# Evaluating Mystiria: Insights from a Pilot Study on Intergenerational Collaborative Gameplay for Climate Change Awareness

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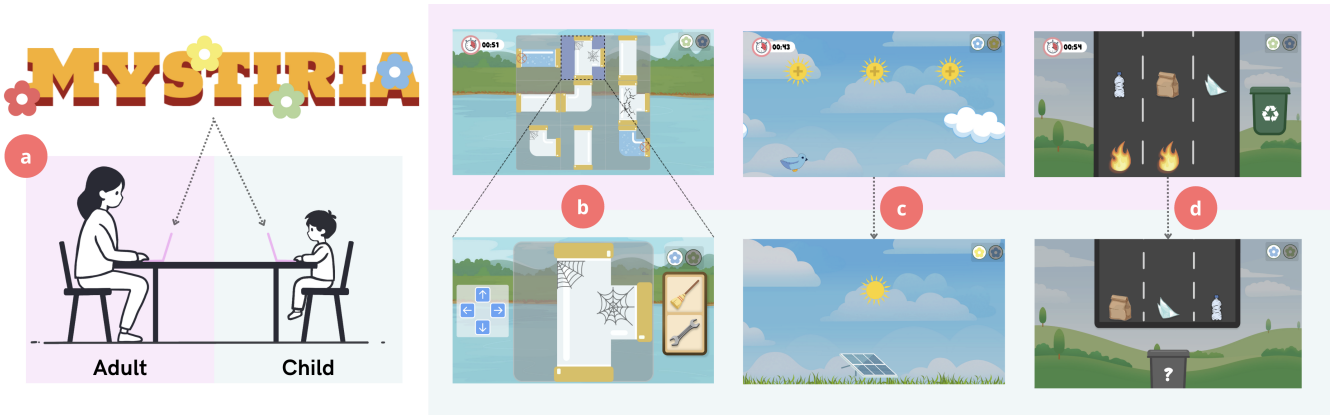


**Figure 1: Collaborative Gameplay Structure of Mystiria: (a) Adult Child Layout - Each of the players has their own screen, which the other player is not allowed to see. The goal is for both players to communicate with each other; (b) Aqua's Mini-game; (c) Electro's Mini-game; (d) Verdis' Mini-game. For (b), (c) and (d), the top screen represents the adult's view, while the screen on the bottom is what the child will see.**

## Abstract

Climate change education should be an urgent global priority for both adults and children. Usually, the existing interventions focus on one of these groups singularly, instead of engaging intergenerational audiences. Mystiria harnesses adult-child interactions in a captivating gaming and learning experience that fosters climate change awareness. This paper delves into how Mystiria's design and gameplay mechanics promote critical thinking and collaboration while also educating on climate change and sustainability. Through a pretest-posttest pilot study and guided interviews with six adult-child pairs, we unveil the game's ability to inspire intergenerational dialogue, deepen understanding and spark meaningful discussions about the current world's environmental issues. The findings from our pilot study indicate that collaborative intergenerational gameplay fosters positive learning outcomes, creating an environment for heightened knowledge transfer and awareness of climate change and sustainability. While these results need to be validated with a larger study, they highlight Mystiria's potential as a model for intergenerational serious games.


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## CCS Concepts

• **Human-centered computing** → **Collaborative interaction**; • **Applied computing** → *Collaborative learning*.

## Keywords

Serious Games, Climate Change, Sustainability, Asymmetric Play, Adult-Child Interactions

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## 1 Introduction

The impacts of climate change can be felt across generations - from children inheriting an uncertain future, to adults witnessing rapid environmental shifts within their lifetime. Despite the urgency of this crisis and it being frequently discussed [7, 9, 12, 20], current approaches often remain tied to specific age groups, rather than fostering meaningful engagement across generations. Climate change is a cross-generational issue, yet there is a lack of platforms that facilitate learning experiences where different generations can engage in dialogue and collaborate towards a sustainable future.

Intergenerational collaborative gameplay has the potential to solve this problem, as it not only encourages teamwork and critical thinking, but also breaks down age-based hierarchies [30] by creating playful, low-stakes environments where creativity and knowledge flow both ways. By engaging in collaborative games, adults and children can share their unique perspectives, possibly leading to a shared sense of responsibility towards improving the world. While the design of climate-focused games has gained increasing attention, there is a lack of research on how such games facilitate intergenerational learning in practice. Few studies critically assess the educational dynamics that unfold when older and younger participants engage in climate-themed collaborative play.

To address this, we have designed and developed Mystiria, a novel serious game for raising awareness about sustainability and climate change, through asymmetric play components between children and adults. While adults are the current decision makers, children are the future ambassadors of the planet and will play an active role in adopting sustainable behaviours. By engaging these two groups in a collaborative problem-solving game, Mystiria seeks to instil a sense of shared responsibility and foster dialogue and learning opportunities. To better understand how collaborative gameplay fosters intergenerational learning on climate change and sustainability, we proposed the following research questions: RQ1 – *What elements of the educational game contribute to user engagement and enjoyment, particularly within the context of climate change awareness?*; RQ2 – *How does the interaction between adult and child promote discussion and/or knowledge transfer about climate change awareness?*

## 2 Related Work

Intergenerational learning represents a dynamic exchange of knowledge, values and skills between different generations [22], with serious games being recognized as effective facilitators [18, 29]. Prior studies have explored intergenerational interactions in multiple contexts, such as museum installations [19], remote communication [31], adult-child play using a tablet [16], collaborative activities such as cooking [21], photo-sharing app for health [2] and increasing connectedness between grandparents and grandchildren [27]. These all show positive results in including cross-generational participants, providing successful use cases of this mechanic.

Asymmetric play, where players take on distinct but interdependent roles, encourages collaboration, immersion, behavioural engagement, understanding and social presence between players [13, 15]. For example, Pais et al. [23] developed an asynchronous asymmetric game for family play, and Chen et al. [4] further investigated how different control mechanisms in asymmetric collaborative games can prompt social interactions. However, research on its application in serious games for climate change awareness has been limited, with most research focusing on family bonding or workplace training. Mystiria extends these intergenerational principles to climate education by merging localized context with asymmetric gameplay components, offering a novel approach to climate education. Unlike generic climate change games, Mystiria embeds region-specific context, making abstract concepts tangible. By merging localized content with asymmetric collaboration, Mystiria uniquely addresses the engagement gap in climate education, while fostering practical intergenerational knowledge transfer.

## 3 Design & Development of Mystiria

Mystiria is a collaborative game designed for one adult and one child (6-10 years old), set on a fictional island which closely resembles Madeira Island, where the game was developed and tested. According to Rowntree et al.[25], a localized context offers the greatest potential for changing beliefs and behaviours.

Players learn how Mystiria has been deeply affected by the impacts of climate change, with the help of: (1) Perla – the heart of Mystiria, who reveals how climate change led to the island's current state; (2) Aqua – guardian of water and emphasizes the importance of its conservation; (3) Electro – guardian of energy, focusing on renewable energy sources; and (4) Verdis – guardian of recycling, bringing awareness to the impact of single-use materials. Players will explore and restore the island through three engaging asymmetric mini-games, each providing a tutorial, and at the end, an educational quiz. Throughout the narrative, there are "conversation starters" to encourage meaningful adult-child interactions, fostering discussions and knowledge transfer. The inclusion of asymmetric play links to previous research, as it has been shown to help collaborative learning, engagement and immersion [15, 23].

**Aqua's Mini-Game - *Connect the Pipes***: This water management mini-game highlights the importance of maintaining an efficient and clean water distribution system. The gameplay features asymmetric cooperation across three increasing difficulty phases: 3x3, 4x3 and 4x4 pipe grid puzzle (see Fig.1-b). The adult, having a full puzzle view, solves the puzzle and guides the child on which pipes to repair or clean, to ensure proper water flow.

**Electro's Mini-Game - *Sunshine Savers***: In this mini-game, the focus shifts to renewable energies, particularly solar. In phase 1 (see Fig.1-c), the adult spawns suns, while the child must catch them with a solar panel, avoiding obstacles such as clouds and birds. In phase 2, the adult places solar panels across Mystiria, but their effectiveness depends on the child clearing obstructing clouds. A dynamic grid system changes the positions and intensity of the sunlight, requiring continuous communication to succeed.

**Verdis' Mini-Game - *Recycle Fest***: The final mini-game focuses on waste sorting. The child catches falling trash in the correct recycling bin, as indicated by the adult (see Fig.1-d). The adult must also extinguish fires that could burn trash (loosing points). Asymmetric mechanics reinforce teamwork by requiring constant communication to maximise the score, while highlighting the negative environmental impacts of improper waste management.

After each mini-game, players answer three quiz questions together. Correct answers increase the score by 10%, with no penalties for incorrect responses. This aims to promote a positive learning experience, encouraging engagement, knowledge acquisition, and fostering meaningful adult-child interactions without the fear of penalty [14]. Towards the end of the game, players will explore different sustainable initiatives on Madeira Island, and take a picture with the game's characters to remind them of lessons learnt.

## 4 Pilot Study

Our pilot study, approved by our university's ethics committee, was conducted with six adult-child pairs (targeting children aged 6-10 years old and their guardians) who were not compensated for their participation. Eligibility criteria included the guardian being over 18 years old and children being between 6 and 10 years old, the ability to interact with computer games, availability and willingness to participate in the study. Adults (n=6, 5 female) ranged from 36 to 51 years old (M=43.83, SD=6.65), and the children (n=6, 4 female) were either 7 or 10 (M=8.5, SD=1.64). Participants interacted with the game using laptops and were seated opposite one another (Fig.1-a).

### 4.1 Data Collection & Analysis

For the pilot study, we adopted a mixed-methods approach, with a focus on the qualitative data. While we collect quantitative data (for informational purposes, such as pretest-posttest scores and in-game metrics), it was not statistically analysed due to the small sample size. Methods used include: (1) Pretest-posttest questionnaires – New Ecological Paradigm (NEP) [1] scale to measure changes in adult players' knowledge or attitudes related to climate change, and the Game Experience Questionnaire (GEQ) [17] to assess game experience; (2) In-game metrics (scores, quiz answers and time taken to complete the game); (3) Observations made during the play sessions, as researchers took notes on player interactions, communication dynamics, comments and any difficulties encountered; (4) Semi-structured post-game interviews to gather more details about the gameplay, educational aspect of the game, communication effectiveness, possible improvements and overall satisfaction. (5) Pictorial Likert scale questionnaire designed for the child participants to gather feedback on their enjoyment of the game, perceived difficulty, favourite aspects and experience playing with the adult.

Regarding the quantitative data, the pretest-posttest scores and in-game metrics were analysed to identify possible trends for future exploration. As for the qualitative data, the interviews and observations were subjected to thematic analysis [3], using Taguette [24], to uncover recurring patterns, player opinions and suggestions.

### 4.2 Results

**Semi-structured Interview Analysis:** We conducted a thematic analysis to evaluate this data. Since the interviews were conducted with both the adult and child, the nomenclature to identify players is, for example, A1 and C1 for the first adult participant and the first child participant, respectively.

*Intergenerational Collaboration* – Several participants highlighted that the game's collaborative nature was key to both their enjoyment and success in completing tasks ("*I had to say the colour of the trash so the child could put it in the right bin.*" - A2). This gameplay mechanic encouraged conversations about strategies and solutions to solve the mini-games, which in turn led to a better understanding of the topics ("*Without communicating with each other, we would not be successful.*" - A4). These interactions also facilitated knowledge transfer between players ("*What can we use for renewable energy?*" - A2, "*The sun.*" - C2, "*We can also use the wind and water.*" - A2). Furthermore, the game offered a platform for guardians to engage in meaningful discussions with their children about difficult topics, presenting and explaining them in a way that both children and adults could understand. It also encouraged conversations on issues that adult participants acknowledged were not talked about at home or were difficult to explain.

*Engagement vs. Challenge* – Aqua's mini-game was frequently mentioned as the most engaging, with 67% of participants stating it was their favourite game. On the other hand, some participants found Verdis' mini-game difficult ("*I found the recycling part the most challenging because the child doesn't yet have a strong sense of how to recycle.*" - A3). These findings suggest that refinement of some game mechanics or improving players' understanding of the topics is necessary to further elevate the overall user experience.

*Intergenerational Environmental Knowledge* – Participants reported that the game positively contributed to their understanding of sustainability topics. Adults appreciated how the mini-games, quizzes and explanations reinforced environmental knowledge ("*It refreshed the topics [...]*" - A2; "*My memory was refreshed on things I already knew, but I was also able to learn new things.*" - A5; "*The game talked about things I didn't know yet.*" - C3). Another notable outcome of Mystiria is its ability to foster intergenerational learning by providing, throughout the game, multiple moments where this knowledge transfer happens between players. As noted by A1, *"As the topics were given, it was easier to talk about them with the child."*.

**Feedback from Children:** After the game, children answered a pictorial Likert scale questionnaire. Results were overwhelmingly positive - 100% found the game fun, underlining the impact of the game's mechanics in contributing to enjoyment and entertainment. Children also expressed an affinity to the game's characters, which likely contributed to an emotional engagement and immersion in the narrative. Notably, 66.7% of children rated "I liked playing with the adult" at the highest level, emphasising the appeal and importance of intergenerational collaboration in gameplay.

**NEP Scale Results**: The NEP scale was used to analyse adult participants' environmental attitudes and awareness before and after engaging with Mystiria. The results were categorized across its five dimensions: (1) *Reality of Limits to Growth* (pre-game: M=9.83, SD=2.04; post-game: M=10.67, SD=2.34) – Increase indicates a heightened awareness of resource limitations; (2) *Anti-Anthropocentrism* (pre-game: M=14.00, SD=1.26; post-game: M=14.67, SD=0.82) – Greater recognition of nature's value independent of its utility to humans; (3) *Fragility of Nature's Balance* (pre-game: M=13.33, SD=1.37; post-game: M=13.83, SD=2.04) – Indicates a better appreciation of the ecological interdependence; (4) *Rejection of exceptionalism* (pre-game: M=11.00, SD=3.16; post-game: M=11.33, SD=3.08) – Small shift in rejecting the notion that humans are superior to nature; (5) *Possibility of an eco-crisis* (pre-game: M=12.67, SD=1.51; post-game: M=13.83, SD=1.94) – Strongest increase, suggesting Mystiria was effective in raising awareness of a potential ecological crisis.

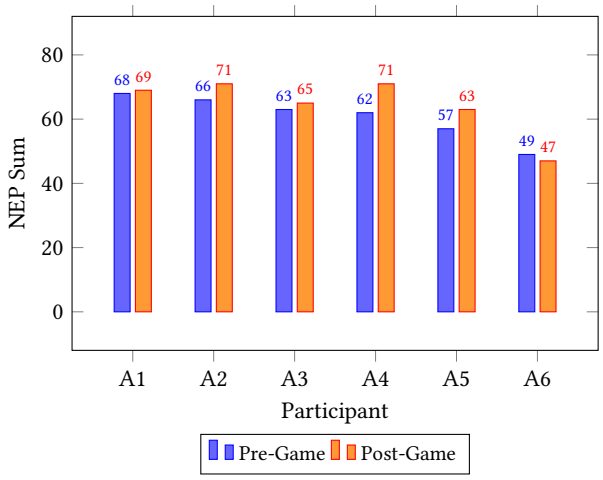


**Figure 2: NEP Scale Sum**

Summing the NEP scores helps assess overall environmental attitudes, with higher totals reflecting stronger pro-environmental beliefs. Most participants showed improvement, while one showed a slight decline (see Fig.2).

**GEQ Scale Results**: We used the core and post-game modules of the GEQ scale to evaluate in-game experiences and reflections after gameplay, respectively. The core module consists of seven components: *Competence* (M=3.17, SD=0.24), *Sensory and Imaginative Immersion* (M=3.69, SD=0.34), *Flow* (M=2.40, SD=1.04), *Tension/Annoyance* (M=0.11, SD=0.19), Challenge (M=1.33, SD=0.77), *Negative affect* (M=0.21, SD=0.42) and *Positive affect* (M=3.80, SD=0.14). The post-game module has the four following components: *Positive experience* (M=3.36, SD=0.37), *Negative experience* (M=0.31, SD=0.36), *Tiredness* (M=0.00, SD=0.00) and *Returning to reality* (M=1.11, SD=1.21). The evaluation reveals a largely positive gameplay experience with strong engagement, enjoyment and immersion, with minimal negative impacts. On the other hand, the variability in flow provides opportunities to further refine the game in future iterations.

## 5 Discussion

Mystiria demonstrates the potential of intergenerational collaborative games to raise awareness about climate change and enhance knowledge transfer between adults and children. Consistent with prior research [8, 11, 26], the game promoted active engagement, communication, and collaboration, as evidenced by the high GEQ scores. These results confirm the effectiveness of asymmetric game mechanics, such as the ones mentioned by Pais et al.[23], in promoting collaboration and knowledge transfer.

Regarding RQ1, the findings indicate that Mystiria's collaborative and asymmetric mini-games were a key element that contributed to user engagement and enjoyment. The need for players to communicate to progress in the game reinforced engagement, aligning with previous research that highlights how collaborative gameplay increases immersion [10]. Furthermore, children enjoyed playing with the adults, emphasizing the appeal of intergenerational play. The narrative also enhanced engagement by providing a purpose to the gameplay actions, aligning with research on how well-integrated narratives improve user experience [6].

Concerning RQ2, the observations and user feedback suggest that meaningful discussions regarding climate change were facilitated in the game, especially during the quizzes and narrative prompts. Adults sometimes guided children in having a better understanding of these topics, reinforcing research on the importance of intergenerational learning in serious games [18, 29]. The adult's presence seemed to support the child's learning process. Additionally, the adults also seemed to improve their knowledge, as indicated by higher accuracy in post-game questionnaire responses. This highlights the game's potential as a sustainability education tool, aligning with studies advocating for game-based learning [5, 26]. Findings also show that adults acted as facilitators, helping children process and better understand sustainability topics. This supports existing literature on the positive influence adult role models have in increasing engagement and knowledge retention [28].

Mystiria succeeded in addressing challenging topics of sustainability and climate change, while also creating a tool for adults to talk about hard topics with children in an enjoyable and accessible manner. Through embedded conversation prompts and localized content, the game encouraged collaborative reflection on real-world environmental issues, reinforcing the urgency of climate action. Despite the positive outcomes, some limitations should be acknowledged. The small sample size and localized focus may impact the generalization of the findings. While a localized approach offers higher engagement [25], it may limit Mystiria's relevance to different geographical contexts. Furthermore, players expressed that Verdis' mini-game was the most challenging, suggesting that its complexity should be reconsidered.

Building on this pilot study, future research should expand to a larger and demographically varied sample size to enable statistical validation of results. The map of Mystiria and the colour of the recycling bins should adapt and mirror the real-world geographical location of where the game is being played, as a localised approach has higher chances of engaging participants. Additionally, Verdis' game mechanics should be revised, and the overall gameplay could dynamically adapt to ensure an engaging, yet accessible, experience for diverse player groups.

## 6 Conclusion

Mystiria poses a promising step toward leveraging serious games for intergenerational climate change education. By engaging adults and children in collaborative gameplay, the game seems to have successfully fostered intergenerational dialogue and knowledge transfer on sustainability topics. Even though our work has certain limitations – a small sample size and localised focus – the results demonstrate the potential these approaches have in addressing urgent climate change challenges. With further refinements to the game and adaptations for different locales, Mystiria could potentially serve as an example for serious games aimed at cultivating a shared sense of environmental responsibility across generations.

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