Understanding the Effect of Fantasy in Augmented Reality Game-Based Learning from a Player Journey Perspective

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ABSTRACT

Contemporary young generations face numerous 21st-century learning challenges, including motivation deficiency, distraction, low effectiveness, etc. Fantasy in game-based learning, creating imaginative and fictional situations that deviate from real-life has demonstrated powerful effects on engaging young participants. Fantasy in games empowered by Augmented Reality (AR) can further immerse participants by generating a "magic circle" where the boundary of digital fantasy and the physical real world is blurred. Despite these positive potentials, there are still concerns regarding the effect of fantasy on player experience, educational contextual adaptation, learning motivation, and learning effect. In this work, we explore the effect of Fantasy in Augmented Reality game-based learning from a player journey perspective, which contains four phases. Four phases are analyzed through an empirical study for each phase. In each study, the effects of fantasy and real-life versions are compared. The purpose of this work is to gain a deeper understanding of the impact of fantasy in AR game-based learning and to provide designers with effective design strategies that help learners overcome the challenges of 21st-century learning.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods; User centered design.

KEYWORDS

Fantasy, Game-based learning, Augmented Reality, Serious games,

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1 INTRODUCTION

The development of 21st-century learning necessitates a paradigm shift in the classroom environment, shifting from traditional, teacher-centered approaches to more learner-centered classrooms that prioritize the individual needs of students [1]. One technology that facilitates this shift is Augmented Reality (AR). AR enables interactive experiences in the real world while overlaying virtual interactive elements onto the physical environment [6]. Integrating graphics, 3D models, and animations into physical materials such as books, blocks, or physical spaces, AR creates interactive and immersive experiences that connect theoretical concepts with practical applications in learning activities [5]. This connection can be more engagingly experienced by participants through game-based learning, a form of serious gaming that incorporates educational content and playful features [18].

Game-based learning allows participants to acquire skills and knowledge by adopting a lusory attitude, which means approaching the learning experience with a playful and engaging mindset [26]. Participants are motivated to overcome challenges presented within the game, leading to a more interactive and enjoyable learning process [28]. Taking a lusory attitude, players step into a space created by games called a “magic circle,” meaning “a temporary world within the ordinary world, dedicated to the performance of an act apart.” Such a boundary is blurred by AR where the real world and the virtual fantasy coexists. By stepping into the magic circle supported by AR Game-based learning, players willingly embrace a sense of make-believe, accepting the game’s rules, learning objectives, and fictional elements.

Although AR provides a natural context for integrating game-based learning, combining playful games, tangible learning materials, and authentic situations [27], designing and integrating these elements is not without challenges. The seamless integration of these components requires careful consideration and decision-making. Some game-based learning applications fail to fully establish the magic circle due to negative experiences such as limited control, abrupt interruptions from instructional content, and unappealing narratives [22]. To construct a convincing and engrossing magic circle in AR game-based learning, careful consideration must be given to the design of game elements that support learning motivation and improve player experience which eventually allow participants to accept the settings and make-believes [11].

Fantasy, unreal experiences, being fueled by imagination in games, engenders a fun and playful experience, enabling participants to approach the design as a game rather than a learning tool [19].

When imaginary or unrealistic experiences are implemented in games, users can experience narratives, visuals, and actions, that they would never experience in real-life [23]. The inclusion of fantasy elements in game-based learning can create an emotionally captivating experience for participants, enticing them to willingly immerse themselves within the enchanting realm of the "magic circle [14]." However, it is not a one-size-fits-all solution for addressing the 21st-century learning challenges to simply apply fantasy in AR Game-based learning. Game-based learning differs from entertainment video games in that participants do not always voluntarily engage in gamified learning activities and may not perceive the activities as playing [4]. If the incorporation of fantasy elements is poorly designed, it can be likened to "chocolate-covered broccoli," where the learning aspects are disguised but ultimately unappealing. To balance the entertainment value of the game with learning content, the incorporation of fantasy should not only be enjoyable but also facilitates effective learning outcomes and fit learning situations [10].

In this work, we explore the effect of fantasy in AR game-based learning from a player journey perspective. Through qualitative and quantitative analyses, we try to understand design strategies for balancing players' engagement and comprehension, as well as effectively integrating the role of teachers and generating design considerations for situated learning with different learning subjects and AR fantasy.

This research will contribute to the development of more effective and engaging AR game-based learning experiences, providing educational practitioners and designers with evidence-based guidelines for incorporating fantasy elements in their designs. Through this research, we hope to assist designers in creating AR game-based learning contexts that effectively address the challenges of 21st-century education.

2 FANTASY IN AR GAME-BASED LEARNING

2.1 The definition of fantasy

Fantasy and unreal experiences, driven by imagination in games, create a fun and playful environment that allows children to engage with the design as a game rather than perceiving it as a mere learning tool [19]. By incorporating imaginary or unrealistic experiences into games, players can immerse themselves in narratives, visuals, and actions that are beyond the realm of their real-life experiences [23]. According to Malone and colleagues, fantasy settings are defined as "contexts that evoke mental images that are not present." The inclusion of fantasy elements in game-based learning has the potential to make the learning experience emotionally appealing to users [14].

2.2 Why fantasy

Game-based learning differs from entertainment video games in that participants may not willingly engage in the gamified learning activities and may not perceive them as playing [4]. This highlights the need to investigate how to enhance engagement and enjoyment within the learning context. Previous research suggests that effective integration of game elements with learning theories can significantly increase motivation and facilitate effective learning [18]. By exploring the role of fantasy in game-based learning, researchers can uncover how fantasy elements can be harnessed to boost motivation and enhance the learning experience. Moreover, to transition from perceiving an educational game solely as a learning tool to fully immersing oneself in a playful and engaging experience, individuals need to enter the "magic circle" by adopting a playful mentality and actively engaging with the game environment [17]. One vital trigger for establishing a pervasive and compelling "magic circle" is a separation from everyday life, i.e., fantasy in games [11].

In game-based learning supported screen interfaces, games can be categorized into simulations based on real-world settings or fantasy games with fictional settings [24]. However, with the advent of AR technology, this classification undergoes a transformation. AR game-based learning offers unique contexts where players can simultaneously perceive the physical world and engage with digital game fantasy, resulting in distinct levels of immersion compared to a fully virtual experience.

However, there are concerns about how fantasy affects learning effectiveness, both for individuals and in classroom settings. Some argue that fantasy might increase cognitive load [2], for children, challenge their prior knowledge connections, and potentially hinder AR-based learning efficiency [25]. In classroom situations, some learning games are criticized for prioritizing fun over learning and not aligning closely with subject-specific knowledge [13]. Additionally, concerns exist about teachers' roles in scaffolding and integrating instructional content with fantasy contexts [3]. Addressing these concerns requires empirical research in specific learning contexts.

3 RESEARCH QUESTIONS

To address concerns and gaps mentioned above, our research aims to investigate the impact of fantasy in AR games for learning. We've developed a player journey map, dividing the interaction into four phases: 1. Before: attraction to gameplay, 2. During: immersion during gameplay, 3. After: knowledge recall after gameplay, and 4. Environment: classroom integration. Each phase is considered a separate study.

We further compose research questions from four key phases in a game-based learning journey's overarching structure:

1. Before: How can fantasy attract/invite children to an AR game for learning?
2. During: How can fantasy support engagement during AR gameplay?
3. After: How can fantasy support learning as a result of AR gameplay (after)?
4. Environment: How do AR fantasy games for learning fit in a classroom environment?

4 DESIGN STUDIES

We design in general four games to answer our questions. Through these games, we conduct four distinct research studies, each aimed at addressing one of the questions we have outlined. In each study, we compare the outcomes of both the fantasy and real-life versions of the game in order to examine the impact of fantasy.

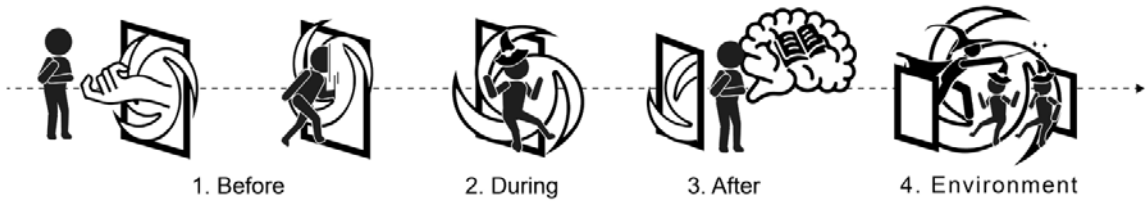

Figure 1: Four phases of the player's journey.

Figure 2: Different avatar versions in the game Mathmythos AR

4.1 Study 1: Mathmythos AR

Mathmythos AR is an augmented reality (AR) game-based learning application that utilizes a mobile phone application and a set of board game cards. In the game, players are presented with four distinct avatars, each offering a unique role and experience (see Figure 2). These avatars encompass a diverse range of tasks, including a magician tasked with liberating a human soul sealed within a monster, a dragon responsible for hatching a dragon egg, a student with the role of placing food orders, and a cow assigned to the delivery of goods.

Players are encouraged to place cards and trigger the virtual button under the AR camera to solve the game task. Utilizing mathematical skills, participants hold and release the virtual button when the correct answer appears. Participants reason to progress through the game and complete the tasks that require calculation.

Aiming to conduct compare studies, we categorize the game with 2 tags, fantasy and similarity. The study employed a within-subject design, where 34 children participants aged 7-8 play different versions of the game under random sequences. Intrinsic Motivation Inventory (IMI) and Player Identification Questionnaire (PI) are employed [16, 20]. IMI is used to identify the enjoyment and interest aspect of motivation whereas PI is used to measure participants' wishful and similarity Identification with different avatars, capturing participants' perceptions of themselves in relation to the avatars they encountered during gameplay.

A significant correlation was observed between Wishful Identification and enjoyment ($r = 0.26$, $p = 0.03$), as well as Similarity Identification and enjoyment ($r = 0.24$, $p = 0.05$), among participants using fantasy avatars. However, these associations were not significant when participants were using real-life avatars.

These findings concerning avatar design serve as a guiding principle for our future work on developing narrative designs driven by fantasy elements. Interestingly, we discovered that incorporating fantasy elements in the design does not guarantee that every player will enter a fantasy state of mind, as each player approaches various game features with their own unique attitude. Consequently, it becomes crucial to assess players' fantasy states in order to gain a deeper understanding of their attitudes towards different fantasy game elements in future research endeavors.

4.2 Study 2: Mathmythos AR 2

After studying participant attraction in the initial stage, we shifted our focus to player engagement and gameplay experiences. Key factors such as autonomy (the freedom of control) and immersion (the sense of being present) are critical indicators of whether players perceive the serious game as a game rather than just a learning tool [15]. we introduce our second design Mathmythos AR 2 to explore methods of creating captivating and engaging games.

We develop Mathmythos AR2 in the format of an augmented storybook. This serves as an extension of MathMythosAR1, incorporating additional animated storytelling content overlaid onto the storybook. This expansion not only increases the total playtime but also allows us to gather more comprehensive data regarding the players' overall play experience. Two game versions are prepared: fantasy and real-life. In the fantasy version (Figure 3, Left), players take on the role of a magic school student learning math magic to battle malevolent forces transforming villagers into monsters. In the real-life version (Figure 3, Right), players become primary school students learning math in class and planning for a class

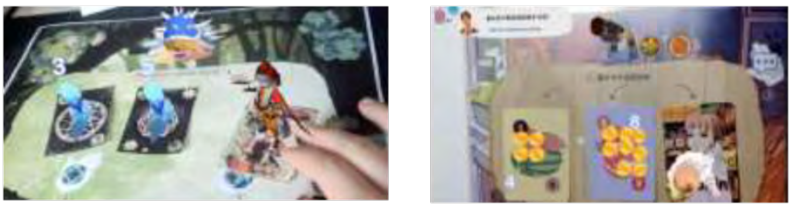

Figure 3: Different narrative versions in the game Mathmythos AR2

party. With two versions of Mathmythos AR2, we conduct a within-subject experiment and collect participants' self-reported data using Player Experience of Needs Satisfaction (PENS) questionnaire, Fantasy State Scale (FSS), and Intrinsic Motivation Inventory (IMI) [8, 20, 21]. Through a comparison of two narrative conditions with 31 participants aged from 7-11 years old, we aim to investigate the effect of different in-game fantasy settings on users' fantasy states, their player experience of need satisfaction, and intrinsic motivation.

A Wilcoxon Signed-Ranks test revealed that imagination induced by the fantasy version of MathMythosAR2 (mean rank = 11.06) was significantly greater than that in the real-life version (mean rank = 7.33), Z = -3.12, p = 0.002. Additionally, the experience of presence in the fantasy version (mean rank = 9.15) was significantly stronger compared to the real-life version (mean rank = 8.50), Z = -2.00, p = 0.042. Similarly, identification scores in the fantasy version (mean rank = 9.08) were higher than those in the real-life version (mean rank = 8.75), Z = -2.00, p = 0.046. These findings prompted us to further explore the potential influence of fantasy states as a mediator between the game's fantasy settings and the player's enjoyment. Therefore, we construct a mediation model. We find that only imagination states of fantasy mediated the relationship between game conditions and enjoyment (a: β =0.32, p<0.05, b: β =0.41, p<0.01, c': β =0.15, p>0.05, R^2=0.04). The bootstrapped confidence interval of indirect effect does not straddle 0 (BootLLCI: 0.24, BootULCI: 0.33), the statistically significant indirect effect is validated, and the mediation model is significant.

This study revealed that creating an engaging and enjoyable imaginative experience requires game designers to immerse players in an augmented reality (AR) game-based learning environment, where the learning process with fantasy can trigger imagination, and is perceived more as a game rather than a traditional learning activity.

4.3 Study 3: Chemikami AR

In our third study, we focus on the learning impact of AR fantasy within Chemikami AR, a card-based game featuring chemical element and application cards. Players match chemical elements with their corresponding applications and trigger animations by scanning the correctly matched cards using the AR camera. There are ten sets of cards to pair.

For the comparative experiment, we offer two game versions: a fantasy version with magical avatars representing chemical elements (Figure 4, left) and a real-life version using the physical appearance of chemical elements' monomers or compounds as representations (Figure 4, right). We also have a baseline version without AR, visually representing chemical elements with real-life monomers or compounds.

In this study, we conducted a quasi-experiment with 124 participants aged 11-14 from the Netherlands and China who had not received formal chemistry instruction. Participants played either the fantasy or real-life card game, followed by a knowledge test. They also tried a non-AR baseline version. Different sets of chemical elements in AR and non-AR settings prevented memory effects, and we counterbalanced the gameplay sequence to mitigate sequence bias. Additionally, we compared different age groups to develop diverse design solutions for specific target groups.

A significant main effect of the "Fantasy vs. Real-life" setting was found on knowledge test scores, F(1,96) = 9.08, p = 0.003, ηp^2 = 0.086. Knowledge test scores significantly differed between the AR fantasy (M = 7.53, SD = 1.58, N = 53) and AR real-life (M = 6.4, SD = 2.10, N = 45) conditions, suggesting that AR fantasy enhances recall more effectively than AR real-life elements for children.

The results indicated a significant location effect, F(2, 116) = 11.05, p = 0.000, ηp^2 = 0.160, and a significant three-way interaction effect involving "Fantasy vs. Real-life," "AR vs. Baseline," and location, F(2, 116) = 3.21, p = 0.044, ηp^2 = 0.052. Gender and age groups did not have significant effects. However, there was a significant within-subject factor effect for the interface "AR vs. Baseline," F(1, 116) = 10.51, p = 0.002, ηp^2 = 0.083, suggesting that participants of all ages recalled more with AR than with their baseline, except for when analyzing children's data only. Additionally, there was a significant interaction effect between "Fantasy vs. Real-life" and "AR vs. Baseline," F(1, 116) = 4.56, p = 0.035, ηp^2 = 0.038. Notably, the between-subject factor "Fantasy vs. Real-life," significant in children's data, became insignificant when adults' data were included.

4.4 Study 4: Fancybook AR & Mathmythos AR 2

Study 4 focuses on a combined investigation with Mathymythos AR2 for mathematic learning and Fancybook AR for English learning. We aim to explore the incorporation of fantasy elements into various educational subjects and learning environments. By conducting both qualitative and quantitative analyses, we are trying to identify key design strategies that enhance players' experience, engagement, and comprehension. Furthermore, we are trying to understand how teachers can effectively integrate their role into the immersive fantasy experience of AR game-based learning.

This study utilizes a sample of 62 participants from two distinct regions in China, 31 participants from Qingdao and an equal number from Hefei. The age range spans from 7 to 14 years old for the respective groups. Each participant engages in the MathMythosAR2

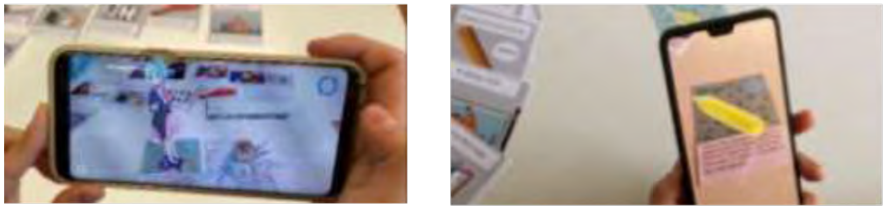

Figure 4: Different avatar versions in the game Chemikami AR

Figure 5: FancyBook AR (Left) and Mathmythos AR2 (Right)

and Fancybook AR games, experiencing both fantasy and real-life versions, in a counterbalanced order. Both games are in forms of AR storybooks with similar narrative structure. The entire procedure is captured using a GoPro Hero9 camera for video analysis.

A stronger mental state of imagination is observed in participants when engaging with the fantasy version compared to the real-life version. Conversely, a stronger mental state of analogy is noted in the real-life version compared to the fantasy version. Emotional engagement is higher in the fantasy versions of both games. However, the fantasy version of Fancybook AR results in negative engagement, including confusion and frustration due to failure. The study reveals that fantasy narratives increase students' engagement in mathematics learning but disengage them in second-language learning. Children report significantly higher enjoyment with the real-life version of Fancybook AR compared to the fantasy version. Interestingly, there is an interaction effect in terms of immersion, suggesting that children perceived stronger immersion in the fantasy version of MathMythosAR2, while the opposite is observed in the game Fancybook AR.

We also observe that teachers primarily employ scaffolding techniques to assist students in comprehending intricate AR interactions in MathMythosAR2 for mathematics learning, given that the concept of AR interaction, including virtual buttons, is relatively novel to the participants. Regarding the fantasy version of MathMythosAR2, teachers need to provide more explanations regarding the narrative compared to the real-life version. However, students also exhibit a greater inclination to explore and experiment initially, even if they do not fully grasp the intricacies of the fantasy narrative. In terms of English learning with Fancybook AR, teachers predominantly utilize scaffolding strategies to facilitate narrative interpretation and the explanation of knowledge. It is observed that participants who encounter difficulties in comprehending the narrative also face challenges in understanding the associated knowledge within Fancybook AR. This circumstance is particularly prevalent in the fantasy version of Fancybook AR compared to the real-life version.

5 THE EFFECT OF FANTASY IN AR GAME-BASED LEARNING

Through four studies, we provided theoretical contribution through enriching knowledge about the definition of AR fantasy and its effect on player experience, motivation, learning outcome, and learning situation.

In the first study, our findings suggest that children's identification with avatars is increased when the avatar design incorporates similarities and elements of fantasy. The correlation between avatar identification and motivation indicates that using similar and fantasy avatars can effectively engage children in games. Our finding is consistent with prior literature that fantasy elements can enhance the appeal and allure of avatars that align with players' self-perception or desired qualities, making players more intriguing and engaging for players. [29].

In the second study, we found that players' imagination plays a mediating role between fantasy settings and engagement. This implies that incorporating fantasy elements can enhance players' engagement by promoting imagination and providing a more immersive experience. This discovery expands upon the current body of literature in media psychology, which highlights the crucial role of imagination in fostering immersion and engagement in gaming experiences [7]. By incorporating perspectives on fantasy narrative design, this study provides new insights and enriches our understanding of intricate relationship between fantasy design, imagination, player experience, and engagement.

The third study revealed that fantasy can improve children's learning and recall of declarative knowledge. Well-designed fantasy elements can transform redundant information into a facilitator for recalling declarative knowledge. This suggests that incorporating fantasy into gameplay can ultimately support learning outcomes. The learning benefit of fantasy, observed in children, likely

stems from its motivational impact. Previous research suggests that children are more motivated by fantasy elements [9], leading to enhanced learning outcomes.

In the fourth study, we discovered that participants' engagement with fantasy is influenced by the challenges they face in the game. When the learning content is intrinsically related to the fantasy narrative, it can become challenging for participants to learn, leading to signs of disengagement. This situation often requires additional support and guidance from teachers or educators. Designers aiming to integrate fantasy into a classroom environment should consider the intrinsic connection between the learning subject and the narrative, the role of teachers, and the need to balance children's engagement and comprehension. These findings are consistent with earlier studies that recognize the intrinsic incorporation of fantasy to align game mechanics with learning objectives. Such intrinsic incorporation is essential for achieving a harmonious blend of engagement and comprehension to stimulate children's motivation for learning [12].

These findings collectively enrich our knowledge of AR fantasy's multifaceted role in enhancing player experiences, motivation, and learning outcomes, providing valuable insights for designers and educators alike. We hope that providing guidelines for researchers on related topics of designing with fantasy in game-based learning can stimulate more exploratory research to utilize the potential of AR and game-based learning.

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