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Knowledge Centers and Edutainment Integration: Bridging Entertainment, Innovation, and Education for Saudi Arabia's Vision 2030

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Abstract Edutainment technologies—such as serious games, simulations, augmented and virtual reality, immersive technology learning environments—are transforming global approaches to education and lifelong learning. This study examines their potential through the lens of Saudi Arabia's ongoing digital transformation under Vision 2030, using scholarly literature and national survey data to assess public readiness and perceived value. Findings indicate strong societal support for immersive, hands-on learning tools that can make STEM subjects more engaging and accessible for diverse learners. At the same time, challenges common across many countries persist, including inconsistent digital infrastructure, limited teacher preparation, and misconceptions about game-based learning. To address these gaps, the study highlights the need for national science and knowledge centers that integrate education, entertainment, and culture. The Sheikh Abdullah Al Salem Cultural Centre in Kuwait is presented as a successful regional model demonstrating how immersive environments can strengthen digital literacy, enhance motivation, and promote lifelong learning. The study concludes with policy recommendations centered on strategic planning, cross-sector collaboration, and sustained investment to scale edutainment-driven learning ecosystems capable of equipping future generations for rapidly evolving knowledge economies.

Keywords Edutainment, Serious Games, Immersive Learning, Educational Simulations, Science Museums, Knowledge Centers

1. Introduction

In recent decades, the rapid advancement of video games and immersive media has both reflected and accelerated fundamental shifts in global education. What were once seen as simple entertainment tools have evolved into complex platforms that simulate real-world systems, stimulate cognitive engagement, and support diverse learning goals. This digital transformation aligns with a broader evolution in educational philosophy, marking a departure from traditional lecture-based instruction toward dynamic, learner-centered, and experience-driven approaches.

As countries adapt to the evolving demands of the 21st century, the imperative to modernize educational systems has become increasingly urgent. Emerging technologies, including serious games, gamified simulations, augmented reality (AR), and immersive learning platforms such as 3D, 4D, and 5D environments, are gaining recognition for their capacity to bridge the gap

between theoretical knowledge and practical application [1]. Within this context, serious games are defined as digital tools specifically designed for educational or training purposes rather than mere entertainment. Holographic instructional tools utilize three-dimensional projection technologies to visually present complex concepts, often in classroom and museum settings. Augmented Reality (AR) introduces virtual elements into real-world environments, while Virtual Reality (VR) creates fully simulated immersive experiences. Mixed Reality (MR) combines both AR and VR, allowing users to interact with physical and virtual components simultaneously. Furthermore, 4D and 5D learning environments extend immersion by incorporating multisensory feedback, such as motion, sound, and tactile stimuli; thereby, enhancing engagement and comprehension in educational settings.

These tools not only enhance motivation and engagement, as suggested by gamification research [2, 3], but also create emotionally and cognitively rich learning experiences that foster deep understanding and skill mastery.

In the Kingdom of Saudi Arabia, these global shifts intersect powerfully with national priorities outlined in Vision 2030. Central to the Vision 2030 is a commitment to human capital development, digital innovation, and the creation of a vibrant society built on lifelong learning. The transformation of the education sector, from traditional classroom models to technology-empowered, skill-oriented systems, is key to realizing these ambitions. Edutainment technologies, including interactive simulations, serious games, AI-powered content, and holographic instructional tools, offer scalable and engaging solutions that can redefine the learning experience for students and citizens alike [4].

While the integration of video game-based learning and simulation technologies in classrooms has begun to gain traction, its reach remains limited. Structural challenges such as a lack of access to modern equipment, limited teacher training, and public skepticism toward screen-based learning continue to slow adoption. However, growing evidence suggests that when these tools are deployed thoughtfully, aligned with curriculum standards and supported by interactive design, they can significantly enhance learning outcomes across disciplines [5, 6].

Given these trends and the urgent need to modernize the Saudi's learning infrastructure, it is no longer sufficient to treat edutainment as a supplementary tool within schools alone. Instead, Saudi Arabia must invest in dedicated spaces, such as national science museums and next-generation learning centers, which serve as hubs of experiential, technology-enhanced education. These facilities would enable learners of all ages to interact with Science, Technology, Engineering, and Mathematics (STEM) content, sustainability challenges, and social simulations through hands-on exhibits, immersive 3D/4D/5D environments, holographic demonstrations, and real-time scenario-based learning.

Science museums and educational centers enriched with advanced edutainment technologies would play a pivotal role in bridging the gap between curriculum and capability. They would allow students to conduct virtual experiments, explore abstract scientific theories, simulate medical or engineering challenges, and practice real-world problem-solving, all within safe and engaging digital spaces [7, 8]. In addition to supporting formal education, these centers would play a vital role in fostering informal learning, promoting family participation, and advancing lifelong skills development, thereby fostering a national culture rooted in innovation and intellectual curiosity.

Strategically, the development of such facilities also aligns with Saudi Arabia's broader goals of tourism expansion and economic diversification [9]. Establishing a flagship center in a city like Yanbu Industrial City, ideally situated between the two holy cities of Makkah and Madinah and in proximity to metropolitan city Jeddah, would enable Saudi Arabia to leverage both religious and leisure tourism flows. In doing so, the center could serve as a multifaceted destination that combines educational enrichment with cultural engagement for diverse local and international audiences.

The proposed initiative introduces innovative concepts: Knowledge Amusement Arenas, Theaters of Wonder, the Artificial Intelligence and Interactive Training Center, designed to be the first and only of their kind in Saudi Arabia. These facilities aim to provide cutting-edge educational entertainment tools that seamlessly merge enjoyment with learning, enhancing the educational experience and fostering personal, social, and cognitive skills. By leveraging interactive and innovative approaches, both children and adults can explore fields such as science, medicine, engineering, arts, industry, and technology through hands-on activities and advanced exhibitions. Figure 1 is a futuristic site design on the shore of the industrial city.

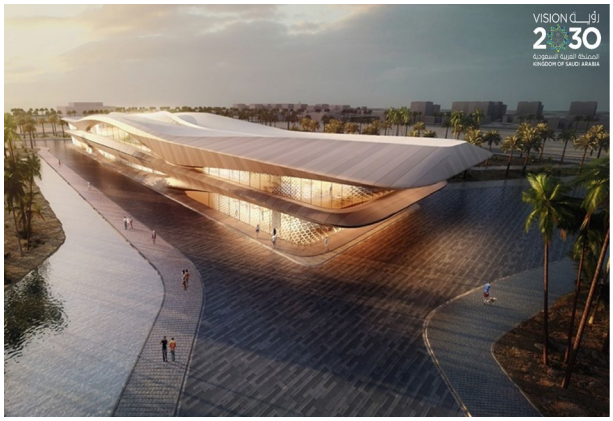

Figure 1. Conceptual pictorial illustration of the proposed center

The center includes simulations, virtual reality (VR), augmented reality (AR), artificial intelligence (AI),

holographic projections, and immersive technologies such as 3D, 4D, and 5D interactive displays. These technologies could convey complex cognitive concepts in visual and interactional ways, making it easier for visitors to understand and absorb content in non-traditional formats, for instance, using interactive learning spaces to demonstrate phenomena like gravity or electricity through engaging experiments. Research supports that these active learning methods significantly enhance comprehension and information retention compared to conventional instruction [10, 11]. Furthermore, entertaining scientific shows are designed to attract and educate audiences playfully, with evidence showing that enjoyment-based educational strategies lead to greater engagement and improved learning outcomes [12, 13].

Beyond direct learning gains, these initiatives can reshape views of gaming and entertainment as channels for meaningful engagement and skill development. Knowledge centers can operate as interactive community spaces where families learn together through exhibits, cultural storytelling, and problem-solving, encouraging multigenerational participation. By blending enjoyment with education, they reinforce national identity and shared values while cultivating a motivated, technically capable workforce.

Additionally, simulators can help high-school students discover academic majors by letting them practice realistic professional tasks and help them select the suitable choice for their college level education. Through scenarios, diagnosing a patient in a virtual hospital, coding a robotic system, or managing a virtual business, students preview day-to-day demands, align interests and aptitudes, and connect course work to real roles.

To scale this transformation, Saudi Arabia should develop sustainable, high-impact knowledge and edutainment centers with diversified funding, public investment, commercial partnerships, retail/hospitality revenue, and paid training, memberships, and events [14, 15]. These models enable financial independence and growth. Developmentally, the centers build digital fluency, creativity, and STEM career-readiness, and act as inclusive innovation hubs where entrepreneurs and creators turn ideas into ventures with incubation and AI support [16]. They also enhance civic engagement, scientific literacy, and social cohesion through cultural participation and informal learning [17, 18]. Alongside direct and indirect job creation, they can expand tourism by offering destinations that blend enjoyment with learning.

Sustaining the momentum of these centers requires alignment with strategic values drawn from global benchmarks. These include financial stability through diversified income, strong governance through clear accountability structures, adaptive programming to serve diverse user groups, and continuous innovation to remain at the forefront of technological trends [19, 20]. Additionally, emphasis must be placed on environmental and social responsibility, staff development, and delivering high-quality, engaging content. By embedding these principles, Saudi Arabia can ensure that its educational transformation is not only ambitious but also enduring and inclusive paving the way for a new national ecosystem where science, culture, and technology intersect to support lifelong learning and national development.

This paper examines the transformative potential of serious games, simulation platforms, and immersive environments within the framework of Saudi Arabia's ongoing educational reform. It assesses public perception, regional readiness, and strategic priorities associated with integrating these technologies into external or formal learning environments. Central to the discussion is the proposed establishment of national edutainment infrastructure, particularly science museums and immersive learning centers, as a means of preparing students for a knowledge-based society while advancing the objectives of Vision 2030. The envisioned national knowledge center would serve not only as an external and experiential learning environment but also as a hub for producing advanced educational media. Through the collaboration of educators, digital content creators, AI developers, and media specialists, the center could produce localized serious games, simulation tools, and immersive 3D/4D/5D content aligned with both curricular and training standards and cultural values, thus supporting both learning and national innovation goals.

Public support is strong. Our survey shows widespread enthusiasm for science museums, edutainment hubs, and knowledge parks, indicating readiness for technology-enhanced, inquiry-based learning. To turn this momentum into results, invest in modern infrastructure and build partnerships with private innovators, the Public Investment Fund, and technology providers. Prioritize solutions that can scale, promote inclusion, and remain sustainable, especially in underserved regions. Align these efforts with Vision 2030 to grow digital fluency and an innovation-led economy. Evidence shows that immersive and game-based tools are central to educational progress. With clear policy and sustained capacity building, Saudi Arabia can become the regional front runner by deploying these approaches through science museums and knowledge centers across education and workforce training.

2. Literature Review

The integration of digital games into educational environments has become a central theme in educational technology scholarship. Initial research on the educational applications of video games primarily emphasized their motivational potential [21]. Over time, scholarly attention has expanded to encompass the cognitive benefits of gaming, highlighting how such tools can facilitate

higher-order thinking, problem-solving, and the transfer of knowledge [5, 22]. These capabilities have positioned serious games, defined as games created for purposes beyond entertainment, as highly applicable to modern educational strategies.

A substantial body of empirical literature now supports the effectiveness of serious games in promoting active learning across diverse academic disciplines. In a comprehensive meta-analysis of 77 studies, Wouters et al. [5] found that serious games outperformed traditional instruction in enhancing both learning and information retention. Similarly, Boyle et al. [6] compiled evidence demonstrating that game-based educational environments consistently lead to improved outcomes when instructional goals are clearly defined. Liu et al. [23] demonstrated that immersive virtual reality (IVR) notably enhanced academic performance and motivation in science among primary school students. This evidence adds to the growing body of research suggesting that immersive technologies and serious games are effective tools for developing both technical skills, such as in science and mathematics and interpersonal competencies like collaboration and communication.

Within the Saudi Arabian educational landscape, research increasingly examines the use of serious games and simulations in curricula. Educators report high engagement and clear usefulness, though limited institutional support and teacher readiness remain barriers [24, 25]. Evidence shows gamification improves outcomes: flipped, gamified classes outperformed non-gamified ones [26], and gamification boosted motivation, cross-subject engagement, and award attainment versus traditional instruction [27].

According to Lister [28], incorporating games and gamification into educational settings significantly enhances student engagement, improves the overall learning experience, and leads to higher academic achievement. Feedback from learners indicated that those in gamified environments found the program more enjoyable and demonstrated greater motivation, particularly in their preparation and deeper involvement with the course material. Moreover, students of the digital generation increasingly expect learning experiences that blend entertainment with education. Their strong interest in modern technologies contributes to a growing demand for interactive methods that extend beyond traditional teaching approaches.

Beyond classrooms, immersive technologies such as 3D/4D/5D platforms, AR, and VR deliver realistic simulations of complex phenomena. In medical education, simulation-based training builds procedural competence without real-world risk [29, 30]. In STEM education, AR has proven to be a powerful tool for visualizing complex scientific concepts and enhancing hands-on learning [31]. By integrating interactive 3D models and simulations into real-world settings, AR enables students to engage with abstract ideas in a more tangible and meaningful way.

This immersive approach boosts motivation and curiosity and deepens understanding and retention. Serious games also build social and emotional skills, including teamwork, communication, and decision making. Multiplayer simulations, such as responding to medical crises or managing disasters, let learners practice complex real-world decisions in a safe, interactive setting [32]. Figure 2 illustrates serious games applied in clinical training.

Figure 2. The use of serious games in the medical field [7]

Although immersive technologies offer substantial educational benefits, their broad implementation faces several obstacles. Key barriers include underdeveloped digital infrastructure, reluctance from traditional educational decision makers, limited teacher proficiency in utilizing digital learning tools, and insufficient longitudinal research assessing their impact [33, 34]. Nonetheless, a clear global movement is emerging, with educational institutions increasingly adopting game-based platforms and immersive technologies to foster essential 21st century competencies through hands-on, experiential learning.

Aligned with Saudi Arabia’s Vision 2030, which prioritizes digital transformation and human capital development, several initiatives have been launched to embed advanced technologies into the education sector [9]. However, few studies discussed the use of AI-supported edutainment applications, the inclusion of gamified elements within national curricula, and the development of interactive science centers. Pilot initiatives conducted in Saudi Arabia by Riyadh Valley Company have tested AR-enhanced modules in secondary schools, reporting promising outcomes in student engagement and academic performance [35]. Serious games and immersive technologies are core to future-oriented reform, not passing trends. Grounded in constructivism, they enable experiential, inquiry-based, and personalized learning, and can address gaps in Saudi education when aligned with Vision 2030. International models illustrate the path: Finland embeds game-based learning in its national

curriculum with teacher PD [36], while South Korea advances serious games via government R&D initiatives [37]. These cases point to priorities for Saudi Arabia policy alignment, educator training, and infrastructure investment.

A critical component of ensuring the success of serious games lies in their alignment with measurable learning objectives. Ifenthaler, Eseryel, and Ge [38] emphasized that educational game mechanics must be grounded in pedagogical theory to yield significant learning outcomes. This has prompted the emergence of instructional design models such as the RETAIN model and experiential learning cycles embedded within gameplay. For Saudi curriculum developers, the adoption of such frameworks is crucial to ensuring the effectiveness and sustainability of game-based educational interventions. The evolution of educational gaming continues to be shaped by emerging technologies such as AI-driven personalization, mixed reality (MR), and haptic feedback systems. AI-enhanced simulations have been shown to dynamically adapt content in response to learner progression and cognitive load [39]. In technical fields such as engineering and biomedical sciences, simulations powered by AI and MR offer real-time interactivity, enabling learners to manipulate virtual data and environments to deepen conceptual understanding [40]. These tools are particularly relevant to Saudi Arabia's increasing emphasis on STEM education and digital capability development.

Martin et al. [41] emphasize that informal educational environments, including museums, offer valuable opportunities to strengthen students' understanding of science and increase their motivation to engage with scientific concepts. Their study revealed notable improvements in students' ability to recall scientific content and in their levels of science-related self-efficacy, perceived value of science, and future aspirations after participating in a science program. Furthermore, these enhancements in knowledge and motivation were linked to more positive attitudes toward everyday practices.

In a separate study conducted by Lee et al. [42], primary school students exhibited high levels of motivation to engage in science museum programs, influenced largely by encouragement from parents and teachers. The research found that students were particularly drawn to interactive and hands-on scientific activities, which captured their interest and sustained their engagement. Participants reported positive experiences, indicating that the museum programs fostered a genuine interest in science. Furthermore, the analysis revealed notable improvements in students' self-efficacy and the value they placed on science-related tasks, suggesting that such informal learning environments can significantly contribute to developing students' confidence and favorable attitudes toward science education.

Li [43] conducted a study to explore how various types of digital exhibits influence children's engagement in science museums by examining their Average Holding Time (AHT). The research involved observing children's interactions with selected digital exhibits at the Liaoning Science and Technology Museum. The study assessed the impact of interactive technologies, particularly digital screens, on children's engagement levels. The findings of this study revealed that hands-on digital exhibits, those allowing direct interaction, were significantly more effective than hands-off ones in capturing and sustaining children's attention. Exhibits equipped with touch screens were especially engaging and contributed to longer interaction times, ultimately supporting greater knowledge acquisition among young visitors.

Establishing a national knowledge center in Saudi Arabia would do more than enrich minors' education; it would serve as a cradle to career hub for lifelong learning and professional training in medicine, engineering, and IT. Using AR/VR, high fidelity simulation, and immersive technological environments, the center would provide safe hands-on practice, interdisciplinary exercises, and scenario-based assessments aligned with industry certifications and credentials. Partnerships with universities, hospitals, industry, and technology firms, along with incubation spaces for student startups, would translate research into deployable solutions and internships. Aligned with Vision 2030's focus on human capital and digital proficiency, the center would advance educational equity, spur innovation, and accelerate the Kingdom's transition to a resilient, knowledge-based economy.

This study aims to assess public awareness, prior experience, and attitudes toward the use of edutainment technologies, such as AR/VR, serious games, holography, and sensory-enhanced 4D/5D environments, within Saudi Arabia's educational and cultural ecosystem. Drawing on Vision 2030's strategic priorities and international exemplars, the study examines support for national science/knowledge centers, as well as demographic patterns in preferences and perceptions. The empirical analysis centers on identifying statistically significant associations between respondent characteristics and their responses to categorical survey items. These findings offer a foundational understanding of public readiness and enthusiasm for immersive learning initiatives in Saudi Arabia.

3. Materials and Methods

3.1. Research Design

This study used a quantitative survey to assess awareness, perceptions, and needs for edutainment technologies like serious games, training simulators, 3D/4D/5D environments, and holograms in Saudi education and training. The literature review revealed that

science museums and knowledge centers enhance informal learning, raise public engagement, and build cognitive and non-cognitive skills while supporting national innovation and aligning with Vision 2030. The survey enabled objective measurement of attitudes, exposure, and perceived value across a diverse sample, allowing correlational analysis.

3.2. Study Population and Sampling

This study aimed to assess public awareness and attitudes toward edutainment technologies, including serious games, training simulators, AR, VR, 3D, 4D, 5D, and hologram environments, within educational and professional training contexts across Saudi Arabia. A total of 233 participants were included in the final sample to ensure a diverse and representative dataset suitable for meaningful analysis. To achieve both relevance and broad reach, a hybrid sampling strategy was employed, combining purposive and convenience sampling methods. Purposive sampling targeted individuals directly involved in the education sector, including school and college students, faculty members, and parents. Initial recruitment was concentrated in Yanbu Industrial City, chosen for its active investment in education and alignment with Vision 2030 priorities, particularly in smart infrastructure and human capital development.

To extend the survey's reach beyond the local context, convenience sampling was subsequently utilized. Initial participants were encouraged to share the survey link with their personal and professional networks, including friends and family, through widely used communication channels such as WhatsApp and Telegram. This snowballing technique enabled wider geographic distribution, capturing responses from various regions across the Kingdom. Additional dissemination methods included institutional email lists, classroom announcements, and parent engagement sessions. This combined strategy facilitated efficient, inclusive, and contextually relevant data collection despite logistical and time-related constraints.

3.3. Instrument Development

The primary instrument for data collection was a structured questionnaire designed in both English and Arabic to ensure linguistic accessibility. The survey comprised four sections: (1) Demographics, (2) Awareness and experience with edutainment tools, (3) Perceived need for these technologies in formal and informal education (see Appendix A). Dichotomous items and Likert-scale statements have been used to measure support and perceived impact. Moreover, the survey was developed based on literature and reviewed by three faculty experts in educational technology for content validity. A pilot test with 10 participants was conducted to assess item clarity and structure.

3.4. Data Collection Procedure

Data collection was conducted over a three-month period using secure digital survey platforms to ensure broad accessibility across Yanbu city and other regions. Participants were provided with a clear digital consent statement at the outset of the survey, outlining the study's purpose, the voluntary nature of participation, and assurances of confidentiality. To uphold ethical research standards, no personally identifiable information was collected, and respondents retained the right to withdraw at any point. All data were automatically anonymized upon submission, encrypted during transmission, and securely stored in a password-protected environment accessible only to the researchers. These procedures reflect adherence to established ethical principles for human-subject research in digital environments, with particular attention to participant privacy, informed consent, and data protection.

3.5. Data Analysis Techniques

Collected data were exported into Microsoft Excel and SPSS for statistical analysis. Descriptive statistics were used to summarize demographic information and general trends. Frequencies and cross-tabulations helped visualize response distributions across variables. To explore statistical relationships between demographic factors and attitudinal variables, Chi-square tests of independence were applied. The threshold for statistical significance was set at $p < 0.05$. These tests were used to understand how perceptions of educational technology differ across sub-populations. All findings were interpreted in alignment with the goals of Vision 2030. The results provided empirical grounding for recommendations related to infrastructure planning, policy, and strategic investments in edutainment centers and immersive learning technologies.

3.6. Justification for Statistical Methods

Given the nature of the research questions, focusing on whether demographic factors influence familiarity with or support for edutainment tools, the Chi-square test of independence was selected as the primary inferential statistical method. This non-parametric test is appropriate for categorical data, particularly for assessing whether distributions of categorical variables differ from one another.

3.6.1. Instrument Development, Reliability, and Pilot Testing

The survey instrument was developed based on an extensive review of prior literature on edutainment technologies, serious games, immersive learning environments, and science museums. Items were designed to capture respondents' awareness, perceptions, and

perceived needs related to these technologies within educational and training contexts in Saudi Arabia. To enhance content validity, the questionnaire was reviewed by subject-matter experts in educational technology and digital learning, and minor wording refinements were made to improve clarity and alignment with the study objectives.

Prior to full deployment, the survey underwent pilot testing with a small group of participants (n ≈ 10) drawn from the target population, including students and educators. The pilot phase aimed to assess item clarity, response time, and overall usability of the online instrument. Feedback from pilot participants indicated that the questions were understandable and no substantive changes to item structure or response options were required.

Internal consistency reliability was assessed using Cronbach's alpha for the perception and attitude items included in Sections B and C of the survey. The analysis yielded a Cronbach's alpha coefficient of 0.13, indicating low internal consistency across items. However, this result is expected, as the survey items were intentionally designed to capture distinct and independent dimensions of edutainment technologies (e.g., training simulators, 4D/5D learning environments, science museums, and educational technology infrastructure) rather than a single latent construct. Consequently, internal consistency was not a primary design objective, and items were analyzed individually rather than aggregated into a composite scale.

3.6.2. Data Analysis Strategy and Justification

Given the categorical nature of the survey data and the exploratory objectives of this study, chi-square tests of independence were employed as the primary method of statistical analysis. This approach was suitable for examining associations between demographic characteristics (e.g., gender, age group, region) and participants' awareness, experience, and perceptions of edutainment technologies. Since the survey consisted entirely of nominal and ordinal data, derived from multiple-choice and Likert-scale items, chi-square analysis was the most appropriate technique.

This approach is widely used in exploratory research to identify statistically significant relationships between two categorical variables without requiring assumptions about normality or interval scaling. In this study, no continuous variables were collected, and the data structure did not meet the assumptions required for parametric tests such as t-tests, ANOVA, or regression models. Therefore, more complex inferential methods were neither necessary nor applicable.

The relatively large sample size (N = 233) and well-distributed response frequencies ensured that the assumptions of chi-square analysis, particularly the requirement for expected cell counts, were met.

Although chi-square tests do not establish causality or control for confounding variables, they are sufficient for the descriptive and exploratory aims of this research. The results provide a statistically grounded overview of public opinion toward edutainment tools in Saudi Arabia, offering a useful foundation for future studies employing more advanced analytical designs.

4. Study Results

The study aimed to investigate how edutainment technologies, such as serious games, training simulators, augmented and virtual reality (AR/VR), immersive 4D/5D environments, and holographic instructional tools, could be meaningfully integrated into the Saudi educational system to align with national priorities, particularly those emphasized in Vision 2030. A structured survey was administered to a purposive sample of 233 participants, including students, educators, and guardians, with the goal of assessing public awareness, levels of exposure, perceived needs, and regional variation in attitudes toward these emerging tools. The survey instrument was carefully designed to capture perceptions across a range of edutainment technologies, and the complete list of items used can be found in Appendix A. This section presents a comprehensive account of the statistical findings, supported by tabular and graphical representations, followed by an interpretive discussion of the most salient patterns and their implications for policy and future implementation strategies.

4.1. Demographic Profile of Participants

The sample (N=233) was demographically diverse across gender, region, age, education, and role. Males comprised 63.9% (n=149) and females 36.1% (n=84). Regional distribution was Western 41.2% (n=96), Central 37.3% (n=87), Eastern 13.7% (n=32), Southern 5.2% (n=12), and Northern 2.6% (n=6). Ages were <18: 10%, 18–24: 38%, 25–34: 40%, and ≥35: 12%. Educational attainment ranged from high school to university degrees, and respondents included educators, students, and guardians. Together, these profiles provide a broad view of public sentiment toward educational innovation and edutainment technologies.

4.2. Experience with Edutainment Technologies

The study found limited exposure to edutainment tools, with only 25% of participants having used serious games, 20% experiencing simulators, and 15% engaging with holograms or immersive technologies. Despite this, over 85% supported their integration into schools and museums, highlighting a strong interest despite limited access. Males reported more interaction, particularly with games and simulators, though females showed equal enthusiasm, especially for educational programs and

museum. Higher exposure in the Western and Central regions reflects better infrastructure and digital access.

4.3. Visual Data Charts

The following visual representations summarize key aspects of the survey data as seen in the following figures: Figure 3: Regional Distribution; Figure 4: Experience with Edutainment Technologies; and Figure 5: Support for Science Museums and knowledge centers. Together, all of these charts can highlight some demographic patterns, technology exposure levels, and overall public endorsement for establishing immersive learning venues nationwide today.

4.4. Clarification: Professional Serious Games

A key distinction in this study lies in the focus on serious games used in professional training contexts, such as emergency response, medical surgeries, and disaster management captured under 'Experienced_Serious_Game' survey item. These high-stakes simulations are designed to build real-world decision-making and procedural skills in safe virtual environments. Although only a minority of participants reported direct experience with such tools (as shown in Figure 6), the overall perceived value was high, reflecting strong support for their integration into specialized education and workforce training, especially in health and safety sectors aligned with Vision 2030's goals.

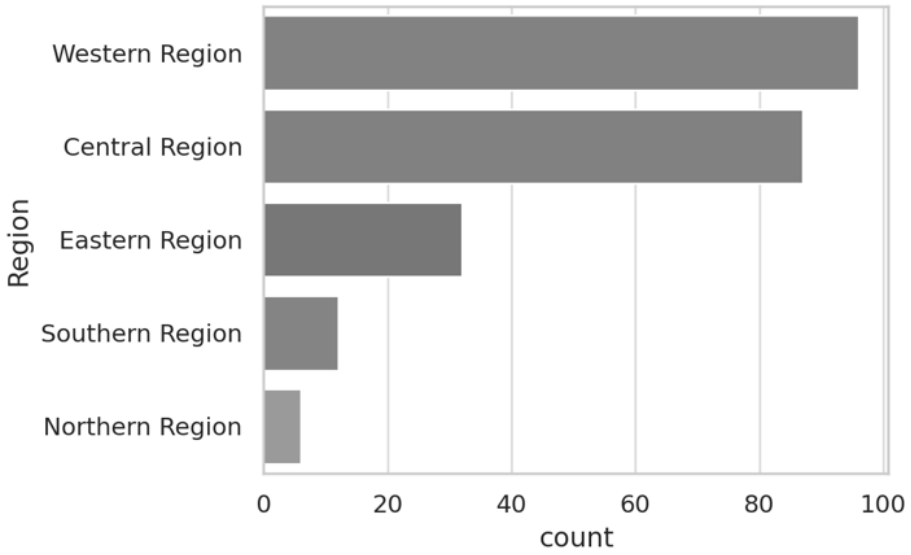

Figure 3. Regional Distribution

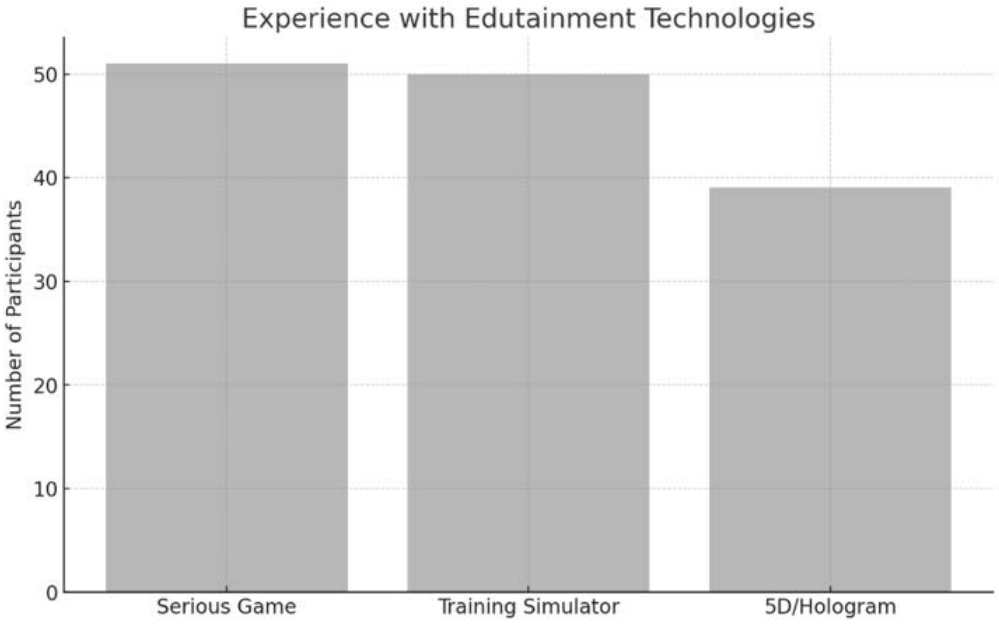

Figure 4. Experience with Edutainment Technologies

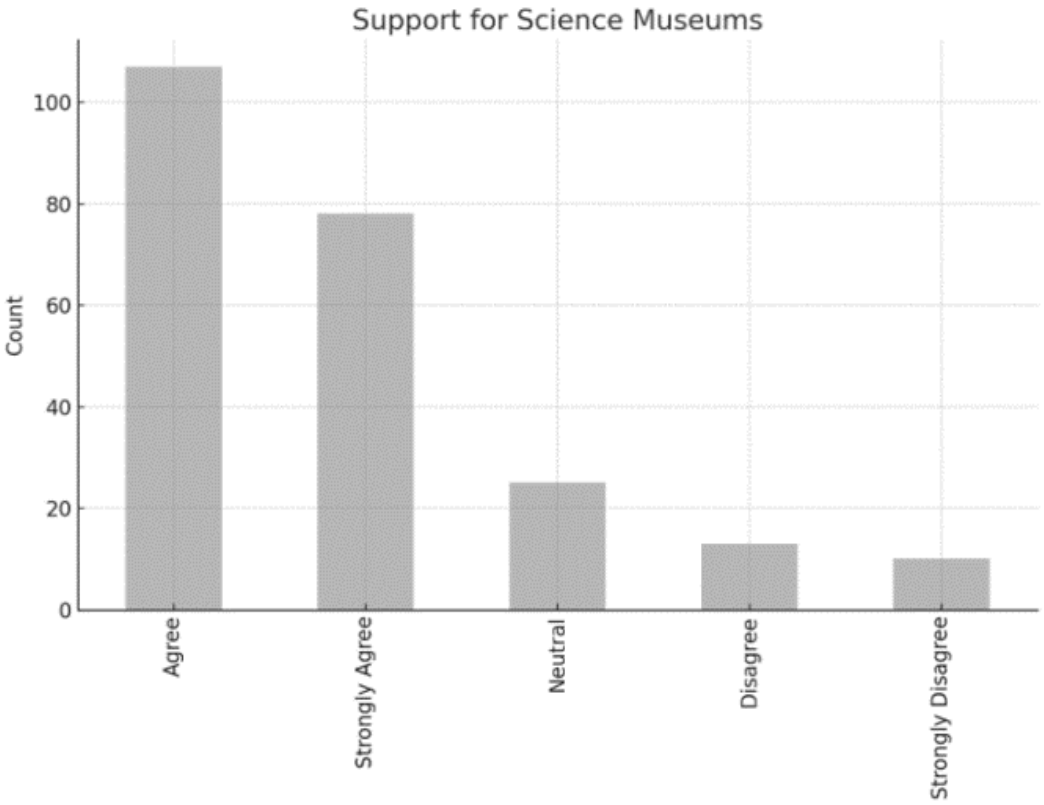

Figure 5. Support for Science Museums

Figure 6. Experience with Serious Games (Professional Contexts)

4.5. Statistical Analysis and Relationships

This section provides a statistical overview of survey results using Chi-square tests to examine relationships between demographic factors like gender, age, region, and education level, and various dimensions of edutainment technologies, such as experience, perceived importance, and support for integration into education and training. The findings highlight patterns of awareness and engagement while offering actionable insights that align with Saudi Arabia's Vision 2030 goals of fostering inclusive, innovative, and technology-driven education.

4.5.1. Relationship between Gender and Edutainment Attitudes

Chi-square analysis found no statistically significant relationships between gender and experience with serious games, training simulators, or 3D/4D/5D/holographic technologies (all p-values > 0.5), indicating similar exposure levels across genders. While males showed slightly more affirmative responses, possibly due to greater engagement with gaming or simulations, both genders expressed support for using these tools in education. For example, the association between gender and perceptions of the need for holograms in schools yielded a Chi-square value of 6.766 ($p = 0.1488$), indicating no statistically significant difference. While not conclusive, this trend may warrant further investigation with larger or more targeted samples to explore potential gender-based patterns.

4.5.2. Age and Edutainment Attitudes

Age significantly influences familiarity with and support for edutainment technologies. A Chi-square test revealed a strong relationship between age and the perceived need for science museums ($Chi^2 = 38.71$, $p = 0.0012$), with participants aged 18–24 and 25–34 showing the highest enthusiasm. This reflects generational expectations for interactive, tech-driven learning. Notably, individuals under 35, who represent nearly 80% of the sample, consistently reported greater familiarity with immersive tools and stronger support for their integration into education and training, aligning with Vision 2030's focus on youth empowerment and educational modernization.

4.5.3. Region and Perceived Needs

Chi-square analysis across regions revealed that while most associations were not statistically significant, regional trends still offer valuable insights into planning (as shown in Figure 7). Participants from the Western and Central regions, where educational infrastructure and tech access are more developed, expressed stronger support for integrating simulators and immersive environments into learning spaces. In contrast, respondents from the Northern and Southern regions showed lower levels of engagement, indicating potential disparities in exposure and readiness that should be addressed in future.

4.5.4. Education Level and Support for Edutainment

Although most associations between education level and support for edutainment tools were not statistically significant (chi-square $p > 0.1$), a clear pattern emerged: participants with higher education levels, especially postgraduates, demonstrated greater awareness and stronger support for serious games and simulation-based learning. This likely reflects their exposure to more specialized and applied academic environments. Support for immersive technologies was also consistently higher among bachelor's and master's degree holders, indicating a progressive educational mindset. These findings highlight the importance of integrating edutainment strategies at the tertiary level, where both faculty and students show strong readiness for innovation.

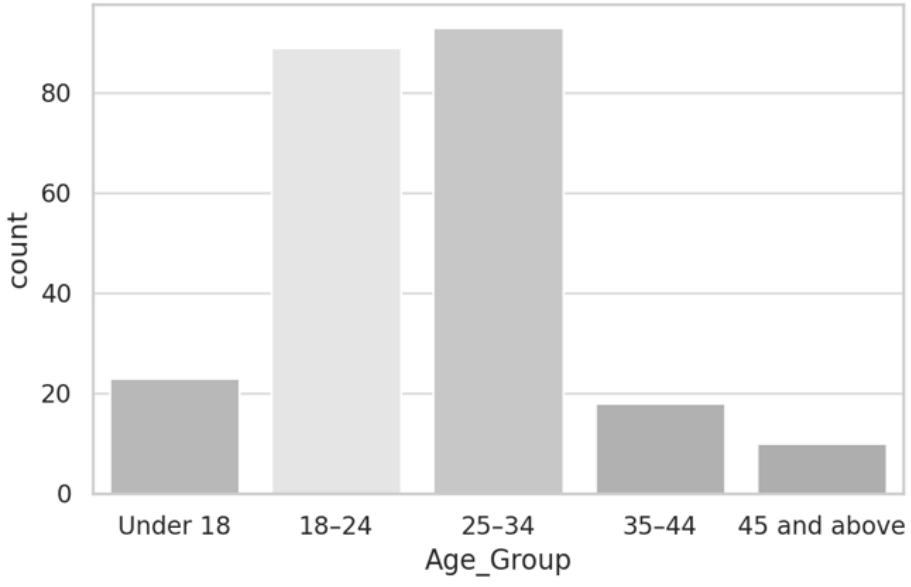

Figure 7. Age Groups of Participants

4.5.5. Experience and Technology Adoption Readiness

Experience with immersive learning tools strongly predicts support for their broader use, as participants familiar with serious games, simulators, or 4D/5D/holographic systems were significantly more likely to endorse their integration in schools and training centers, supporting the 'familiarity hypothesis' in edtech. Notably, even those without prior exposure expressed high enthusiasm, suggesting strong perceived value across the board. For Saudi policymakers, this indicates that public readiness may not be a major barrier. Well-designed pilot programs offering early access to students and educators could play a crucial role in accelerating national adoption.

4.5.6. Cross-Variable Interpretation

When examining demographic factors, a nuanced view of public attitudes toward edutainment emerges. Younger, college-educated participants, especially those from the Western and Central regions, reported greater exposure to simulators and immersive technologies and aligned more closely with Vision 2030's innovation goals. Notably, support for science museums was high across all groups, regardless of prior experience, reflecting broad recognition of their value. College students and recent graduates showed the strongest enthusiasm, making them key targets for future initiatives. These insights highlight the need for tailored strategies that consider age, education, region, and digital familiarity while focusing on digitally literate youth in tech-ready regions to accelerate early adoption and impact.

5. Discussion

5.1. Vision 2030 Alignment and Policy Implications

The vision presents a forward-looking agenda for national development, with education at its core. A key component of this transformation involves the integration of edutainment technologies, such as serious games, simulators, and immersive technologies classrooms into learning systems to foster innovation, engagement, and lifelong learning. This study confirms strong public support for such technologies, highlighting their potential to revolutionize instructional design and align with Vision 2030's goals for digital fluency and critical thinking. Notably, the findings reveal a high demand for science museums and informal learning spaces to bridge STEM education gaps and promote public scientific literacy. While current exposure to advanced technologies remains limited, public enthusiasm is high, underscoring the urgent need for access, teacher training, and curriculum reform. These insights suggest a timely opportunity for policymakers to invest in inclusive, future-ready educational infrastructure that cultivates national talent and reduces regional disparities, thus advancing the human capability development program envisioned in Vision 2030.

5.2. Edutainment for National Development: Policy Pathways toward a Knowledge-Enriched Saudi Arabia

5.2.1. The Educational Revolution at the Crossroads of Saudi Vision 2030

Saudi Arabia's Vision 2030 emphasizes innovation, digital transformation, and human capital development, with education as a central focus. To meet the demands of a modern knowledge economy, edutainment, blending education with immersive technologies like VR, AR, AI, and simulations, offers a powerful solution. These interactive tools promote creativity, critical thinking, and digital fluency, aligning with national goals to create engaging, future-ready learning environments for all.

5.2.2. Unlocking Deeper Learning and Skill Development

Modern research strongly supports the use of edutainment technologies in fostering deeper comprehension, stronger retention, and higher engagement. Simulation-based learning, serious games, and interactive displays create multisensory experiences that allow learners to actively explore complex concepts. Whether it is a child learning about gravity through an augmented experiment or a university student practicing disaster response through AI simulations, edutainment promotes experiential learning, a method proven to enhance both cognitive and non-cognitive outcomes. This mode of learning is also instrumental in developing 21st century skills such as critical thinking, problem-solving, creativity, adaptability, and teamwork. In today's interconnected world, these skills are not optional, but are essential for personal growth, employability, and national competitiveness.

5.2.3. Establishing National Edutainment Learning Centers and Science Museums: A Strategic Imperative

The time is ripe to transform edutainment into a national asset through the creation of a National Museum and Learning Center for Edutainment Technologies. This center would serve as an educational hub offering STEM-aligned activities, immersive labs, and AI-powered exhibits for all age groups. It would also act as an innovation catalyst by hosting hackathons and simulation-based challenges, while promoting community learning through interactive storytelling and gamified experiences. Additionally, it would support workforce readiness via real-world simulations in healthcare, industry, and crisis response. Integrating education with entertainment, this facility would bridge formal instruction with practical application, symbolizing Saudi Arabia's commitment to innovation, inclusivity, and sustainable knowledge advancement under Vision 2030.

5.2.4. Policy Recommendations to Operationalize Edutainment Infrastructure

To realize the vision of a national edutainment transformation, a comprehensive and strategically grounded implementation plan is essential. This plan must extend beyond infrastructure and content to include regional accessibility, long-term sustainability, and alignment with national development goals. A key initial step is selecting an optimal location for the flagship edutainment center. In this context, Yanbu emerges as a compelling choice. Positioned between the two holy cities of Makkah and Madinah, Yanbu lies along major pilgrimage and tourism routes, drawing millions of visitors annually. Its connectivity via air, land, and sea, combined with its growing role as an industrial and residential hub, makes it ideally suited to host a high-impact, nationally significant project. Moreover, establishing the National Edutainment Museum and Learning Center in Yanbu would maximize public engagement by attracting a broad audience including residents, school groups, tourists, and international visitors. The initiative would support Vision 2030 objectives such as enhancing science awareness, fostering cultural tourism, and stimulating local economies. Strategically, placing the center in Yanbu decentralizes innovation and education investment, encourages collaboration across sectors like tourism and education, and enriches the region's visitor experience by offering intellectual and cultural value alongside spiritual journeys.

To ensure long-term success, additional policy measures should accompany the site selection. These include forming public-private partnerships with local industries and global edtech firms to support content creation; aligning the center's offerings with national curricula in coordination with the Ministry of Education; and designing a modular expansion model to scale across underserved regions. Educators in surrounding provinces, creating sustainable revenue streams through events and memberships, and integrating the center into broader tourism and urban development plans will ensure that the project serves as both a national prototype and a catalyst for regional and educational transformation. Anchoring the first national edutainment center in Yanbu combines logistical logic with symbolic significance that advances equity, innovation, and cultural engagement in support of Vision 2030.

5.2.5. Global Benchmarking and Regional Leadership Potential

Globally, institutions such as the Exploratorium in San Francisco, the Science Museum in London, and Technopolis in Belgium have become global symbols of science literacy and public innovation. By establishing a comparable or superior edutainment facility, Saudi Arabia can join this elite group, drawing tourists, researchers, and collaborators from around the world. Moreover, the Kingdom can lead the region in educational innovation, positioning itself as a regional pioneer in integrating culture, creativity, and STEM education.

5.2.6. Global Exemplars with a Focus on Sheikh Abdullah Al Salem Cultural Centre (ASCC)

As Saudi Arabia advances under the transformative Vision 2030 initiative, there is a growing emphasis on educational reform that integrates digital innovation, learner-centered environments, and lifelong learning principles. Central to this transformation is the development of immersive and interactive edutainment spaces that bridge the gap between traditional pedagogy and future workforce needs. The proposed Edutainment and Immersive Learning Center in Yanbu aims to become a flagship hub that leverages emerging technologies such as serious games, simulation platforms, 3D/4D/5D-enabled modules, and holographic instructional tools.

To evaluate the viability and strategic relevance of this initiative, it is essential to compare it against international benchmarks. Among these, the Sheikh Abdullah Al Salem Cultural Centre (ASCC) in Kuwait serves as a paragon of edutainment excellence, offering invaluable insights into how such initiatives can succeed and where opportunities for differentiation lie. By comparing the Saudi proposal with the ASCC and other notable centers globally, we can better frame its potential contributions to national goals and identify best practices for design and implementation.

The proposed edutainment center in Yanbu is envisioned as a dynamic, technology-enhanced learning ecosystem that fosters cognitive engagement, practical skills, and scientific curiosity among learners of all ages. Targeting formal and informal education sectors alike, the center will provide serious games for emergency response training, medical surgeries, and environmental simulations. It will offer interactive 3D, 4D, and 5D experiences designed to deliver STEM concepts, sustainability education, and historical immersion. Furthermore, it will feature augmented and virtual reality (AR/VR) platforms for concept visualization and experiential learning.

The ASCC in Kuwait City, opened in 2018, is widely considered one of the most ambitious museum complexes in the Arab world. Spanning over 22,000 square meters, the center houses six interconnected museums: the Natural History Museum, the Science and Technology Museum, the Space Museum, the Arabic Islamic Science Museum, the Fine Arts Museum, and motion and robotics zones [44]. Key features include a state-of-the-art planetarium, interactive exhibits using robotic arms and virtual screens, and educational workshops targeting school-age children. Its mission is to elevate public understanding of science and culture through a well-curated, museum-based experience that blends entertainment with education [45].

While the ASCC is rooted in museum-based learning, primarily offering semi-interactive exhibits and curated content, the Saudi Center places a stronger emphasis on experiential, learner-centered, and skill-driven pedagogy. The Saudi proposal promotes learning by doing,

consistent with constructivist learning theories. Moreover, while ASCC functions mostly as a public museum with limited integration into school curricula, the Saudi model proposes direct curriculum alignment, with embedded lesson plans, modular learning outcomes, examination assessments, and teacher collaboration for content co-creation.

The ASCC is situated in the capital of Kuwait, serving a wide urban population and international visitors. It positions itself as a tourism and cultural asset. Conversely, the Yanbu center is strategically located between Makkah and Madinah, leveraging religious and leisure tourism. It uniquely targets underserved regions in Saudi Arabia, making it a decentralized investment in educational equity.

Although the ASCC features cutting-edge exhibits, it focuses on technology as a tool for display rather than interaction. In contrast, the Saudi proposal introduces adaptive learning technologies, simulated training environments, and game-based modules, pushing boundaries by transforming users from passive observers into active participants.

The Saudi Vision emphasizes human capital development, digital transformation, cultural tourism, STEM proficiency, and lifelong learning. The proposed center strongly serves these pillars by developing future-ready skills through digital pedagogy, providing advanced training simulations for emerging industries, stimulating local tourism through educational attractions, and building a culture of scientific inquiry through hands-on learning. By contrast, while ASCC supports similar objectives in Kuwait, it lacks a direct connection to workforce development and broader curricular transformation.

Internationally, leading institutions such as the Exploratorium in San Francisco [46], Science Centre Singapore [47], Technopolis in Belgium [48], and the Perot Museum of Nature and Science in Dallas [49] serve as valuable models. These centers are renowned for their emphasis on experiential, inquiry-based science education, the integration of augmented and virtual reality technologies, and the promotion of early engagement in scientific research. In contrast, the proposed Saudi initiative distinguishes itself through its comprehensive, multipurpose design, functioning simultaneously as a learning laboratory, science museum, professional training facility, and a center for digital content production, strategically tailored to support national educational and developmental goals.

6. Conclusions

The findings of this study indicate strong readiness for the adoption of edutainment instructional technologies in Saudi Arabia. Although participants reported limited direct experience with serious games, holograms, and immersive simulation technologies, there was significant enthusiasm for their integration into educational and cultural settings. This enthusiasm appears driven more by aspiration and perceived value than by resistance or skepticism. Key barriers identified were infrastructural limitations, underdeveloped policy frameworks, and unequal access—rather than a lack of interest or willingness.

Notably, younger participants aged 18 to 34, particularly students and early-career professionals, expressed the highest levels of support. Gender-based differences emerged, particularly in relation to preferences for simulators and holographic learning environments, pointing to the need for inclusive and culturally sensitive content design. Regional disparities were also observed: participants from the more digitally connected Central and Western regions exhibited higher exposure and stronger support, whereas those from the Northern and Southern regions showed less familiarity, reinforcing the importance of addressing geographical inequities in future rollouts.

These insights underscore the potential of piloting edutainment initiatives in strategically positioned cities like Yanbu, where synergies between education, tourism, and economic development can be maximized. In alignment with Saudi Arabia's Vision 2030, such technologies offer a transformative pathway to enhance digital fluency, modernize teaching practices, and prepare learners for emerging sectors including artificial intelligence, robotics, and digital health.

However, several limitations must be acknowledged. First, as a self-report survey, the data may be subject to recall bias or social desirability bias, affecting the accuracy of participant's responses. Second, the sampling strategy—relying on convenience and purposive sampling through educational networks and digital platforms—limits the representativeness of the sample and may skew results toward more tech-savvy or engaged individuals. Consequently, the generalizability of findings to the broader Saudi population is constrained. Additionally, the study focused on perceptions and awareness rather than on behavioral outcomes or measured impacts.

Future research should address these limitations through more representative sampling across all regions, inclusion of underrepresented demographics, and the use of mixed-methods or longitudinal designs to assess behavioral engagement, learning outcomes, and long-term impact. Further exploration of adaptive edutainment powered by artificial intelligence and the governance of immersive learning environments will also be critical for building sustainable, inclusive national learning ecosystems.

Despite these limitations, this study constitutes an important foundational step in understanding public readiness, societal expectations, and strategic opportunities for edutainment technologies within the Saudi context. By combining a comprehensive literature

synthesis with empirical survey evidence, the research provides one of the earliest systematic insights into how serious games, simulations, and immersive environments are perceived across diverse demographic groups in the Kingdom. As such, it offers a credible baseline upon which future experimental, longitudinal, and policy-driven studies can build. More importantly, the findings highlight that investment in national science museums, immersive learning centers, and edutainment infrastructures is not speculative but grounded in demonstrated public demand and aligned with Vision 2030 priorities. Strategic investment in these initiatives represents a long-term commitment to human capital development, digital capability building, and educational equity. When viewed through this lens, the present study serves not as a conclusion, but as a starting point—one that underscores the urgency and value of transitioning from conceptual support to actionable, evidence-informed implementation of immersive learning ecosystems across Saudi Arabia.

Appendix

Appendix A: Survey

Section A: Demographic Information
Age: ☐ Under 18 ☐ 18–24 ☐ 25–34 ☐ 35–44 ☐ 45 and above
Gender: ☐ Male ☐ Female
Educational Level: ☐ High school or less ☐ Diploma ☐ Bachelor's degree ☐ Master's degree ☐ Doctorate
Marital Status: ☐ Single ☐ Married
Are you a video game player? ☐ Yes ☐ No
Do you currently work in education or a teaching-related job? ☐ Yes ☐ No
Which region of Saudi Arabia are you currently living in? ☐ Western Region ☐ Eastern Region ☐ Northern Region ☐ Southern Region ☐ Central Region
Section B: Perceptions and Needs for Edutainment Technologies
Holograms can help explain complex subjects more effectively in school classrooms. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Training simulators can enhance practical learning, especially in fields like medicine, aviation, or engineering. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
5D technologies (including motion, sound, and touch) make learning more immersive and enjoyable for students. ☐Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Saudi schools should integrate more advanced technologies like interactive holograms or game-based simulators. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Training centers in Saudi Arabia would benefit from using serious games or simulators for skill development. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
I would support the introduction of science museums in Saudi Arabia that include interactive exhibits using holograms and simulators. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
There is a need to establish science museums in Saudi Arabia that offer engaging educational experiences using modern technologies. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
I believe students would be more motivated to learn if schools used educational technologies similar to video games. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Edutainment tools such as 5D environments and simulations should be considered essential, not optional, in modern education. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Section C: Familiarity with Serious Games and Edutainment
Have you ever heard of or used "serious games" (games designed for learning/training purposes)? ☐ Yes ☐ No ☐ Not sure
I believe serious games are an effective way to teach real-world skills in schools and training environments. ☐ Strongly Disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree
Have you personally experienced any of the following? (Select all that apply) ☐ A serious video game used for learning or training ☐ A training simulator (e.g., for driving, flight, surgery, etc.) ☐ A 5D or holographic educational experience (e.g., museum, expo, school) ☐ None of the above

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