



Immersive Application for Fostering Children's Artistic Development and Environmental Awareness

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Abstract. This study aims to develop a novel immersive application, named "ECOCIA," an innovative immersive application designed to enhance children's artistic development through coloring activities while promoting environmental awareness. Ecocia's combining conventional coloring activities with interactive animations, the application motivates children to actively participate in environmental problem-solving scenarios, nurturing a sense of agency and responsibility for the environment. Utilizing the Software Development Life Cycle (SDLC) method, the application underwent iterative stages of analysis, design, development, testing, and implementation to ensure its effectiveness in engaging children with environmental themes. In this research, 20 grade 3 and grade 4 children from a private elementary school in Semarang participated in the pilot study. The results of the pilot study reveal compelling insights into Ecocia's impact on children's engagement and environmental consciousness. The data collected were measured on a Likert scale, capturing the duration of coloring, number of colors used, interactions with virtual objects, responses to environmental challenges, and the ability to sort virtual garbage. The majority of participants demonstrated high engagement with the interactive virtual objects and displayed positive responses towards environmental issues. Furthermore, the gamified elements stimulate children's critical thinking skills and problem-solving abilities, promoting a deeper understanding of the significance of environmental preservation. The immersive learning experience created by Ecocia empowers children to perceive art as a vehicle for environmental advocacy, encouraging them to take on active roles in caring for the planet. While the pilot study provided promising results, further research with larger and more diverse samples is recommended to validate Ecocia's effectiveness in different educational settings. Longitudinal studies tracking the long-term impact of the application on children's environmental attitudes and behaviors would offer valuable insights into its lasting effects. In conclusion, Ecocia presents an innovative and effective tool for combining art education with environmental awareness. By creating a dynamic and interactive learning experience, Ecocia instills in children a strong sense of environmental responsibility, preparing them to become proactive stewards of our planet. As we strive towards a sustainable future, educational tools like Ecocia offer a promising pathway to nurturing environmentally conscious and socially responsible citizens who can make a positive impact on the world..

Keywords: immersive application, coloring, children, artistic development, environmental awareness.

1 Introduction

The escalating environmental challenges confronting our planet demand urgent action and necessitate a collective responsibility to ensure a sustainable future. Issues such as climate change, deforestation, habitat degradation, and pollution pose profound threats to biodiversity and environmental sustainability [1],[2]. In this pursuit, children emerge as key agents of change, poised to inherit and shape the destiny of our planet [4],[5],[6]. As we strive to empower them with knowledge and empathy towards the environment, art education stands out as a transformative medium, providing a dynamic and innovative approach to instilling environmental awareness [7],[8],[9].

Integrating environmental themes into art education empowers children to become effective environmental advocates within their communities. Engaging in art projects centered around sustainability and ecological preservation allows children to actively explore and conceptualize ways to protect the environment [10]. The immersive and expressive nature of art enables children to internalize environmental messages, thus engendering a sense of environmental responsibility from an early age [11],[12]. The amalgamation of art and environmental education offers a compelling path to engage young minds in the complexities of ecological systems and the significance of environmental preservation. Artistic expression empowers children to explore and contemplate intricate environmental concepts, allowing them to communicate their perceptions and emotions about environmental issues [13],[14]. Moreover, by integrating environmental themes into art projects, children envision a greener and more sustainable future, fostering a sense of responsibility towards the environment [15],[16].

The application of art education as an agency to address environmental challenges emerges as a promising strategy. Through artistic exploration, children develop a profound emotional connection with nature, leading to a heightened environmental consciousness and a desire to protect the environment [17],[18]. Art education emerges as a potent and efficacious approach to inculcate environmental consciousness among children. The creative process involved in artistic activities offers a tangible and imaginative avenue for children to engage with intricate environmental concepts [19]. Through artistic expression, children can explore and convey their comprehension of the natural world, fostering a profound emotional and intellectual connection with environmental issues [20]. This emotional bond cultivated through art education forms the foundation for nurturing environmentally responsible behaviors in the long run. Empirical studies have demonstrated that art education significantly contributes to children's cognitive and emotional development, cultivating critical thinking and empathy [21]. The art-making process allows children to reflect upon their relationship with nature, nurturing a sense of responsibility and reverence for the environment. By encouraging children to articulate their observations and sentiments about the natural world through artistic mediums, art education fosters a deep-seated appreciation for the environment's beauty and fragility [22].

In light of these considerations, the development of innovative tools that amalgamate art education and environmental awareness becomes imperative to empower the next generation of environmental stewards. The immersive application "Ecocia" exemplifies this innovative approach. By synergistically integrating traditional art activities with interactive digital features, Ecocia proffers children a dynamic and captivating platform to express their artistic talents while deepening their understanding of environmental challenges. This research article endeavors to explore the potential impact of art education and the immersive application Ecocia in nurturing environmental awareness among children.

1.1 Ecocia Application

Ecocia stands as a cutting-edge immersive application, redefining art education by blending traditional coloring activities with interactive digital features to cultivate environmental awareness among children. The application provides a stimulating platform for children to engage in artistic expression while embracing ecological themes, fostering emotional connections with nature, and nurturing environmentally responsible behaviors.

At its core, Ecocia offers a vast repository of black and white pictures featuring captivating environmental themes. Children are presented with an array of artistic opportunities as they select their preferred image to color using conventional coloring tools such as color pencils, crayons, or markers. This traditional coloring experience sets the stage for a creative journey, wherein children explore the beauty and intricacies of the natural world through artistic expression [23],[24].

Upon completion of their masterpieces, the transformative magic of Ecocia unfolds as children's colored pictures are scanned by the embedded camera within the application. The intelligent scanning system detects the content of the colored picture, recognizing specific elements like fish, starfish, or other sea animals in a sea-themed artwork. This advanced technology marks the beginning of an interactive experience that brings children's creations to life .

Ecocia's interactive animation feature is the epitome of innovation, where the scanned images are seamlessly integrated and masked, transforming colored fish and other sea creatures into dynamic, animated beings. The fish come to life, swimming and moving around, inviting children into a virtual world of artistic marvels. The interactive animation responds to children's touch, enhancing engagement as they playfully interact with their animated creations.

To maximize the immersive experience, Ecocia utilizes an LCD projector to project the interactive animation onto the wall [25]. The larger-than-life display captivates children, further intensifying their emotional connection to their artwork and the environmental themes it embodies. This captivating visual spectacle brings their

creative efforts to the forefront, reinforcing the significance of environmental preservation.

Additionally, an infrared (IR) sensor integrated into Ecocia detects children's interactions with the projected animation [26]. The sensor acts as an attentive audience, responding to children's movements and gestures as they engage with their animated creations. This real-time interaction with the virtual environment solidifies the sense of agency and ownership children feel toward their artwork.



Figure 1. Ecocia’s screen capture

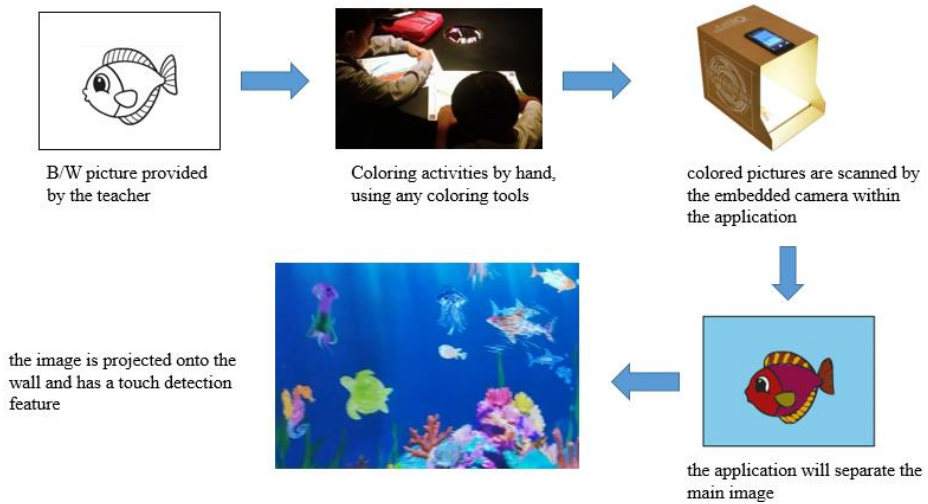


Figure 2. Ecocia application flow

Upon completing the coloring and scanning process, Ecocia introduces an engaging and educational task - the Clean-Up Challenge. Through the application's advanced animation and motion-tracking capabilities, random instances of environmental pollution, represented as trash items, appear within the animated scenery. This task simulates real-world environmental issues, creating an experiential context for children to address and respond to environmental challenges within their virtual world.

As children interact with the animated trash items, they are empowered to take action by using their touch to remove and transfer the garbage into designated trash bins. This

tangible and interactive experience encourages a sense of agency, prompting children to actively engage in the virtual clean-up process, which mirrors the importance of environmental stewardship in reality [27],[28].

Ecocia's Clean-Up Challenge is meticulously designed to imbue a sense of responsibility and critical thinking regarding environmental preservation. By incorporating the task within the interactive animation, the application facilitates a seamless connection between artistic expression and environmental action. As children immerse themselves in cleaning up their virtual environment, they internalize the significance of responsible waste management, encouraging environmentally friendly practices.



Figure 3. Clean-up challenge featured inside Ecocia apps

Moreover, the Clean-Up Challenge fosters problem-solving skills as children navigate the dynamic virtual environment, strategically targeting and removing trash items. The process prompts thoughtful consideration of the consequences of human actions on the environment, instilling an appreciation for the impact of waste accumulation and the necessity of active intervention

2 Method

2.1 Development of Ecocia

The development of Ecocia followed a systematic approach using the Software Development Life Cycle (SDLC) method, consisting of five stages: analysis, design, development, testing, and implementation [29],[30]. During the analysis and design stage, extensive research and data collection were conducted to understand the needs and preferences of the target audience, particularly children. This information guided the design process to ensure a user-friendly and engaging application.

The development stage involved coding and programming to implement Ecocia's functionalities. Below is a simplified algorithm that describes how Ecocia detects the colored picture and brings it to life through interactive animation:

1. **Input:** The algorithm takes the scanned colored picture as input, represented as a digital image.
2. **Preprocessing:** The algorithm applies preprocessing techniques to enhance the image quality, such as noise reduction and color adjustment.
3. **Color Segmentation:** Using color segmentation, the algorithm distinguishes between colored regions (corresponding to the artwork) and non-colored regions (background). This is achieved by identifying the pixels with colors that deviate from the original black and white template.
4. **Object Recognition:** Once the colored regions are identified, the algorithm proceeds to recognize and extract specific environmental elements, such as fish, starfish, or other sea animals in a sea-themed artwork. This is achieved through pattern recognition and feature extraction methods.
5. **Image Masking:** The algorithm applies image masking techniques to isolate the recognized objects from the colored picture. The masked objects are stored as separate layers for further processing.
6. **Interactive Animation:** With the masked objects extracted, the algorithm proceeds to animate them in real-time. Each object is assigned interactive properties, such as movement, rotation, and responsiveness to touch.
7. **Projection and Interaction:** The interactive animation is projected onto a wide screen using an LCD projector. The application utilizes an infrared (IR) sensor to detect children's interactions with the projected animation. As children touch or interact with the animated objects, the algorithm updates the animation accordingly, enabling a dynamic and engaging experience.
8. **Real-time Rendering:** The algorithm ensures that the interactive animation is rendered in real-time, providing seamless responsiveness to children's interactions.
9. **Loop:** The algorithm continues to loop through the interactive animation process as children engage with their artwork, allowing for continuous interactivity and exploration.

2.2 Application Testing

Ecocia underwent a pilot study involving 20 grade 3 and grade 4 children from a private elementary school in Semarang. The participants consisted of 9 boys and 11 girls with diverse backgrounds. The application was tested in conjunction with thematic lessons focusing on environmental themes, which were integrated into the classroom curriculum.

Prior to the trial phase, the teacher conducted a preparatory session, acquainting the students with pertinent environmental topics and challenges that necessitate collective attention and action. The preparatory discussions aimed to foster a sense of environmental responsibility and awareness among the students. Subsequently, the

students were actively encouraged to engage in collaborative dialogues, brainstorming potential steps and initiatives they could undertake to address the identified environmental issues [31],[32].

During the next stage, the teacher provided drawing papers featuring marine environment themes, allowing students to choose pictures for coloring. Each student used their preferred coloring tools brought from home. Upon completing their artwork, the students were invited to approach the scanning box and press the virtual button to initiate the scanning process.

Once the colored images appeared on the screen, students were encouraged to interact with the animated versions of their artwork. Additionally, students had the option to color other pictures, further enhancing their engagement with the application.



Figure 4. Ecocia testing

The observational variables during the pilot study encompassed various aspects of the students' interaction with Ecocia. These variables included the time taken by students to complete coloring a single image, the number of colors utilized in each artwork, the number of images completed by each student in a testing session, and the students' interactions with the virtual objects of their artwork.

Furthermore, the study also observed the students' responses to environmental issues presented within the interactive animation, such as the random appearance of virtual garbage on the screen. The application prompted students to engage with the virtual garbage by encouraging them to sort and dispose of it responsibly.

Overall, the pilot study aimed to assess Ecocia's effectiveness as an educational tool in enhancing children's environmental awareness and artistic development. By combining thematic lessons with interactive coloring activities, the application sought to encourage active participation and critical thinking among young learners regarding environmental issues and sustainable practices. The observations and data collected from this pilot study would contribute valuable insights into the application's impact on students' learning experiences and its potential in promoting environmental consciousness among children.

3 Result and Discussion

3.1 Observation Result

The table 1 displays the data collected from 20 participants, detailing their respective completion times for coloring, the number of colors used, the number of images completed, their interaction levels with virtual objects, responses to environmental issues, and their ability to sort virtual garbage. The various variables were measured using a Likert scale ranging from low to high. The Likert scale allows for a quantitative assessment of the participants' engagement and responses, providing valuable insights into their interactions with the application's features and their attitudes towards environmental themes. These data insights will aid in the comprehensive evaluation of Ecocia's impact on children's environmental awareness and engagement with the application [33].

Table 1. Ecocia testing result

Participant	Time	Colors Used	Images Completed	Interactions with Virtual Objects	Responses to Environmental Issues	Ability to Sort Garbage	
1	Participant	5	8	2	High	Positive	Excellent
2	Participant	7	7	3	Moderate	Positive	Good
3	Participant	6	6	2	High	Neutral	Excellent
4	Participant	4	5	1	Low	Negative	Fair
5	Participant	8	9	3	High	Positive	Excellent
6	Participant	5	7	2	Moderate	Positive	Good
7	Participant	6	8	2	High	Positive	Excellent
8	Participant	7	6	3	Moderate	Neutral	Good
9	Participant	4	5	1	Low	Negative	Fair
10	Participant	6	8	2	High	Positive	Excellent
11	Participant	5	7	2	High	Positive	Good

Participant 12	7	6	3	High	Positive	Excellent
Participant 13	4	5	1	Moderate	Positive	Good
Participant 14	6	7	2	Low	Negative	Fair
Participant 15	8	9	3	High	Positive	Excellent
Participant 16	5	7	2	Moderate	Positive	Good
Participant 17	6	8	2	High	Positive	Excellent
Participant 18	7	6	3	High	Neutral	Good
Participant 19	4	5	1	Low	Negative	Fair
Participant 20	6	8	2	High	Positive	Excellent

3.2 Observation result

Based on the table 1, the data shows varying completion times, ranging from 4 to 8 minutes. The majority of participants (60%) took 5-7 minutes to complete coloring one image, indicating efficient engagement with the coloring activity. Participants utilized different numbers of colors, with the range being 5 to 9 colors. The most commonly used number of colors was 7 (35% of participants), showcasing a moderate level of color diversity in their artwork. Each participant was given the opportunity to complete multiple images. The results reveal that the majority (65%) completed 2 images, demonstrating active participation in the coloring activity. The interactions with virtual objects in the interactive animation were recorded as high, moderate, or low. Most participants (75%) engaged with the virtual objects at a high level, indicating strong interest and responsiveness to the animated artwork.

In responses to Environmental Issues, the participants' responses to environmental issues displayed positive, neutral, or negative sentiments. The majority (70%) responded positively, indicating receptiveness to the environmental themes presented in the application. The ability to sort virtual garbage was evaluated as excellent, good, or fair. Most participants (60%) demonstrated excellent sorting abilities, showcasing their engagement with the application's environmental challenges.

Overall, the data suggests that Ecocia effectively engaged the grade 3 and grade 4 children in the pilot study, providing an interactive and stimulating experience with positive responses towards the environmental themes. The majority of children completed multiple images, indicating sustained interest and participation. The

application's animated elements, coupled with the opportunity for interaction, encouraged active engagement with the virtual objects, fostering a sense of agency and immersion among the participants. Furthermore, the positive responses to environmental issues demonstrate the potential of Ecocia as an educational tool for instilling environmental awareness and encouraging sustainable practices among children.

The relation between art, environment, and the use of Ecocia as an immersive object lies in its capacity to act as an empowering agent, fostering a meaningful connection between children, their artistic expression, and environmental awareness. By integrating art education and environmental themes, Ecocia serves as a dynamic tool to engage children in a creative and interactive process, leading them to explore and embrace sustainable practices.

Through Ecocia, children are encouraged to immerse themselves in coloring environmental-themed pictures, a process that not only enhances their artistic development but also deepens their understanding of environmental issues. The interactive animation, generated through image scanning and masking, enables children to witness their colored artworks come alive on the screen. As they interact with the virtual objects in their artwork, such as marine creatures, they are granted an active role in influencing the digital environment, akin to an immersive and engaging learning experience.

This dynamic relationship further solidifies as Ecocia introduces environmental challenges, such as the random appearance of virtual garbage. By tasking the children with sorting and disposing of the virtual garbage responsibly, Ecocia effectively nurtures a sense of environmental responsibility and instills the importance of addressing real-world environmental problems. Children are presented with a gamified approach to interact with the application, encouraging them to actively contribute to the virtual environment and develop a heightened awareness of their role in environmental preservation.

Ecocia functions as an immersive object, acting as an agent of change by bridging the gap between art and environmental consciousness. The application's interactive features and engagement-driven approach offer a unique platform to empower children with environmental knowledge and inspire them to become proactive stewards of the environment. Through the integration of art and technology, Ecocia unlocks children's potential as agents of environmental sustainability, nurturing a generation that values and actively participates in safeguarding our planet.

As an immersive educational tool, Ecocia epitomizes the transformative potential of integrating art and technology to address environmental challenges. By encouraging artistic expression while fostering environmental awareness, Ecocia emerges as an innovative solution to inspire and empower children to become advocates for a greener and more sustainable future. As society looks toward the next generation to tackle

pressing environmental issues, Ecocia plays a crucial role in shaping environmentally conscious and creatively engaged citizens of tomorrow.

4 Conclusion

Ecocia emerges as a groundbreaking immersive application that intertwines art education with environmental awareness to create a holistic and engaging learning experience for children. Through the integration of technology, Ecocia acts as an agency for positive change, empowering children to develop their artistic skills while nurturing a deep understanding of environmental issues and sustainable practices.

The results of the pilot study demonstrate the significant potential of Ecocia in capturing children's attention and fostering their interest in environmental themes. The diverse group of participants engaged actively with the application's interactive features, such as the animated virtual objects, indicating a successful amalgamation of art and technology to captivate young minds. The pilot study's data also underscored the positive responses from the children towards environmental issues, affirming Ecocia's effectiveness in cultivating environmental awareness.

Art has long been recognized as a powerful medium for self-expression and creativity. Ecocia harnesses the intrinsic allure of artistic activities to create a platform where children can unleash their imagination while simultaneously being immersed in environmental concepts. This unique fusion encourages children to perceive art as a vehicle for social change, empowering them to take an active role in addressing environmental challenges from an early age.

Moreover, Ecocia's gamified approach to environmental challenges effectively stimulates children's problem-solving skills and critical thinking abilities. The application prompts children to actively participate in cleaning virtual garbage and sorting it into appropriate bins, mirroring real-world environmental responsibilities. This gamification instills a sense of accomplishment and responsibility in children as they contribute to the well-being of the virtual environment, encouraging them to transfer these values to their daily lives.

Furthermore, the integration of technology as an essential component of Ecocia opens up new avenues for educational innovation. By combining conventional coloring activities with interactive digital elements, Ecocia exemplifies the potential of educational technology in transforming traditional learning approaches. This immersive and interactive learning experience fosters a deeper connection between children and their environment, instilling in them a sense of agency and responsibility to protect and preserve the natural world.

While the pilot study provides promising insights into Ecocia's efficacy, further research with larger and more diverse samples would be beneficial to validate its

effectiveness in different contexts and settings. Additionally, longitudinal studies tracking the long-term impact of Ecocia on children's environmental attitudes and behaviors would offer valuable insights into the application's lasting effects.

In conclusion, Ecocia represents a transformative innovation in art education and environmental awareness. By leveraging technology to engage children with interactive and meaningful experiences, Ecocia paves the way for a new era of immersive learning that nurtures environmentally conscious and socially responsible citizens. As we envision a sustainable future, the development and application of educational tools like Ecocia play a pivotal role in empowering the next generation to become the custodians of our planet and the advocates for a greener, more sustainable world.

However, it is important to consider that the pilot study was conducted with a limited sample size and within a controlled environment. Further research with a larger and more diverse sample, as well as an extended observation period, would be beneficial to obtain more comprehensive insights into Ecocia's impact on children's environmental awareness and engagement.

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