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Understanding Interaction Design and Student's Engagement in Augmented Reality Card for Education

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ABSTRACT

Elementary students often get bored with passive teaching methods, such as listening to the teacher and paying attention to the blackboard, because they prefer playing the game, exploring things, and interacting with peers. Augmented Reality (AR) card games have emerged as an alternative education media, offering interactive 3D visuals that enrich the learning experience. This study explores how the interaction design of an AR card game influences the engagement of second-grade elementary school students in learning animal vocabulary. Using a qualitative case study approach, observation was conducted during one class session, and the collected data were analyze based on learning outcomes and interaction design principles. The findings revealed a dynamic engagement trajectory, with students starting with curiosity and excitement or needing AR guidance, then actively participating, becoming master, and finally becoming bored after repeated the AR card game. From student engagement, this study revealed that the AR interaction design of the card game fostered curiosity, motivation, enjoyment, collaboration, and attention. The study demonstrated that the 3D visualization, animation, gameplay, interaction variations, audio narrative, and text supported vocabulary development, contextual understanding, memory retention, and problem-solving. However, sustained engagement depends on the variety of AR interactivity, so the insights contribute to improve the user interaction and gameplay design.

Keywords: augmented reality; user experience; interaction design; flashcard; learning

INTRODUCTION

Learning in elementary schools in Indonesia is generally conventional, monotonous, and teacher-centered, dominated by lecture method and the use of blackboard (Durisa et al., 2022). These activities only encourage students to memorize material and lack variety (Aulia et al., 2025) so the students's opportunities to experiment, discuss, or use interactive media are still limited (Ochsania et al., 2025). Monotonous, uninteresting, and uninnovative learning is also found in elementary schools in Tangerang (Ayshara & Kamil, 2024; Nurdin & Adinda, 2025; Tsabitah et al., 2025), which results in students easily becoming bored and losing focus (Aulia et al., 2025; Nurdin & Adinda, 2025; Ochsania et al., 2025).

Interactive media can be used as a solution to monotonous learning in schools. Interactive media is a crucial factor in improving student learning outcomes and encouraging student engagement in learning because it enables two-way interaction between teachers and students, allowing them to provide input and receive feedback (Ayshara & Kamil, 2024). Interactive media integrated with immersive reality technology also supports student participation in class (Hefira, 2024). One of interactive media with immersive technology that can help in a non-monotonous, engaging, innovative way, and help understand the material is AR card game. AR card game is easy to use, practical, and portable (Sari et al., 2021), thus addressing the problem of teacher's inability to use sophisticated media (Tsabitah et al., 2025). AR card game is an augmented reality-based flashcard that utilize technology on mobile devices. AR technology has been widely adopted in learning (Ferawati et al., 2024; Oktanuryansyah & Kusumaningtyas, 2024; Presser et al., 2025; Priyadi, 2022; Yoliando, 2022) and card game has been designed to enhance learning outcomes such as cognitive development, memory, communication, and motivation (Maharani, 2020; Santoso & Agustin, 2023). In the context of visual learning, AR card displays educational visual and textual elements such as animal names and storytelling (Yoliando, 2022). The 3D object visuals in AR create an interactive and realistic learning experience and have been

shown to enhance understanding of shape, size, color, and object details (Law & Heintz, 2021; Syaputra et al., 2023).

Research on AR card games has addressed usability and effectiveness evaluations, but there is limited in-depth study of interaction design aspects that influence the user experience. AR card games have been shown to enhance learning interest and cognitive abilities such as memory and problem-solving in children (Sari et al., 2021; Sukmawan & Putra, 2025), but these studies did not explore how AR interaction design influences student engagement from initial introduction to boredom. The exploratory suggestion of using animal-introducing content in AR card games to understand student's learning experiences (Ruswanti et al., 2025) underpins interaction design research on animal AR card games for elementary school students.

Based on the problems and research gaps that have been described, this study decides on the research questions: 1) How is the user engagement journey map when students learn with AR card games? 2) How is the AR card game interaction design to increase the student's engagement? The purpose of this study is to analyze and understand the user experience pattern by journey map when using AR card game so that it can provide insight into the interaction design of AR-based educational media.

Therefore, this research is expected to contribute to the field of educational interaction design by offering design insights into how AR card game should be designed to be not only visually appealing but also able to maintain focus, facilitate social interaction, and enrich elementary school children's learning experiences.

RESEARCH METHOD

This study uses a qualitative case study approach with an interpretivism paradigm. The focus is to understand student's experiences and engagement in interaction design while playing AR cards. The case study was chosen for an in-depth exploration of the specific phenomenon of elementary student's interactions

with AR-based for educational media. The instruments used consist of AR flashcards Animal 4D+ from Octagonedu as the main educational media, mobile device to run the AR application, structured observation notes prepared with categories, and game master who giving rules and directions. Animal 4D+ was chosen because it is suitable for second grade elementary school science learning materials, is easily available in the market, has a variety of features and gameplay, and is quite popular.

The participants consisted of fifteen students aged 7–9 years from an elementary school in Tangerang, Indonesia. They were selected using purposive sampling to allow for detailed behavioural observations within a limited class time. The small sample size allowed to observe the details of each student's expressions, gestures, and movements, rather than the entire class. This provided in-depth data, simplified the testing process, solved the issue of limited equipment (one tablet device per class), and shortened the research time. The participants had been choosing based on category active, passive, high score, middle score, and low score students. The gender composition was nearly balanced, with seven boys and eight girls. A teacher was present but as a remote supervisor, without directly influencing the session.

Data was collected through direct observation during AR card game sessions in the school. Students were gathered in a classroom, seated in a circle. A game master accompanied the students, and a researcher recorded the classroom events. The game master showed the students AR flashcards and the AR app using a smartphone. The game master then explained how to use the AR app, the game mechanics, and assisted students with any difficulties while playing the AR card game. The researcher also observed and recorded the student's actions, interactions with the AR card game, and verbal responses. Observation notes were organized into categories of memory, language and literacy, problem solving, social cognition, and interaction. These categories served as anchors to capture user experiences and engagement. The primary data consisted of field notes detailing the student's responses, questions, and interaction flow.

Data analysis was conducted using theory-based descriptive approach, focus on learning behaviour and interaction design (Mayer, 2005; Sharp, 2019). The categories consist of:

1. Curiosity. The initial reaction about AR card game and interest when viewing the cards.
2. Engagement. The enthusiasm with AR card game, active participation, distraction, boredom, attention span, and social interaction.
3. Memory and recall. The ability to recall and remember animals name and diet.
4. Literation. The ability to read and understand the context about animals.
5. Problem Solving. The ability to figuring out the game mechanics and initiative to asking for guidance.

RESULT AND DISCUSSION

Understanding how interaction design shapes engagement requires a foundation in learning and interaction theory. According to the cognitive theory of multimedia learning (Mayer, 2005), learning will be meaningful if students actively get the information by visual and verbal elements. This theory is used to view 3D visual, text, and audio as beneficial for improving memory retention. However, without appropriate guidance, excessive sensory stimuli can increase cognitive load, highlighting the importance of structured interaction. Meanwhile, constructivist learning theory (Vygotsky, 1978) states that knowledge is begin through social interaction and guidance from the facilitator. Therefore, the roles of the game master, teacher, and peers were crucial in helping students from curiosity to understanding the information during learning activities with an AR card game. From a motivational perspective, the ARCS Model (Keller, 2010) identifies attention, motivation, activeness, curiosity, and self-confidence as aspects for maintaining student engagement. This relates to the student's user journey and dynamic learning outcomes. The ARCS Model helps this study understand the AR card game experience that captures attention through the novelty of 3D visuals and interactivity, along with the need for briefs, instructions, and interactivity design to maintain motivation. The interaction design principles (Sharp, 2019) such as

usability, attention, feedback, consistency, and affordance determine how intuitive and engaging a digital experience is for users. When these elements are aligned, the interface not only gain understanding but also encourages exploration until proficient. Based on the theoretical perspectives, the following section discusses how students experienced the phases of engagement when interacting with an AR card game.

User Experience of Students using AR Card Game

Based on classroom field testing, this study gained insight into the user experience and engagement journey map. Students were first introduced to the AR card game. They had seen and played card games but had never seen cards with AR technology before. This provided the opportunity for the study to explore their user journey and experience from start to finish (Mayer, 2005).

Figure 1. AR card game by Octagonedu
source: author's documentation

The game master opened the game by showing the yellow card packaging containing pictures of animals, one of which was an elephant. The game master briefly questioned the image, but not everyone understood that it was an elephant. Afterward, the game master opened the packaging, took out the cards, and showed them to the students. Upon seeing the cards, the students recognized them as animals. Some of them could name the animals in Indonesian language, while the cards were in English language version. There were several animal illustrations

that the students became confused, such as raccoon, iguana, penguin, and ostrich. They even identified whale and called it fish. Of the 26 cards, the only animals they could identify were monkey, frog, kangaroo, elephant, cow, and fish. Some children seemed to cheat by reading the name written on the card and they realized that the card was written in English. Some students looked confused when the "monyet" card written as monkey. This activity identified the student's initial understanding of animal names and engagement level when the card game did not use AR. The card game without AR could direct student's attention, focusing on the animal illustration. In line with card game design (Santoso & Agustin, 2023) which is useful as a media for sharing stories with peers. However, the unmoving illustration made students less interested in the cards.

Figure 2. The card design
source: author's documentation

The main card has three design layouts, which are an instruction layout, an animal layout, and a food layout. The instruction layout design shows images of food, habitat, and types of bones illustrated in a low-poly visual style. The instruction layout card design is related to the animal layout card design. In the ant card, the bottom of the card contains three illustrations that provide information that ants are omnivores, live on farms, and are invertebrates. This helped students guess the ant's identity by matching the image between the instruction card and the animal card. So students not only learn about the shape of the ant. The animal card layout design consists of an animal illustration and three information icons that help students get complete information. After

students knew that ants are omnivores, they could then look for a food card that is suitable for ants, for example a banana card. The food card layout design only consists of the food card text, the food name, and the food illustration. This makes the design layout the simplest compared to the instruction and food cards so that children can focus on finding the right food without distraction.

When students were first shown AR technology using smartphones, they were already curious about what would be displayed and appear. Some of them immediately paid attention to each card shown and participated enthusiastically. AR card games not only directed student's attention to focus on the animal illustration but also helped students listen to instructions and questions. The classroom atmosphere was also more conducive due to student enthusiasm. Students asked many questions and discussed with their friends. Students were able to actively share events or knowledge about animals and their food. The attention span of students to continue paying attention to the animals was also longer compared to using card games without AR because students could explore the user interface and see the animal movements from animation. Student's curiosity increased because they wanted to know the detail physical form, gestures, and what the animals did on the cards. Some students seemed happy with the animation of a horse walking for grass. They were enthusiastic about playing the AR card game.

When students were invited to try playing the AR card game on their own, they were confused and needed guidance to navigate the AR application. However, shortly after being taught, they were able to navigate the AR application. The confusion they faced prompted them to actively ask questions and seek assistance. This encouraged them to find simple problem-solving strategies for using the AR card game. Students also learned to adapt to technology, and their adaptation proved to be excellent. This is evidenced by their success playing the AR card game on their own. The user interface is also simple enough for students to learn easily. The AR card game can improve motivation, interest, focus, engagement, and cooperation among elementary school students.

The AR card game keeps students enthusiastic, allowing them to repeat the game. This repetition increases student's ability to correctly guess the names of animals and their food. The more repetitions, the more correct their guesses, and the more confident they become in participating in the game. The AR card game helped students immerse themselves in a fun, immersive world, encouraged them to enthusiastically explore the immersive world. They wanted to touch the animals (3D objects) and observed the 3D objects of animals in detail. Some children observed the movements and gestures of the animals and discuss them with their classmates. Students also noticed the funny gestures made by the monkey when eating a banana and laugh about it. All the children looked happy and forgot that they were actually learning and being tested. They actively participated in the game. The following Table 1 shows the learning outcomes with a Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

No	**Statement**	**1**	**2**	**3**	**4**	**5**
1	Students curious about the AR card game.				✓	
2	Students want to approach the AR card game.					✓
3	Students stare at the AR card game continuously.				✓	
4	At the first time, students react spontaneously.				✓	
5	Students actively engaged.					✓
6	Students bored.		✓			
7	Students focused.				✓	
8	Students actively discussing.				✓	
9	Students enjoy the media.				✓	
10	Students continue playing.				✓	
11	Students hold the cards.			✓		
12	Students remember the name and food.				✓	
13	Students can retell/explain.				✓	
14	Students understand the content.					✓

15	Students able to distinguish animal objects.					✓
16	Students able to read all of the text.			✓		
17	Students able to speak a foreign language.	✓				
18	Students complete the game.					✓
19	Students take initiative.				✓	
20	Students think logically.				✓	

Table 1 Learning outcome
source: author's documentation

The table shows that student's curiosity and engagement with the AR card game were quite good. The AR card game helped students understand the learning material and maintain focus during the game. Students were able to discuss and take initiative in completing the game. Through AR card game, students learned through play while exploring a new immersive world (Ferawati et al., 2024; Priyadi, 2022; Yoliando, 2022). The interactive 3D visuals support students to recognize the shape, texture, and gesture. Interaction like combining the cards and quiz gave real-time feedback that encouraged curiosity and cognitive involvement, in line with cognitive theory of multimedia learning (Mayer, 2025), where visual and verbal integration strengthens comprehension.

However, student's enthusiasm and engagement are not consistently high. Students that proficient have completed the game and they will become bored and lose their engagement. Students who repeat the same game and see the same cards will reach a point of boredom. According to (Keller, 2010; Vygotsky, 1978), student engagement in learning is dynamic, not constant. The attention and satisfaction are maintained only when learners experience new challenges or varied stimuli. To understand how user experience impacts student engagement with the AR card game, this study maps the student user experience into a user engagement journey map (Figure 3). Rather than simply measuring student engagement qualitatively using a Likert scale, Figure 3 allows for capturing the dynamics of engagement and highlights critical touchpoints where interaction design can support or fail to maintain learning engagement.

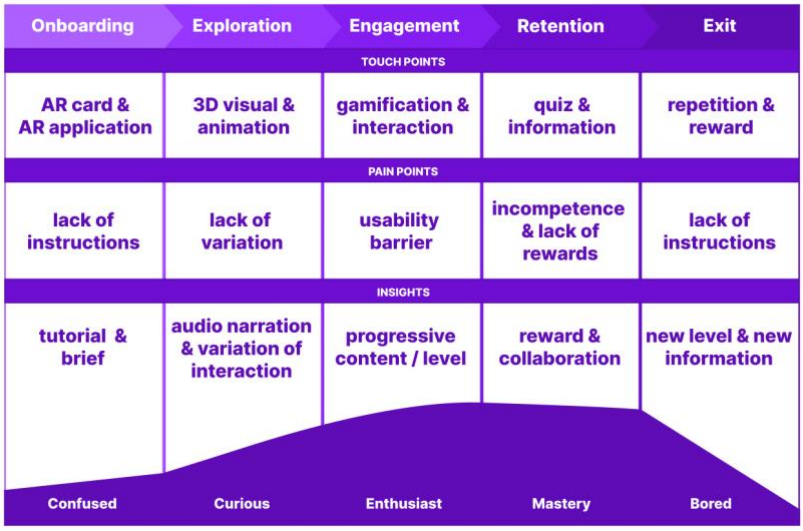

Figure 3. User engagement journey map
source: author's documentation

As shown in the engagement journey (Figure 3), students began with strong curiosity when the 3D animals appeared. However, after several repetitions, their enthusiasm declined as the game interactions became more predictable and less challenging. Figure 3 demonstrated that student engagement with the AR card game learning media did not remain constant, but rather developed through five phases:

1. On boarding. The first introduction is when students saw and used the AR card game. Students were curious about the 3D animal visuals that suddenly appear. Enthusiasm and engagement with the game begin to build. Initial 3D visuals can increase cognitive load while capturing attention is crucial in transforming curiosity (Keller, 2010; Mayer, 2005). Some students who experienced confusion need simple tutorial and briefing not just instruction how to use AR card. During this phase, the teacher or facilitator must actively assist the students (Vygotsky, 1978).

Figure 4. Visual 3D AR card game
source: author's documentation

2. Exploration. Students played with an AR card game and explore AR interactions. They observed 3D objects in the form of animals and entered an immersive and imaginative world. If students had two related cards, for example a monkey card and a banana card, students could see the monkey eating the banana. Interaction variations were needed to ensure students feel comfortable while playing. Students felt less afraid to learn and being confident in completing the learning process. This phase was such as a warm-up phase, preparing students to learn and following the rules. According to the cognitive theory of multimedia learning (Mayer, 2005), students able to understand deeper when visual and audio elements are embedded. This AR card game use the principle of multimedia effect where 3D visual, animation, and audio work together to improve the engagement and vocabulary learning.

Figure 5. AR interaction in card game
source: author's documentation

3. Engagement. Students were actively and enthusiastically engaged in reviewing the subject material and interacting with the AR application. AR card game has several interaction features. Student could change languages. They could rotate the 3D animals 90 degrees, so the animal bodies were lying on their backs to observe their overall shape. Students

also played Animal Detective, a game with quiz-like mechanics. There were questions that students could answer by playing cards. Students were able to teach their peers, thus creating a fun learning environment in line with constructivist learning theory (Vygotsky, 1978). This phase allowed students to absorb as much of the learning material as possible, such as names, types of food, physical characteristics, gestures, and behaviours of some animals. To absorb information, this AR card game needs the progressive level or content. According to Ghosh, et.al (2025), learning by AR card requires adaptive learning algorithms or challenges such a difficulty level to build sustainable engagement.

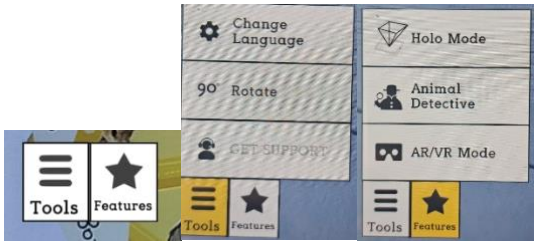

Figure 6. AR features gamification and quiz
source: author's documentation

4. Retention. Students mastered the learning content and could retell what they had learned. In this phase, some students began to appear bored with the AR card game because they had already mastered the material. Albayrak (2022) observed the declines of the children's engagement while using AR because of the lack task variation or the lack of social collaboration. Therefore, it will be best to provide simple rewards by overall score and collaboration gameplay to stimulate student engagement. This phase demonstrated the student's abilities and understanding.

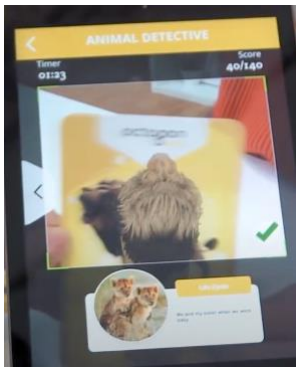

Figure 7. AR quiz to test and reward
source: https://www.youtube.com/watch?v=zRtdmzvPbEA

5. Exit. After playing the AR card game several times, students got bored and distracted by other things. They felt fulfil by learning and playing. At this point, student engagement drops, causing them to drop out or exit the game. Engagement drops not because the media fails, but because learning goals have been achieved and the novelty and curiosity effect have decreased (Chen, 2022). Once students have mastered a task, they exit and sometimes distract their peers. However, several students failed to achieve their learning objectives but were already bored. To solve this problem, a variety of layered interactions are needed to keep children curious and engaged (Keller, 2010; Sharp, 2019).

Engagement Factors in the Interaction Design

The visual and interactive elements of an AR card game certainly influence student engagement. To understand engagement factors in interaction design, user interaction analysis is required. User interaction analysis provides insight into which design aspects successfully engage children and which require further development to maintain learning engagement (Sharp, 2019). The following Table 2 shows user interaction feedback about the AR card game design.

No	Statement	1	2	3	4	5
1	AR interactions are easy.					✓
2	AR interactions are enjoyable.					✓
3	AR interactions are fun/exciting.					✓
4	AR interactions are useful.				✓	
5	AR interactions are helpful.					✓
6	AR interactions are clear.				✓	
7	AR interactions are keep attention.				✓	
8	AR interactions are improve memory.					✓
9	AR interactions are support collaboration.				✓	
10	AR interactions are support motivation.					✓

Table 2 User Interaction Design Feedback
source: author's documentation

There are six factors found during field testing and are sorted based on the best combination of aspects:

1. Engagement (very good). Demonstrated through relatively high enjoyment and fun factors, supported by 3D visuals and object animations. Students enjoy the immersive world.
2. Learning Support (very good). Evidenced by excellent memory and motivation. AR interactions support repetition of material until mastery.
3. Usability and Clarity (good). Evidenced by easy and clear factors. AR interactions are easy to use due to their simplicity, but the user interfaces are less intuitive, requiring children to receive a briefing or tutorial first when on boarding. To improve this, AR card games should include some brief instructions or a video tutorial at the beginning.
4. Usefulness (good). Demonstrated through the usefulness and helpfulness factors. AR interactions are beneficial for understanding and remembering the subjects, but not outstanding or monotonous. Usefulness can be improved with additional features like mini games, zoom in interaction on

animal details, animal location maps, and additional information. Not just about feeding animals and guessing its names.

5. Sustained Attention Span (need improvement). Demonstrated through the attention factor. Student's focus at the beginning is significant and helpful for education, but the focus declines after mastering or repeating the media. Game mechanics variation or AR interactions are needed.
6. Social Interaction (need improvement). Evidenced by the collaboration factor. Collaboration between students is less tangible and less focused. Sometimes students simply discuss and spontaneously talk with friends without any context that leads to deeper understanding of the subject material. Collaboration can be improved with multiplayer modes, allowing students to play together, solve problems together, and enable fun group competitions. Gamification can also be sequenced or assigned levels for more focused learning.

The AR interaction generally fun, engaging, and motivating, while also helping students retain information. However, ratings for clarity, sustained attention, and collaboration were lower, suggesting that the interaction design lacked adequate guidance, variety, and social support. AR interaction demonstrated strong curiosity and enthusiasm when first interacting with the 3D visuals, but attention gradually declined after repeated use. Without additional variation in interaction mechanisms, engagement tended to become saturated, and children shifted to social play or distraction.

The AR card game still supported some forms of meaningful learning. The animated visuals helped children recognize, analyze, and remember the names of animals and their food. Although the AR app did not include audio narration, the visuals encouraged peer discussions about animal behaviour, physical characteristics (such as an elephant's trunk and tusks), and movement. Through this AR card game, students were able to compared the relative sizes of animals and their food, strengthening spatial reasoning. In some cases, the interface encouraged incidental English vocabulary learning, as students attempted to read or pronounce the words displayed on the screen. Furthermore, interactive 3D

models stimulate storytelling and peer-to-peer discussions, allowing children to create simple narratives and exchange knowledge socially. While the animated 3D visuals initially sparked curiosity and excitement, limited interaction options often led to repetition and eventual disengagement.

AR Card Game Interaction, Engagement, and Learning Outcome

The user experience and interaction design of the AR card game provide concrete evidence of the success and usefulness of this media in the learning process. The findings can be summarized through the interaction and engagement pathway illustrated (Figure 8), which links user interface (UI) features, user experience (UX) factors, and learning outcomes.

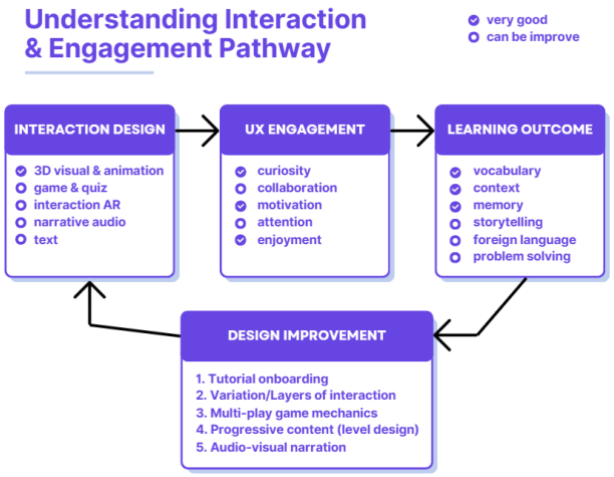

Figure 8. Interaction and engagement pathway
source: author's documentation

Figure 8 shows the relationship between interaction design, user engagement, and learning outcomes. Essentially, this diagram proposes that effective design is not simply aesthetics, but also a strategic flow that directly impacts what students learn. The diagram clearly distinguishes between design elements considered superior (such as 3D visuals and gamification) and elements that can be improved (such as audio and text narratives), providing valuable insight into which elements have the greatest impact on creating memorable experience. This hierarchy suggests that more interactive and immersive elements tend to excel in driving user engagement.

UX engagement is a crucial bridge to learning outcomes. Engagement is measured not only by the duration of use but also by the quality of interactions that spark curiosity, encourage collaboration, sustain motivation, capture attention, and provide enjoyment. This section explains that successful design is one that positively evokes user emotions and cognition. For example, the use of games and quizzes not only makes learning enjoyable but also fundamentally increases student motivation and attention.

Learning outcomes outline how effective design and engagement lead to measurable outcomes. This diagram highlights that interaction design is highly effective in improving vocabulary acquisition, contextual understanding, and memory retention. However, it also highlights limitations, where elements such as storytelling, foreign language learning, and problem-solving still need improvement. While gamification and 3D visualization are powerful, the AR card game is not yet fully optimized to support more complex cognitive processes and requires a deeper narrative or more directed structure.

The design improvements serve as feedback, offering concrete solutions to strengthen the overall flow. Points like on boarding tutorials and progressive content directly address challenges in learning outcomes by ensuring users have a strong foundation before moving on to more complex material. Furthermore, multiplayer mechanics and interaction variations are designed to enhance collaboration and enjoyment, key components of UX Engagement. This feedback confirms that successful design is not a static product, but rather an iterative process that is continually refined based on data and observations of user experiences.

This diagram provides a robust and practical framework for designers. It not only demonstrates the causal relationship between design, engagement, and outcomes but also provides a clear roadmap for improvement. This model challenges the notion that online learning is simply about delivering information. Instead, it asserts that the essence of effective learning is creating immersive and

interactive experiences that organically encourage users to engage, explore, and absorb knowledge.

CONCLUSION

This study explores user experiences when playing AR card games and how interaction design can enhance learning engagement. The findings reveal that AR card games can support curiosity, attention, and motivation through multisensory and visual interactions, align with the cognitive theory of multimedia learning (Mayer, 2005), which suggests that the use of multisensory media enhances learning. However, engagement tends to decline when interaction patterns are repeated, consistent with constructivist learning theory (Vygotsky, 1978) and the ARCS Motivation Model (Keller, 2010), which emphasizes the importance purposeful interaction design in maintaining student's engagement.

The engagement process follows a dynamic user flow influenced by the gameplay, interactivity, feedback, and collaboration. From a design perspective, features and interactivity influence student's memory retention and motivation. Maintaining student engagement requires not only engaging visual aesthetics but also game mechanics, purposeful instruction, and peer collaboration. Designers should consider integrating adaptive or task based on challenges, diverse interaction variety, and audio-visual narratives to broaden attention and deepen learning outcomes. The key is to maintain student curiosity through additional AR interaction layers. By refining and developing the AR card game's interaction design, student engagement will be maintained. This aligns with interaction design theory (Sharp, 2019) and the AR integration findings of Albayrak (2022) and Chen (2022).

This study contributes to the development of interaction design for more interactive, multisensory, and socially responsive educational media. Limitations of this study is the small sample size and one session testing. Future research could involve a larger group of participants or compare different AR interaction models.

Further explores in interaction variations is also needed to understand the forms of AR interaction layers.

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