully combined.

Felt skillful

Figure 4.64 reports on participants' self-assessment of how skillful they felt while playing Green Siesta. This question captures whether players believed they were capable of handling the challenges and mechanics of the game. In other words, it focuses on self-perceived competence, which is a key dimension of game experience and motivation.

The results show that the majority of participants placed themselves in the positive range, with fairly being the most frequent choice, followed by moderately and extremely. Very few selected the lower categories, indicating that most players felt competent while playing. From a Universal Design for Learning (UDL) perspective, this outcome relates to the principle of Action and Expression, as it shows

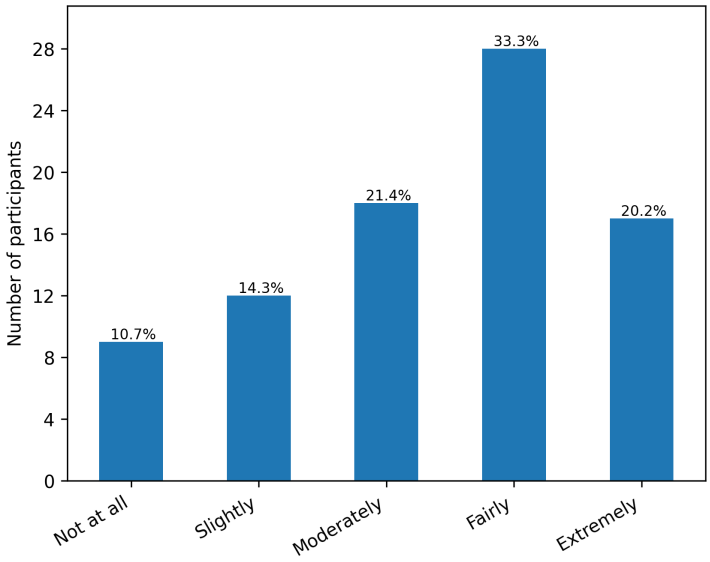

Figure 4.64: Participants' self-reported feeling of skillfulness during gameplay.

that the game enabled participants to interact with mechanics in a way that fostered confidence and reduced frustration. Feeling skillful is particularly important in a serious game context, since competence supports not only enjoyment but also sustained engagement with the educational content.

Interested in story

Figure 4.65 shows participants' responses to the statement "I was interested in the game story." This item reflects the narrative dimension of gameplay, focusing on whether players felt engaged by the storyline itself, as opposed to just the mechanics or educational content.

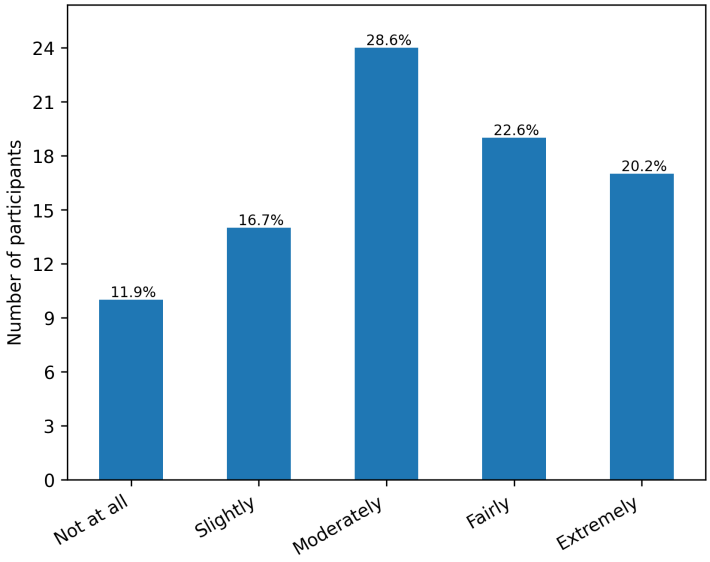

Figure 4.65: Participants' interest in the game story.

The results lean positive overall but are more evenly distributed compared to other measures, forming a pattern closer to a normal distribution centered around moderately. This suggests that while many players were interested in the story, the short playtime during testing and the linear structure of the story mode may have limited deeper narrative engagement. For future iterations, it would be valuable to provide more openness and choice in how the story unfolds, while still keeping the design accessible and structured in line with Universal Design for Learning (UDL) principles, so that players can follow

the narrative without getting lost.

Entertaining

Figure 4.66 presents participants' responses to the question of whether they found Green Siesta entertaining. This measure captures the extent to which the game provided enjoyment, which is an important aspect even in a serious game primarily designed for education and awareness-raising.

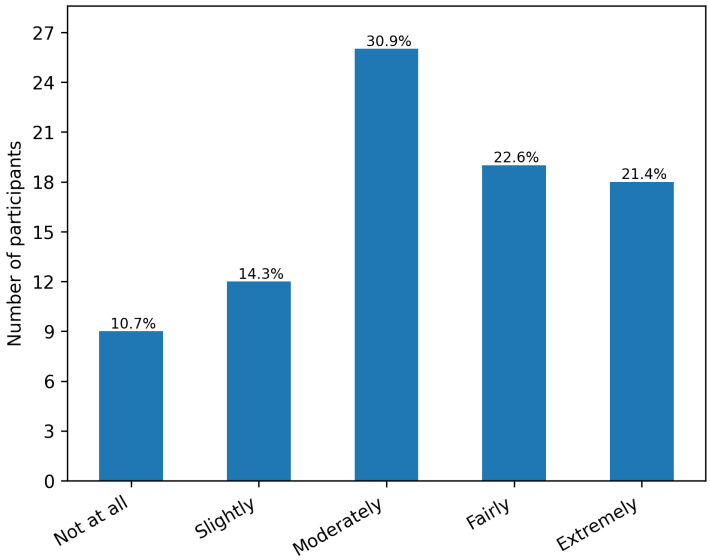

Figure 4.66: Participants' views on whether the game was entertaining.

The distribution of responses is quite similar to the previous question on interest in the story, leaning positive but also more evenly spread, with moderately at the center. This suggests that while participants generally found the game enjoyable, the relatively short testing session and structured progression may have limited the sense of open-ended fun that longer or less constrained play could bring. In terms of design, the balance achieved here is encouraging: the game succeeded in being enjoyable without compromising its educational purpose. Future work might explore additional optional content or playful side activities to strengthen entertainment value while still maintaining clarity and accessibility in line with Universal Design for Learning (UDL) principles.

Fully occupied

Figure 4.67 presents participants' responses on whether they felt fully occupied with the game. This question reflects the degree of mental focus and engagement players experienced while playing, and whether the game succeeded in holding their attention throughout the session.

The results are best described as a mixed bag, with responses spread rather evenly across the scale. The only clear trend is that very few participants selected the lowest extreme, indicating that most players experienced at least some level of occupation. This distribution suggests that while the game was able to hold attention for many, it did not consistently achieve a deep sense of absorption across the entire group. One possible explanation is the short, structured testing session, which may have limited opportunities for players to become fully immersed. Future iterations could explore how to support more varied play styles and sustained engagement, while maintaining simplicity and clarity to remain aligned with Universal Design for Learning (UDL).

Felt happy

Figure 4.68 presents participants' responses on whether they felt happy while playing Green Siesta. This item captures the positive emotional dimension of the gameplay experience, reflecting whether the game was able to generate joy and a sense of satisfaction beyond its educational purpose.

The results are clearly skewed towards the positive end of the scale, with fairly, moderately, and extremely being the most frequent responses. Only a small minority placed themselves in the lower

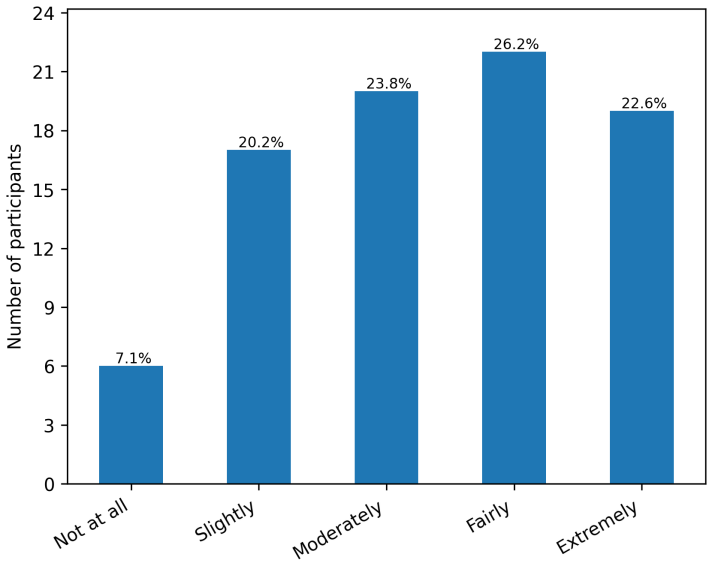

Figure 4.67: Participants' self-reported feeling of being fully occupied by the game.

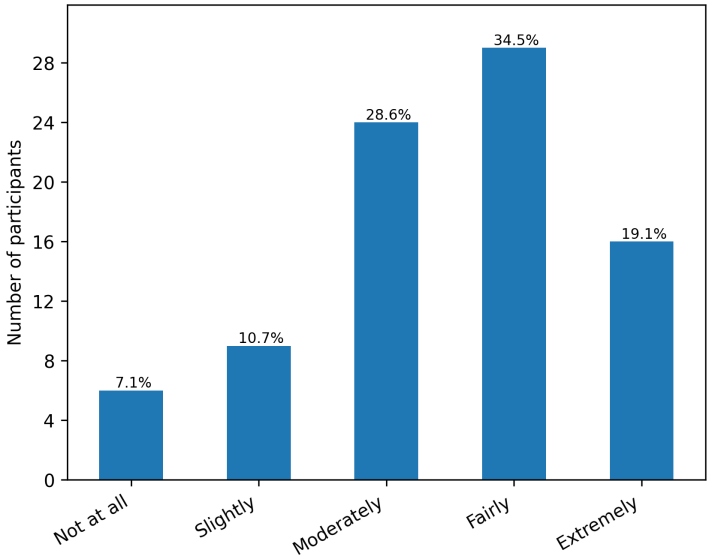

Figure 4.68: Participants' self-reported happiness during gameplay.

categories. This suggests that the game was effective at creating a generally cheerful and enjoyable atmosphere, even within a short and structured testing session. In terms of design implications, this outcome is important because happiness is closely tied to intrinsic motivation. When players feel good about the experience, they are more likely to engage deeply and retain what they learn. The finding therefore strengthens the case that Green Siesta succeeded not only as an educational tool but also as a positive and motivating gameplay experience.

Provoking a bad mood

Figure 4.69 shows participants' responses on whether playing Green Siesta put them in a bad mood. This question was included to capture the potential negative side of the gameplay experience, such as frustration, irritation, or discouragement, which can sometimes occur in serious games if tasks feel unclear or overly demanding.

The distribution is very favourable, with the large majority selecting not at all and only a small number choosing any higher category. This indicates that Green Siesta was successful in avoiding negative emotional responses and instead maintained a generally positive atmosphere for its players. From a design

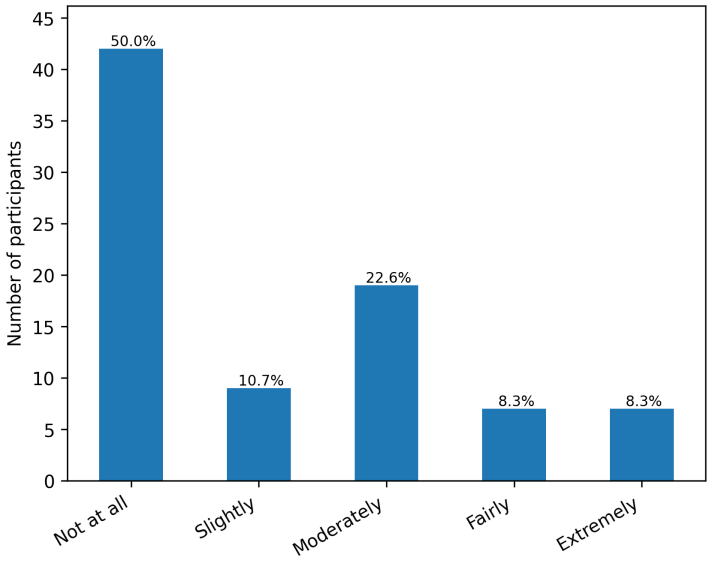

Figure 4.69: Participants' self-reported feeling of being in a bad mood after playing.

perspective, this is a strong outcome, as it shows that the balance of challenge and clarity worked well enough to prevent frustration. Minimizing negative affect is especially important in educational games, where the primary goal is to motivate players to engage with content and not to alienate them through unnecessary difficulty.

Thought on other things

Figure 4.70 presents participants' responses on whether they found themselves thinking about other things while playing Green Siesta. This question is designed to assess the degree of distraction or divided attention during gameplay, which can affect both engagement and learning outcomes.

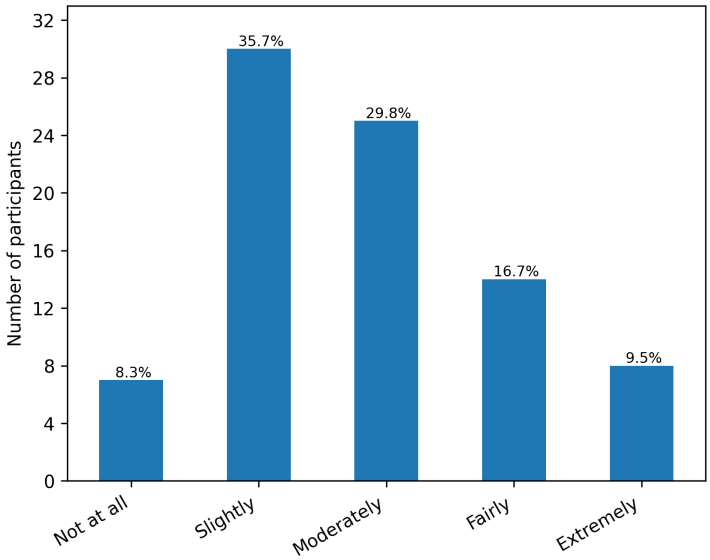

Figure 4.70: Participants' self-reported tendency to think about other things while playing.

The most frequent response was slightly, indicating that while some participants were distracted, most did not strongly experience this effect. This outcome can be partly explained by the structure of the pilot sessions: the gameplay was limited to a relatively short period, and participants were aware that several other activities would follow. Such contextual factors likely influenced their focus. For future implementations, providing more time for gameplay and minimizing interruptions could reduce

these distractions, enabling participants to immerse themselves more fully in the game experience.

Tiresome

Figure 4.71 shows participants' responses on whether they found playing Green Siesta to be tiresome. This question focuses on the potential fatigue or repetitiveness that can sometimes arise in serious games, especially when educational elements are presented in a linear and structured way.

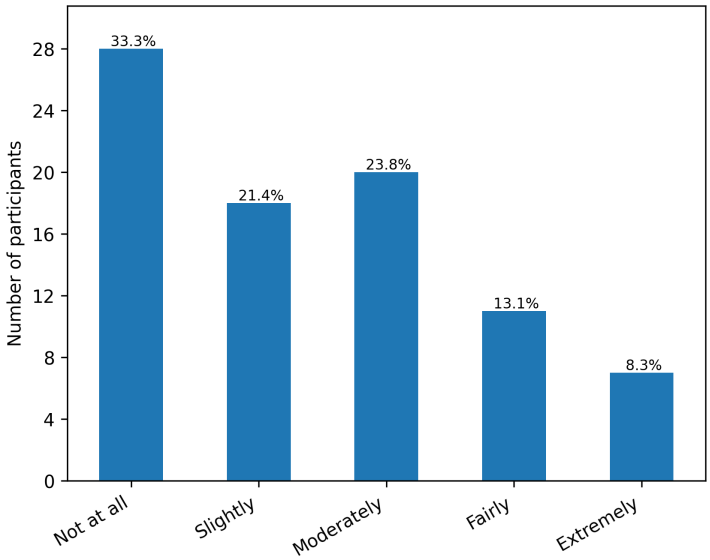

Figure 4.71: Participants' self-reported feeling of the game being tiresome.

The results are encouraging, with not at all being the most frequent response, followed by a gradual decline across the higher categories. This pattern suggests that the majority of players did not experience the game as repetitive or tiring. Considering that the story mode follows a relatively linear structure and tasks are well-defined, this is a positive outcome. It indicates that the balance between gameplay and educational objectives was maintained in a way that kept players engaged without overwhelming them, reinforcing the value of clear design in a serious game context.

Felt competent

Figure 4.72 presents participants' responses on whether they felt competent while playing Green Siesta. This measure reflects players' perception of their ability to handle the tasks, challenges, and mechanics offered by the game, and is closely tied to confidence and motivation in gameplay.

The results show a distribution centred on moderately, with extremely also receiving strong representation, while fewer participants placed themselves in the lowest categories. This creates a pattern resembling a normal distribution, suggesting that competence was experienced by most players but to varying degrees. Such a profile indicates that the game was accessible to a wide range of players, supporting different levels of gaming experience. From a design perspective, this balance is valuable: it suggests that tasks were challenging enough to create a sense of achievement but not so difficult as to discourage less experienced participants, aligning with Universal Design for Learning principles of providing appropriate challenge and support.

Difficulty

Figure 4.73 shows participants' responses on whether they found Green Siesta hard to play. This item addresses the perceived difficulty of the game, reflecting whether players considered its mechanics, tasks, and progression to be challenging or manageable.

The results are strongly skewed towards not at all, with very few participants indicating that they found the game difficult. This favourable outcome can be explained by the inclusion of a clear introductory level, predictable game mechanics, and simple controls. These design elements ensured that players, regardless of prior gaming experience, could quickly learn how to navigate and interact with the game.

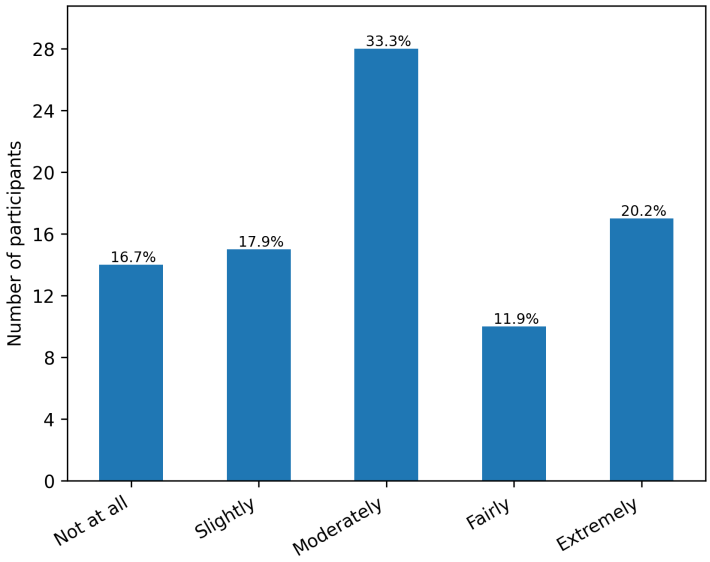

Figure 4.72: Participants' self-reported feeling of competence during gameplay.

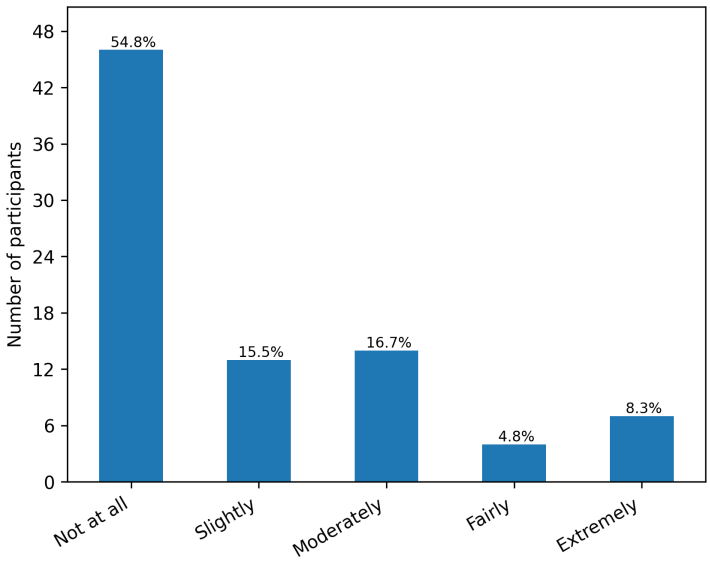

Figure 4.73: Participants' self-reported perception of the game's difficulty.

Such accessibility is consistent with Universal Design for Learning principles, as it reduces barriers to entry and allows participants to focus on the educational content rather than struggling with gameplay mechanics.

Aesthetics

Figure 4.74 shows participants' responses on whether they considered Green Siesta aesthetically pleasing. This question captures the visual and artistic appeal of the game, which is an important factor for player engagement even in an educational context.

The responses cluster mostly around moderately and fairly, each with close to one third of participants, while extremely attracted around one fifth. Very few selected the lowest categories. This is a positive outcome, especially considering that most participants played on older computers where the game automatically adjusted to lower video quality settings to ensure smooth performance. The ability to preserve a generally favourable perception of visuals even under such conditions highlights the effectiveness of the adaptive design. From a Universal Design for Learning perspective, this adaptability is an important feature, as it allows all players to engage with the content without technical barriers, even

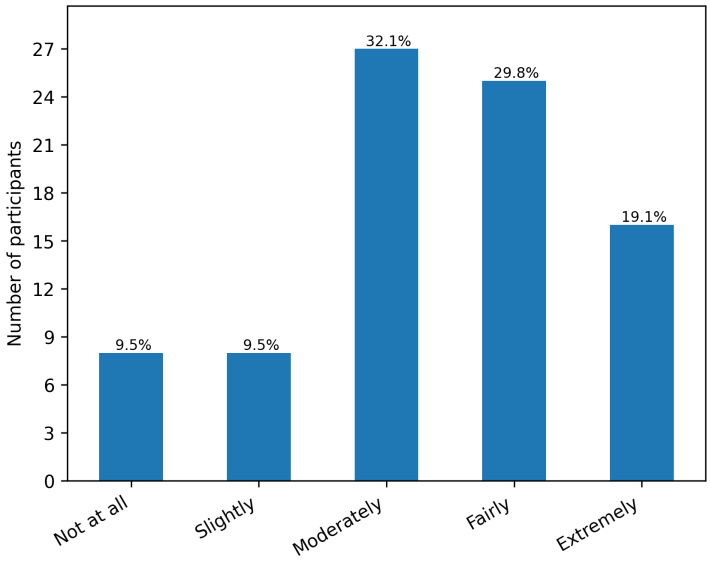

Figure 4.74: Participants' self-reported views on the game's aesthetic appeal.

if the full fidelity of the visuals is not always accessible.

Felt absorbed

Figure 4.75 presents participants' responses to the statement "I felt absorbed by the game." This question focuses on immersion in the strongest sense: whether players became so engaged in the experience that they temporarily forgot about their surroundings.

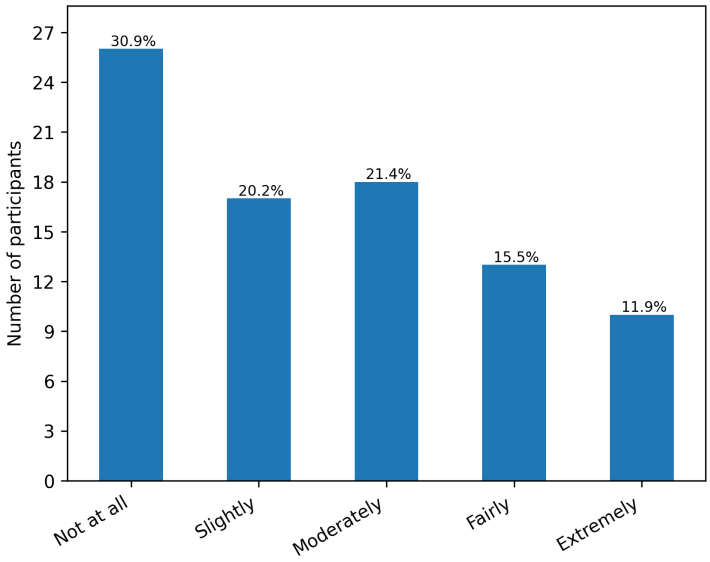

Figure 4.75: Participants' self-reported feeling of being absorbed by the game.

The responses show that around one third of participants selected not at all, with the remaining answers gradually spread across the higher categories. While this indicates that full absorption was not achieved for most players, the result is not surprising given the short, structured testing sessions, which were designed for evaluation rather than extended play. Importantly, the distribution still shows that a meaningful share of participants reported moderate to high levels of absorption, suggesting that the foundations for deeper immersion are present. With longer playtime and opportunities for freer exploration, it is reasonable to expect that the sense of absorption could grow significantly. From a design perspective, this outcome highlights the game's potential rather than a limitation, especially

since immersion is often cumulative and benefits from extended engagement.

Felt good

Figure 4.76 presents participants' responses on whether they felt good while playing Green Siesta. This question captures the general sense of well-being and positive affect generated by the game, beyond specific emotions like happiness or contentment.

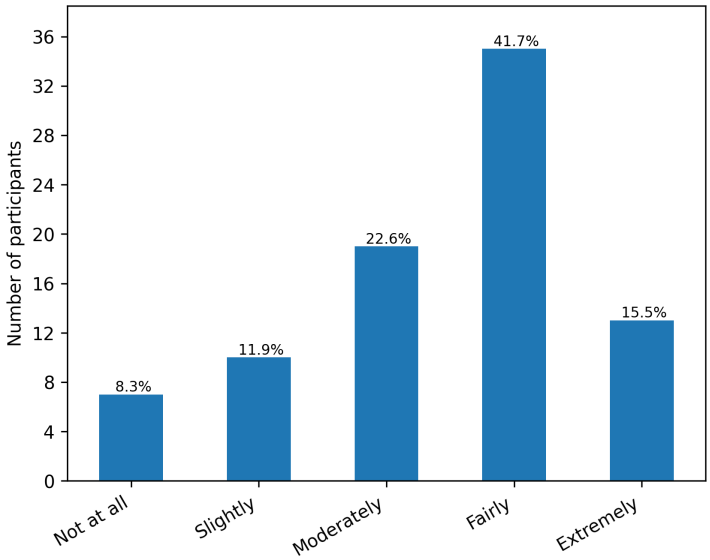

Figure 4.76: Participants' self-reported feeling of goodness during gameplay.

The distribution leans strongly toward the positive side, with fairly reported by 42 percent of participants, followed by moderately at 22 percent and extremely at 15 percent. The lower categories were selected much less frequently. These results suggest that the game was able to generate a consistent sense of positive affect for most players, an important factor for sustaining motivation and engagement. From a design perspective, this aligns well with the overall goals of Green Siesta as a serious game: while its primary focus is education and awareness, it also provides players with a rewarding and pleasant experience, which enhances its effectiveness as a learning tool.

Felt bored

Figure 4.77 presents participants' responses on whether they felt bored while playing Green Siesta. This question was included to assess whether the game was able to sustain interest throughout the session, which is particularly important in a serious game where educational content needs to be delivered in an engaging way.

The responses were spread across the categories, with slightly and moderately being the most common, followed by not at all. This distribution is consistent with previous results, which suggested that while Green Siesta was generally enjoyable and motivating, its structured and linear testing format left some players less engaged than they might have been in longer or more open-ended sessions. Importantly, the game succeeded in keeping boredom relatively low overall, which is a promising outcome for a serious game whose primary goal is education and awareness rather than entertainment alone.

Felt successful

Figure 4.78 presents participants' responses on whether they felt successful while playing Green Siesta. This item captures the degree to which players perceived themselves as accomplishing the game's challenges, an important factor in motivation and learning.

The distribution is clearly favourable, with the highest shares in fairly and moderately, followed by a substantial number who reported extremely. Only a minority placed themselves in the lower categories. These results are particularly significant in the context of Green Siesta's goals: feeling successful is closely tied to raising awareness and fostering knowledge and skills related to green topics. When players perceive

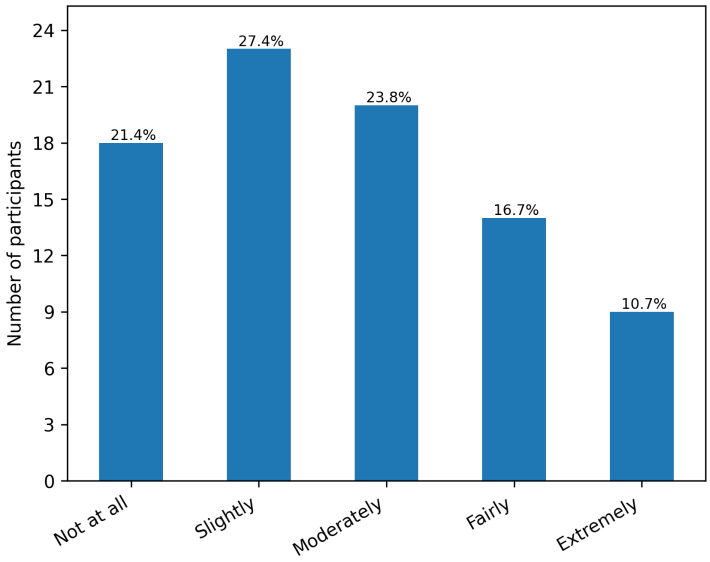

Figure 4.77: Participants' self-reported feeling of boredom during gameplay.

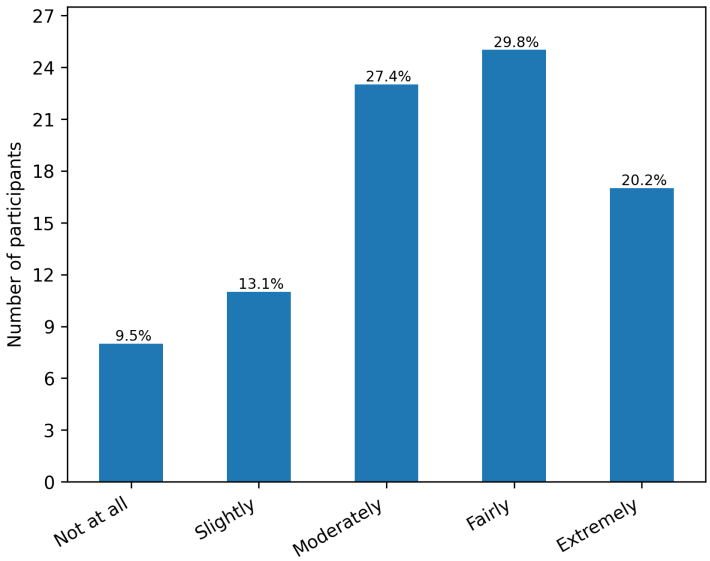

Figure 4.78: Participants' self-reported feeling of success during gameplay.

themselves as succeeding in tasks such as recycling, re-purposing materials, or uncovering green secrets, they not only enjoy the gameplay but also reinforce positive learning outcomes. This suggests that the game's balance of accessible mechanics and meaningful content worked effectively to make players feel both competent and accomplished.

Felt annoyed

Figure 4.79 shows participants' responses on whether they felt annoyed while playing Green Siesta. This item was included to capture any irritation that might arise from unclear instructions, technical issues, or repetitive tasks, all of which can negatively affect engagement in educational games.

The results are strongly favourable: more than half of the participants selected not at all, with the rest spread thinly across the higher categories. This outcome indicates that Green Siesta largely succeeded in avoiding sources of frustration that could undermine the learning experience. The clear onboarding, simple mechanics, and structured progression all contributed to keeping annoyance at a minimum. From a design perspective, this is important because minimizing negative emotional states supports sustained attention and openness to learning, which are key objectives in the context of serious games.

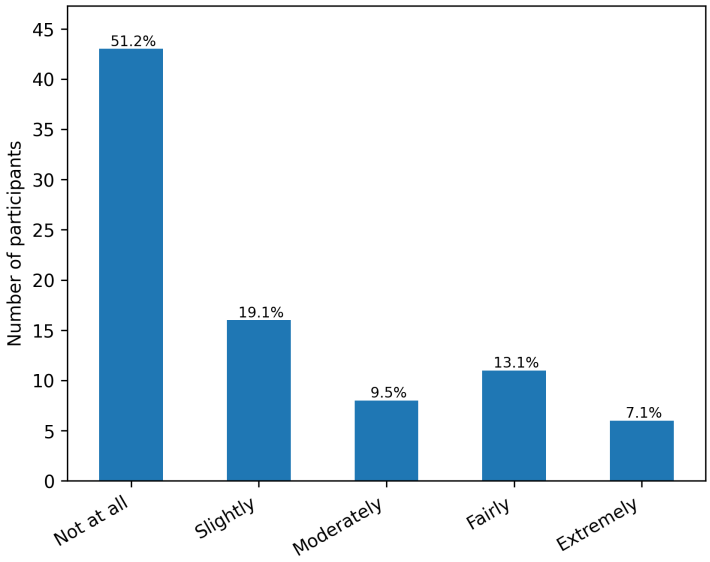

Figure 4.79: Participants' self-reported feeling of annoyance during gameplay.

Lost track of time

Figure 4.80 presents participants' responses to whether they lost track of time while playing Green Siesta. This question explores a classic indicator of immersion, often linked to the concept of "flow," where players become so engaged that they no longer monitor time passing.

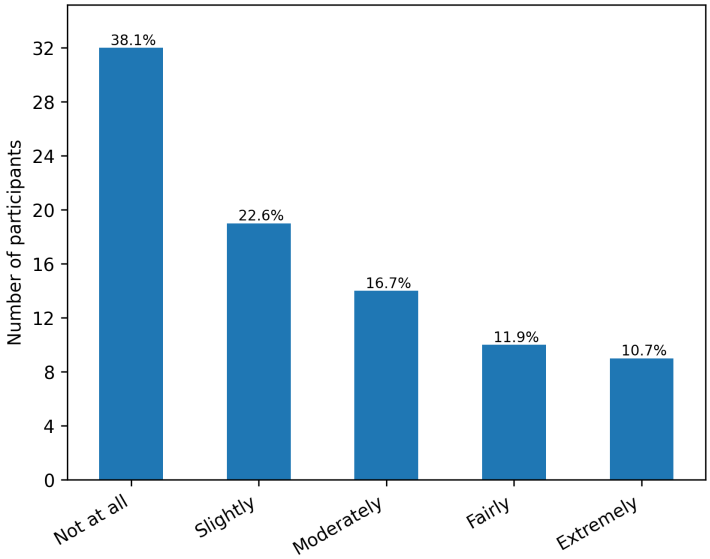

Figure 4.80: Participants' self-reported experience of losing track of time while playing.

The results show that about 38 percent of participants selected not at all, with gradually fewer responses in the higher categories. At first glance, this might suggest that losing track of time was not a common experience. However, the context of the pilot helps explain the outcome: gameplay sessions were short, highly structured, and often embedded within a broader event program. Under these conditions, participants were naturally aware of time and of other scheduled activities. The fact that some still reported moderate to high levels of losing track of time is therefore encouraging, as it suggests that the game has the potential for deeper immersion in longer, less constrained play sessions. From a design standpoint, this reinforces that Green Siesta provides a solid foundation for flow experiences, which could be further supported in future implementations with extended and less interrupted playtime.

Felt challenged

Figure 4.81 shows participants' responses on whether they felt challenged while playing Green Siesta. This item measures the degree to which the game demanded effort and problem-solving, an important factor in maintaining engagement without overwhelming players.

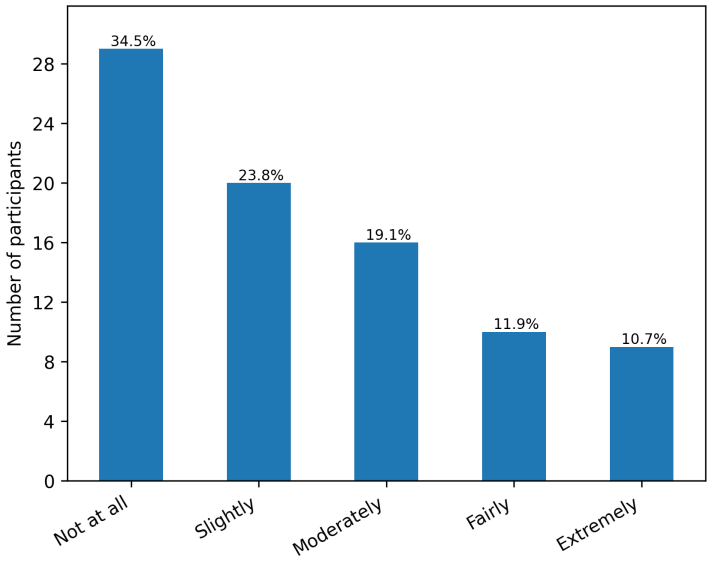

Figure 4.81: Participants' self-reported feeling of challenge during gameplay.

The distribution runs from 34.5 percent at not at all to about 10 percent at extremely, decreasing steadily across the categories. This outcome reflects the game's design emphasis on accessibility: the onboarding process and intuitive mechanics made the experience manageable, even for participants with limited gaming experience. While some challenge was present, it appears to have been calibrated primarily for casual players rather than for those seeking high difficulty. From a Universal Design for Learning perspective, this is a strength, as it ensures that the majority of players can participate fully and focus on the educational content. At the same time, the results suggest that additional optional challenges could be introduced in the future to better engage experienced players without raising barriers for beginners.

Felt the ability to explore

Figure 4.82 presents participants' responses on whether they felt they had the ability to explore while playing Green Siesta. This question targets an important dimension of player experience, since exploration supports curiosity, autonomy, and deeper engagement with the learning content.

The results lean positively, with fairly and moderately together accounting for more than half of the responses, followed by a meaningful share in extremely. Only a small portion of participants felt that exploration was limited. This reflects the effectiveness of the game's level design, which offered space for curiosity beyond the main storyline. A notable element here were the "green secrets" — spinning boxes scattered across the map that, when discovered, provided players with fun facts linked to the green theme of each level. This mechanic not only rewarded exploration but also tied directly into the project's educational goals, reinforcing learning outcomes in a playful and voluntary manner. By blending exploratory freedom with structured learning, Green Siesta demonstrated how design choices can motivate players to seek out additional knowledge.

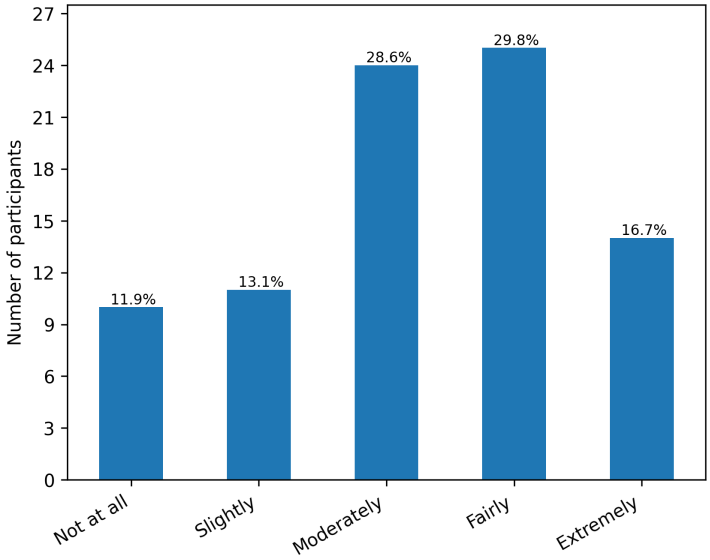

Figure 4.82: Participants' self-reported ability to explore during gameplay.

5 Conclusions

Chapter 5

Conclusions

Play2Green, a project with a primary focus on promoting universal access to green education through serious games, delivers a wide range of features and insights. This report, prepared as one of the project's deliverables, highlights its most significant results. At the core of the project is the development of three serious games grounded in emerging technologies: **Green Siesta** (AI-based), **HoloZoo** (hologram-based), and **Green Siesta Quiz** (AR-based). Beyond the innovative use of these technologies, the educational content designed for each of the games is of particular value. Together, the games provide an additional tool in the global effort to combat climate change and, most importantly, to raise awareness about sustainability.

Naturally, game development itself was not the ultimate goal of this project. Rather, the broader aim was for these games to be disseminated and actively used by the intended audiences, including students, teachers, and the general public. Accordingly, another key outcome of the project was the piloting and evaluation of the developed serious games. Even without delving into detailed analytics, the participation numbers alone are telling: a total of 360 participants were involved (see Table 3.1), which is 20% above the initial target. This figure underscores both the reach and the impact of the project.

Additional figures further confirm this impact. It is worth highlighting the percentage of learners who reached the learning outcomes, with over 90% of participants achieving them successfully (Figures 4.60, 4.61, 4.59 and 4.62). Furthermore, the success rate of the three games is also evident in the willingness the participants in the pilot evaluation have in recommending these developed solutions for the exact cause they were made for; raising awareness in the ongoing fight against climate change and bringing the "green agenda" closer to the general public. All of these results, which are highly encouraging, prove the success of the implemented solutions and the emerging technologies that were used.

Additionally, piloting Green Siesta and Green Siesta Quiz covered a broad spectrum of learner categories (Figure 4.4), specifically seven categories were included: high school students, university students, PhD students, teaching assistants, postdoctoral fellows, teachers, university professors, and others. This exceeds more than twice the initial plan of three learner categories, and includes all of the targeted users whose input was valuable in the evaluation of these solutions.

A particularly noteworthy outcome concerns accessibility. Over 22% of participants reported having a disability which might affect their perception of or their ability to play the game (approximately 80 participants, Figure 4.9), exceeding the target more than fivefold. Among these users, visual impairments were most common (reported by nearly half), while around 15% reported hearing, cognitive, or mental disabilities (Figures 4.11 and 6.6). Their feedback was crucial in assessing the importance and effectiveness of Universal Design for Learning (UDL) principles embedded in the three piloted games. Overall, participants responded positively to these features, noting that most UDL-related elements were successfully implemented and fulfilled their intended purpose (see Section 4.2.2).

While the large number of positive indicators highlights the success of the project, opportunities for further improvement remain. Future research and testing could broaden the scope by including additional population groups, particularly younger children and older adults, thereby enriching the dataset and enabling more comprehensive analysis. Moreover, extending the testing period, where feasible, would allow participants to engage in a more relaxed environment, improving immersion and flow.

In conclusion, the results of this pilot not only demonstrate the successful evaluation of the developed games but also confirm that the project's outputs, both the serious games and the accompanying deliverables, are of high quality. Collectively, these outcomes validate the overall success of Play2Green and its contribution to advancing green education through innovative and accessible digital solutions.

Chapter 6

Appendix

Green Siesta Quiz

This section presents insights for *Green Siesta Quiz* in the form of plots with descriptive captions. Evaluations were conducted during the multiplier event in Dubrovnik, within the university course *Human Factors in Computing*, and in a private testing session with higher-education lecturers.

Demographics

The demographic profile of participants provides context for understanding engagement and outcomes in *Green Siesta Quiz*.

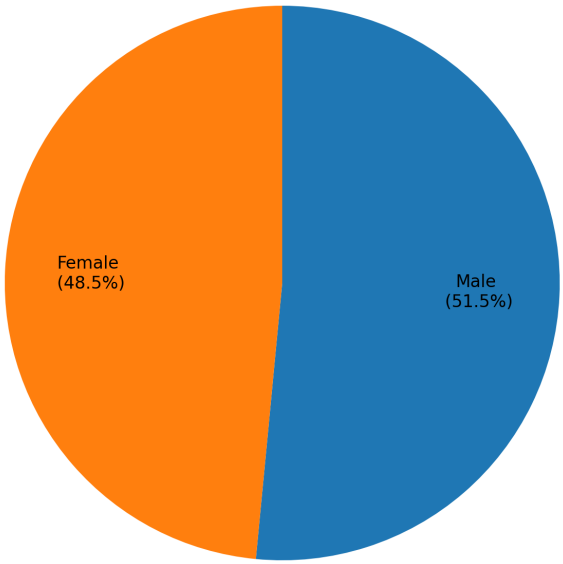

Figure 6.1: Gender distribution of participants in *Green Siesta Quiz*.

Figures 6.1–6.3 illustrate the gender profile and age-related participation and recommendations.

Accessibility

Accessibility characteristics highlight inclusivity aspects of *Green Siesta Quiz*.

Figures 6.4–6.6 summarize accessibility-related participant characteristics.

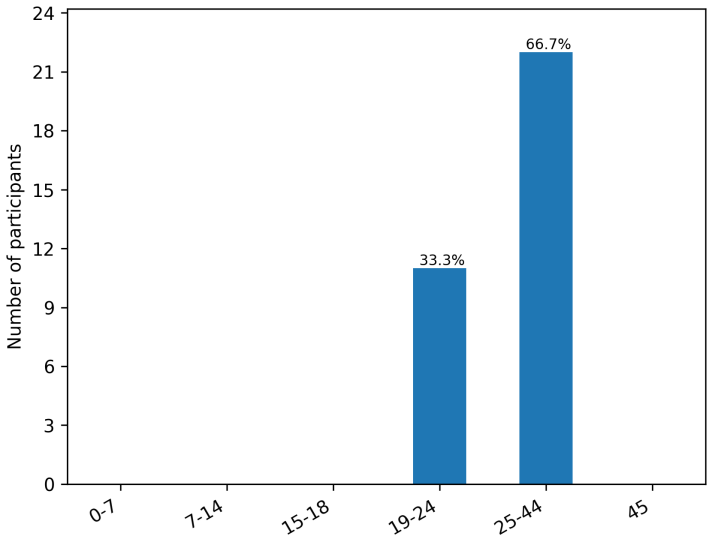

Figure 6.2: Age group distribution of participants in *Green Siesta Quiz*.

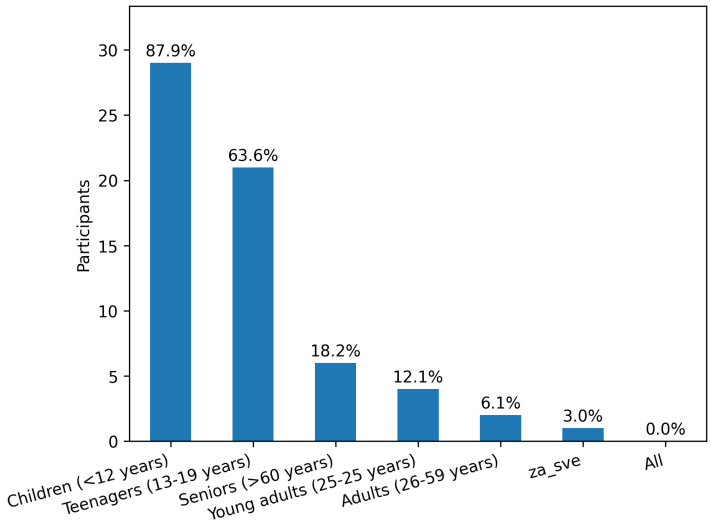

Figure 6.3: Recommended age categories for *Green Siesta Quiz*.

Gaming background

Prior exposure to video games and serious games provides context for interaction patterns in *Green Siesta Quiz*.

Figures 6.7–6.9 provide insights into prior gaming experience of participants.

Onboarding and navigation

Onboarding and navigation perceptions shape the usability of *Green Siesta Quiz*.

Figures 6.10–6.14 show how players perceived onboarding, navigation, and goal clarity.

Language and visuals

Text clarity, subtitles, and visual appeal support comprehension and engagement in *Green Siesta Quiz*.

Figures 6.15–6.18 present perceptions of textual clarity, subtitle quality, and visual presentation.

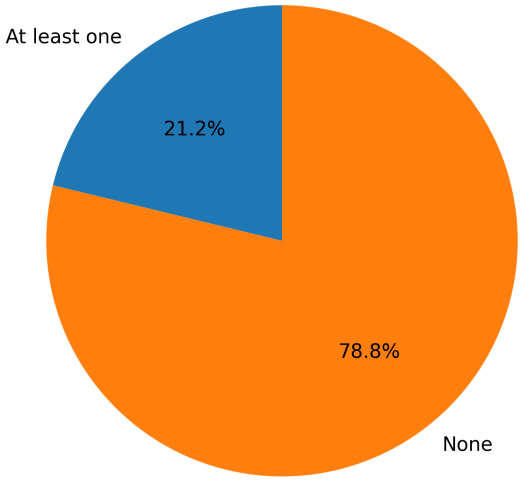

Figure 6.4: Participants reporting disabilities (binary) in *Green Siesta Quiz*.

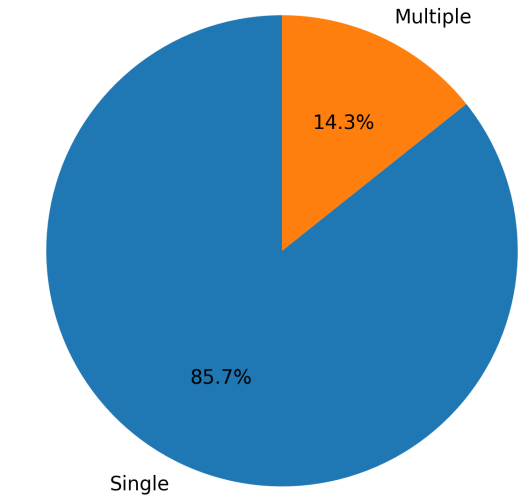

Figure 6.5: Distribution of disability categories in *Green Siesta Quiz*.

Engagement and flow

Indicators of fun, immersion, and effort illustrate engagement in *Green Siesta Quiz*.
Figures 6.19–6.25 illustrate participants' engagement, immersion, and perceived challenge.

Feedback and motivation

Feedback and reward systems affect motivation in *Green Siesta Quiz*.
Figures 6.26–6.29 summarize the motivational role of feedback, unlocks, and progress tracking.

Learning and competence

Learning outcomes and perceived competence are central to the educational goals of *Green Siesta Quiz*.
Figures 6.30–6.34 present educational outcomes and competence perceptions.

Narrative and aesthetics

Narrative quality and aesthetic impressions contribute to the overall experience of *Green Siesta Quiz*.
Figures 6.35–6.37 summarize player perceptions of narrative and aesthetic aspects.

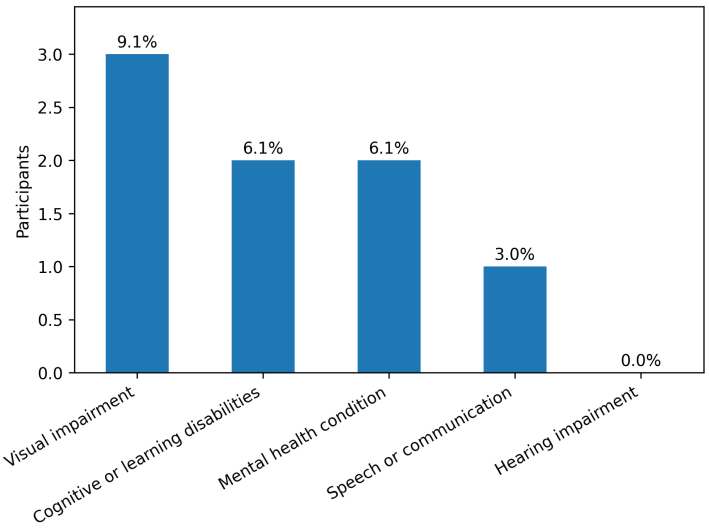

Figure 6.6: Bar representation of disability categories among participants in *Green Siesta Quiz*.

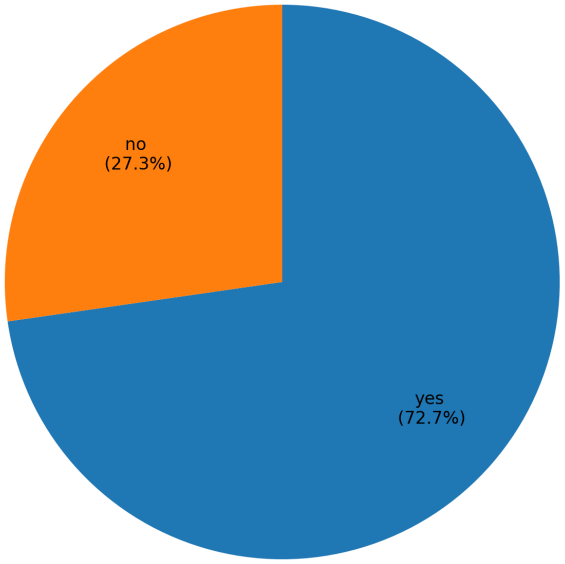

Figure 6.7: Participants who played video games prior to *Green Siesta Quiz*.

Personalization and avatar

Personalization features aim to increase identification and engagement in *Green Siesta Quiz*.

Figures 6.38–6.41 highlight personalization and avatar-related engagement.

Emotional responses

Self-reported emotions provide a nuanced view of player experience in *Green Siesta Quiz*.

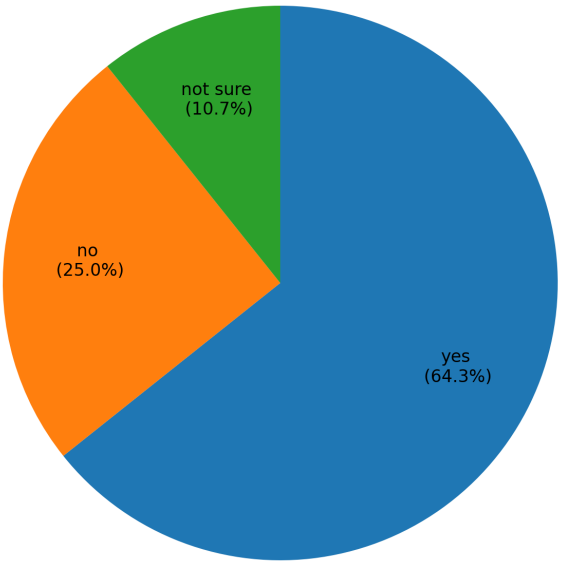

Figure 6.8: Participants with experience playing serious games before *Green Siesta Quiz*.

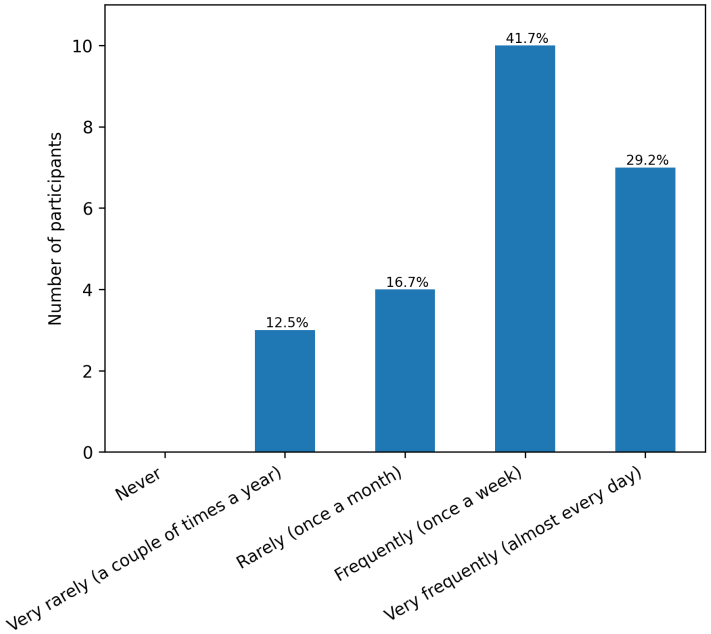

Figure 6.9: Self-reported frequency of playing video games among *Green Siesta Quiz* participants.

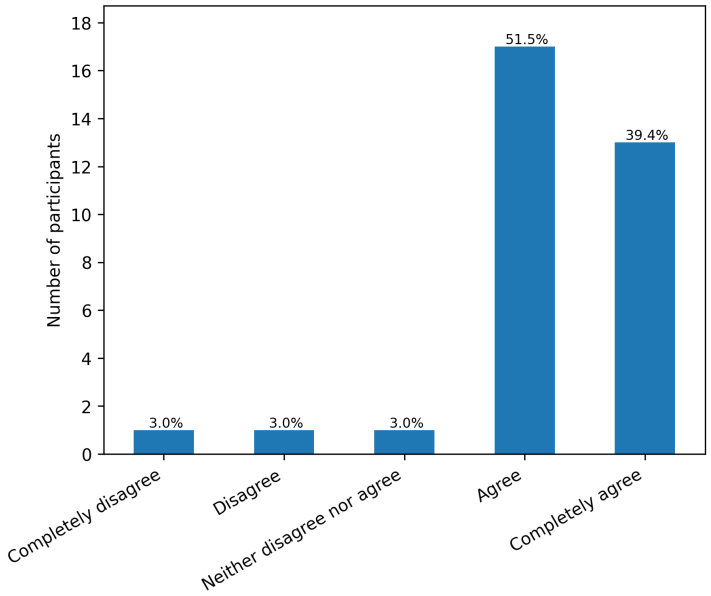

Figure 6.10: Perceived usefulness of onboarding in *Green Siesta Quiz*.

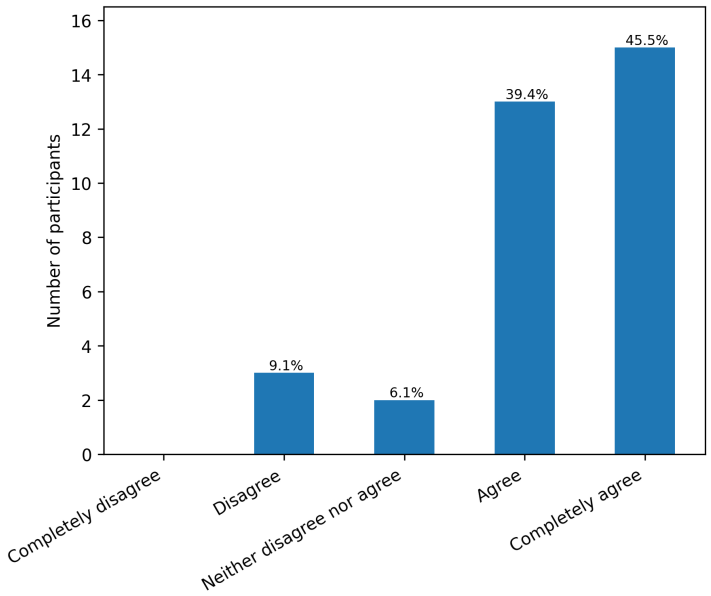

Figure 6.11: Perceived quality of onboarding design in *Green Siesta Quiz*.

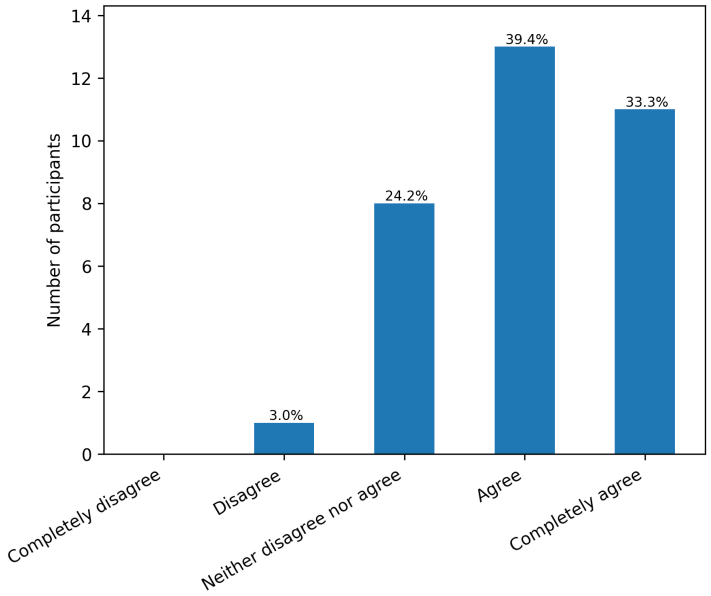

Figure 6.12: Perceived intuitiveness of navigation in *Green Siesta Quiz*.

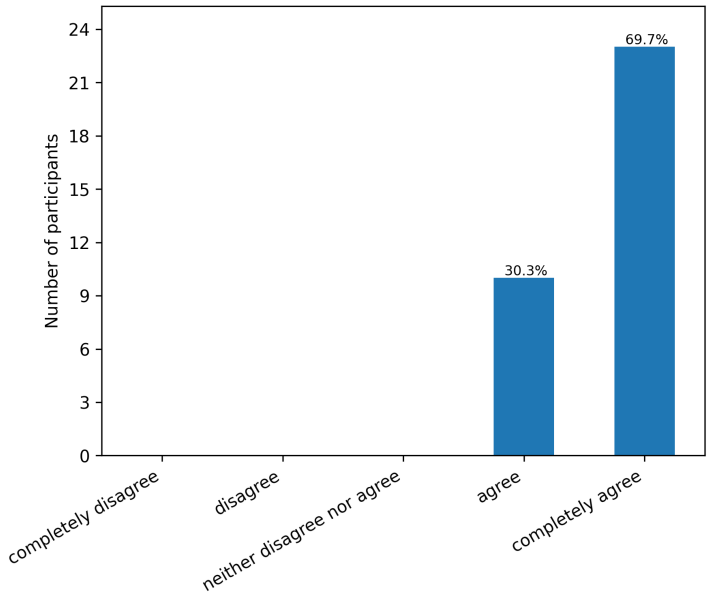

Figure 6.13: Clarity of goals as perceived by players in *Green Siesta Quiz*.

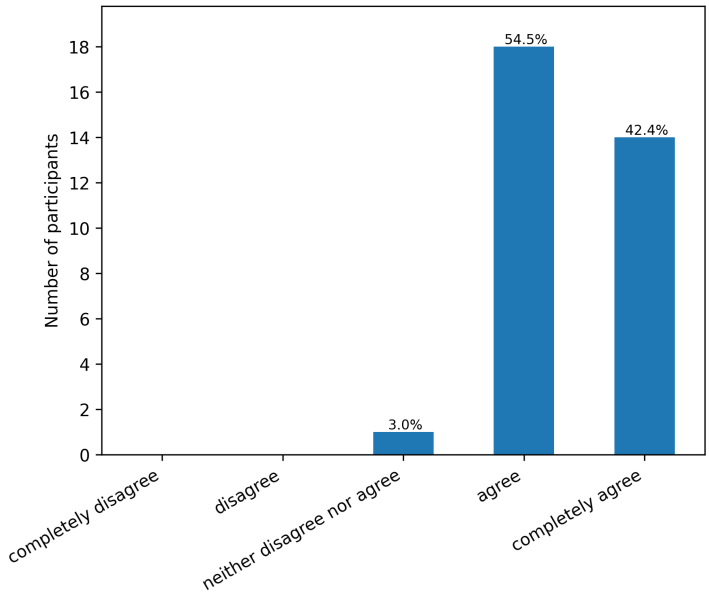

Figure 6.14: Evaluation of goal clarity in *Green Siesta Quiz*.

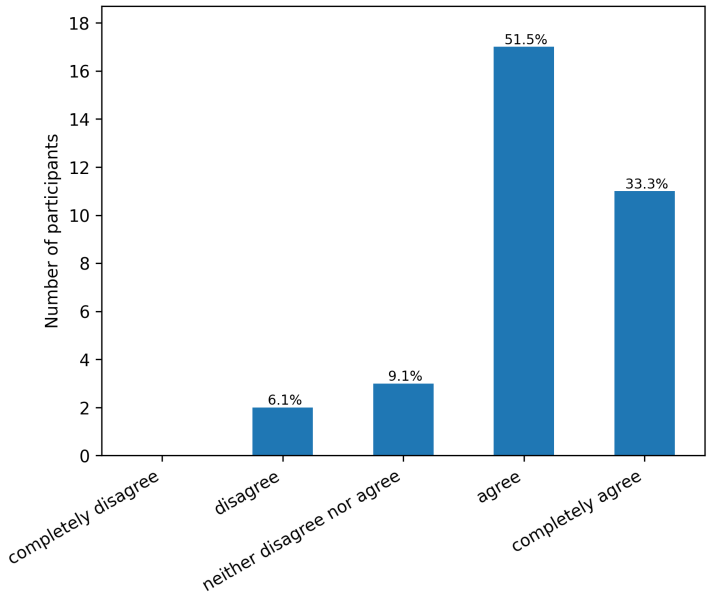

Figure 6.15: Clarity of narrative text in *Green Siesta Quiz*.

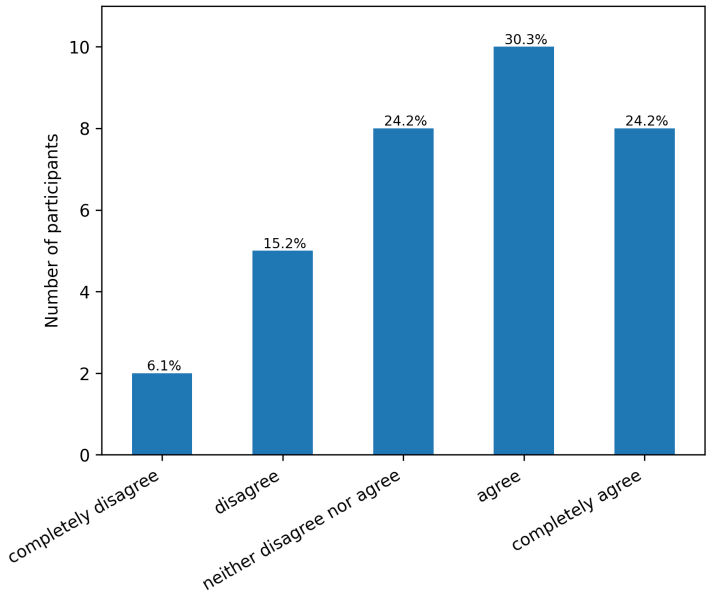

Figure 6.16: Perceived adequacy of subtitles in *Green Siesta Quiz*.

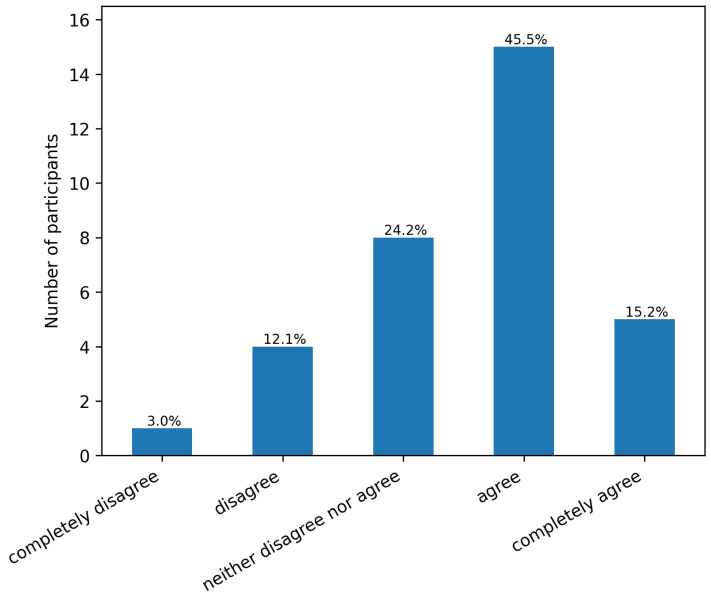

Figure 6.17: Perception of visual attractiveness in *Green Siesta Quiz*.

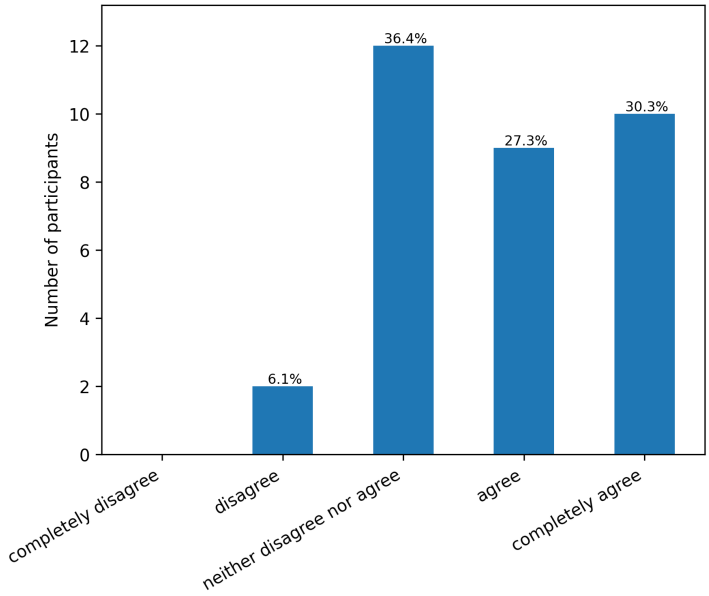

Figure 6.18: Perception of multilingual support in *Green Siesta Quiz*.

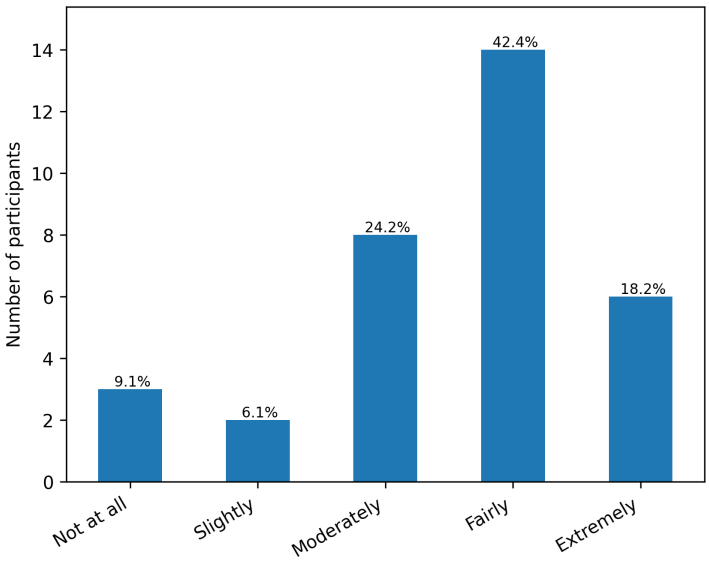

Figure 6.19: Reported fun during *Green Siesta Quiz*.

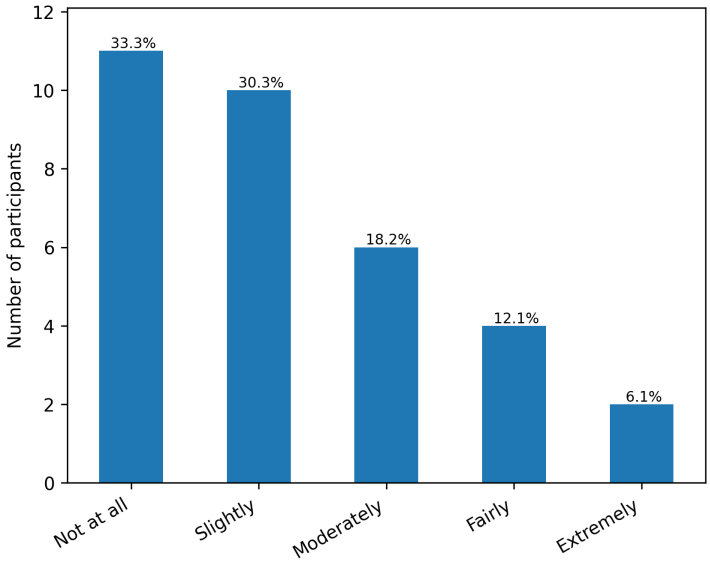

Figure 6.20: Participants losing track of time while playing *Green Siesta Quiz*.

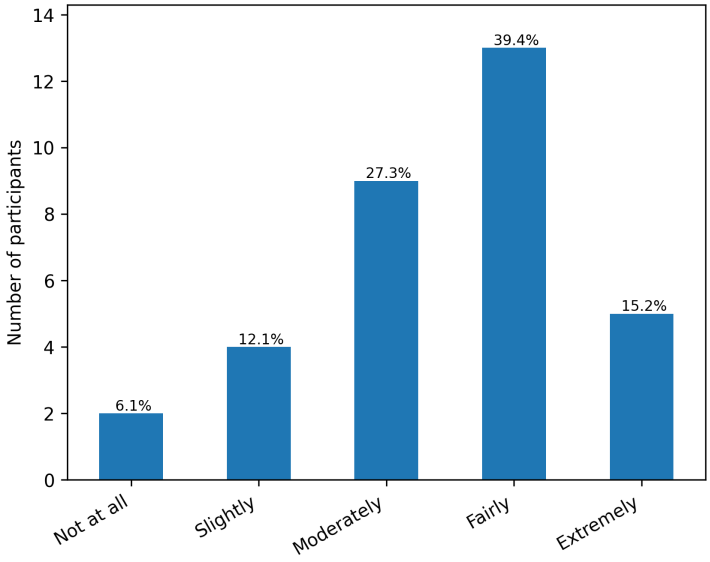

Figure 6.21: Perceived occupation/absorption during *Green Siesta Quiz*.

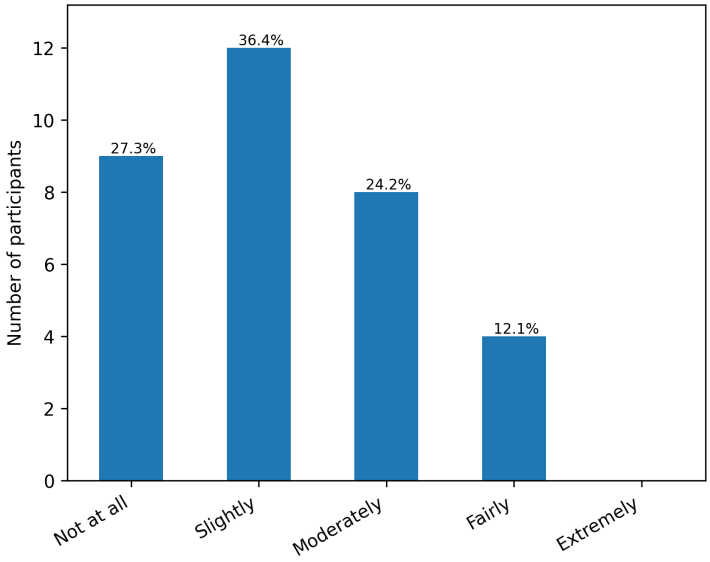

Figure 6.22: Thinking of other things while playing *Green Siesta Quiz*.

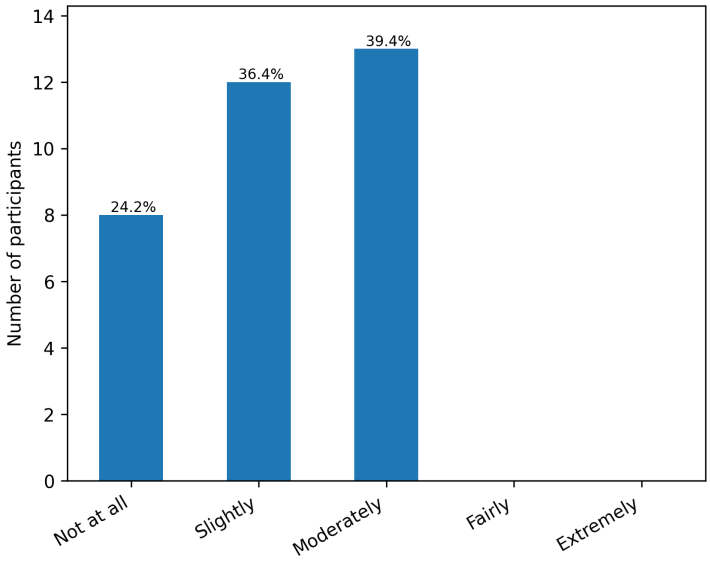

Figure 6.23: Perceived effort required during *Green Siesta Quiz*.

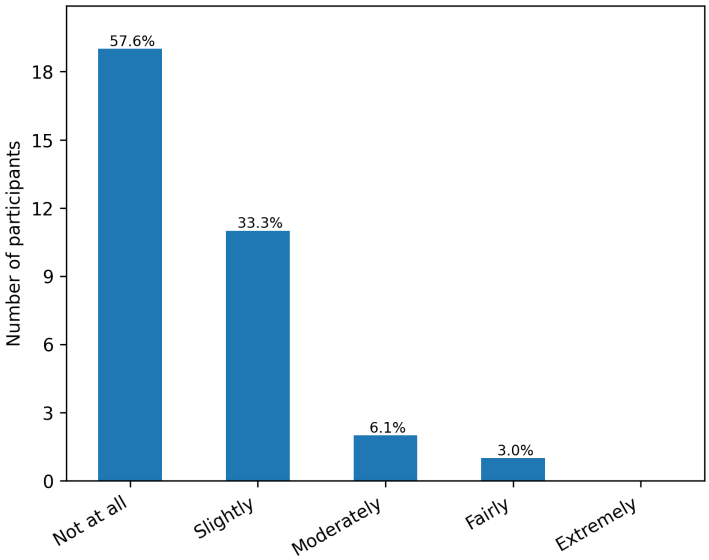

Figure 6.24: Perceived difficulty of *Green Siesta Quiz*.

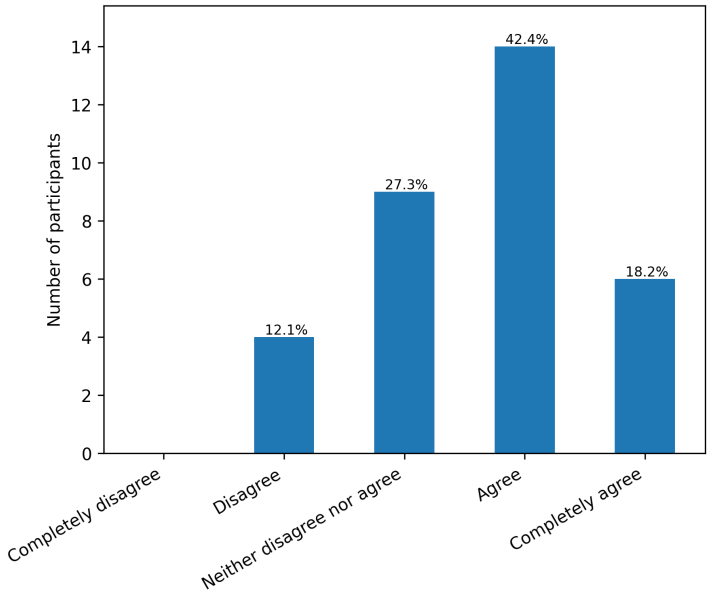

Figure 6.25: Whether difficulty prevented boredom in *Green Siesta Quiz*.

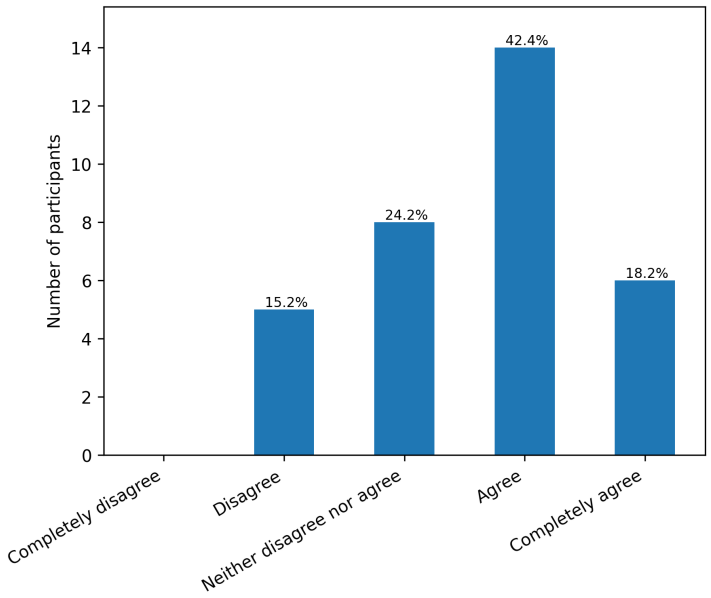

Figure 6.26: Perceived motivational effect of feedback in *Green Siesta Quiz*.

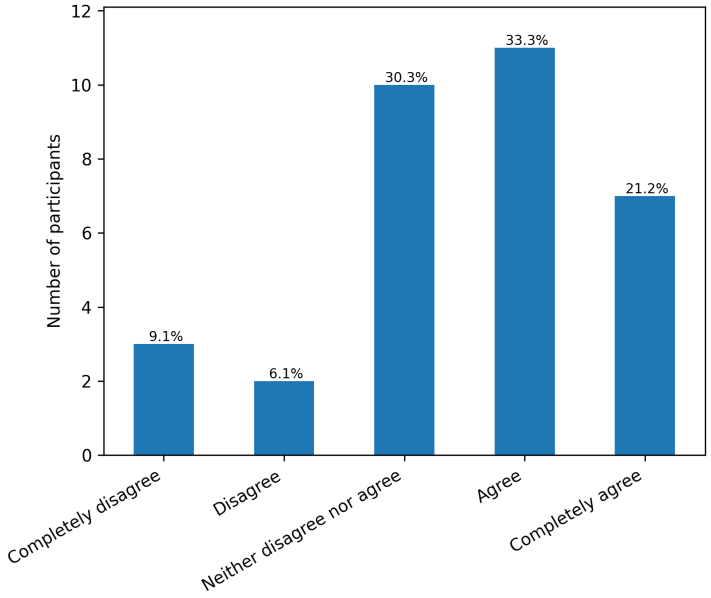

Figure 6.27: Motivational impact of unlocking features in *Green Siesta Quiz*.

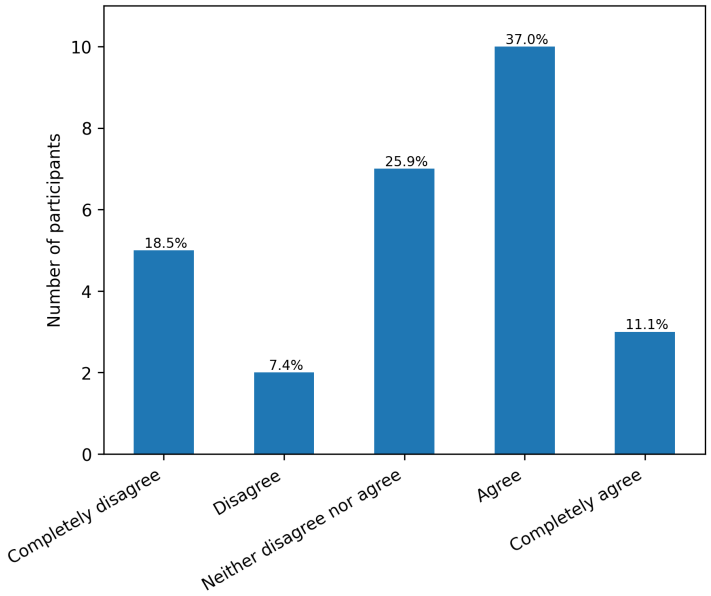

Figure 6.28: Motivation attributed to AR-related unlocks in *Green Siesta Quiz*.

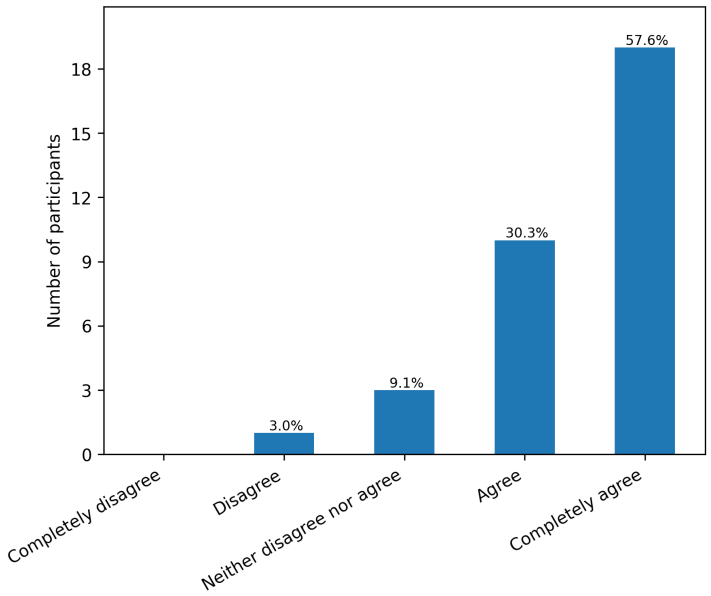

Figure 6.29: Perceived usefulness of progress tracking in *Green Siesta Quiz*.

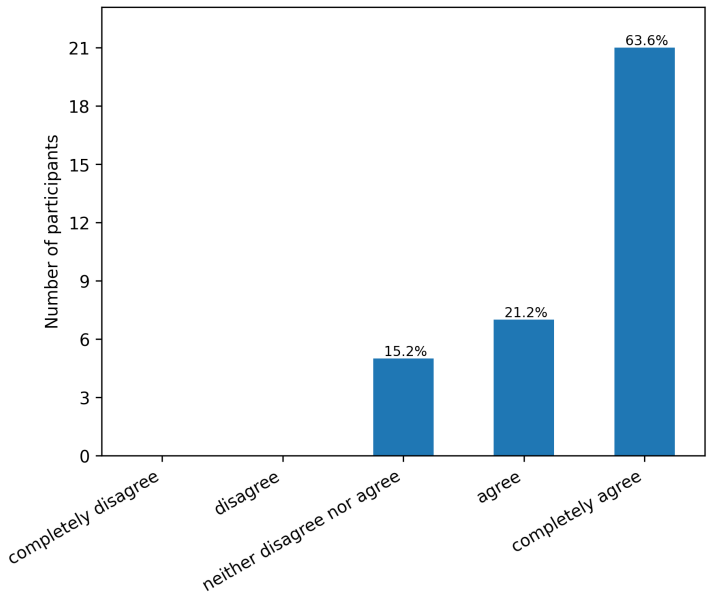

Figure 6.30: Perceived educational value of green content in *Green Siesta Quiz*.

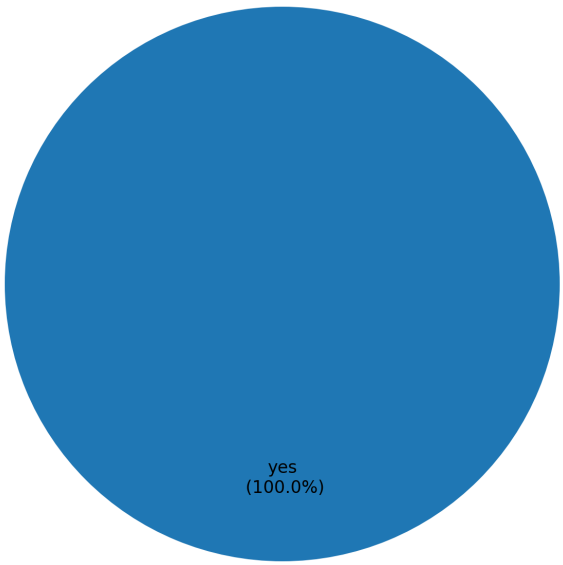

Figure 6.31: Overall quiz success in *Green Siesta Quiz*.

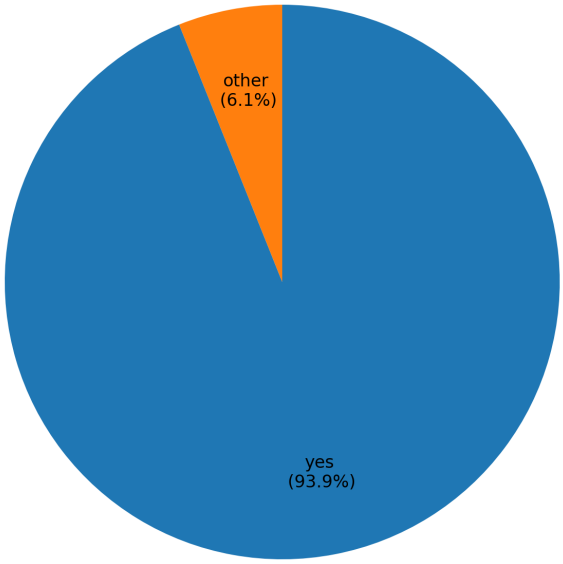

Figure 6.32: Success on recycling and waste-related quiz items in *Green Siesta Quiz*.

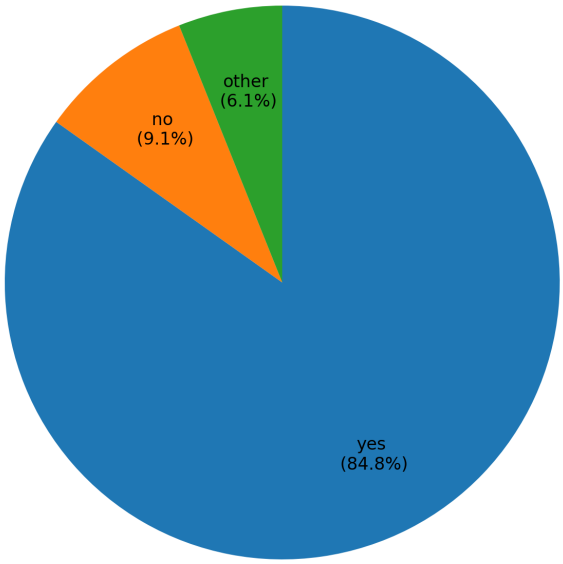

Figure 6.33: Success on appearance-related quiz items in *Green Siesta Quiz*.

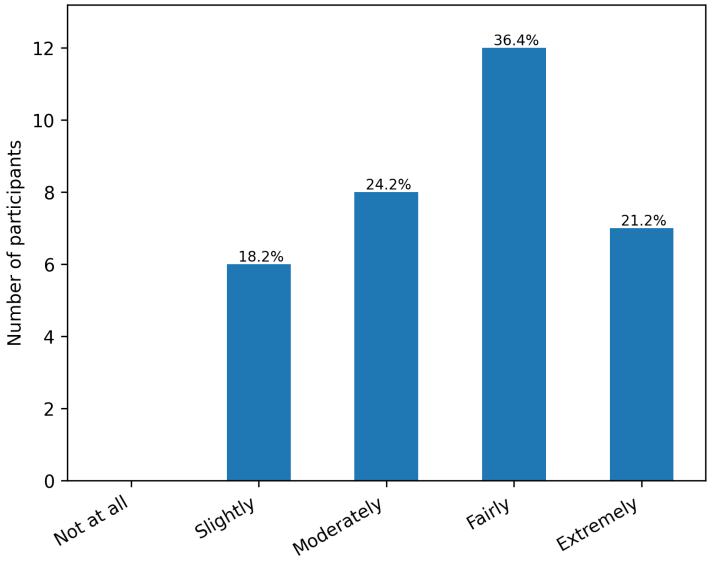

Figure 6.34: Perceived competence while playing *Green Siesta Quiz*.

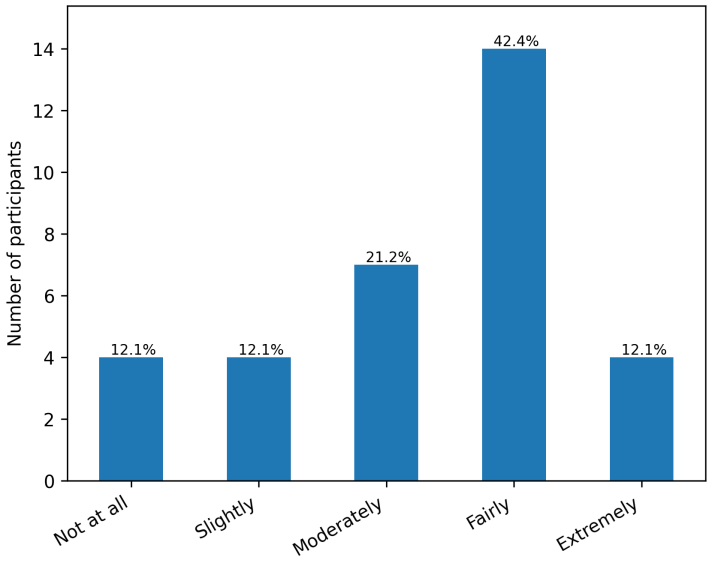

Figure 6.35: Interest in the story of *Green Siesta Quiz*.

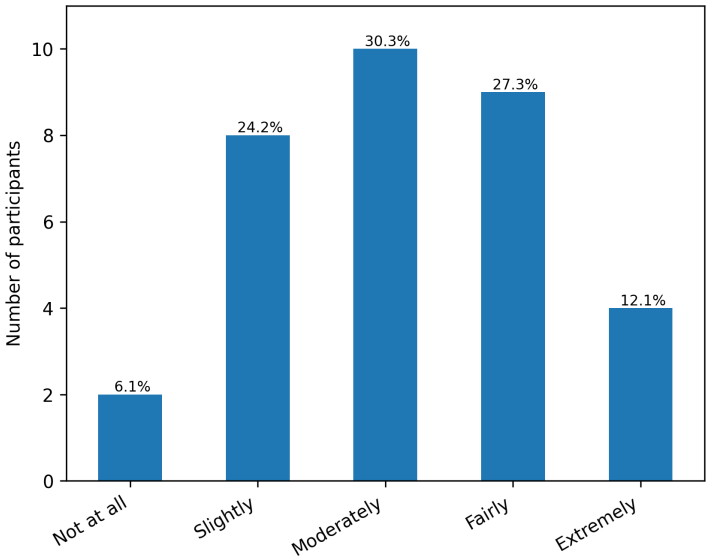

Figure 6.36: Overall impression of *Green Siesta Quiz*.

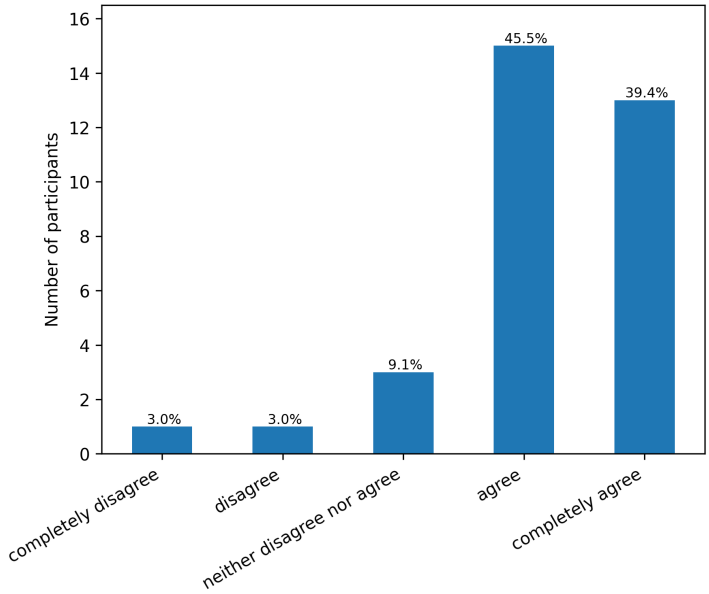

Figure 6.37: Perception of topic splitting into dream-like segments in *Green Siesta Quiz*.

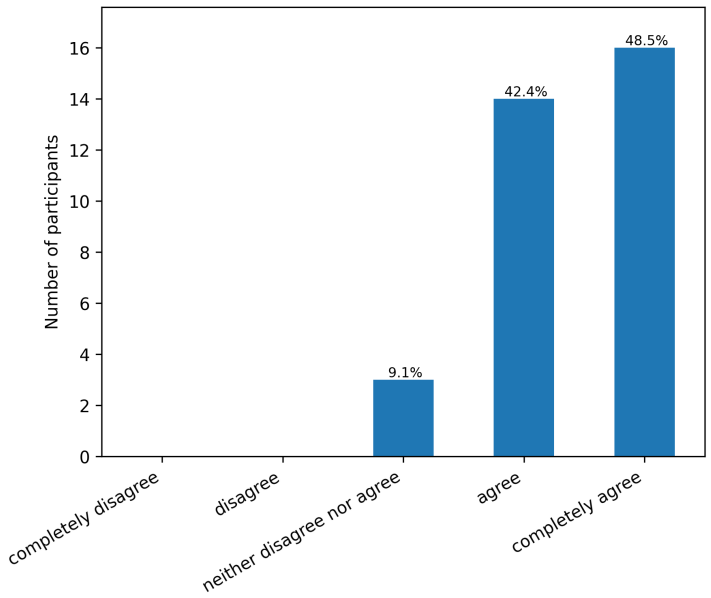

Figure 6.38: Whether participants managed to personalize their experience in *Green Siesta Quiz*.

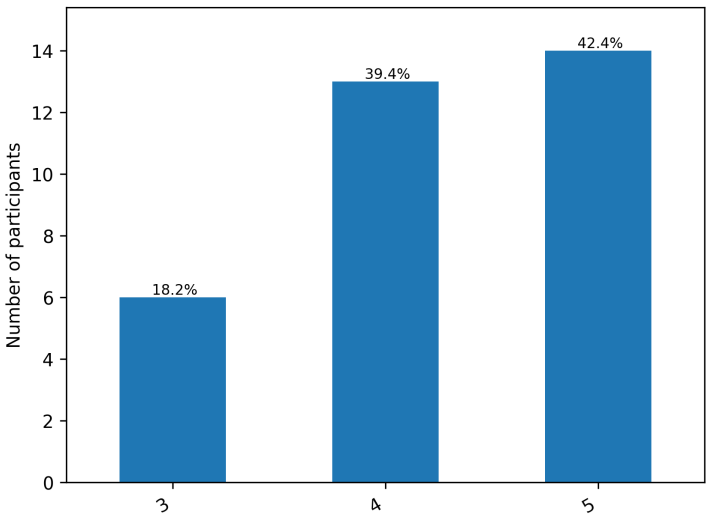

Figure 6.39: Perceived quality of personalization in *Green Siesta Quiz*.

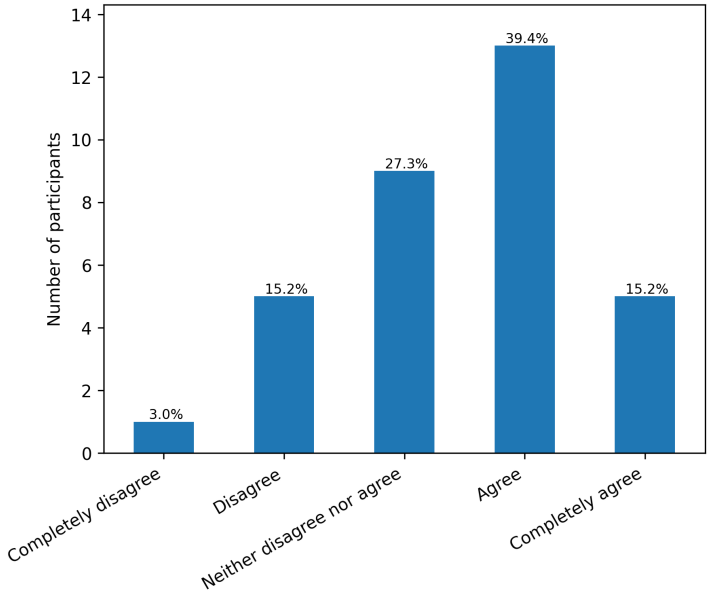

Figure 6.40: Effect of avatar personalization on engagement in *Green Siesta Quiz*.

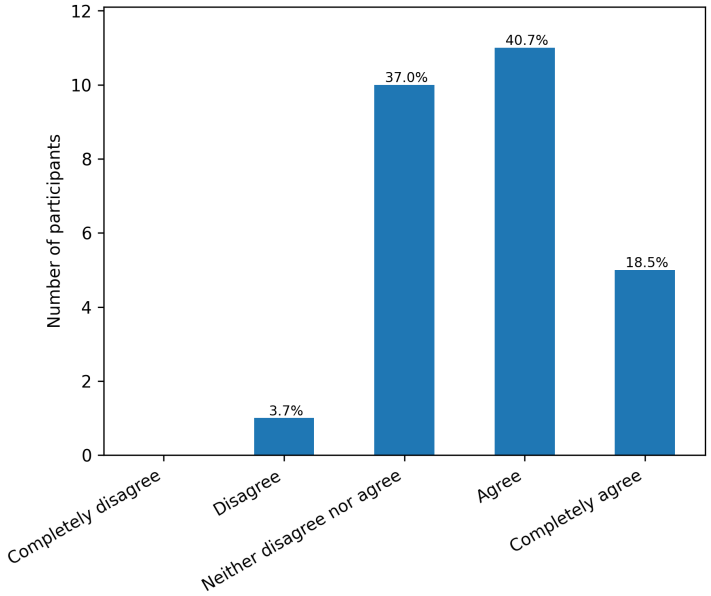

Figure 6.41: Excitement elicited by avatar modifications in *Green Siesta Quiz*.

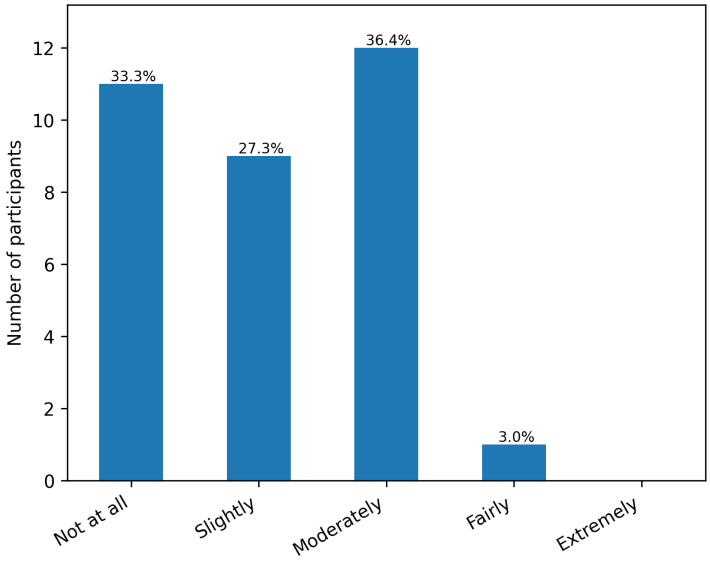

Figure 6.42: Feeling energised while playing *Green Siesta Quiz*.

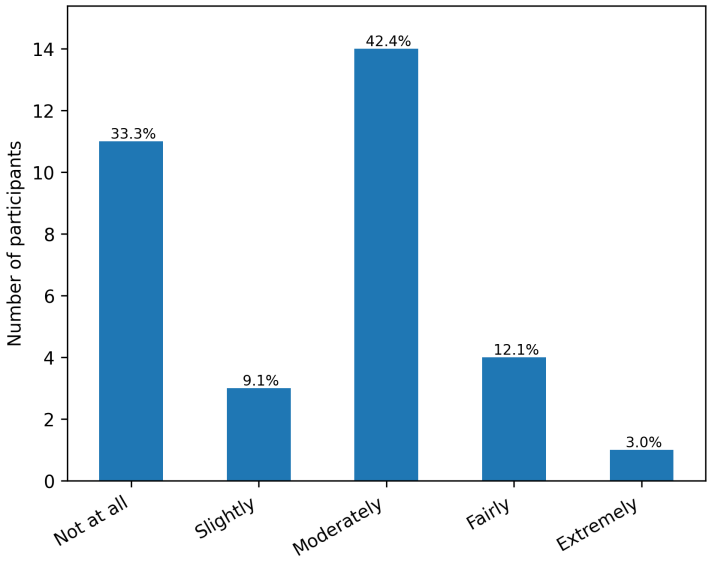

Figure 6.43: Feeling revived during or after *Green Siesta Quiz*.

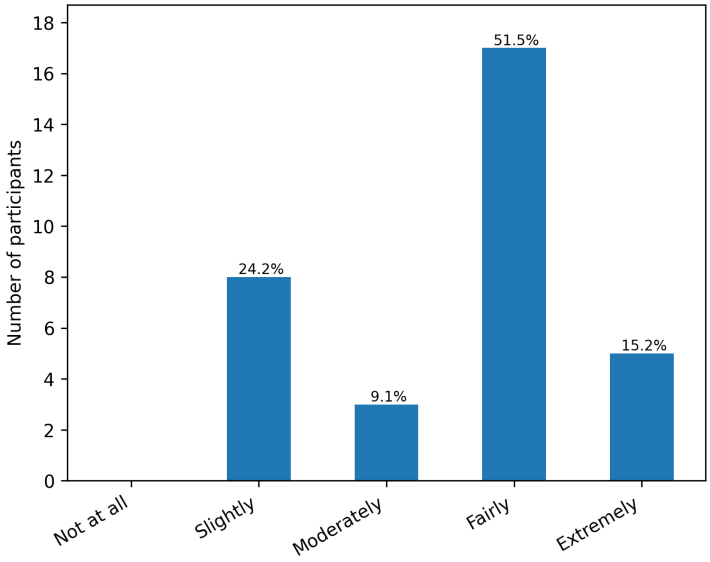

Figure 6.44: Feeling skilful while playing *Green Siesta Quiz*.

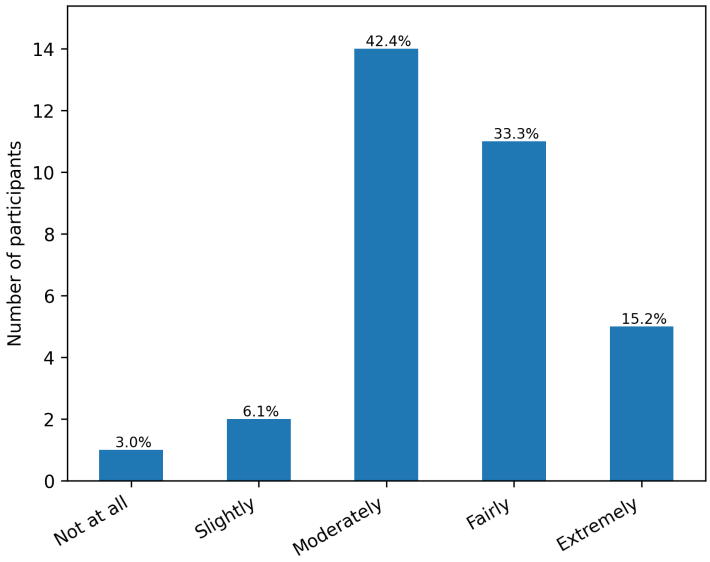

Figure 6.45: Feeling successful while playing *Green Siesta Quiz*.

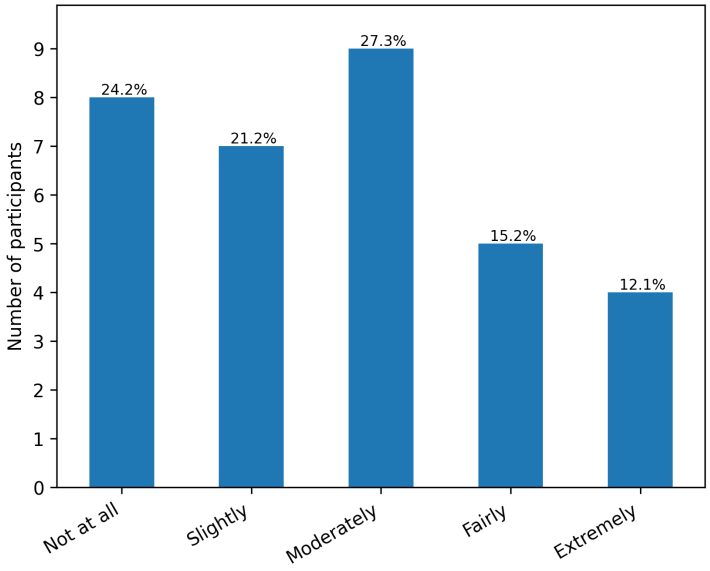

Figure 6.46: Feeling proud in relation to *Green Siesta Quiz*.

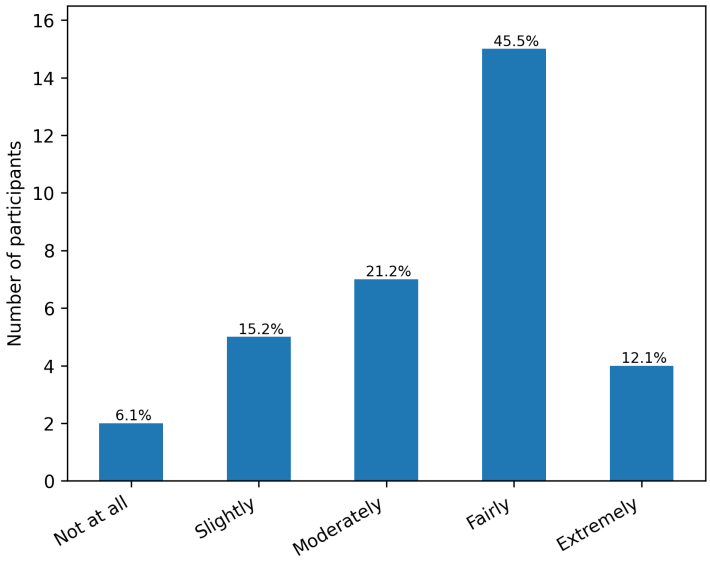

Figure 6.47: Feeling satisfied after playing *Green Siesta Quiz*.

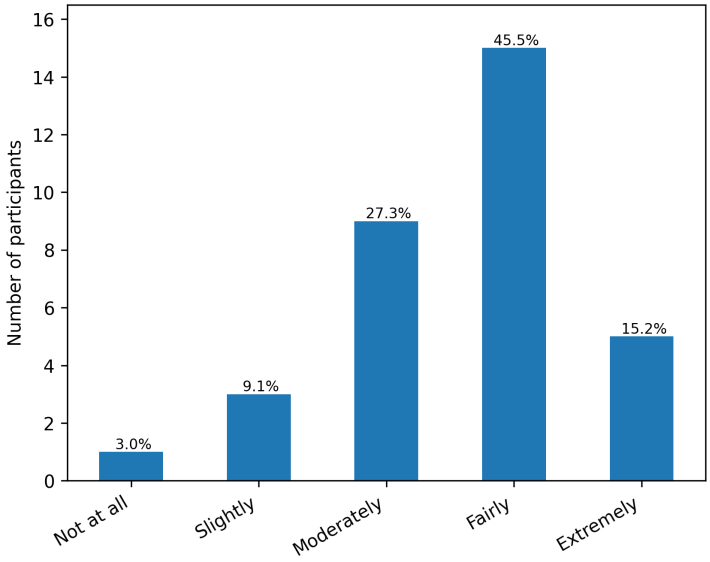

Figure 6.48: Feeling good while playing *Green Siesta Quiz*.

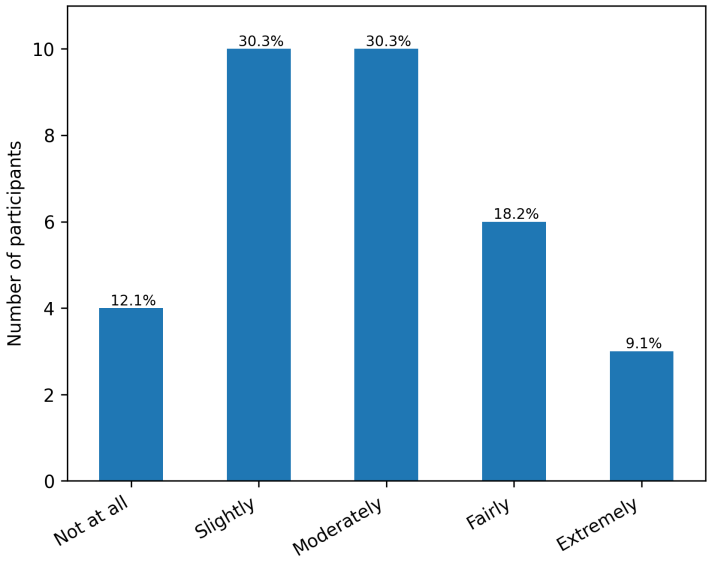

Figure 6.49: Feeling challenged during *Green Siesta Quiz*.

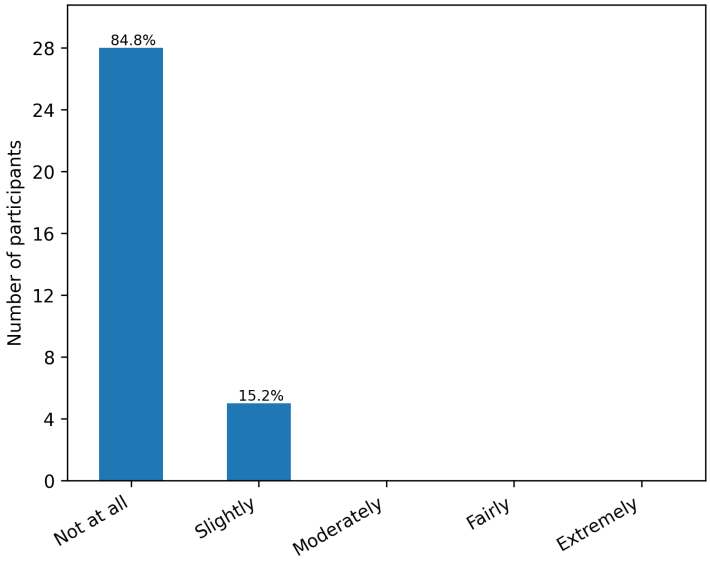

Figure 6.50: Feeling exhausted in relation to *Green Siesta Quiz*.

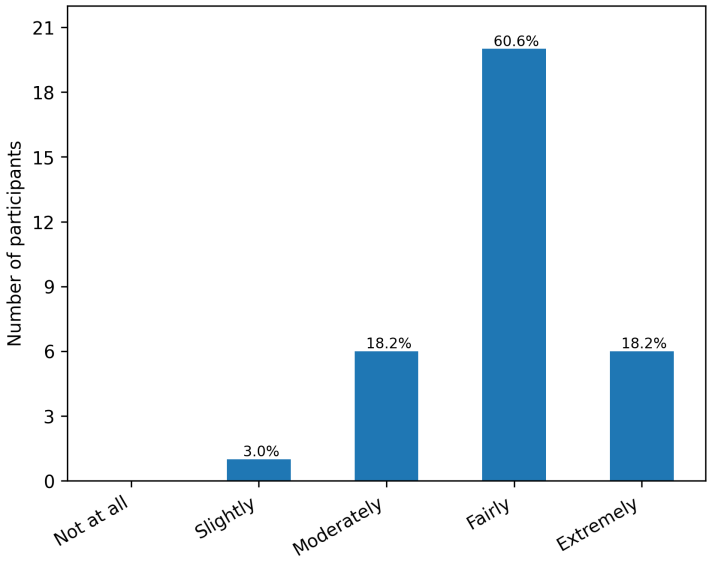

Figure 6.51: Feeling content while playing *Green Siesta Quiz*.

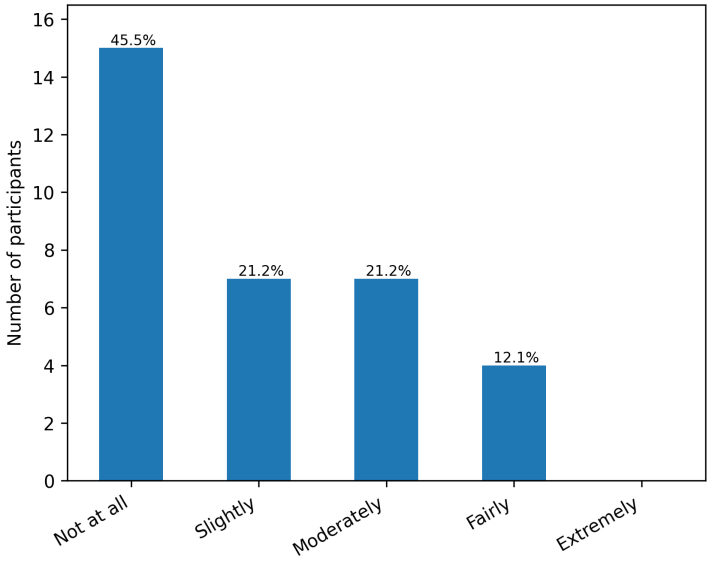

Figure 6.52: Feeling powerful while playing *Green Siesta Quiz*.

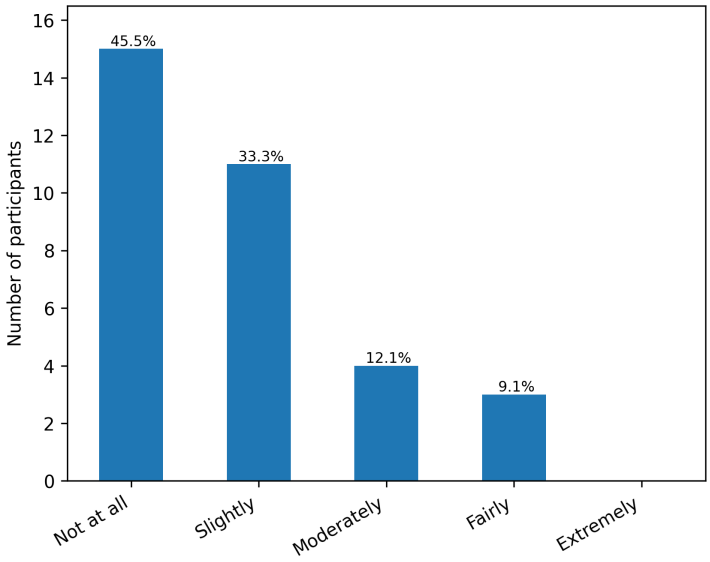

Figure 6.53: Feeling irritable in relation to *Green Siesta Quiz*.

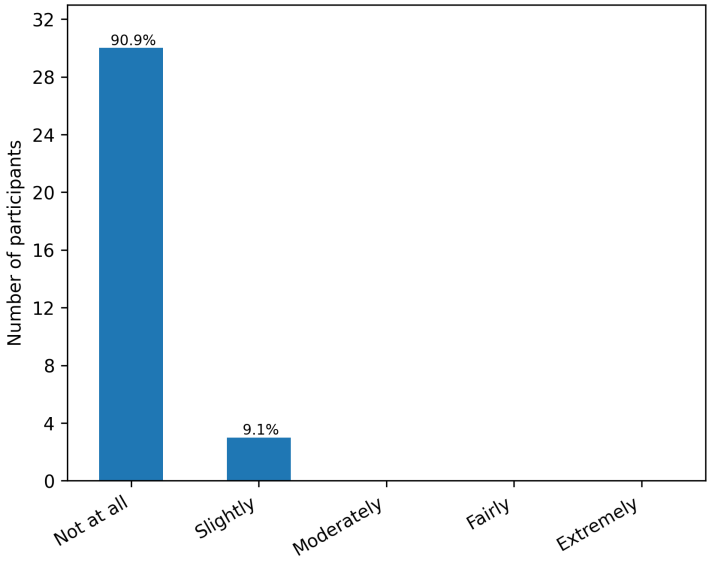

Figure 6.54: Feeling bad while playing *Green Siesta Quiz*.

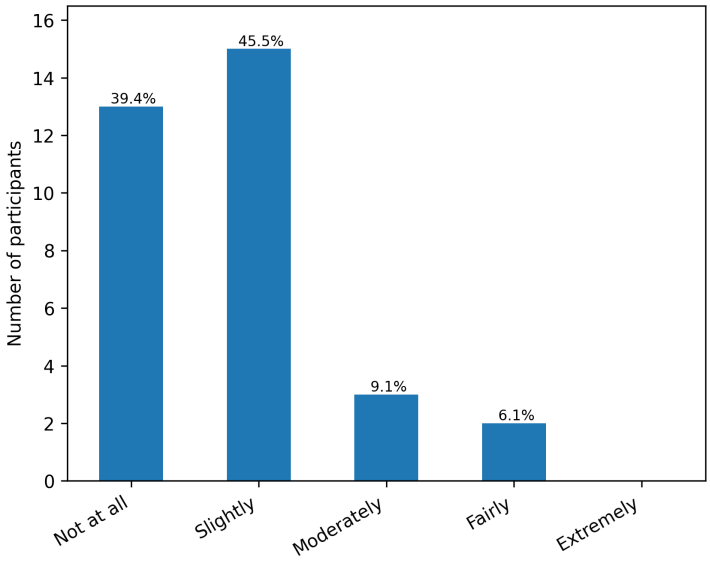

Figure 6.55: Feeling annoyed while playing *Green Siesta Quiz*.

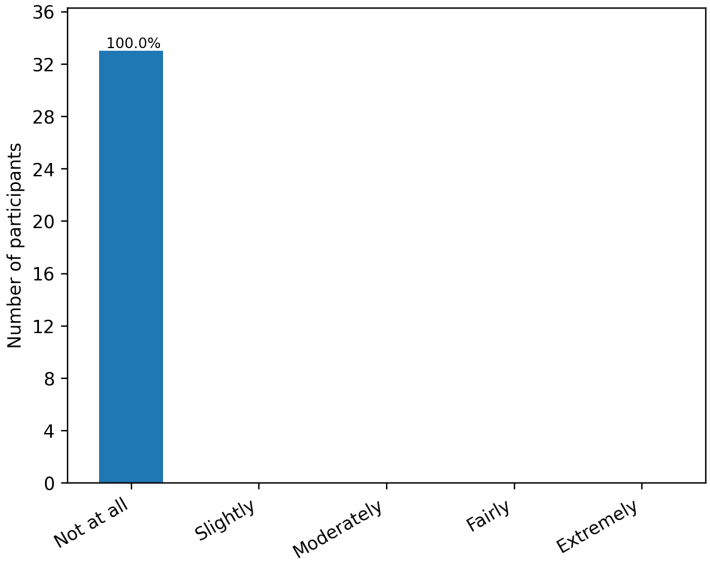

Figure 6.56: Feeling disoriented while playing *Green Siesta Quiz*.

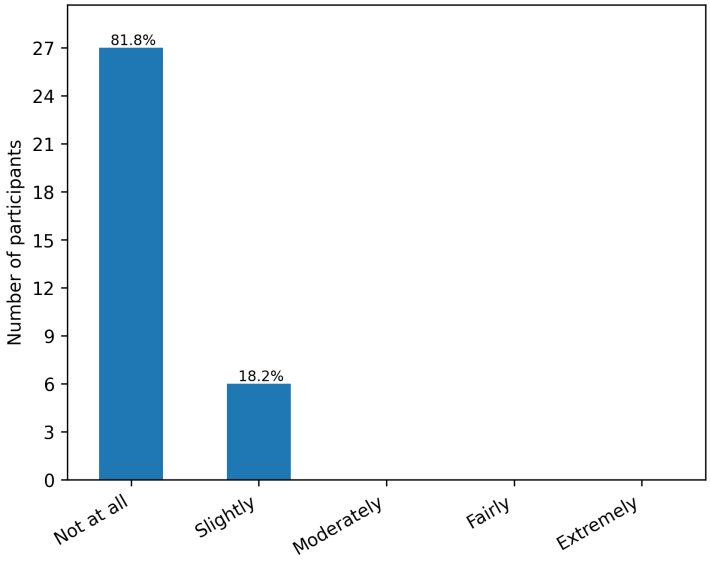

Figure 6.57: Feeling weary in relation to *Green Siesta Quiz*.

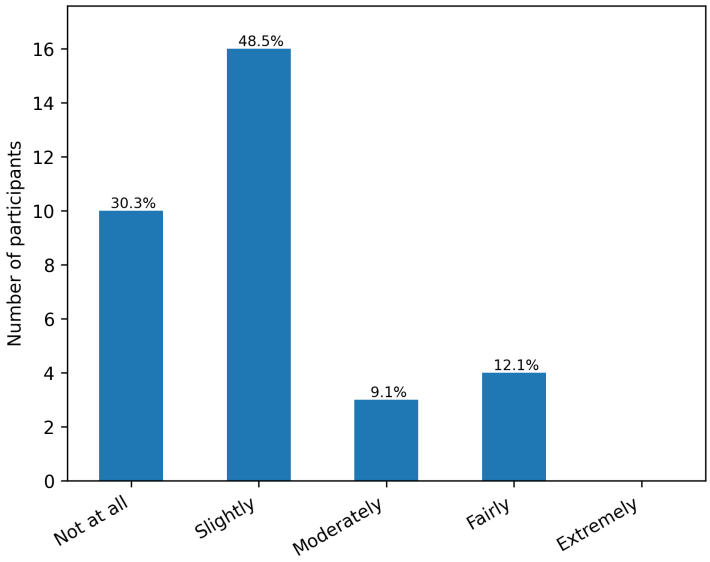

Figure 6.58: Feeling bored while playing *Green Siesta Quiz*.

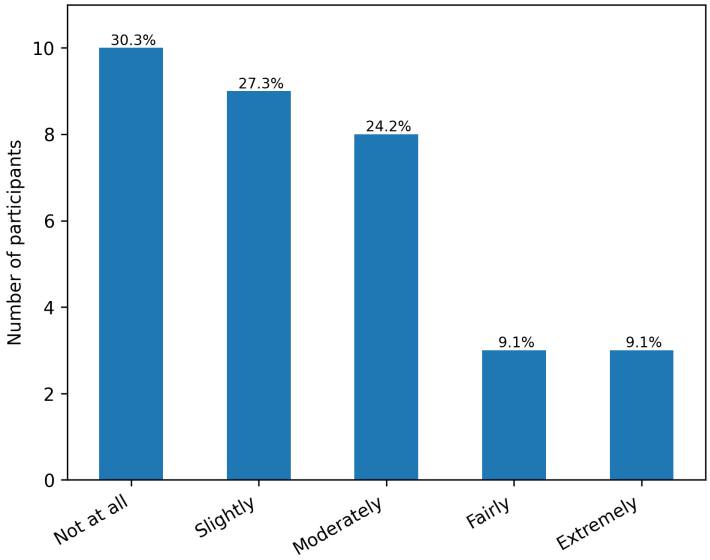

Figure 6.59: Forgetting everything around while playing *Green Siesta Quiz*.

Figures 6.42–6.65 provide a detailed overview of emotional responses reported by participants.

Overall evaluation

Overall evaluations summarize the quality and recommendation of *Green Siesta Quiz*.

Figures 6.66–6.67 summarize global evaluations and recommendations.

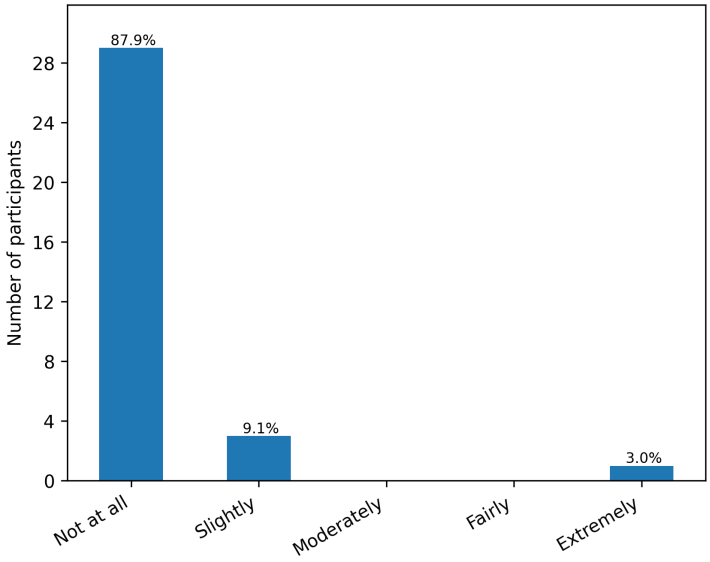

Figure 6.60: Difficulty returning to reality after *Green Siesta Quiz*.

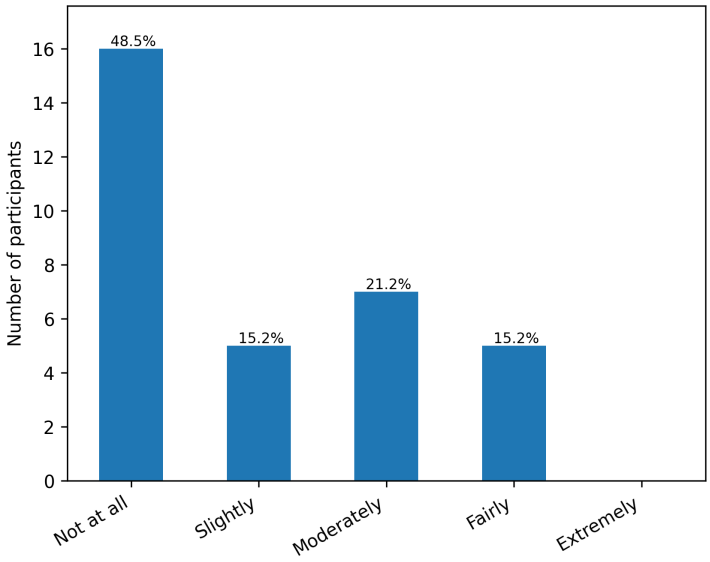

Figure 6.61: Feeling that one could have done more in *Green Siesta Quiz*.

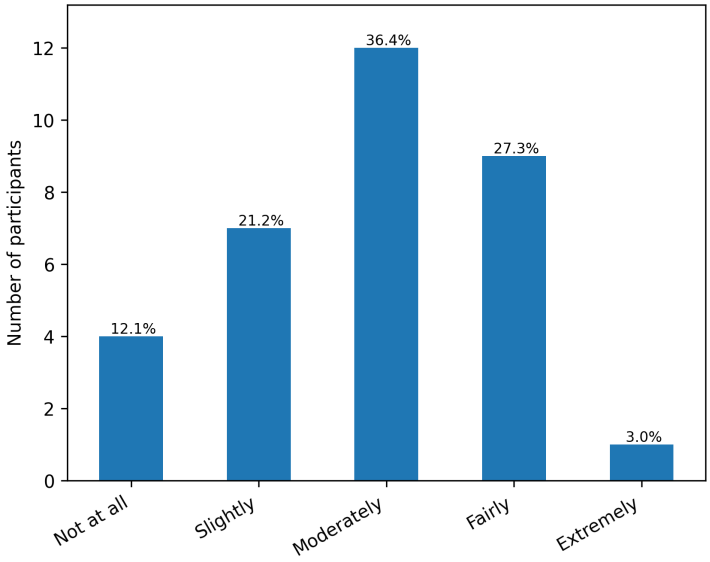

Figure 6.62: Feeling victory in relation to *Green Siesta Quiz*.

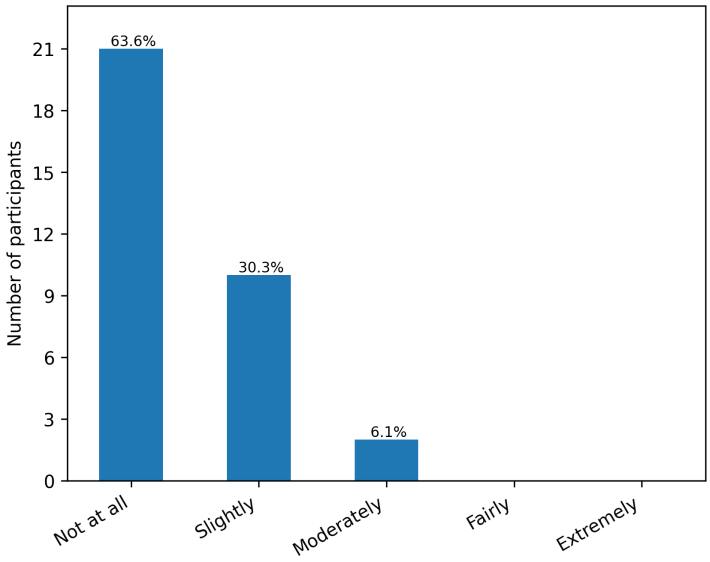

Figure 6.63: Feeling that play was a waste of time in *Green Siesta Quiz*.

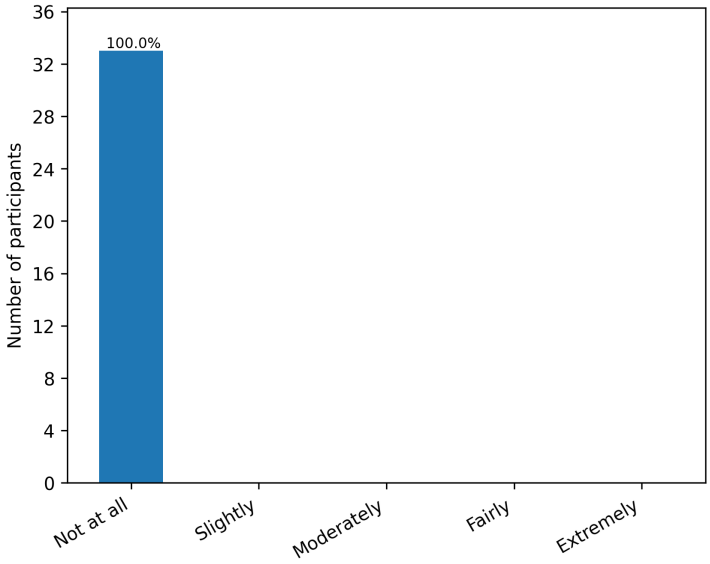

Figure 6.64: Feeling guilty in relation to *Green Siesta Quiz*.

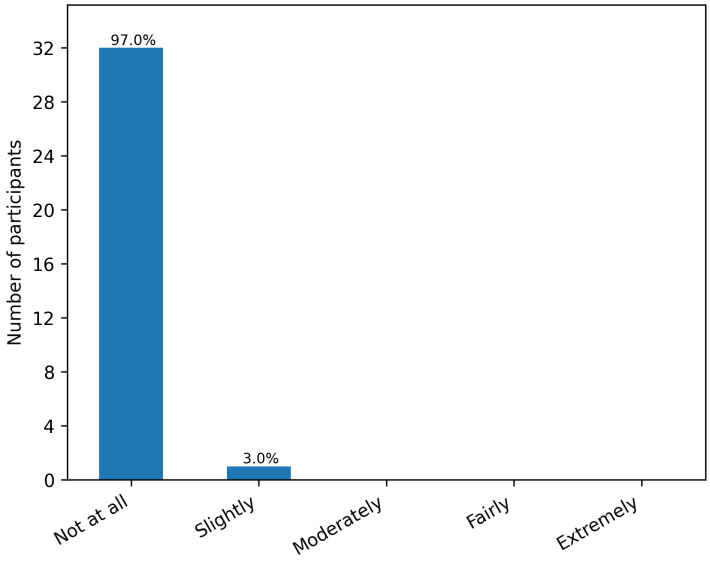

Figure 6.65: Feeling regret in relation to *Green Siesta Quiz*.

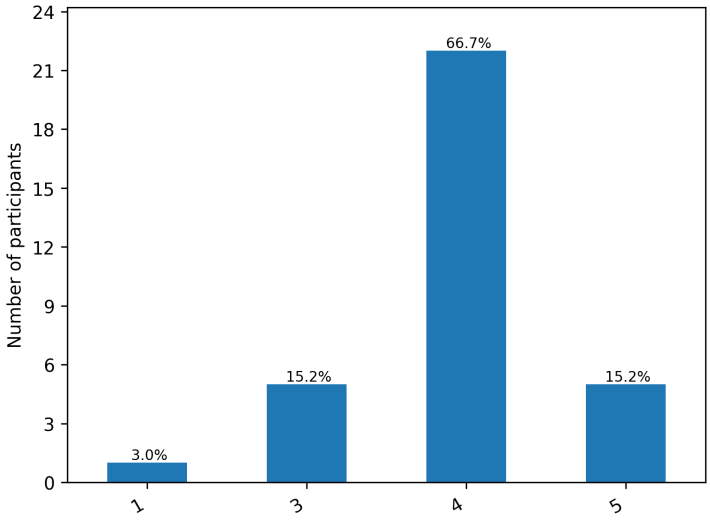

Figure 6.66: Overall game rating for *Green Siesta Quiz*.

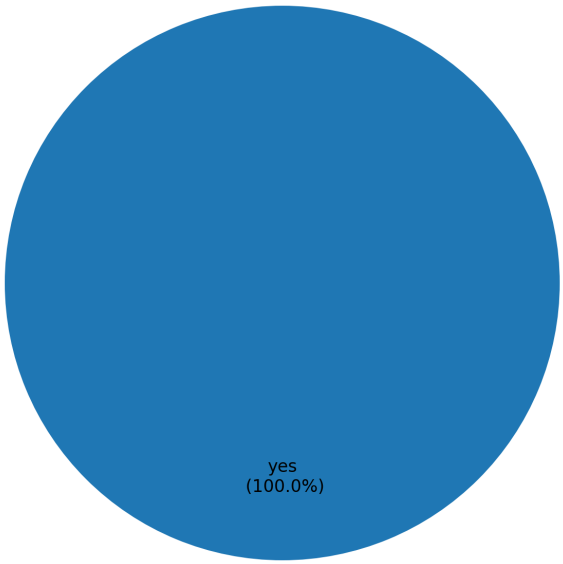

Figure 6.67: Recommendation of *Green Siesta Quiz* for target groups.

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