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APPLYING GAMIFICATION PRINCIPLES THROUGH THE DESIGN THINKING FRAMEWORK FOR DEVELOPING A MIXED REALITY EDUCATIONAL GAME IN NUMERACY LEARNING

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Abstract : *Numeracy is one of the most crucial literacy skills to develop at a young age. These skills are taught in the classroom through mathematics. According to several studies from the Programme for International Student Assessment (PISA), students' mathematical abilities in Indonesia remain low when compared to other literacy skills. This subject is often perceived as challenging and tedious. Furthermore, the concept of teaching numeracy skills cannot be approached abstractly initially, especially for children who require tangible objects for manipulation. The research employed a design thinking approach, encompassing diverse methods such as observation, interviews, questionnaires, literature review, direct observations involving children, and problem analysis. This project aims to create educational media infused with gamification elements such as points, badges, levels, and leaderboards. The final product of this design project is an educational toy named "LIGI" seamlessly integrated with a mobile app, referred to as "mixed reality." The product's difficulty level can be tailored based on the abilities of each individual child. Moreover, in-game navigation employs the perceptual user interface (PUI), involving device movements and spoken commands to provide an interactive experience. This study effectively demonstrates the application of gamification elements in the development of mixed reality educational games, aimed at helping children understand and practice numeracy skills in a more interactive and innovative manner, following the design thinking framework stages of empathize, define, ideate, prototype, and testing. The study provides valuable guidance for product designers interested in creating impactful mixed reality educational games by integrating gamification principles. The authors stress the importance of integrating gamification elements during the ideate stage and conducting timely testing with children to comprehend their preferences and enjoyment.*
Keywords*: educational toy, mixed–reality, gamification, perceptual user interface*

1. Introduction

Education is critical because it is a major factor in determining knowledge and skills in human life. Through education, an individual's character can be developed in order to make better decisions, particularly in the future work world (Gumulya et al., 2022). To learn human need literacy and numeracy skills (Kennedy et al., 2008). As a result, the proper literacy method and learning must be developed from an early age. Children are taught reading, writing, and numeracy skills to help them solve everyday problems (Belkin, 2016).. Numeracy is one of the most important skills in everyday life, from counting days to reading a clock to shopping and a variety of other activities. Numeracy is taught in the classroom through mathematics lessons. However, this lesson is frequently regarded as a difficult and boring subject (Yuliandari & Anggraini, 2020). According to a study conducted by the Research on Improving Systems of Education (RISE) team with students in Indonesia using elementary school level math problems, students' mathematical skills decreased between 2000 and 2014 (Beatty et al., 2018). Aside from that, Indonesia's score in the 2016 Programme for International Student Assessment (PISA) for mathematics competence is 386, which is lower than the average score of 490 (see figure 1).

To address the issue of declining mathematics scores in PISA for Indonesia, the incorporation of mixed reality technology (MR-T), such as educational apps and games that seamlessly blend virtual elements with the real-world environment, has been proven to be essential. First, they can provide interactive and intuitive learning experiences. MR-T can present math in ways that help children understand difficult concepts, providing tangible images and representations (Goodwin & Highfield, 2013). Second, they employ captivating visuals and interactive elements that bridge the gap between abstract ideas and concrete understanding (Hirsh-Pasek et al., 2015). Moreover, MR-T is driven by algorithms, evaluate a child's mathematical abilities and accordingly customize the learning content, so it can facilitate personalized learning experiences that cater to each child's unique pace and proficiency (Cleeton, 2011). Furthermore, educational apps and simulations can immerse children in real life scenarios where math is instrumental, such as managing a virtual store or building structures (Schlichting, 2019). This contextualization helps children understand the relevance of math

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in their daily lives, demonstrating its practical applications and fostering a deeper appreciation for the subject. Aside from providing contextualization, MR-T can facilitate immediate feedback to children's answers, whether they are right or wrong. This allows them to understand their mistakes and correct them promptly (Mayer, 2004). Lastly, MR technology can introduce gamification to the process of learning math. Numerous educational math games have been developed that convert mathematical exercises into immersive challenges, seamlessly integrating elements of challenge, curiosity, and fantasy through game-based learning (Ramli et al., 2020). This approach captures children's attention and enhances their motivation to tackle math problems. Research indicates that the implementation of gamification in educational contexts fosters a heightened sense of achievement and satisfaction among students (Metwally et al., 2021).

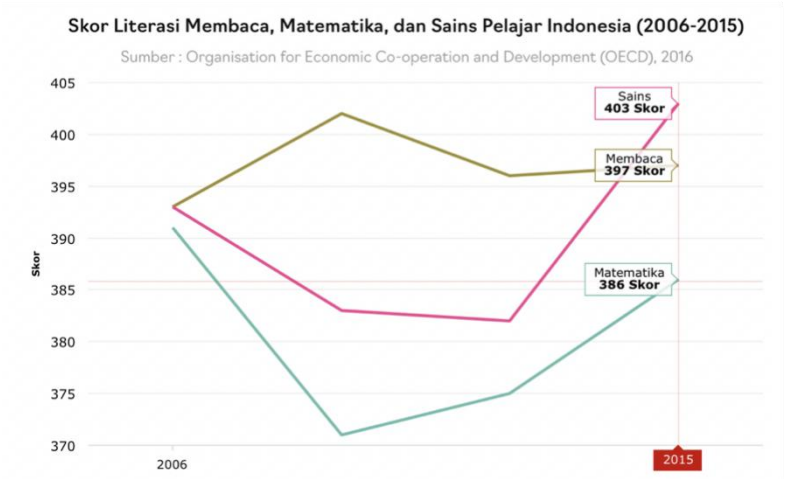

Figure 1 Reading, Mathematics, and Science of Indonesian Students Literacy Scores Based on PISA Research by the Organisation for Economic Co–operation and Development
Source: (OECD, 2016)

Seeing that there are many benefits of incorporating MR-technology in learning Math, the study aims to create educational toy to learn about Math with mixed reality technology based on the concept of gamification. By creating the mixed reality game about Math, hopefully the study can help children to their learning process, understanding, and facilitate children's visualization with tactile media for learning Math in a more interactive and innovative way by utilizing technology that is integrated with the product.

Regarding those issues, it demonstrates the possibility of developing educational learning media to assist children in understanding the concept of Math. The goal of this study is to create educational toy based on the concept of gamification in order to improve the learning process, understanding, and facilitate children's visualization with tactile media for learning Math in a more interactive and innovative way by utilizing technology that is integrated with the product. On a research paper by (Manzano-León et al., 2021) examining the impact of educational gamification on student motivation and academic performance in the last five years through systematic literature review with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) methodology. From reviewing 198 papers that mostly come educational background. The review concludes that educational gamification has a potential impact on the academic performance, commitment, and motivation of students.

On the other hand, the design research stream has discussed on how to design educational app with gamification principle such as (Robledo-Rella et al., 2017). Their study exemplifies the application of gamification concepts, including challenges, points, and rewards, within the context of designing an educational web app named CocoGame that set in an adventure-themed Universe and targets entry-level university students. It aims to foster their understanding of Physics and Math. CocoGame introduces a wide spectrum of question formats, encompassing multiple-choice, fill-in-the-blank, as well as open numeric and text-based queries. This diverse array of cognitive challenges ensures that players engage with a rich variety of tasks, thereby enhancing their learning experience and catering to different learning preferences and styles. Furthermore, the app implements a reward system as an intrinsic motivational tool. Students accumulate stars and other commendations in response to their accomplishments within the game. This dynamic mechanism

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not only reinforces positive behaviors but also mirrors the journey of growth and achievement of the app's protagonist, thus encouraging continuous engagement and progress among the players.

Another study of (Deterding et al., 2011) offers a comprehensive insight into various game design elements, encompassing game interface design patterns, game design patterns and mechanics, game design principles and heuristics, game models, and game design methods. These elements collectively contribute to a holistic understanding of how gamification principles can be effectively integrated. These considerations are crucial for the comprehensive implementation of gamification principles in educational contexts.

While extensive research has delved into the application of gamification principles within various educational contexts, there is a gap when considering the gamification principles into the design of mixed reality (MR) educational games. The existing studies (Deterding et al., 2011; Robledo-Rella et al., 2017) have not provided clear guidance on how to apply gamification principles in designing educational games, especially those with mixed reality features. The study aims to bridge this gap by illustrating the process of designing a mixed reality educational app for numeracy learning for grade 1-3 students. Through a research-through-design approach, the research not only considers the pedagogical implications but also addresses the aesthetic, functional, and experiential dimensions of integrating gamification elements into the product. This broader outlook opens avenues for harnessing gamification principles to enhance user engagement, satisfaction, and interaction beyond educational settings.

In the study conducted by (Villegas et al., 2019), an insightful perspective emerges on the potential synergy between gamification and the design thinking process. Their findings suggest that gamification can play a pivotal role in elevating design thinking experience. By integrating gamification elements, the design thinking process gains an enhanced capability to capture and maintain user engagement throughout the entire design journey. Based on the literature review the study raises the research question of: How to apply gamification elements in the creation of Mixed Reality Educational Game for Numeracy Learning through design thinking framework?

2. Method

To solve the problem, the research method employed a design thinking approach based on (Platner, 2015). The information was gathered through observation, interviews, and a review of the literature. Following the completion of the information, the data is analyzed to generate sketch ideas. Testing prototypes with children were also carried out in order to obtain more information directly from children's opinions and observe their problems when playing math. Parents of children aged 6 to 8 from Jabodetabek, Karawang, and Bandung are asked to complete a questionnaire, participate in a focus group discussion, and provide feedback.

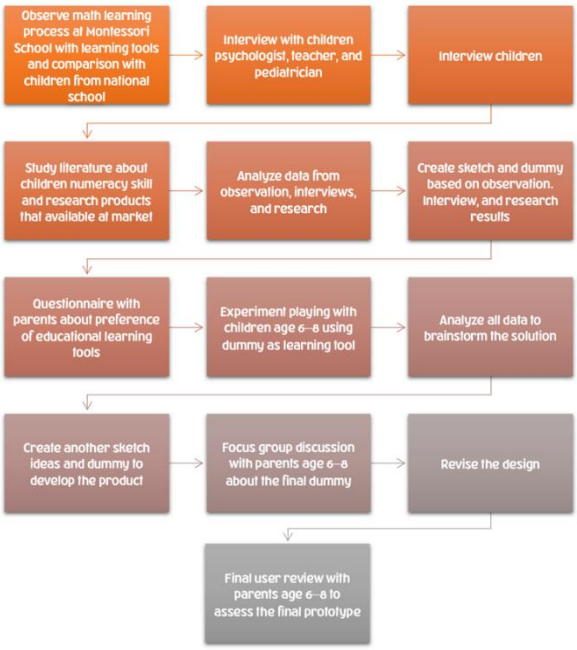

Figure 2 Research Process
Source: Researcher's Data (2020)

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By applying the design thinking framework, the aim is to create an iterative and user-centered approach that enables the development of innovative solutions. This approach encourages a deep understanding of user needs, creative problem-solving, and the creation of prototypes that are tested and refined based on real-world user interactions.

3. Result

A. Empathize

Observation

Authors observe Montessori school and national school to gather primary data. We found out that Montessori School and National School have different learning methods and processes. First authors found out the Math topic for grade 1-3 students is Arithmetic, a branch of mathematics that deals with properties of numbers and the basic operations of addition, subtraction, multiplication, and division (Difference.com, 2011). The Montessori School's curriculum enables children to grasp arithmetic concepts at a faster and more advanced pace. This is primarily due to the availability of learning tools that aid in comprehending these concepts. As a result, even lower primary class students at Montessori School are able to tackle multiplication and division involving hundreds, thousands, and even millions. In contrast, students at National Schools are still focused on fundamental multiplication and division up to the hundredth grade, without the assistance of any learning tools. However, in certain exercises, teachers incorporate pictures to assist students in understanding arithmetic principles. Through observations, it has become evident that there is a significant demand for timely feedback and detailed explanations to assess their answers more effectively.

Interviews

The interview results encompass a broad spectrum of statements regarding the process of acquiring numeracy skills. From the teacher's perspective, the learning process cannot be imparted abstractly; instead, children necessitate manipulative media. According to psychologists, children aged 6-8 in primary school are situated in a transitional phase between pre-operational and operational concrete stages. As a consequence, they initiate the practice of evaluating and commenting on various matters, including their peers, which can be delicate and impact the self-esteem of other children, especially those encountering learning difficulties. Beyond this, mastering numeracy entails logic and the children's focused attention. Pediatricians suggest that numeracy skills should be cultivated based on children's mathematical abilities and developmental milestones from an early age. A multisensory approach that employs tangible and vibrant tools can substantially assist children's learning process.

Questionnaire

A questionnaire was distributed to 25 parents of children aged 6 to 8 years old to collect information regarding their educational tool preferences and concerns about their children's math learning difficulties. From the questionnaire several conclusions can be made:

- A significant 80% of the respondents have encountered children between the ages of 6 and 8 who struggle with counting.
- The survey identifies multiplication (56%) and division (44%) as the most challenging subjects to teach children in this age group.
- It's noteworthy that the frequency of toy purchases for children is not high, occurring at least once a month. When buying educational toys, the factors receiving the most attention are functionality, game design, and the preferences of the children.
- Regarding media or games for helping children aged 6-8 learn counting, 44% of the respondents specifically chose the snake and ladder game. This choice is attributed to the game's simplicity, use of straightforward numbers, its ability to aid children in following instructions, and the presence of challenges through the game's ascending and descending movement mechanics, accompanied by diverse visual element.
- Educational toys designed to practice counting provide children with a hands-on experience that helps them better grasp the concepts.
- Board games offer the advantage of being portable and can be enjoyed by the entire family, promoting social interaction among children, as well as with adults.
- In terms of product development, a notable market preference is observed for tile-based products, with 50% of respondents favoring them, closely followed by board games at 47.2%. These choices have the

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potential to enhance both the motor and cognitive skills of children. Additionally, the age group of 6-8 years is particularly suitable for exploring and understanding the game's dynamics and rules, this can aid in memory training for children.

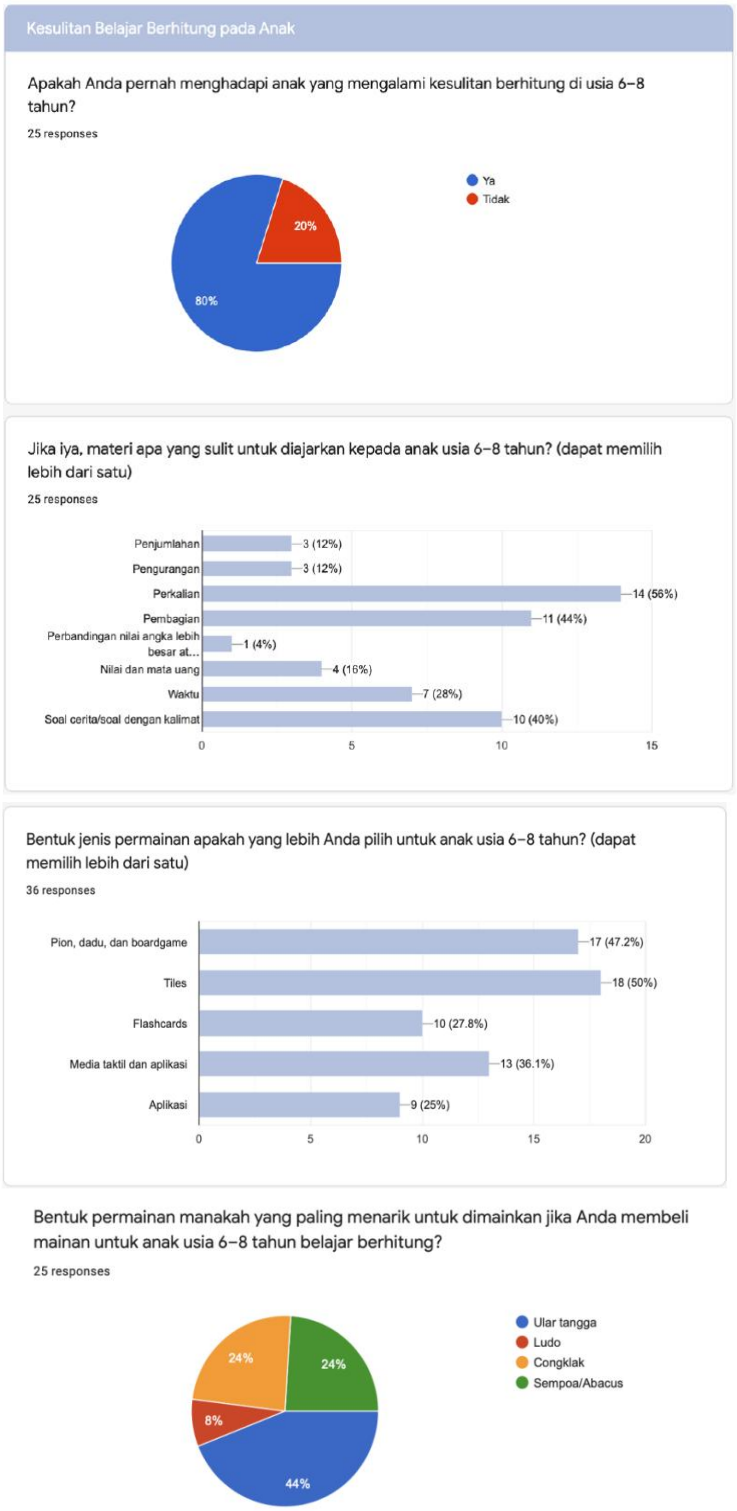

Figure 3 Questionnaire Result
Source: Researcher's Data (2020)

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B. Define

Based on the observations, interviews, and experiments conducted, the authors defined the needs that the children have in order to understand the arithmetic concepts, particularly when it comes to basic operations such as multiplication and division (see figure 3). They have a preference for tactile media to aid their learning process. These children also show a need for prompt feedback and explanations to assess their answers effectively. It was observed that they feel anxious and hesitant when discussing their math-related difficulties. Moreover, market observation has revealed a scarcity of tactile resources designed for teaching multiplication and division. Therefore, the authors' primary objective is to concentrate the research efforts on designing an educational game that incorporates tactile media, uniquely customized for the purpose of enriching the learning experience in the areas of multiplication and division.

C. Ideate

The ideation process commences with a brainstorming phase that takes into account the primary findings of the questionnaire. These findings have revealed a market preference for educational tools such as board games, tactile media, tiles, and mobile apps. Respondents indicated that the game that effectively teaches their children basic arithmetic is the "Snakes and Ladders" game (refer to figures 4 and 5). Based on this valuable insight, we have decided to develop a mixed reality educational game that seamlessly integrates physical and digital components.

During the ideation phase, we generate creative ideas by mind mapping all the components essential for the design process The game mechanics, theme, and components. We also create various game themes that tap into this preference, aiming to achieve a harmonious fusion of tangible and digital elements. This approach harmonizes with the evolving educational landscape, catering to the diverse preferences of learners while leveraging the opportunities presented by technology. This innovative direction not only aligns with market preferences but also enriches the learning experience by offering an engaging blend of traditional and modern educational tools.

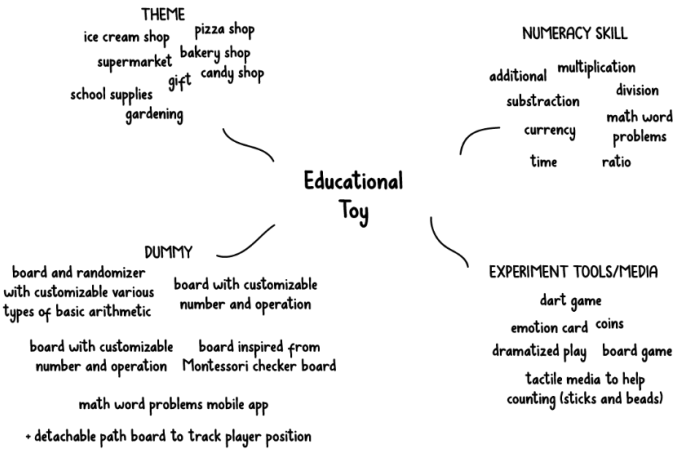

Figure 4 Mind mapping for Ideation
Source: Researcher's Data (2020)

After establishing the initial game concept, we proceed to define the game's mechanics, theme, and core components. While each game idea features distinct themes, the foundational elements remain consistent, comprising the game board, characters, and a randomizer. The first idea centers on a food theme where players engage in creating ice cream by collecting ingredients. This involves aiming at specific numbers on a dartboard (refer to figure 5). The core focus of the game is on multiplication and division operations, covering numbers from 1 to 10. In this gameplay, children target the correct answer by hitting the corresponding number on the dartboard, serving as the multiplier or divisor. To assist in counting, children can use a magnet as tactile media. Successful answers to the multiplication questions will earn them ice cream ingredients as rewards. The gamification elements are outlined on table 1.

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Table 1 Gamification elements of ice cream shop game idea

Points	Badges	Levels	Leaderboard
Players earn points for each correct answer in the multiplication game.	Beginner Chef Badge: Awarded when the player completes the first level successfully.	Sundae Novice: Initial level, with simpler multiplication questions (1-5) and basic ice cream ingredients.	Global Leaderboard: Displays the top players globally based on total points earned.
Points can be based on the difficulty level of the multiplication question, with harder questions earning more points.	Ice Cream Maestro Badge: Awarded after a certain number of consecutive correct answers.	Sorbet Specialist: Progresses to slightly harder multiplication questions (6-10), with more challenging ingredient combinations.	Friends' Leaderboard: Allows players to compare their scores with friends who also play the game.
			Weekly/Monthly Leaderboard: Recognizes the players with the highest points within specific time frames.

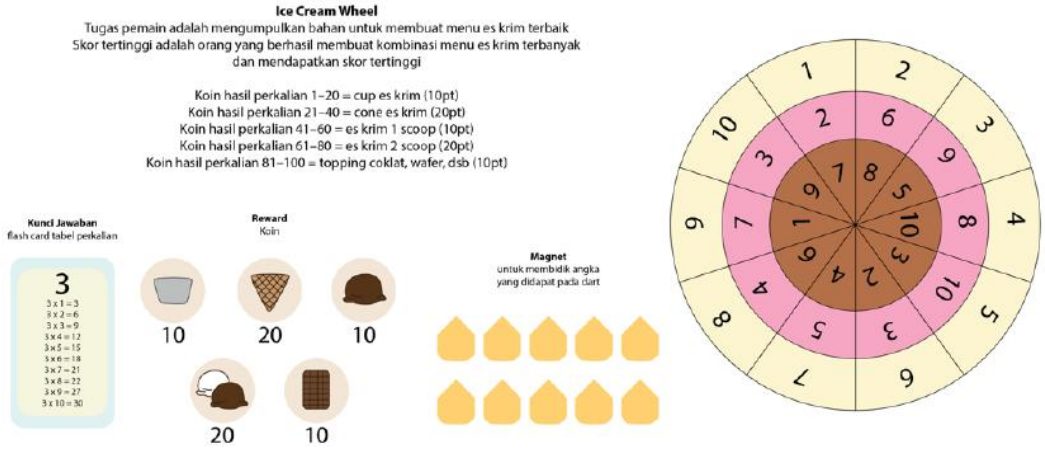

Figure 5 Ice cream game
Source: Researcher's Data (2020)

Table 2 Gamification elements of farming game idea

Points	Badges	Levels	Leaderboard
Players earn points for each correct answer in the multiplication game.	Rice Master: Earned by achieving a certain level of rice yield, showing proficiency in multiplication and division.	Seedling Farmer: Beginner level, introducing basic multiplication and division problems. Rice yield goals are achievable, and the thief's challenges are relatively simple.	Global Leaderboard: Displays the top players globally based on total points earned.
Points can be based on the difficulty level of the multiplication question, with harder questions earning more points.	Harvest Champion: This badge is obtained by reaching specific milestones in the rice harvest, demonstrating sustained engagement and effort.	Paddy Protector: Intermediate level, with more complex math questions and increased rice yield targets. The thief's attempts become more challenging.	Friends' Leaderboard: Allows players to compare their scores with friends who also play the game.
			Weekly/Monthly Leaderboard: Recognizes the players with the highest points within specific time frames.

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The second theme introduces a farming theme, where children take on the role of farmers striving to cultivate as much rice as possible through correct answers to questions. In this engaging concept, children receive a number from a randomizer, and their task involves multiplication or division based on the block number they encounter on the rice field. However, the journey is not without challenges; a mischievous thief lurks along the way, aiming to steal the paddy. If they meet thief all the paddies will be taken away their points get deducted and there's a rice processing machine to manage too that can multiply the points. This immersive game experience not only enhances numeracy skills but also adds an element of strategy, problem-solving, and decision-making as players navigate the farming adventure. The gamification elements are outlined on table 2.

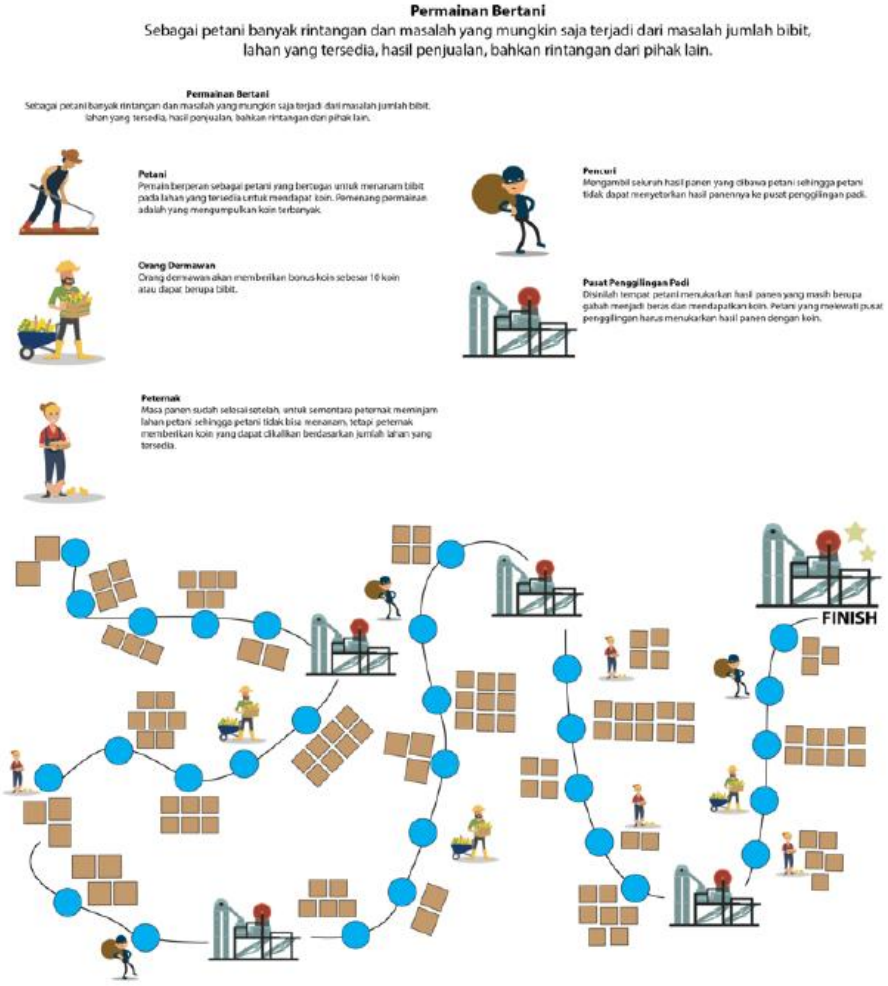

Figure 6 Farming game
Source: Researcher's Data (2020)

After ideating these concepts, we proceeded to the next phase of the design process, building dummies, and conducted an early user feedback involving two children aged 7 and 8. The results of the dummy test provided valuable insights. Both children expressed a high level of enjoyment with the randomizer feature, as it introduced an element of surprise, enhancing their engagement. Moreover, the tactile media component garnered positive feedback, as it effectively facilitated counting skills for the children. Remarkably, the farming theme emerged as a favored option among the children than the ice cream theme, as it presented a novel and intriguing addition to the game board, aligning with their interests and making the learning experience more captivating. However, the children did express a desire for more challenging aspects in the game. The next step is to refine the garden theme games and create the prototypes. This iterative approach, guided by design thinking principles, enables us to refine our game's themes and features based on real user feedback, ensuring a more user-centered and engaging final product.

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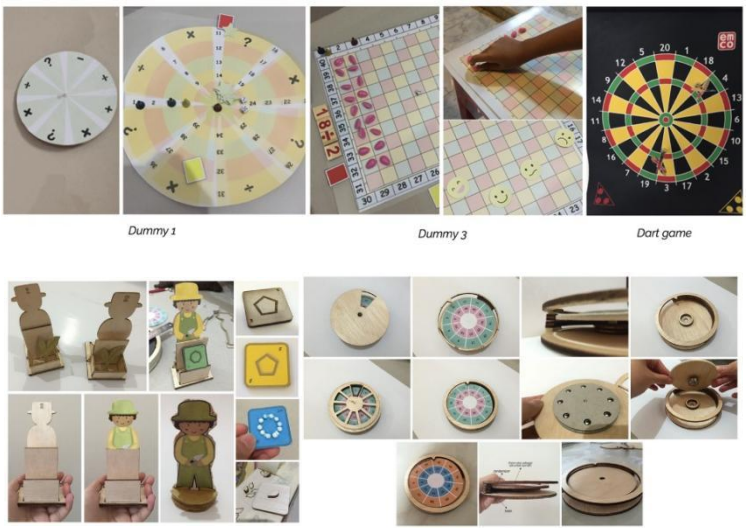

Figure 7 Games' Dummy
Source: Researcher's Data (2020)

D. Prototype

We created the prototype based on the dummy and further detailed the challenge of game with the gamification elements of the game, including points, badges, levels, and leaderboards. Our development process began with the formulation of the game's rules, where we chose to implement the rules commonly found in ladder snake games due to the questionnaire's revelation that it is among the most popular games for learning math (see figure 4). We decided to name the game "LIGI," combining the words "perkaLIan" and "pembaGIan." In LIGI, each square on the board has a number, which children should multiply or divide by the appended numbers. Unlike traditional ladder snake games, LIGI enables children to arrange their own path start to finish by arranging the game block, and each square exclusively features numbers from 1 to 10.

The game consists of three levels: level 1 (multiplying factors of 1, 2, 5, 10), level 2 (multiplying factors of 3, 4, 7, 8, 9), and level 3 (all multiplying factors). LIGI can be played by a single player or in a group, with a maximum of 4 players. The scoring system assigns values of 1, 2, 5, and 10. In general, the point system for all levels follows the principle that the easier the task, the lower the points earned. Detailed steps for playing LIGI are illustrated in figures 8 to 12, providing a clear explanation of the gameplay process. The game board consists of different blocks that player can rearrange by themselves.

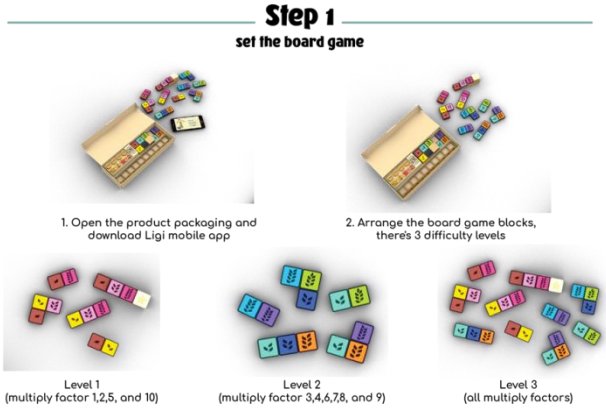

Figure 8 Play Instructions: Step 1
Source: Researcher's Data (2020)

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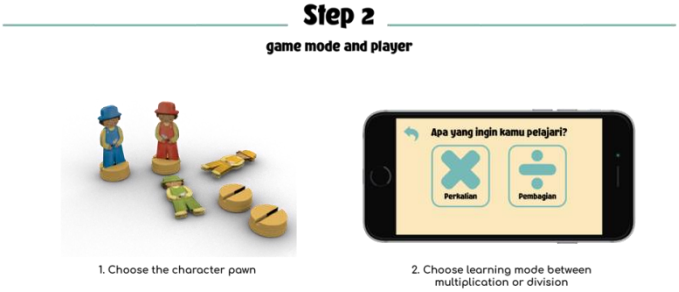

Figure 9 Play Instructions: Step 2
Source: Researcher's Data (2020)

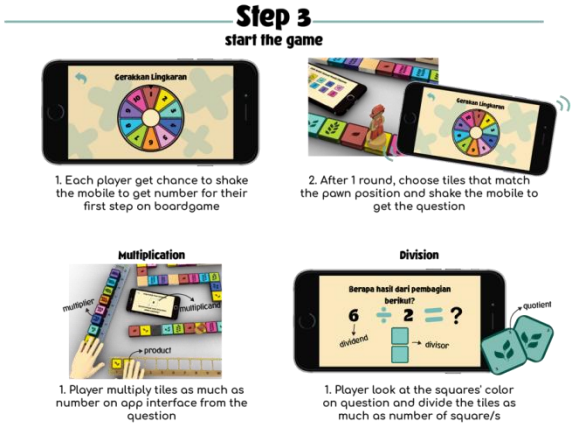

Figure 10 Play Instructions: Step 3
Source: Researcher's Data (2020)

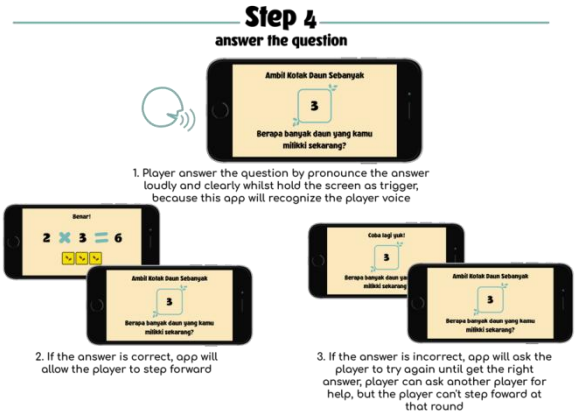

Figure 11 Play Instructions: Step 4
Source: Researcher's Data (2020)

Figure 12 Play Instructions: Step 5
Source: Researcher's Data (2020)

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In addition to levels and point system, another gamification elements are badges, and leaderboards. The badges are a type of "trophy" or "achievement" given to the players. If a player's answer is correct, they can choose from three badges: extra points, gardening tools, and breeders (see figure 14). Like the snake in the ladder snake game, the challenge in LIGI is that there are thiefs in certain paths that are indicated by black squares, and they can take 20 points. Furthermore, the leaderboards are displayed after the player has completed all of the questions on each level. Because LIGI is a mixed reality educational game that uses PUI as the interface's navigation, this project will utilize motion control and voice recognition as triggers for using the app. The authors included both a learning and playing mode to assist players with sound effects and animated explanations after they answer the questions. The animations for explaining multiplication and division can also be accessed in the learning mode, similar to digital flashcards, and the interface can be switched to table mode for easier access. These features are intended for players who are still struggling with multiplication and division.

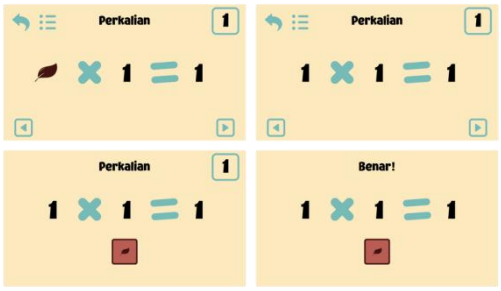

Figure 13 Explanation Interface in Learning and Playing Mode
Source: Researcher's Data (2020)

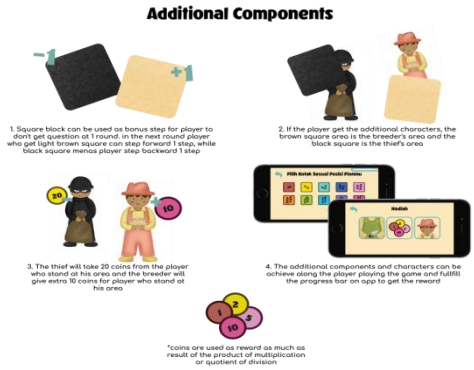

Figure 14 Additional Components
Source: Researcher's Data (2020)

Figure 16 presents the prototype of LIGI, crafted using 3mm multiplex and 3mm acrylic materials. The components of the prototype include game blocks, characters, tactile tiles, and a tile holder designated area for positioning the tactile tiles, which assists players in performing calculations.

Figure 15 **Final Prototype**
Source: Researcher's Data (2020)

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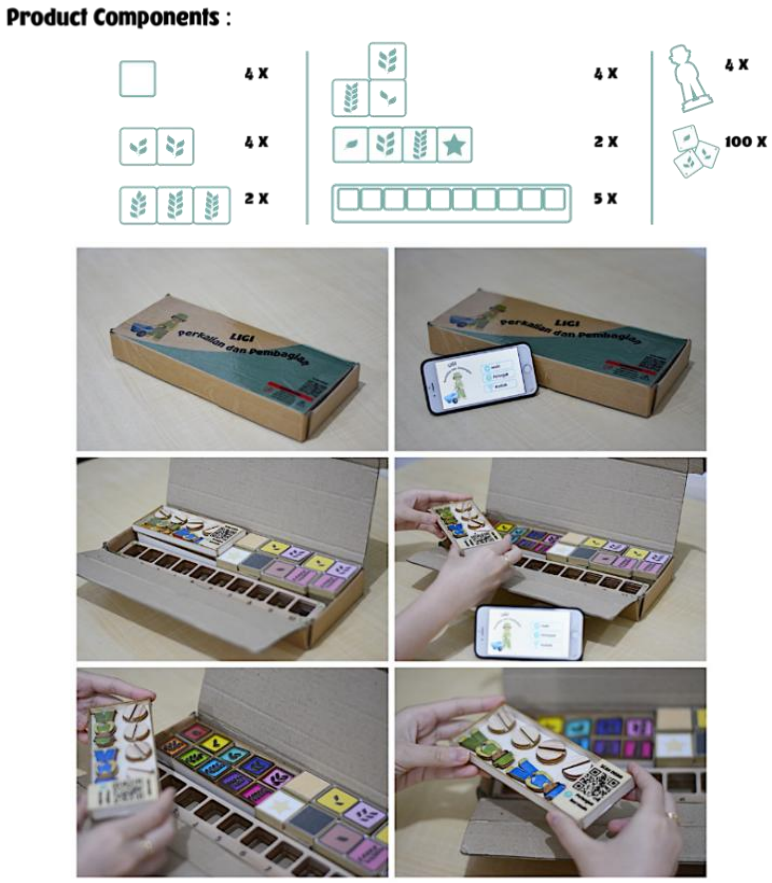

Figure 16 **Final Prototype**
Source: Researcher's Data (2020)

E. Testing

The game has received a high overall impression score of 4.65, reflecting strong positive feedback from users. Its Visual Appeal is particularly noteworthy, drawing praise for its attractive graphics and straight forward. Users have found the game visually appealing, which contributes to the overall enjoyable experience. Additionally, the game has proven to be highly effective in enhancing learning, specifically for multiplication. Division getting lower score because it is a harder subject for children. Users have indicated that the game effectively supports the learning of multiplication, making it a valuable educational tool.

However, the aspect of Ease of Use received comparatively lower scores. Some users may have encountered challenges due to the game having many components, such as the board, the tiles, the characters, and the apps. While this area presents room for improvement, the game's strong performance in other aspects, particularly its Visual Appeal and Learning Effectiveness for multiplication, demonstrates its potential as an engaging and educational resource. Overall, with its impressive average score and standout attributes, the game has proven to be a promising tool for learning multiplication, although some enhancements in usability could further elevate the overall user experience.

Figure 16 depicts the prototype being tested with the same children who evaluated our dummies, by answering the following questions in likert scale 1-5. where 1 represents the lowest level of agreement or satisfaction and 5 represents the highest level:

1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

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Table 3 Questions in likert scale 1-5

No	The questions	A	B	C	D	E	Average
1	Visual Appeal: How visually appealing did you find the game's graphics and art style?	5	4	5	5	5	4,8
2	Ease of Use: How easy was it for you to navigate through the game menus and controls?	5	3	5	5	4	4,4
3	Learning Effectiveness: How well do you feel the game helped you learn multiplication?	5	4	5	5	5	4,8
4	Learning Effectiveness: How well do you feel the game helped you learn division?	4	4	5	5	5	4,6
5	Favorite Feature: What is your favorite feature of the game?	The apps	The tile	The characters	The apps	The game	
Overall average							4,65

4. Discussion

In this section, the novelty of the research results is discussed. The outcome of the research has led to the design of the "LIGI" product and app, which incorporates a gamification concept and a customizable board game feature to cater to children's varying abilities. The gamification concept ensures that children or players have an unlimited number of attempts to arrive at the correct answer. Both players who succeed on their first try or after several attempts contribute to filling the progress bar. Additionally, every player who completes a task receives badges as rewards. As children advance in their math learning journey, the gaming system can become more intricate by integrating app-based components.

LIGI's product components encompass various shapes of board game blocks, tiles, and tile holders, along with character pawns. In contrast to a solely physical product, LIGI integrates an app as a randomizer, reducing the number of physical components required. This approach is advantageous for teaching multiplication and division using tactile media, demanding a diverse array of math questions. LIGI's app-based solution provides several benefits, including immediate feedback to evaluate children's responses, increased accessibility, and a wider range of learning features. These advantages are achieved by utilizing smartphones or devices that parents already own. The LIGI app features two modes: learning and playing, each accompanied by explanatory animations corresponding to the tactile media. The interface of this mixed-reality product adopts a Perceptual User Interface (PUI). This choice aligns with the findings of (Olympiou & Zacharia, 2012) who assert that PUIs facilitate learning through visual and physical interaction. The app also integrates a motion-controlled system, allowing players to obtain the first-step number on the board game and the question by shaking the phone. The voice recognition system permits players to respond to questions by pronouncing the correct answer audibly and clearly, using screen touch as a trigger for voice recognition. If the answer is correct, the app allows the player to proceed; if not, the app prompts the player to try again until the correct answer is achieved. In the context of design thinking and gamification study, this study has effectively demonstrated the application of gamification elements in the creation of mixed reality educational games, following the design thinking framework stages of empathize, define, ideate, prototype, and testing. The authors identified that the incorporation of gamification elements should be addressed during the ideate stage and be promptly tested with children to understand their preferences and enjoyment. This valuable feedback from the children informs the subsequent step, which is the prototyping stage, where the gamification elements are refined based on the insights gathered from the children's responses.

The study also manages to extend the example of gamification element with PUI as the interface's navigation, It utilizes motion control and voice recognition as triggers for using the app. So, gamification elements are not only limited to points, badges, levels, and leaderboards, but the game user experience can be enriched through motion control and voice recognition, this extend the (Deterding et al., 2011; Robledo-Rella et al., 2017) research. The study also expands the gamification element example by incorporating Perceptual User Interface (PUI) as the app's navigation. This feature leverages motion control and voice recognition as triggers

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for app interaction. This indicates that gamification elements go beyond the conventional points, badges, levels, and leaderboards. By integrating motion control and voice recognition, the user experience of the game is enhanced, thus extending the findings beyond what was discussed in the research by (Deterding et al., 2011; Robledo-Rella et al., 2017).

5. Conclusion

The study successfully incorporates gamification elements, including points, badges, levels, and leaderboards, into a mixed reality toy using the design thinking process. The innovative aspect of the product lies in its integrated learning experience, combining physical components (game blocks and tactile media for counting) with digital elements (randomizer, badges, points, animated explanations, and leaderboard through the app). This approach presents a innovative solution to enhance math learning for children aged 6-8. The study acknowledges the mixed reality educational game's capacity to transcend conventional methods, promoting independent learning. The game's high score of 4.65 in user testing suggests its effectiveness in supporting numerical learning for children aged 6-8, solidifying its value as an educational resource.

However, it's important to acknowledge the study's limitations, such as the small sample size (tested on 5 children) and the current stage of the apps are still in prototype stages not finished product. Therefore, the researchers suggest further research with a larger number of participants and collaboration with informatics mobile app developer to enhance the market readiness of the research.

In summary, this study offers valuable insights for product designers aiming to develop effective mixed reality educational games while integrating gamification principles. It emphasizes the significance of incorporating gamification elements early in the design process, gathering user feedback, and refining the elements through the prototyping stage. This holistic approach provides essential strategies for designers seeking to create engaging and impactful educational experiences.

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7. Authors Contribution

Devanny Gumulya[1] : author in charge, develop background, research methods, discussion & results, conclusions

Yosefin Suhanto [2] : data collection, literature study, discussion & results, conclusions

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