



Fostering Environmental Awareness and Sustainable Problem-Solving in Early Childhood: Design Thinking Approaches to Plastic Waste Education

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Abstract. This research investigates environmental awareness and sustainable problem-solving skills regarding plastic waste in learning experiences based on the design thinking process. The study employed a qualitative methodology with a sample group of 17 early childhood children (aged 5-6 years) from the Demonstration School of Khon Kaen University, Kindergarten Division. Data were collected through observations and interviews with children, teachers, and parents. The results revealed that children developed an awareness of the environmental impact of plastic waste, connecting real-life problems with environmental impacts and subsequently developed alternative solutions to plastic waste problems. For instance, using alternatives to plastic bags, choosing reusable items, avoiding single-use plastics, implementing waste management strategies, and recycling. In addition, children demonstrated the ability to communicate and encourage others to reduce plastic waste, including inviting parents to participate in environmental conservation and waste collection activities. The research findings indicate that learning experiences based on the design thinking process enhance children's plastic consumption behaviors, foster environmental awareness, and develop systematic problem-solving skills. Additionally, children gained a deeper understanding of plastic waste problems, identified potential solutions, and implemented them in real-world contexts, demonstrating that even at an early age, children can positively influence sustainable practices within their families and communities.

Keywords: Environmental Awareness, Problem-Solving Skills, Learning Experiences, Design Thinking, Early Childhood

1. Introduction

Environmental problems are intensifying globally, with plastic waste pollution emerging as a critical issue requiring urgent intervention. The Global Risks Report 2024 (World Economic Forum, 2024) highlights extreme weather events as a major threat to ecosystems. In Thailand, waste management remains a pressing issue. Data from the Pollution Control Department (2022) reveals that Thailand generates 24.98 million tons of municipal solid waste annually, or 68,434 tons per day, with single-use plastic packaging accounting for 2.32 million tons (38.02%). Thailand ranks among the top six countries contributing to marine plastic pollution, according to a global marine debris survey conducted by researchers from the University of Georgia. Furthermore, the Pollution

Control Department (2023) reports that Thailand produces a substantial amount of plastic waste, underscoring the urgency of implementing plastic reduction strategies. Beyond its environmental consequences, this issue also reflects unsustainable consumption behaviors, necessitating immediate intervention.

The 565 children attending the Demonstration School of Khon Kaen University, Kindergarten Division, are 4-6 years. It is one of the largest kindergartens in Khon Kaen Province. The school operates from 07:30 to 17:00, providing care that includes morning snacks, lunch, and afternoon snacks. This results in the substantial use of single-use plastic packaging—such as milk bags, food boxes, and plastic water bottles—leading to the generation of approximately 1,000 pieces of plastic waste each day. This reliance on single-use plastics presents significant environmental risks if not properly managed. Fostering environmental awareness from an early age is crucial to mitigating long-term ecological challenges. Learning experiences centered on problem-solving and creative thinking are crucial for early childhood sustainability education, a point underscored by research from Elliott & Davis (2009). and active child participation lay a strong foundation for future sustainable practices. The researchers highlight the importance of supportive government policies and suggest that early childhood educators adapt their teaching methods and learning management strategies to better prepare children for future environmental challenges. In addition, a study by Sihvonen et al. (2024) examined a recycling project in a Finnish kindergarten for children aged 4-6. The research found that hands-on learning through play and recycling activities effectively promotes environmental awareness among children. Furthermore, collaboration between teachers and parents was identified as crucial for fostering sustainable behavior.

Developing problem-solving skills in early childhood is an important approach to creating awareness, responsibility, and participation in solving environmental problems. Problem-solving involves employing logical thinking to address challenges. Research by Tempeim et al., 2023 indicates that creative problem-solving skills help individuals cope with problems and obstacles through innovative methods that differ from conventional approaches. The design thinking process serves as an important tool for developing creative problem-solving skills and generating new ideas, emphasizing learning through practice to find user-centered solutions that focus on creating tangible future outcomes to meet the needs of users and various situations (Vitoon & Butkatunyoo, 2022)

Despite increasing recognition of the importance of early childhood environmental education, research explicitly targeting the development of environmental awareness and sustainable problem-solving skills in young children remains limited—particularly concerning issues such as plastic waste (Nature of Early Play. (n.d.); Playto. (2024). This gap is partly attributed to prevailing assumptions among teachers and parents that young children lack the cognitive capacity to grasp complex environmental challenges. However, Veeravatnanond (2003) contends that environmental education for young learners should prioritize building conceptual understanding. When children receive appropriate environmental information, their knowledge and understanding expand, equipping them to analyze environmental data, raise their awareness, and make more informed decisions about resource use. Emerging evidence highlights the value of early childhood environmental education (ECEE) in fostering not only environmental literacy, but also cognitive, social-emotional, and problem-solving skills through play-based, nature-rich, and hands-on approaches (Nature of Early Play. (n.d.); Playto. 2024). Programs that include inquiry-based and participatory activities have demonstrated positive outcomes in promoting environmental knowledge, stewardship values, and a sense of agency in young children (Veeravatnanond, 2003; (Playto, 2024). This study investigates how learning experiences structured around the design thinking process can enhance environmental awareness and problem-solving skills in early childhood, focusing specifically on plastic waste (McCarthy, 2022). They are adopting the framework, the studies utilizes the

following five phases: Empathize, Define, Ideate, Prototype, and Test. The iterative, hands-on nature of the design thinking process actively engages children in step-by-step problem-solving and supports conceptual learning (Yalçın, 2022). By exploring the integration of design thinking in plastic waste education for young children, this study seeks to establish evidence-based guidelines for fostering environmental awareness and problem-solving capabilities. Ultimately, strengthening these foundational skills in early childhood may contribute to nurturing a generation of environmentally responsible citizens prepared to address pressing sustainability challenges in the future.

2. Methodology

This study employs a qualitative case study approach to examine environmental awareness and sustainable problem-solving skills in young children. The study sample consisted of 17 young children (aged 5-6 years), enrolled in kindergarten 2 at the Demonstration School of Khon Kaen University. Initially, the study intended to recruit 37 children; however, only 17 parents provided informed consent in compliance with ethical research approval procedures. The reduction in sample size was due to various factors, including parental concerns regarding their children's participation in interviews and time constraints. Despite this limitation, the study ensured data richness by employing in-depth interviews, content analysis, and behavioral observation to obtain comprehensive insights.

Data were collected during the second semester of the 2024 academic year over six weeks (January to March 2025), with sessions held three days per week for 50 minutes per day. This study focused on fostering environmental awareness and sustainable problem-solving skills related to plastic waste through learning experiences based on the design thinking process.

In-depth data collection from the sample group was conducted through interviews, divided into:

In-depth interviews with children included five questions on environmental awareness and five on plastic waste problem-solving (totaling ten questions). The interviews were conducted one-on-one after the activities, with audio recordings and key content transcribed for analysis.

Interviews with teachers and parents gathered insights on behavioral changes in children's environmental awareness and sustainable problem-solving skills, both at school and at home.

Data obtained from the interviews were analyzed using content and behavioral analysis (Clarke & Brau, 2017). Observations, transcription of audio recordings, and photographs were examined to assess children's thoughts, expressions, and behaviors related to environmental awareness and sustainable problem-solving skills. To enhance credibility, data triangulation was applied by comparing the perspectives of children, parents, and teachers. Additionally, member checking was conducted to verify the accuracy of transcribed data.

This research was certified by the Human Ethics Committee of Khon Kaen University on January 14, 2025 (Approval No. HE673529), with informed consent obtained from teachers and parents. The researcher has strictly adhered to ethical regulations.

3. Findings

Engaging children in learning about plastic waste through the design thinking process offers a dynamic, student-centered approach that cultivates both environmental awareness and essential problem-solving skills. Design thinking encourages young learners to investigate real-world problems with empathy, creativity, and collaboration, making environmental education more meaningful and actionable. This process not only helps children understand the complexities of issues like plastic waste but also transforms them

into active participants and innovators in seeking sustainable solutions (Pruneau et al., 2019; Sustainable Design Thinking, 2024)

3.1 Design Thinking Process

3.1.1 Empathize

The first step of the design thinking process is to enable children to learn and understand the plastic waste problems occurring in their daily lives. Teachers use challenging problem situations about plastic waste problems in the school, beginning with an exploration of the classroom garbage bins. This allows children to observe real objects, ask questions about the origin of the waste, and engage in critical thinking. The waste found in the classroom included plastic boxes, plastic milk bags, plastic water bottles, and paper. Children were able to identify the sources of this waste, recognizing that it originates from daily life activities. They engaged in a discussion about the types of waste generated in a day. One child said, “Plastic waste comes from humans using plastic and then throwing it away.” Another child added, “The garbage truck will take it to the garbage mountain.”

To enhance children’s understanding, teachers used the stories “Who Swallowed Garbage” and “Miriam with a Thousand Plastic Bags” as learning materials to stimulate discussion and analyze the impact of plastic waste on marine animals. After listening to the stories, many children reacted with shock and sadness upon realizing that plastic waste in the ocean is often mistaken for food by marine animals. Through guided discussions, teachers asked, “How do children feel when they hear that animals eat plastic waste?” One child reflected their thoughts and feelings by saying, “Miriam (the dugong) thought the plastic bag was food, ate it, and got a stomachache and died.” Another child commented, “It’s pitiful for the animals in the sea. The animals don’t know that plastic is not edible.” To further enhance children’s understanding of the problem, teachers showed a documentary on the environmental impact of plastic waste. After watching the documentary, some children began to question the human role in waste pollution, asking, “Why do people throw garbage in the water?” and “Will the garbage we throw away at school become garbage in the sea?” The teacher then posed the question, “Do the children think we contribute to plastic waste? Why?” One child responded, “The milk bags at school are plastic bags. Children drink milk every day, so there is a lot of waste.” Another child noted, “We contribute to plastic waste because the bread boxes we eat in the evening are also plastic.”

To further reinforce their understanding, children participated in an art activity of drawing on the topic “If plastic waste is in the sea, what will happen to marine animals?” This activity encouraged them to visually express their awareness of the problem and its environmental impact.

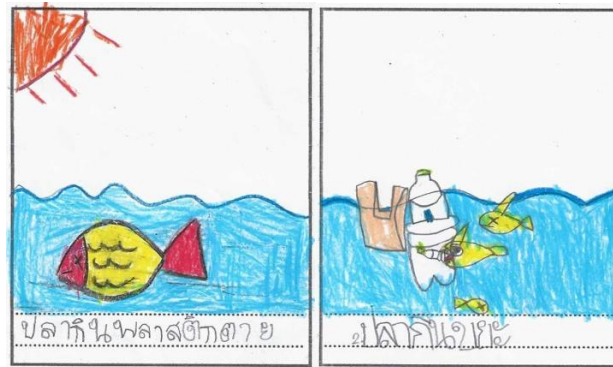


Figure 1: Children's drawing illustrates the impact of plastic pollution in the sea, showing fish dying after consuming plastic waste.

In summary, the empathize step in the design thinking process is a crucial first step as it allows children to develop a deep understanding of the impact of plastic waste on the environment. This is achieved by engaging in real-life experiences such as observation, exploration, storytelling, documentary viewing, discussion, exchange of opinions, and creative art drawing. Through these activities, children connect information with their learning experiences, enabling them to express their thoughts, emotions, and perspectives on environmental issues more clearly. The stage, "Empathize," is about understanding the plastic waste problem from the children's perspective. Teachers facilitated real-life explorations—such as investigating the school's garbage bins—allowing children to observe actual plastic waste and ask questions about its origins. Children encountered plastic boxes, milk bags, water bottles, and paper, leading discussions on how daily activities generate waste. To deepen their understanding, teachers used stories ("Who Swallowed Garbage" and "Miriam with a Thousand Plastic Bags") to illustrate the impact of plastic waste on marine life, evoking empathy and emotional responses in the children. Viewing a documentary further prompted critical questions about the human role in pollution, with children connecting their actions (e.g., using plastic milk bags) to broader environmental issues. Art activities, like drawing how plastic waste affects marine animals, helped children visually express their newfound awareness and emotions. This stage is critical for building empathy, a foundational principle in design thinking, and encourages children to connect their experiences and feelings to complex, real-world problems (SAGU Foundation, 2024; EdCan Network. (n.d.).

3.1.2 Define

The second step of the design thinking process builds upon children's understanding of waste issues to establish a problem framework that leads to brainstorming solutions in the subsequent step. Teachers demonstrate real-life situations by presenting snack boxes from the school—common examples of single-use plastic packaging. Children observe these items and respond to thought-provoking questions, such as: "These boxes are plastic waste in the school that is increasing every day. How do the children think we can get rid of this plastic waste?" Children expressed their opinions, suggesting solutions such as: "We can give it to the uncle at the recycling shop." Another child said, "We can recycle the plastic waste." A third child suggested, "We can use plastic boxes or bottles to make toys." These responses reflect that children have ideas for plastic waste management through recycling and reuse.

To facilitate the children's transition from understanding the plastic waste problem to defining a clear problem statement, the teacher guided them through reflective questioning

and discussions. By using real-world examples and posing thought-provoking questions, such as

The teacher presented the school's snack boxes, which are single-use plastic packaging, for the children to observe and posed a thought-provoking question:

"These boxes represent plastic waste in our school, the amount of which increases daily. Children, how do you think we can manage this plastic waste?"

The children were able to share various ideas on how to manage the plastic waste.

One child said, "We can take them to the uncle [or 'man'] at the waste buyer shop."

Another child said, "We can recycle the plastic waste."

Another child suggested, "We can use the plastic boxes or water bottles to make toys."

The children learned through hands-on activity. Most could sort the waste correctly, but some children still didn't fully understand the concept of biodegradable organic waste. Some children wondered, "Why do we have to put food scraps and leaves into the green bin?" This point of confusion prompted the teacher to reinforce the understanding of decomposition. As a result, the teacher planned an experiment on the decomposition of different types of waste for the next learning stage.



Figure 2: Children learn about waste separation and play a waste sorting game using different colored bins.

In addition, teachers incorporated videos and games on waste sorting as educational tools. During the activity, children practiced sorting waste into appropriately colored bins. It was found that many children were able to sort waste and dispose of it in the correct bins, but some children still did not understand the issue of biodegradable organic waste. Some children wondered, "Why do we have to throw food scraps and leaves in the green bin?" Their questions prompted the teacher to further explain decomposition by planning an experiment on how different types of waste break down in the next step.

In the "Define" stage, children, building on their awareness, collaboratively identified and articulated the core problems of plastic waste at school. Teachers presented single-use plastic snack boxes as tangible examples and led discussions with questions such as "How can we get rid of this plastic waste?" Children's responses—suggesting recycling, reusing for toys, and giving waste to recycling shops—showed their ability to conceptualize practical approaches for managing plastic waste. Through guided discussion, teachers helped the children frame the problem—understanding the environmental impact of not recycling, such as "mountains of garbage" and its smell, and the benefits of recycling, like "keeping the world cooler" and "preventing plastic from ending up in the sea." Waste sorting games revealed knowledge gaps (e.g., the role of green bins for organic waste), prompting teachers to plan decomposition experiments. This step is about synthesizing observations and identifying the specific aspects of the plastic waste issue that the children believe they can address, aligning with design thinking's focus on defining the problem space before ideating solutions (Wong, 2019; Sustainability Directory, n.d.).

3.1.3 Ideate

The third step of the design thinking process focuses on creating and presenting diverse, creative ideas to address plastic waste issues. This step is a continuation of the defined step

to reinforce a concrete understanding of the decomposition process of different types of waste. Teachers provided various types of snack packaging waste from the school, including banana leaves, leaves, plastic boxes, plastic bags, plastic cups, straws, paper plates, paper cups, foam containers, vegetable scraps, and fruits. Children observed and identified these materials as snack packaging from the school. The teacher then encouraged them to think critically by asking, “If we bury these items in the ground for six weeks, what do you think will happen?” Most children hypothesized that “plastic waste will disappear in the ground.” Some children hypothesized that “leaves and banana leaves would wither,” while others hypothesized that “vegetables and fruits might completely disappear.” To test these hypotheses, children experimented by burying the waste and observing the results. During the activity, it was found that the children were interested, excited, and enthusiastic about doing the activity. After six weeks, their hypotheses were tested by digging up the buried waste. Observations revealed that plastic waste and foam remained unchanged, while banana leaves, and paper had begun to decay. Vegetables and fruits decomposed and disappeared. The soil in the bin where vegetables and fruits were buried had many earthworms living in it. One child suggested, “If we don’t finish eating vegetables and fruits, we can bury them in the ground to feed the animals that live in the soil,” showing that the child gained new knowledge during the activity.



Figure 3: Children experimenting on the decomposition of various types of waste.

When children understand that each type of waste takes a different amount of time to decompose, especially plastic waste that takes hundreds of years to decompose, and that burying plastic waste is not a good solution, the children discussed and brainstormed to design methods to solve plastic waste problems, and expressed their ideas through art on the topic “How do children solve plastic waste problems?” The children proposed various solutions to plastic waste problems, such as suggesting, “When going shopping, use cloth bags or paper bags instead of plastic bags.” A group of children suggested, “When going to a milk shop or coffee shop with parents, bring your glasses instead of using the shop's plastic cups, and also don’t take plastic straws.”

One child suggested, “If we buy food from a convenience store, we shouldn’t take plastic spoons.” The child reasoned that if we bring the food back to eat at home, we already have spoons at home, so there is no need to use plastic spoons. Another child added, “After finishing a plastic water bottle, we can refill it instead of throwing it away.” A group of children suggested, “We can use plastic waste to make toys.” Another child noted, “Using banana leaves to wrap snacks instead of plastic boxes is better because banana leaves decompose naturally.” These ideas demonstrate that children can connect knowledge from the waste decomposition experiment, choosing to use natural and environmentally friendly materials instead of plastic, which takes a long time to decompose. The children’s creative solutions reflect a perspective on how to reduce plastic

utilization in everyday life, which represents a practical solution and aligns with the 3R concept:

Reduce plastic use by opting for eco-friendly alternatives such as bananas. leaves.

Reuse: Repurposing plastic waste for new functions, such as making toys.

Recycle: Choosing to refill plastic bottles instead of discarding them.

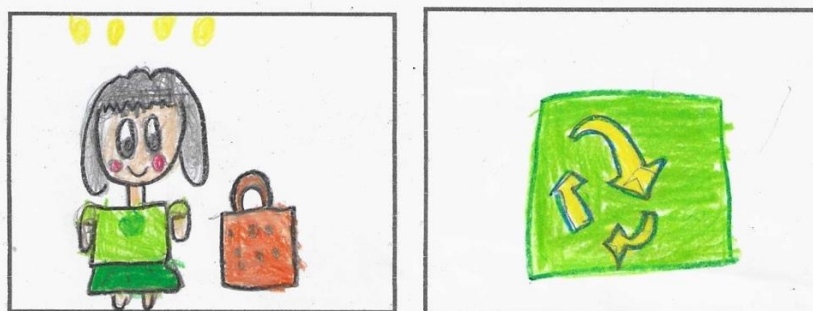


Figure 3: Children's drawings depicting solutions to plastic waste problems, such as using cloth bags instead of plastic bags and choosing products with recycling symbols.

The "Ideate" phase fostered creativity, encouraging children to brainstorm and propose diverse solutions. Teachers introduced a variety of packaging materials (banana leaves, plastics, paper, foam, food scraps) and asked children to hypothesize what would happen if these were buried for six weeks. Many predicted plastics wastes would disappear, while others anticipated organic matter would wither or disappear. The subsequent experiment confirmed only organic waste decomposed, while plastic and foam remained intact. This real-world evidence shifted children's understanding of decomposition times and the problems with plastic waste. Drawing on this knowledge, children generated practical ideas to reduce plastic use, such as using cloth or paper bags, reusing bottles, avoiding plastic utensils, and repurposing plastic for art or toys. They recognized the value in using natural materials like banana leaves for packaging and articulated their solutions through art and group discussions. This stage highlights the importance of creativity and divergent thinking, enabling learners to explore many possibilities, as emphasized in collaborative design thinking approaches to sustainability challenges (Sustainability Directory (n.d.); Appalachian State University (n.d.); EdCan Network (n.d.)).

3.1.4 Prototype

The fourth step of the design thinking process is where children implement practical solutions to plastic waste problems developed during the ideate step. Children addressed the problem by repurposing plastic waste to create artwork. They transformed plastic bottles into plant pots, bottle caps into spinning top toys, and plastic boxes into bags. They followed their designs and implemented them according to plan, while also solving problems that occurred during the creation process, for instance, during the process of making a bag from a plastic box, when glue was applied to the plastic box and paper was attached, some types of paper peeled off the plastic box after the dried. Children could find a solution by changing to a thinner type of paper and using stickers to reinforce it.



Figure 4: Children's creative works from plastic waste, such as bags from plastic boxes and plant pots from plastic water bottles.

During "Prototype," children physically implemented their proposed solutions. They repurposed plastic bottles as plant pots, made toys from bottle caps, and created bags from plastic boxes—experiencing the process of turning ideas into practical, tangible outcomes. Challenges were encountered, such as glue not adhering well to some papers, prompting iterative problem-solving—switching to thinner paper or securing materials with stickers. Prototyping allows for testing and refining ideas, an iterative loop central to design thinking, where students gain hands-on experience and problem-solving skills (Appalachian State University (n.d.); EdCan Network (n.d.)).

3.1.5 Test

In this final step of the design thinking process, children evaluated and tested their problem-solving approaches. The teacher posed open-ended questions to encourage reflection and critical thinking.

Example: "Did the children's final products align with their initial designs? What were the reasons for this?" One child remarked, "My work closely resembled my design because I was committed to adhering to it." Conversely, another child noted, "Not entirely, as the paper detached from the plastic box, prompting me to opt for thinner paper."

One parent said, "When I [the mother] go to buy coffee, my child reminds me not to forget my personal cup and not to use a plastic straw." Another parent mentioned, "My child usually gets excited and happy when seeing sorting bins. They will sort the waste by type before throwing it away."

Another parent shared, "My child is very enthusiastic about learning the impact of plastic waste on nature. They asked to be taken to the beach to see marine debris and encouraged [us/me] to join beach cleanup activities. As a father, I feel proud of my child's changed mindset and behavior."

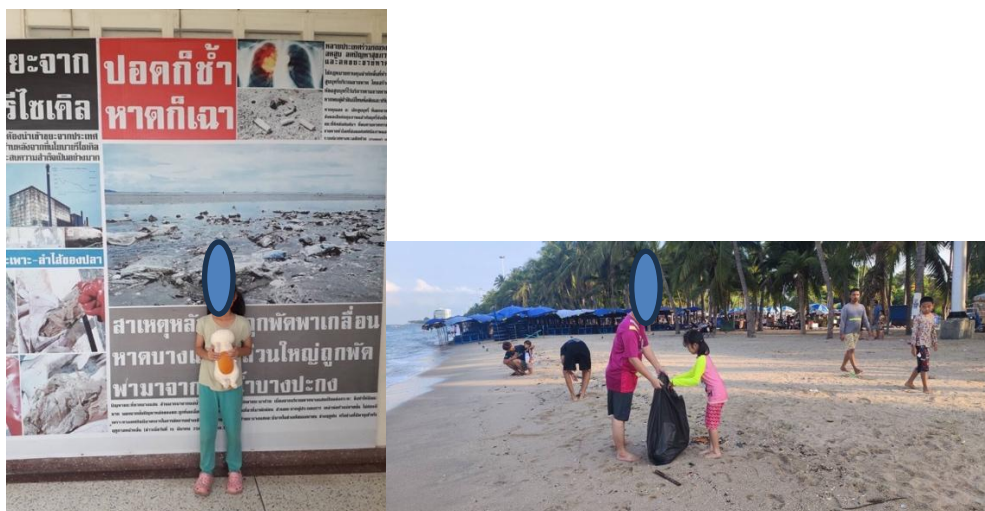


Figure 5: Parents and children visiting an exhibition on marine debris and participating in a beach cleanup activity, reflecting environmental awareness.

The children's behavior, as reflected in the parent interviews, demonstrates the application of classroom knowledge to real-life situations. This is considered a significant outcome of creative and sustainable learning. Children are exhibiting environmental leadership behaviors and can persuade adults to follow suit. This reflects change initiated by children that impacts the entire family. Most parents expressed great satisfaction and believed this activity has had positive effects on the children's thinking, attitudes, and behavior, which could potentially lead to broader implementation at the community and societal levels in the long term.

The final "Test" stage involved evaluating the effectiveness of their solutions through reflection and peer discussion. Teachers posed open-ended questions: Did the final product match the plan? What obstacles did they overcome, and how? Did their solution help reduce plastic waste? Children gave thoughtful responses, noting both successes and failures—such as adjusting their approach when paint stained hands, or paper detached from prototypes. They recognized both practical and environmental benefits, like saving money and reducing waste by transforming plastics into toys or other useful items. Testing encourages reflection, critical analysis, and iteration, ensuring solutions are user-centered, feasible, and impactful—mirroring best practices in design thinking for complex environmental problems (Appalachian State University (n.d.); EdCan Network (n.d.)).

4. Conclusion

From parent interviews, it was found that most provided consistent information: the children's behavior has changed for the better, particularly in terms of environmental awareness and actions reflecting social and environmental responsibility. Many parents reported that their children are reducing plastic bag usage, requesting cloth bags instead of plastic ones when shopping at markets or department stores, and participating in waste sorting at home. Furthermore, some children have taken on roles as change leaders within their families, persuading members to reduce plastic use, recommending waste separation before disposal, and suggesting ways to reuse plastic, such as crafting toys from plastic bottles or donating plastic waste to organizations for recycling.

5. Discussion

This study demonstrates that organizing learning experiences based on the design thinking process, focusing on plastic waste can effectively promote environmental awareness and sustainable problem-solving skills in early childhood children. Even at an early age, children can recognize plastic waste issues, identify their sources in daily life, and relate this knowledge to their own experiences. They can explain the connection between problems and environmental impacts, such as the impact on living things and animals (marine animals die from eating plastic bags), water pollution, soil and landscape degradation (burying waste in the soil damages the soil, hindering plant growth), climate change (burning plastic contributes to global warming), and public health risks (burning plastic waste causes a bad smell and may cause cancer; plastic waste clogs drains causing floods). These findings align with Yalçın (2022), who examined the design thinking model in early childhood education and found that this approach promotes creativity, problem-solving skills, communication, and cooperation among early childhood children. Children aged 4-5 years can adapt well to this approach. However, children aged 3 years may face problems in working in groups and sharing responsibilities within the team.

Children also demonstrated the ability to generate sustainable solutions for plastic waste. They suggested reducing plastic use (e.g., using cloth bags, wrapping snacks in banana leaves instead of plastic), reusing items (e.g., bringing personal water bottles, avoiding disposable plastic utensils), and recycling waste (e.g., sorting waste, repurposing plastic for artwork, and choosing recycled products). These ideas reflect that this learning helps children think of sustainable ways to solve plastic waste problems. Research by Haenilah et al. (2021) studied the effect of science-based learning on problem-solving skills in early childhood children, measuring results before and after the experiment. It was found that children who learned through the science approach through observation, questioning, experimentation, and communication—showed significantly increased development in problem-solving. Their research indicates that this approach can effectively enhance analysis and problem-solving in early childhood children. This is consistent with research by (Kamola et al. 2024), which studied high-quality teaching strategies of teachers in Early Childhood Education Centers (ECEC) in Norway that use coding play to enhance problem-solving skills in children aged 3-5 years, using open-ended questions, supporting trial-and-error learning, and creating an environment conducive to creative thinking and exploration.

Interviews with parents highlighted notable changes in their children's behaviors at home. Many parents consistently reported that their children encouraged them to adopt more sustainable practices, such as using cloth bags instead of plastic ones, reducing plastic packaging, and sorting waste for easier recycling. Children also demonstrated creativity by using plastic waste to make toys and utensils. Additionally, some parents noted that their children expressed interest in visiting beaches to assess plastic waste levels and even invited their parents to join beach cleanup activities. Parents expressed high satisfaction with their children heightened environmental awareness and proactive efforts to reduce plastic waste. They observed that their children have become more conscious of sustainable practices and frequently remind family members to embrace eco-friendly habits at home. Further interviews with teachers following the learning activities revealed positive changes in children's behavior. Students now prioritize sorting waste before disposal, recognizing the impact of improper waste management on the environment and community quality of life. This increased awareness and responsibility suggest a promising shift towards sustainable environmental practices among the children. Organizing learning experiences based on the design thinking process, focusing on plastic waste, can modify plastic consumption behaviors in early childhood children, create environmental awareness, and develop systematic problem-solving skills. Children can understand the plastic waste problem, think of solutions, and implement them in real-world

practice. This process provides opportunities for children to construct knowledge on their own and understand that one problem may have many solutions, or some problems may not be completely solvable. This type of experience will help develop children's flexible thinking and learning skills in the long term (Britz 1993). Children can create prototypes of approaches to solving plastic waste problems, demonstrating both creativity and practical problem-solving abilities.

6. Recommendation

This study demonstrates that design thinking is an effective method for fostering environmental awareness and sustainable problem-solving skills in young children. Our findings indicate that even at a young age, children are capable of recognizing environmental issues, developing innovative solutions, and applying these strategies in real-world contexts. The research reveals significant behavioral changes, as children not only understand the theoretical aspects of plastic waste issues but also express a keen interest in witnessing real environmental impacts. For instance, many children request visits to beaches to observe plastic waste firsthand and take the initiative by inviting their parents to participate in beach cleanup activities. Importantly, the study shows that young children can positively influence adult behavior by encouraging sustainable practices within their families. Moreover, the study underscores the critical role of collaboration between schools and families in reinforcing children's sustainable behaviors. Integrating structured, hands-on learning experiences into early childhood curricula can yield long-term benefits in nurturing environmentally responsible citizens.

Recommendations for future research include:

Exploring Home-School Collaboration in Environmental Education: Future studies should investigate effective strategies to enhance collaboration between home and school environments to reinforce sustainable behaviors in young children. This includes examining parental involvement programs, home-based activities, and school-community partnerships.

Integrating Sustainability Education into Early Childhood Curricula: It is recommended that educational policymakers incorporate sustainability education into formal early childhood curricula. This can be achieved by developing structured programs, training teachers in environmental pedagogy, and incorporating hands-on activities that promote real-world applications of sustainable practices.

7. References

- Ardoyn, N. M., & Bowers, A. W. (2020). Early childhood environmental education: A systematic review of the research literature. *Educational Research Review*, 31, 100353.
- Appalachian State University. (n.d.). Collaborative design thinking workshop focuses on eliminating plastic waste. <https://faa.appstate.edu/news/collaborative-design-thinking-workshop-focuses-eliminating-plastic-waste>
- Britz, J. (1993). Problem Solving in Early Childhood Classrooms. ERIC Digest. School at Stanford University. 2021. "Design Thinking Bootleg."
- Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology*, 12(3), 297–298. <https://doi.org/10.1080/17439760.2016.1262613>
- EdCan Network. (n.d.). Design thinking: A strategy for classroom innovation. <https://www.edcan.ca/articles/design-thinking/>
- Elliott, S., & Julie, D. (2009). Exploring The Resistance: An Australian Perspective on Educating for Sustainability in Early Childhood. Vol. 41.
- Haenilah, E., Hermi Y., & Rizky. 2021. "The Effect of the Scientific Approach-Based Learning on Problem Solving Skills in Early Childhood: Preliminary Study." *International Journal of Instruction* 14(2):289–304. doi:10.29333/iji.2021.14217a.
- Kamola, M., Francesca., Kristin., & Elin R. (2024). "High-Quality Strategies for Supporting Children's Problem-Solving Skills: A Study on Coding Toy Activities in Norwegian

- ECECs.” European Early Childhood Education Research Journal. doi: 10.1080/1350293X.2024.2319783.
- McCarthy, S. (2022). Design Thinking? Thank an Engineer. *Dialectic*, 3(1)
- Nature of Early Play. (n.d.). The importance of early childhood environmental education. *Nature of Early Play*. <https://natureofearlyplay.com/the-importance-of-early-childhood-environmental-education/>
- Playto. (2024, December 4). Teaching environmental awareness in daycare. In Playto Blog. <https://playto.com/blog/teaching-environmental-awareness-in-daycare>
- Playto. (2024). Teaching environmental awareness in daycare. In Playto Blog. [accessed 2024 month date]. <https://playto.com/blog/teaching-environmental-awareness-in-daycare>
- Pruneau, D., et al. (2019). Design Thinking. EdCan Network, February 5, 2021. Sustainable Design Thinking: How Students Can Solve Real-World Problems Using Creative Solutions. (2024, December 28). LPS Global.
- Pollution Control Department. (2023). “Thailand State of Pollution Report 2023.” Pollution Control Department, Ministry of Natural Resources and Environment.
- Pollution Control Department, Ministry of Natural Resources and Environment. (2022). Thailand State of Pollution Report 2021.
- SAGU Foundation. (2024). Applying design thinking approach for sustainable waste consumption. <https://sagufoundation.org/2024/10/17/applying-design-thinking-approach-for-sustainable-waste-consumption/>
- Sihvonen, P., Riikka, L., Jaana, H., & Maija, A. (2024). “Promoting Sustainability Together with Parents in Early Childhood Education.” *ducation Sciences* 14(5). doi: 10.3390/educsci14050541. Tempeim.
- Sustainability Directory. (n.d.). How can design thinking help us address the challenges of plastic waste management? <https://sustainability-directory.com/question/how-can-design-thinking-help-us-address-the-challenges-of-plastic-waste-management/>
- Tempeim, W., Samahito, C., & Butkatunyoo, O. (2023). “The Effects of Learning Experience Provision Using Phenomenon-Based Learning on Creative Problem-Solving Abilities in Young Children.” *Interdisciplinary Academic and Research Journal* 3(5):143–52. doi: 10.14456/IARJ.2023.245.
- Wong, A. (2019). Design thinking in education: A critical review of literature. *Asia Pacific Journal of Education*, 39(6), 840–853. <https://eric.ed.gov/?id=EJ1203703>
- Veeravatnanond, V. (2003). “Environmental Education.” Bangkok: Odean Store. (in Thai).
- Vitoon, P., & Butkatunyoo, O. (2022). “Integrated STEAM Education Learning Provision for Developing Design Thinking of Young Children.” *An Online Journal of Education* 17(1):OJED1701001–OJED1701001. doi: 10.14456/OJED.2022.1.
- World Economic Forum. 2024. The Global Risks Report 2024 19th Edition Insight Report.
- YALÇIN, V. (2022). “Design Thinking Model in Early Childhood Education.” *International Journal of Psychology and Educational Studies* 9(1):196–210. doi:10.52380/ijpes.2022.9.1.715.