

Design of a Conversational Adventure app to Promote Argumentation in Science

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Abstract: Currently, the use of energy has become a socio-scientific issue characterized by its complexity, controversy, and direct impact on society, where science and technology play a crucial role. Such open-ended problems, without definitive answers, require active citizen participation in making informed decisions, respecting the values and rights of all individuals in society. In this context, schools must assume a social commitment. With the aim of promoting argumentation skills in science education regarding socio-scientific issues, a research project focused on the creation of video games is being carried out. This work presents the design of the conversational adventure 'Energy Island', conceived as a mobile application intended to enhance these skills. This video game transports participants to a fictional island, where they encounter various scenarios, such as a school, a town hall, a scientific research center, a market, a bank, and a recycling point. In each scenario, players must solve different challenges through interaction with various characters. These challenges range from actions for water conservation to decisions about building a nuclear power plant, recycling components of a photovoltaic panel, or finding a cure for respiratory problems derived from pollution. The ultimate goal of the game is for participants to make an informed decision about the most suitable energy source for the island, considering options such as wind, solar, nuclear, hydroelectric, biomass, or natural gas energy. In an initial testing phase, the video game was implemented with preservice secondary teachers at the University of Malaga (Spain) to identify the strengths and weaknesses of the application. These participants completed a satisfaction and usability questionnaire, evaluating aspects such as ease of gameplay, potential drawbacks, need for prior explanations, complexity, motivation, accessibility, and encountered difficulties, using a 5-point Likert scale (from "strongly disagree" to "strongly agree"). The application was generally well-received by the participants, who found it easy to use and did not perceive significant performance issues. However, it is suggested to provide additional resources to improve the user experience and maximize pedagogical use.

Keywords: Video Game, Conversational Adventure, Socio-scientific Issue, Energy, Argumentation, Decision-making.

1. Introduction

The relationship between science, technology, and society is undeniable, as scientific knowledge has significantly contributed to improving various aspects of daily life. This improvement is reflected in fields such as health, nutrition, or the development of new materials (Lusher et al, 2017; Van Heuvelen et al, 2020). This social dimension of science can begin to be addressed from an early age by presenting students with some socio-scientific issues (López-Fernández et al, 2021), that is, social problems with a strong scientific and technological foundation. These are open, complex, controversial, real, citizen-centric, unresolved, and without defined answers, which can be approached from different perspectives (Simonneaux, 2001; Zohar & Nemet, 2002; Sadler & Zeidler, 2005) and require active citizen participation to make reasoned decisions that respect the values and rights of all individuals in society (España & Prieto, 2009; Franco-Mariscal, 2024). Some examples of socio-scientific issues are related to the use of nuclear energy (Cruz-Lorite et al, 2023), the use of plastics (López-Fernández et al, 2022), or genetically modified foods (España-Ramos & Rueda, 2023).

In this context, the proposal of socio-scientific issues in the classroom plays a fundamental role in improving scientific and technological literacy and in the formation of citizens capable of making informed decisions that benefit society (Rahayu, 2019; Ke et al, 2021). Thus, students also learn to question, discuss aspects of science and technology, or make decisions, all of which can affect their lives and society in general (López-Fernández et al, 2021). The importance of scientific education is increasingly significant within a more democratic, informed, and empowered society, facing the major challenges that the technological world brings to new generations (Harlen, 2015; Forsthuber et al, 2012; Nistor et al, 2019; Rocard et al, 2007; Tavares & Almeida, 2015).

Currently, energy and resource use have become a socio-scientific issue that is gaining increasing attention from citizens. Some examples include electricity prices, dependence on Russian gas caused by the war in Ukraine, or the European Union's recommendation to consider nuclear energy as clean energy. Another evidence is that the United Nations (2015) includes this issue as part of Sustainable Development Goal 7, which aims to ensure access to affordable, reliable, sustainable, and modern energy for all citizens. There is no doubt that the energy,

recognized as a core and unifying concept across all science disciplines and grade levels (Park & Liu, 2016), is of great educational interest as it promotes argumentation and informed decision-making, essential skills in critical thinking (Franco-Mariscal, 2024). Science education must raise awareness among new generations about the social and environmental problems associated with the generation and consumption of energy, encouraging the search for sustainable solutions to ensure a better future for our planet (Feinstein & Kirchgasser, 2015).

On the other hand, the use of educational video games has proven to be an effective tool for promoting critical thinking skills such as argumentation in science (Franco-Mariscal, 2024) and facilitating learning in subjects such as biology, physics, and chemistry. These video games provide an interactive and motivating environment that encourages active student participation in their own learning process. According to Tavares (2021), digital educational resources can contribute to learning in science education through the use of animations, games, simulations, or quizzes.

The growing demand and accessibility of mobile devices have led to an increase in the popularity of educational mobile applications worldwide, creating new opportunities for students to exploit the possibilities of these technologies (Chang et al, 2018; Kearney et al, 2020). Thus, most teachers use mobile applications with their students, not only to promote scientific knowledge but also to foster student guidance and engagement in the learning process, to (re)present scientific information, or to develop scientific attitudes (Tavares, 2021).

Educational research on the benefits of using mobile applications for science teaching has substantially proliferated in recent years (Kearney et al, 2020), leading to a growing number of projects dedicated to developing such applications for science learning purposes (Bano et al, 2018; Kyza & Georgiou, 2019).

One format of interest is the conversational adventure, a genre of video games in which the description of the situation in which the player finds themselves comes mainly from text. Interactive adventure games can facilitate vocabulary learning and the development of various language skills such as argumentation (Krashen, 2004). Additionally, they are well-received by students, maintaining positive attitudes towards this type of video game. Story-based conversational adventures also present significant benefits in science education. Humanizing science through the use of a story makes the subject more appealing to many students, promoting interest and motivation (Matthews, 2015; Klassen & Klassen 2014). Moreover, it has also been shown that conversational adventures have a positive effect on the acquisition of new science knowledge (Flynn & Hardman, 2019). Conversational adventure games, which include mini-games, enrich the experience. A single mini-game alone is not a sufficient experience to contextualize the student. A series of different mini-games incorporating various game modes and mechanics on a learning theme helps students assimilate new knowledge and mental models (Frazer et al, 2007).

This study presents the design of the *Energy Island* mobile application in conversational adventure format to develop argumentation skills in science teaching, as well as the evaluations carried out in a testing study by preservice secondary teachers at the University of Malaga (Spain).

2. Methodology

2.1 Conversational Adventure Design

Energy Island is an application designed for Android mobile devices and has been developed with the participation of a team consisting of researchers in science education (the authors of this work), a programmer, and a graphic designer. In the initial phase, the video game was developed as a prototype, i.e., without sound or animations, which would require the use of specialized tools for such tasks.

The game development engine (Game Engine) used was Unity, created by Unity Technology, which uses OpenGL for the Windows operating system, chosen for its versatility and ease of use. Unity allows for the creation of both 2D and 3D video games and requires basic programming knowledge.

The development environment for programming its components, functionalities, and mechanics incorporated into the video game was done using the C# programming language and PHP for connecting to the database that stores the learning outcomes of the participants. The images used were created by a graphic designer using the Sketchbook program. The target audience of the application, available for single-player use, includes future secondary school teachers and students at this educational level, as well as anyone interested in science and technology. The video game is set on an island that includes various scenarios such as a school, the town hall, a technological research center, the commercial zone, a bank, and a recycling point (Figure 1).



Figure 1: Game Setting of *Energy Island*

In each scenario, players must solve different challenges by interacting with various characters (Figure 2) or by solving mini-games (Figure 3). These challenges range from actions for water conservation to decisions about building a nuclear power plant, recycling components of a photovoltaic panel, or searching for a cure for respiratory problems derived from air pollution.



Figure 2. Conversation with the operator of the recycling point centre on *Energy Island*.

The final goal of the video game is for participants to make an informed decision about the most suitable energy source for the island, considering options such as wind energy, solar energy, nuclear energy, hydroelectric power, biomass energy, or natural gas.

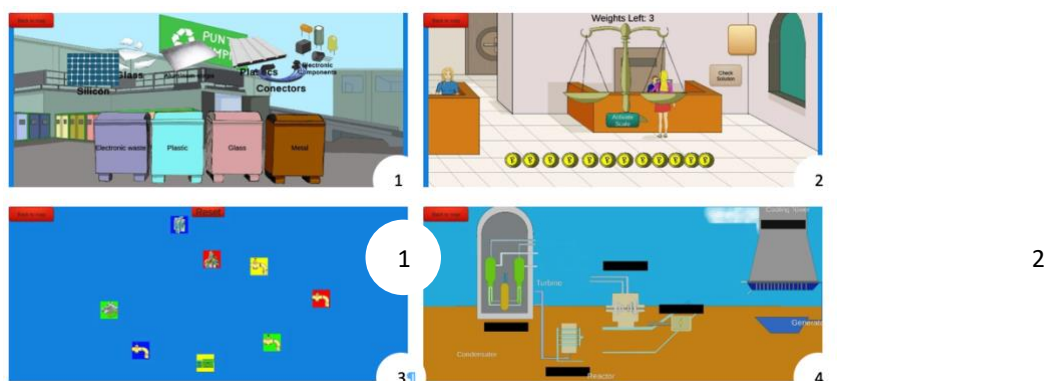


Figure 3: Some mini-games in *Energy Island*: 1: Mini-game about recycling components of a solar panel; 2: Mini-game about measuring the masses of different coins; 3: Mini-game about the geographical distribution of oil pipelines; 4: Mini-game about building a nuclear power plant.

2.2 Participants

This application is currently in the testing phase. The participants in the study were 29 preservice secondary teachers (82.8 % male, 13.8 % female, and 3.4 % preferred not to indicate) enrolled in the Master's Degree in

Secondary Education Teaching at the University of Malaga (Malaga, Spain) specializing in Technology, Computer Science, and Industrial Processes. Among them, based on their background training, there were industrial engineers, computer engineers, forestry engineers, chemical engineers, and architects. 44.8 % of the participants had used educational apps recommended by a teacher, 41.4 % had never used educational apps, 10.3 % had used them for leisure, and 3.5 % had used them with their teacher and also for leisure.

2.3 Implementation Plan

The Energy Island application is designed to be integrated into the curriculum of preservice teachers. The goal is to incorporate it into several class sessions over the course of a semester, complementing both theoretical and practical content of the subjects. This implementation will allow students to explore and apply scientific and didactic concepts in an interactive and dynamic environment, reinforcing their learning and fostering a deep understanding of the topics covered. At the beginning of the semester, the preservice secondary teachers were informed about the importance of argumentation in science education and received instruction in argumentation. Subsequently, various types of resources for science teaching were worked on in the classroom. Afterward, the students were introduced to the application and the socio-scientific issue presented. The preservice teachers had two weeks to use the application. Towards the end of the semester, participants engaged in a reflection session to discuss their experiences with the game. At the end of the semester, they completed the data collection instruments.

2.4 Data Collection Instruments

The data collection instrument was a questionnaire designed to assess the usability and satisfaction level of the video game by initial training teachers. This instrument was administered at the end of the game session, which lasted for 30 minutes, and consisted of 26 items (15 usability items and 11 satisfaction items) (Cebrián-Robles, 2015, p.101), which the student had to rate on a Likert scale from 1 to 5 points (1: strongly disagree, 2: somewhat disagree, 3: indifferent, 4: somewhat agree, and 5: strongly agree).

The validation of the questionnaire showed a reliability of 0.889, acceptably high, for evaluating educational platforms (Serrano-Angulo and Cebrián-Robles, 2014). The questionnaire was designed to be brief, avoiding the tendency to respond quickly to the items by presenting statements formulated in both positive and negative forms. Additionally, this questionnaire included a rating of the video game from 0 to 10 points and an optional open-ended question for making comments about aspects not included in the instrument.

For this study, the following items were selected:

- The mobile application was easy to use.
- It was exhausting to use the application.
- I needed little time to handle the application.
- I needed help to access the video game.
- At some point, I felt panicked.
- The video game requires help from an expert.
- The given responses are difficult to understand.
- The response time in interaction is slow.
- The aids to understand the application were helpful.

The results regarding the assessment of the application and the degree of satisfaction were analyzed quantitatively by counting the ratings given for each item. The responses given in the open-ended question were analyzed qualitatively by categorizing the responses into the addressed themes. For each category, the frequencies and percentages of response were calculated.

3. Results

This section presents the findings obtained from the questionnaire. Regarding the evaluation of the application, 62 % of the preservice teachers rated it between five and eight points (Figure 4). The average rating of 4.79 out of 10 points suggests that there is scope for improvement in the mobile application.

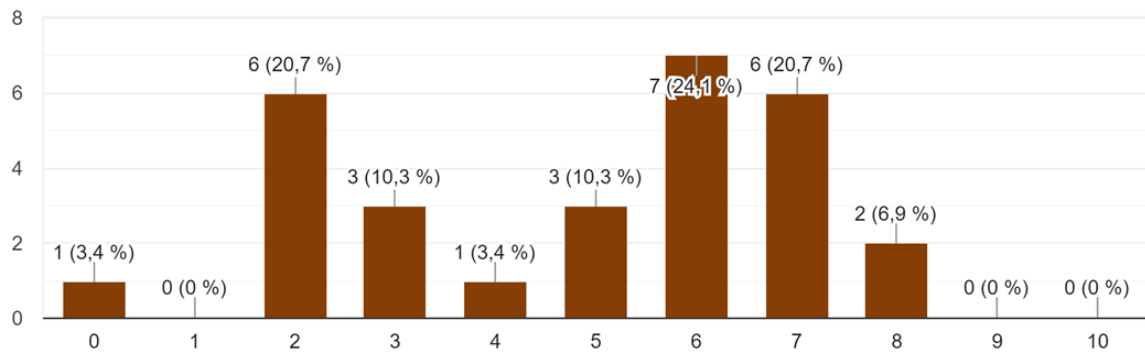


Figure 4: Evaluation of the *Energy Island* application.

The majority of participants (37.9%) were indifferent to the statement "The mobile application was easy to use" (Figure 5). Several initial training teachers indicated being somewhat disagree or somewhat agree with the statement (24.1% for both options). Only 3 out of 29 subjects (10.3%) strongly disagreed with this item.

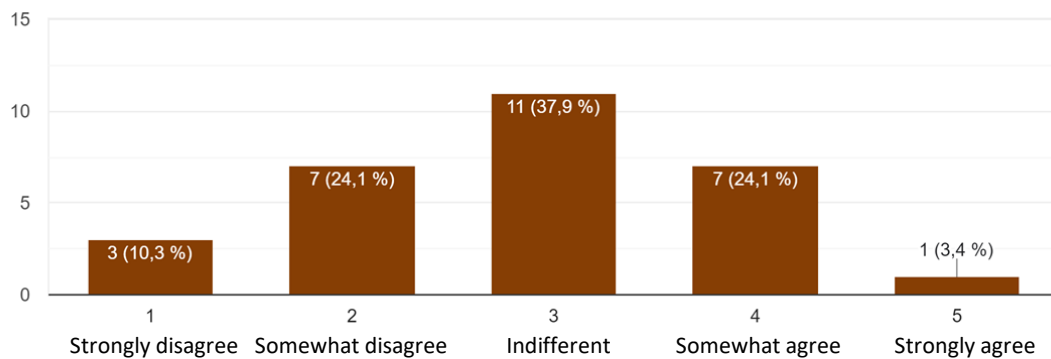


Figure 5: Degree of agreement/disagreement for the item *The mobile application was easy to use*.

37.9 % of the participants were indifferent to the item "It was exhausting to use the application." Only 10.3 % strongly agreed, and 20.7 % somewhat agreed (Figure 6).

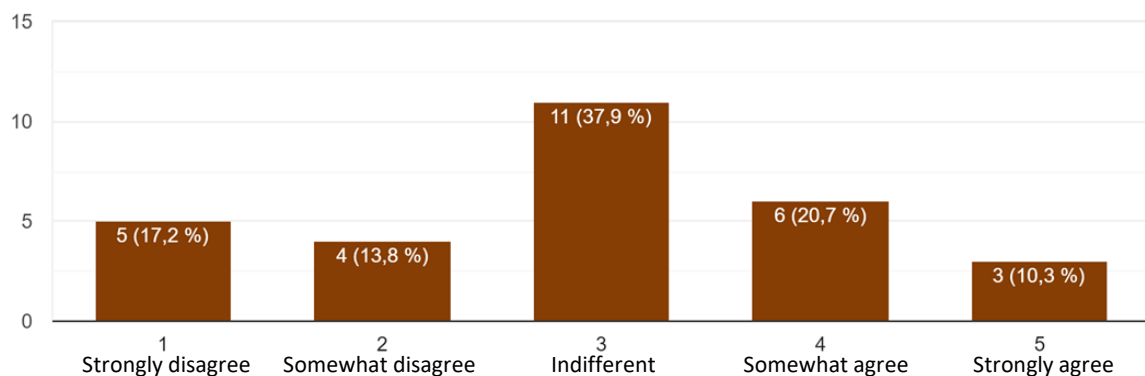


Figure 6: Degree of agreement/disagreement for the item *It was exhausting to use the application*.

The majority of initial training teachers (58.6 %, 17/29) were somewhat or strongly in agreement with the item "I needed little time to handle the application" (Figure 7). 34.5 % (10/29) were indifferent, indicating that it is possible to understand its operation in a short time.

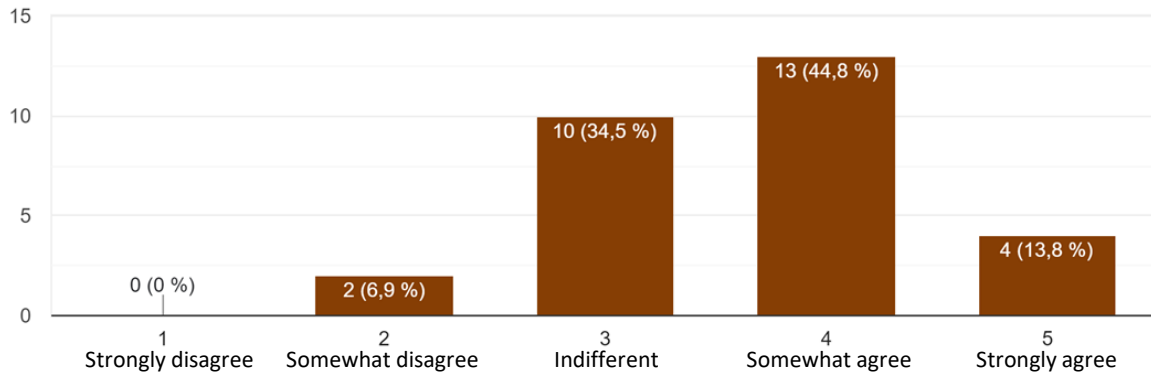


Figure 7: Degree of agreement/disagreement for the item *I needed little time to handle the application*.

The rating given to the item "I needed help to access" offered controversial responses (Figure 8). On one hand, 34.5 % of the participants strongly disagreed because they did not encounter difficulties in accessing. On the other hand, another 34.5% indicated that they somewhat agreed with the item due to some difficulties in accessing the application.

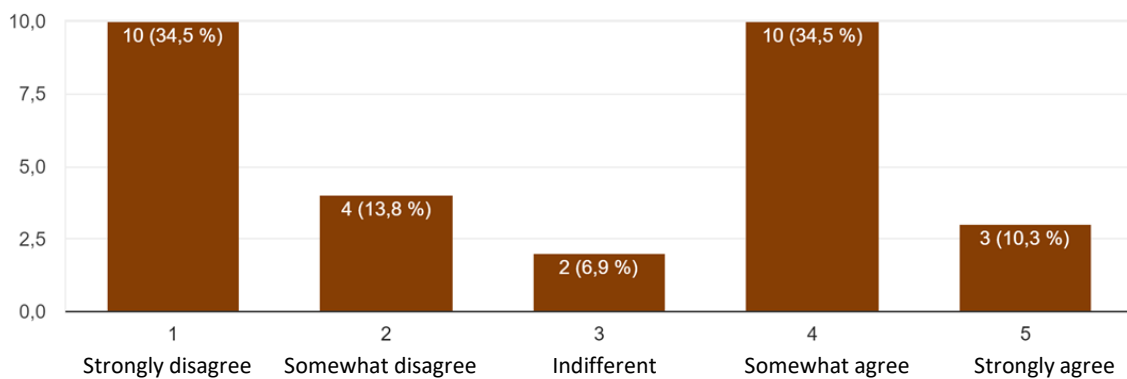


Figure 8: Degree of agreement/disagreement for the item *I needed help to access*.

A significant number of participants (58.6 %) disagreed strongly with the item "At some point, I felt panicked" (Figure 9).

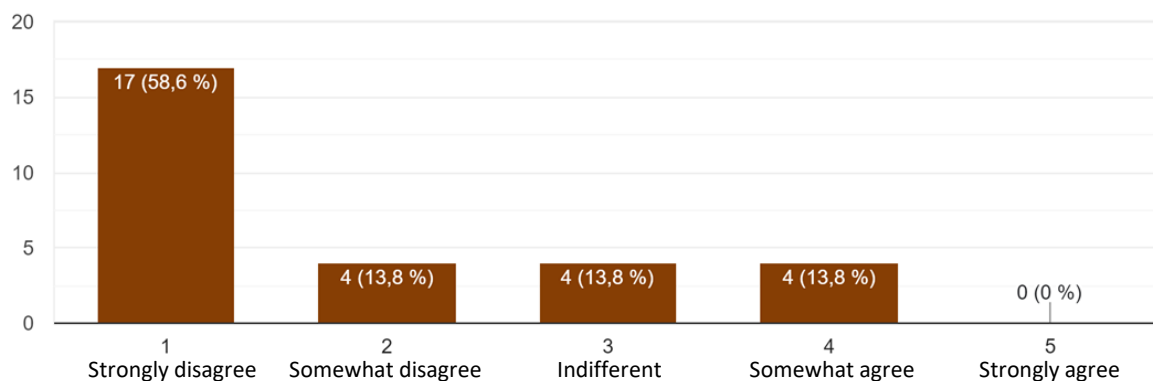


Figure 9: Degree of agreement/disagreement for the item *At some point, I felt panicked*.

Likewise, 79.3% of preservice teachers expressed being strongly disagree, disagree, or indifferent to the item "The video game requires help from an expert" (Figure 10). Only a few marked the options somewhat agree (17.2%) or strongly agree (3.4%).

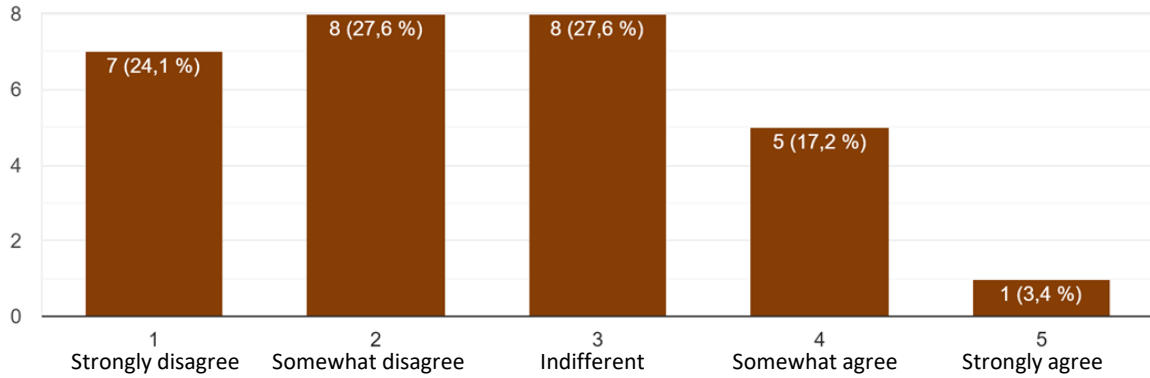


Figure 10: Degree of agreement/disagreement for the item *The video game requires help from an expert.*

Similarly, the responses given in the application were straightforward and easy to understand, as nearly half of the participants (48.3%) expressed being indifferent to the statement "The given responses are difficult to understand" (Figure 11). However, 27.8% disagreed somewhat with this item, and no participant indicated being strongly agree with it.

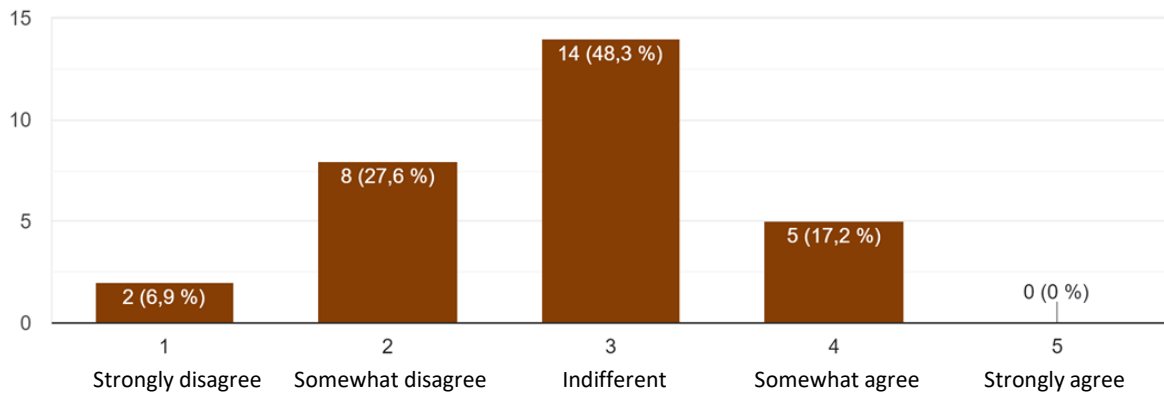


Figure 11: Degree of agreement/disagreement for the item *The given responses are difficult to understand.*

Regarding the item "The response time in interaction is slow" (Figure 12), the findings seem to indicate that the application's response is smooth. Many of the participants were indifferent (44.8%) or somewhat disagree (27.6%).

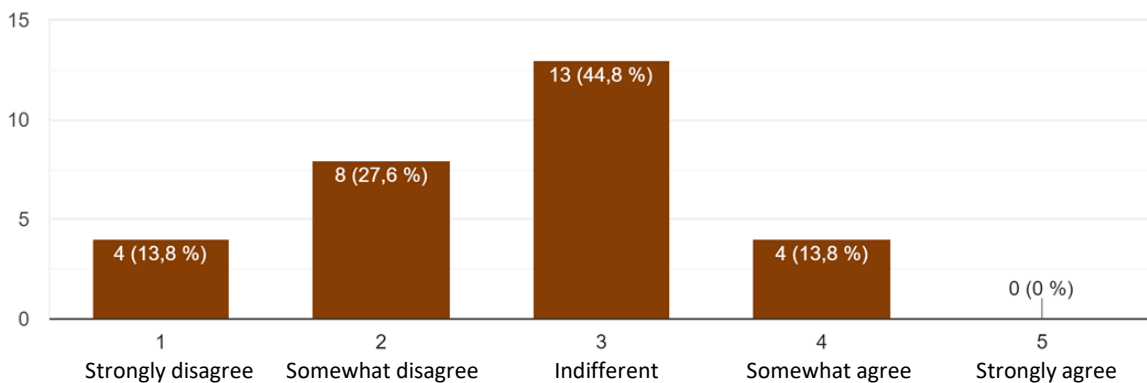


Figure 12: Degree of agreement/disagreement for the item *The response time in interaction is slow.*

On the other hand, not all subjects needed help to understand the application (Figure 13). For this reason, 37.9% were indifferent to the item "The aids to understand the application were helpful." Of those who needed help, one-third (34.5%) stated they were strongly or somewhat agree.

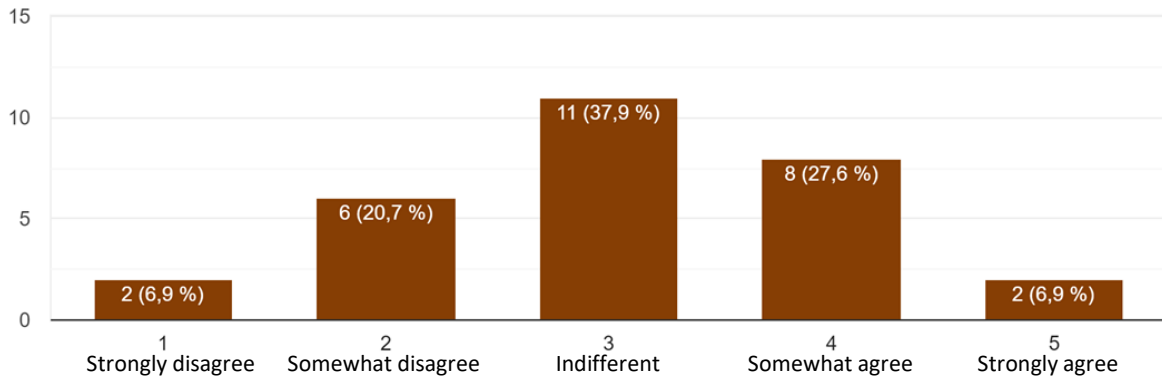


Figure 13: Degree of agreement/disagreement for the item *The aids to understand the application were helpful.*

Table 1 summarizes the response categories found in the open-ended question. Most of the observations referred to the design and interface of the mobile application, suggesting improvements regarding font size, menus, or buttons. Other observations related to the scientific content regarding energy addressed by the application, indicating that its level of difficulty was low. Finally, some preservice teachers provided comments regarding access to the application or the aids to solve the mini-games.

Table 1: Response categories in the open-ended question

Response Category	Percentage (%)	Example
Design and interface	46.67	<i>The font is too small to read the texts.</i> <i>The text size is small, and some are quite lengthy.</i>
Scientific content	40.00	<i>I didn't rate some topics highly because I find them trivial. Perhaps they would be interesting to a teenager.</i>
Access or assistance to solve mini-games	13.33	<i>I don't see the registration as necessary.</i> <i>The mini-game with the scales should be able to be restarted. There are few clues or aids for finding the materials in the mini-game with the photovoltaic panels.</i>

4. Conclusions

The evaluation of the *Energy Island* mobile application by preservice teachers specializing in technology in the Master's Degree in Secondary Education Teaching after participating in a testing study reveals several significant findings.

Firstly, the application was not perceived as exhausting by the majority of participants, which is positive as it suggests that the user experience is not overly demanding, thus facilitating its integration into the educational environment. Additionally, most participants found that the time needed to become familiar with the application was brief, indicating a relatively fast learning. However, it is important to consider that some users may need more guidance to fully utilize all the features of the application. In this regard, providing additional support resources, such as hints to solve the proposed challenges, an aspect that was demanded by the participants, could enhance the user experience and the effectiveness of the application for pedagogical use. On the other hand, most participants did not experience issues with response speed during interaction with the application, suggesting a smooth performance and contributing to a more satisfactory user experience. It is also important to note that the content of the mobile application was designed for secondary school students, so some participants may have found it too simple.

Another fundamental aspect is to continue monitoring and optimizing the technical performance of the application to ensure its optimal operation in different environments and devices. As a next line of research, the learning outcomes related to energy achieved by the sample of preservice teachers using the application will be analyzed. These results will allow for improvements to be made to the application before conducting studies with secondary school students.

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