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Augmented Reality in Mobile Gaming and Player Engagement: A Quantitative Study

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Abstract*—Augmented Reality (AR) technology has had a profound effect on the gaming industry in recent years by enabling game designers to create interactive virtual environments that overlay upon a player's physical space. Through an in-depth investigation of the effects of AR on mobile game player engagement this paper will explore four dimensions of player engagement: immersion, interaction, enjoyment and the user experience. In order to collect and analyze data, a quantitative methodology was utilized that includes a standardized Likert scale survey designed for the mobile AR gaming community as well as the examination of secondary market and industry data reports from 2022-2026. Survey results indicate that AR positively impacts player engagement on all four measures, most notably with respect to augmented, geospatial and location-based mechanics, and this finding is corroborated by relevant industry and market reports. In 2024, the global AR gaming market was valued at USD 14.2 billion and is projected to increase at a compound annual growth rate (CAGR) of 28.1% through to 2033 to reach USD 141.7 billion. Moreover, when Scopely bought Pokemon Go for $3.5 billion in 2025, it was clear to see that businesses were willing to pay significant capital in exchange for AR technology to use as an engagement mechanism. The contribution to knowledge made by this study is to bring together both primary source survey data collected from real-world users and secondary sources of market data to offer evidence-based insights into the impact of AR on player engagement that previous research had not previously accomplished, thereby offering practical guidance to researchers and industry developers interested in the development of both more user engaging and economically profitable AR-based games.

***Keywords*—Augmented Reality; Technology; Player Engagement; Immersion; User Experience**

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I. INTRODUCTION

The gaming industry has always been known for its fast evolution, yet the way the gaming market has progressed in the last 10 years is no less than extraordinary. The introduction of the smartphone has allowed a once-niche game to be played by millions around the world. With the emergence of augmented reality (AR) as a second wave of mobile gaming development in under 20 years, the changes we see will differ significantly from what we have seen with previous hardware developments. This type of hardware allows players to take the game to them, as opposed to them travelling to the game. Images and animation can be overlaid over the player's physical world in real-time, utilizing either a smartphone screen or head mounted display [1], [2]. Unlike screen-based titles, AR blurs the line between play and place.

Niantic's Pokémon GO is the most visible example of what this new hardware can achieve; it turned the urban sidewalk and city parks into a game arena, and it managed to gather millions of players at launch and has retained them ever since [3]. Pokémon GO's retention numbers were exceptionally unique in the mobile space and has caused game developers as well as investors to view AR as a credible gaming platform instead of a passing phase. Today, the adoption rate of this new mobile AR format has resulted in an exponential growth of mobile users globally [4].

The measurement of player engagement is often an indicator of success for games in development,

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research and analysis. The term engagement represents how invested players are in a game in order to drive various aspects of their behavior including retention, session length, and in-app purchase amounts [5]. The reason for this is that traditional game platforms rely exclusively on a screen's stimulation to keep players interested whereas mobile AR gaming leverages the player's environment, movement and social interactions as an integral component of gameplay. Players are naturally more emotionally engaged as a result of their experience and thus have the intrinsic motivation to play longer. This fact has sparked increased support for utilizing AR as a viable solution to solve many of gaming's inherent problems, such as reduced player engagement and shortened game-life cycles [7].

Augmented reality overlays digital visual, audio, and other sensory content to the user's environment in real time [1]. AR and virtual reality differ most essentially in this sense, that the user stays in the real physical location, whereas virtual reality places the user in a simulated world [2]. For gaming, this means that the virtual reality player is "in" a game, the augmented reality player remains "in" his or her world, yet that world has interactive objects embedded within it. The fact that AR users remain embedded in a physical location makes their experiences different in a number of fundamental ways [3].

Player engagement refers to a cognitive, emotional, and behavioral set of dimensions that simultaneously apply to player interaction with games [4]. Csikszentmihalyi's flow theory of flow as a state of highly concentrated intrinsic focus on an activity is a theory that has become widely applied in the understanding of player engagement [5]. Flow depends on three basic conditions, including a perceived balance of challenge to skill, clear and immediate feedback, and a feeling of control over outcomes. AR mechanics could potentially support all three conditions, and they have the potential to do so by situating challenges in real physical locations and providing tangible spatial feedback rather than abstract visual feedback. As reviewed by Koivisto and Hamari, location-aware, responsive interaction was seen as a particularly effective means for promoting sustained player engagement [6]. Liu, Li, and Zhang conducted research on game-based learning using AR, and found that perceived enjoyment, social interaction, and the perceived relevance of gameplay events to the player's own location predicted continued use and participation [9]. Similarly, Hamari, Malik, and Klock investigated mobile games across many genres, and found that mobile games that incorporated AR mechanics that utilized the real locations around players resulted in game sessions that were around 34% longer on average, as well as higher retention rates among users after the first seven days of gameplay [18]. These behaviors can be seen as analogous to the dimensions of player engagement measured here, immersion, enjoyment, and interactivity.

Immersive technology refers broadly to virtual reality and augmented reality [7]. Radianti, Majchrzak, Yoon, and Wohlgenannt conducted a review of the literature on immersive virtual reality for higher education and found that immersion, presence, and interactivity were the primary factors that mediated the effectiveness of immersive technologies [7]. Santos, Dias, and Santos found similar results in mobile augmented reality-based gaming for education, where the incorporation of mobile augmented reality-based gaming elements in game-based learning was associated with higher motivation and engagement and increased time spent playing games [8]. The psychological processes are likely similar across educational and entertainment settings, but differ in motivation, goals, and outcomes; in educational settings, motivation derives from goals like learning and performance, whereas motivation in entertainment games tends to derive from the pursuit of enjoyment and fun. Perng, Chung, and Wang researched the role of perceived enjoyment and social presence in mobile augmented reality gaming. They found that mobile augmented reality gameplay was strongly augmented when combined with social features that allowed players to interact, with social play associated with both higher enjoyment and longer intended play times [19]. The implications of this finding are that community and player-to-player interaction are critical to promoting player engagement. Dünser, Grasset, and Billinghurst investigated the technical aspects of augmented reality game design and identified the most critical factors to consider in designing augmented reality games: interface usability, stable spatial tracking, and natural interactions with the virtual objects and their placement in the physical world [12]. Lack of tracking and other interface-related factors would undermine the sense of presence that promotes the observed behavioral engagement. As described by Shneiderman et al., users require feedback and interactivity from interfaces to experience satisfaction [13].

The requirements of augmented reality game design were important considerations when developing both the augmented reality game prototype described here and the metrics used to measure

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engagement in the study conducted with it. More recently, Zhao, Li, and Chen conducted a review of augmented reality usability research and studies in the context of mobile games. This review found that frame rate consistency and intuitive gesture interface and interaction were the two most important usability factors associated with engagement [20]. The non-functional requirements identified here were important to address when designing the prototype described in the next section.

II. PROPOSED METHODS

A. Research Design

We used a quantitative approach for this research, gathering primary data via a questionnaire and secondary data from already-published market and industry sources. The quantitative data generated scores for the four dimensions of engagement, and these were evaluated in the light of AR gaming as a commercial and technological activity through the secondary data [10], [11]. These two datasets were then used together when drawing conclusions.

B. Data Collection

Data collection proceeded along three parallel tracks:

- **Literature review**: Journal and conference papers on AR, game development, player engagement and mobile user experience published from 2022 to 2026 were reviewed to support the theoretical framework of the study and to identify current research [1], [6], [9], [18], [19], [20]
- **Industry and market data**: Data on the growth and future of AR gaming and its technology trends were collected from industry research reports produced in 2025–2026 [14], [15], [16].
- **Player questionnaire**: A questionnaire that used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used to gather data from participants who were mobile AR game players. The questionnaire measured four dimensions: immersion, enjoyment, interactivity and overall user experience, and the questions were drawn from validated engagement questionnaires used in the previous research [5], [6], [9].

C. Prototype AR Application

To In order to test participants with a controlled prototype AR system, a prototype AR mobile application was built at the same time as the data was collected. The functional (for real world interaction with objects, user input and system output) and non-functional (for performance, usability, mobile devices and usability) requirements of the prototype were defined in the analysis and design stage [12], [13], while the prototype application architecture was designed using game flow diagrams and storyboards, and the components, interfaces with the game framework and mobile devices are shown in [10], [11]. The prototype was built using an AR framework that can work with recent model Android and iOS devices and enables the player to identify real objects in the world and overlay objects on the real world using the camera and to interact with objects using a touchscreen, a technique found to have been adopted by commercial AR titles [2], [12].

D. Evaluation Procedure

To evaluate engagement levels in our prototype, participants played the prototype game, with engagement measured both objectively and subjectively. Player engagement was measured with two different metrics: objectively, through the time spent playing and with player return; subjectively, through a five-point Likert scale questionnaire that was filled in immediately after the play session. Participants were recruited from people who had played mobile games in the past and played an AR game in the last six months to provide an accurate indication of AR gaming engagement, as reported by experienced players [6], [9]. The data was then summarized with descriptive statistics on the questionnaire items, and relationships between AR technology features and scores from the four engagement dimensions were identified with inferences drawn from these descriptive statistics.

E. Validity and Reliability

The questionnaire items used in this study were based on previously established questionnaires [5], [6] to ensure validity and were piloted with ten participants to further refine the questions before full deployment. The questionnaire was found to have a Cronbach's alpha value higher than 0.70, a commonly accepted value in the social sciences, indicating good internal consistency of the questionnaire [12], [14], [15]. Questionnaire data validity was further supported by comparing the subjective player engagement measures and the objective playtime and return values, with the results agreeing on the same trend.

III. EXPERIMENTAL RESULT

A. Market Context: AR Gaming Growth

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Secondary market data establishes the commercial scale within which the primary engagement findings sit. IMARC Group values the global AR gaming market at some USD 14.2 billion in 2024 and estimates a climb to close to USD 141.7 billion in 2033 [14]. This rise is significant in that it surpasses the growth of the overall mobile gaming market; and implies that developers and investors are focusing on augmented reality technology as a way to differentiate their products.

A further factor driving this projected growth is infrastructure; Deep Market Insights suggests that improved networks (5G in particular) and better cloud rendering technology means the technology is not as latency-sensitive, which has previously restricted real-time AR gaming to consumer devices [15]. With increasing real-time AR responsiveness of devices, mechanics that utilise real-time spatial processing can be used to create games accessible to the wider mass market, rather than to early adopters with top-spec gaming phones.

Another report by 360iResearch estimates market growth from USD 15.41 billion in 2025 to USD 63.01 billion in 2032 [16]. As the numbers are slightly different between the three sources, this may be due to different market definitions. However, the general consensus across all three reports is clear: the market is expected to grow, driven by real market demand and not just speculative interest in the market.

Table I. Global Mobile AR Gaming Users by Year (Statista, 2024) [4]

Year	AR Users (M)	YoY Growth
2023	983	—
2024	1,025	+4.3%
2025	1,067	+4.1%

Table II. Mean Player Engagement Scores by Dimension (1–5 Likert Scale)

Engagement Dimension	AR Game (Mean)	Non-AR Game (Mean)
Immersion	4.31	3.02
Enjoyment	4.18	3.24
Interactivity	4.22	2.97
User Experience	4.09	3.11

B. Questionnaire Results

Table II shows the mean engagement score for AR versus non-AR mobile games, averaged across the four dimensions, as reported by questionnaire respondents. Scores are consistently higher across all four dimensions in AR games. The largest score difference exists in the Interactivity dimension (4.22 vs. 2.97); this is followed by Immersion (4.31 vs. 3.02). Enjoyment and User Experience show a similar directional difference, though with less effect size. These findings agree with flow theory [5] and are consistent with the results of Koivisto and Hamari [6]; by placing challenges into a contextual space, and feedback into the spatial experience, AR is raising the cognitive and affective dimensions of engagement above purely visual screen-based interaction.

Location-based mechanics were cited more than any other engagement driver in the open response section of the questionnaire. Respondents emphasised that the embodied experience of moving (to the location, in the right direction towards a location, or into a location) was rewarding; this differs to tapping on a touchscreen, which is less physically engaging. This supports Perng et al.'s argument that engagement arises from embodied AR interaction, rather than the visual novelty of AR per se [19].

C. Case Evidence: Pokémon GO

The performance of the 2016 title Pokémon GO is perhaps the most compelling real-world example as it has the largest amount of real-world performance data to draw on. If the engagement mechanics of the prototype application were truly successful in promoting player retention, then we would expect that to be reflected in the market success of Pokémon GO. The game uses the GPS, AR camera, and other community mechanics as a way of gamifying and socialising a location-based game experience; the game has maintained player activity levels for several years, with retention levels significantly higher than other mobile games [3]. In early 2025 the game franchise was bought by Scopely for USD 3.5 billion [17], indicating that, not just on the basis of present revenue, the high engagement of community AR gaming is supported by the valuation. This provides external commercial validation of the engagement scores reported on the questionnaire in Table II; this player experience is economically valuable when experienced at scale.

D. Data Validity Check

The behaviour measures collected via the application prototype are in line with the self-report questionnaire findings. Location-based AR mechanics

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in the prototype resulted in sessions 28% longer than overlay-only AR, and participants who reported an immersive score of above 4.0 had a seven-day return rate 19 percentage points higher than non-immersed participants. These behavioural indicators support the validity of the questionnaire findings.

E. Discussion

The story told by the market data, questionnaire data, and behavioral data, combined with the case study of Pokémon GO, is consistent and supportive. In AR, the real world is brought into the game, and this creates increased player engagement. The players move to real places, they use physical orientation for gameplay, and they interact with virtual objects in a place and time-sensitive context. This type of engagement involves cognitive, bodily, and social abilities that screen-based games are not designed to exploit, resulting in higher levels of every type of engagement shown in Table II.

As shown in Table I, AR games in the market show steady growth in the number of users, which may indicate that this type of engagement is spreading beyond early adopters of the technology to the larger mass of mobile gamers. We expect AR games available on mass market devices will be richer in engagement mechanics as the technical limitations of hardware are overcome [15] and network latency is reduced (e.g., 5G). High end engagement features, like persistent and shared AR scenes, time-critical multi-player spatial interaction, and content adaptation via AI are not yet available on consumer hardware but will be in the forecast period.

It is clear from the results in this study that higher AR engagement is not simply achieved by superimposing game assets on a video scene. The AR games with the highest engagement mechanics, and with the highest market value, are the ones where the AR layer is meaningful both spatially and contextually, and where players use the real world for gameplay rather than just the appearance of it. If developers do not treat the real world as important for game mechanics, only as an image, it is unlikely their games will achieve the same effect on engagement.

Some caveats should be mentioned. The engagement questions were based on self-report and thus may have been subject to recall bias and social desirability effects. Our focus on the mobile platform may have excluded the engagement benefits of AR on the headsets, since the experience there may have been more immersive because of the different form factor. The relatively brief observation window of the study limits the applicability of the results to longer time horizons; it will be of interest to determine if there is an engagement effect of AR once novelty effects are worn off. Finally, while the prototype game is a good vehicle for understanding mobile AR game design, it is not necessarily identical in quality, play experience, or social network to the commercially deployed product Pokémon GO.

These issues are addressed in the suggested next steps in the conclusion below and suggest future research that will help to more fully characterize the AR engagement effects across platforms and timescales and for different populations of users.

IV. CONCLUSION

The study results show that AR enhances player engagement in mobile games by increasing levels of player engagement across all measured categories. Player engagement, specifically immersion, interactivity, enjoyment, and user experience, is increased in AR games relative to screen-based games, with a stronger effect on interactivity and immersion. This result is supported by the player survey, market intelligence, and Pokémon GO data.

In the market analysis, it is clear that the value of the AR gaming market is expected to continue to grow significantly over the forecast period, from USD 14.2 billion in 2024 to 141.7 billion in 2033. Furthermore, the acquisition of a mobile AR game (Pokémon GO) at the price of 3.5 billion USD confirms that there is commercial motivation to understand and take advantage of effective engagement. Thus, AR engagement is a valuable area for further research, as evidenced by the results in this study, and is worth pursuing given the current and projected state of the AR game market.

The original research question for this paper was: “How does use of AR technology in mobile games impact player engagement?” Based on the results of the survey, market analysis, and case study analysis presented in this paper, we can now conclude that the use of AR in games increases levels of player engagement. The AR layer adds value to games beyond simply making them look more interesting but rather makes them more immersive and interactive and thus leads to better player experiences overall, with the strongest impact on immersion and interactivity.

Based on the limitations of the present study and the results, three directions are suggested for further research into the impact of AR on player engagement. First, future work could include longitudinal analysis

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to see if the engagement impact of AR persists over time (over 6 month or a year). This would give a sense of whether the AR engagement is still present once novelty effects are diminished. Further work could include analysis of which engagement mechanics in AR have a longer-lasting impact. Second, future work could focus on engagement with AR games on AR headsets, to assess if the engagement effect is a result of the specific design of the game or if it is also an effect of the form factor. Third, the study results can serve as a base for further research into how generative AI can be used in AR games to create new content in real-time (for example, creating dynamic NPCs). Research into the question of whether these generative AI-based AR content will have different types of engagement (in different dimensions and over different lengths of time) than static AI-generated AR content would provide insight into AI-driven engagement in AR.

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