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Stages of Creating Digital Resources Based on AR Technologies for Future Primary School Teachers

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Abstract

This study explores the integration of Augmented Reality (AR) technologies in the education of future primary school teachers, focusing on the stages of creating digital resources. The literature reveals that AR fosters an interactive, constructivist learning environment, improving engagement, understanding, and learning outcomes. Key studies, including the XR-Ed framework, highlight the importance of aligning AR technologies with educational goals to enhance inclusivity, interactivity, and motivation in the classroom. The research also emphasizes the significance of AR in gamification and language learning, addressing challenges such as declining student motivation and cognitive overload. AR's applications in inclusive education, particularly for students with disabilities, demonstrate its versatility and potential to meet diverse learning needs. Despite these advancements, gaps in the literature persist, particularly in evaluating AR's role in promoting inclusivity and its practical implications for teacher training. This study underscores the necessity for further research and development to equip future educators with the skills to effectively integrate AR technologies into their teaching practices.

Keywords: *Augmented Reality (AR); Digital Resources; Teacher Training; Educational Technology; Primary Education.*

Introduction

The exploration of Augmented Reality (AR) in educational contexts has evolved significantly over the years, reflecting a growing recognition of its potential to enhance teaching and learning experiences. The foundational work by Dalim et al. (Dalim et al., 1970) provides a comprehensive review of the factors influencing the acceptance of AR in education. Their analysis of 49 articles reveals that AR can enrich educational practices by facilitating a constructivist learning environment, where learners engage actively with virtual objects, thus improving understanding and achieving greater learning outcomes. This early insight laid the groundwork for subsequent studies that further explored the application of AR in educational settings.

Building on this foundation, Kerawalla et al. (Kerawalla et al., 2006) conducted empirical research focusing on primary school science education, emphasizing the dialogue between teachers and students when using AR compared to traditional teaching methods. Their findings suggest that while teachers recognize the value of AR in making complex subjects more accessible, there remains a need for increased interactivity within AR applications to fully harness their educational potential. This study highlights the importance of mediatory tools in transforming educational activities, reinforcing the notion that AR's integration into classrooms is still in its nascent stages.

The systematic review by Quintero et al. (Quintero et al., 2019) further expands the discourse by examining AR's role in creating inclusive learning environments. Their analysis of various studies illustrates how AR can cater to diverse educational needs, particularly for students with disabilities. By showcasing successful AR applications designed for specific learning challenges, the authors underscore the necessity of designing AR resources that promote educational inclusion. Despite the positive findings, they note a gap in the literature regarding the comprehensive understanding of AR's role in addressing the diverse needs of students.

Yang et al. (Yang et al., 2020) contribute to the conversation by proposing the XR-Ed framework, which aims to guide the design of extended reality systems in education. Their methodical approach to reviewing existing literature reveals common themes and mechanisms underlying the effective use of XR technologies in learning. This framework emphasizes the importance of aligning technology with educational goals, thereby providing a structured pathway for future research and application of XR in educational contexts.

In the realm of gamification, Godoy (H. Godoy, 2021) discusses the integration of AR with game-based learning to enhance student engagement and motivation. His proposed mobile application, ScavengEarSci, exemplifies how AR can serve as a supplementary tool in the classroom, addressing the challenges of declining student motivation. This study highlights the potential of AR to not only enrich the learning experience but also to create a more engaging educational environment.

Lastly, Ebadi and Ashrafabadi (Ebadi & Ashrafabadi, 2022) explore the impact of AR on English as a Foreign Language (EFL) learners, emphasizing its role in improving reading comprehension and overall academic achievement. Their systematic review indicates that AR not only enhances student engagement but also reduces cognitive load, facilitating a more effective learning process. The integration of AR into language learning contexts exemplifies its versatility and potential to transform various educational domains.

Together, these studies illustrate the multifaceted applications of AR in education, from enhancing inclusivity to promoting engagement and comprehension. The literature reveals a trajectory of increasing sophistication in AR applications, underscoring the need for continued research and development to fully realize the benefits of AR for future primary school teachers.

2. Literature review

The article titled "Factors influencing the acceptance of augmented reality in education: A review of the literature" by (Dalim et al., 1970) provides a comprehensive overview of the integration of augmented reality (AR) in educational contexts. The authors conducted a thorough review of 49 relevant studies, highlighting the significant themes and common issues that arise in the discourse surrounding AR technologies in education. This review serves as a critical resource for understanding the factors that contribute to the acceptance and effectiveness of AR in teaching and learning environments.

One of the key insights from the article is the assertion that AR can significantly enhance teaching and learning practices. The authors emphasize that the use of AR technologies has been shown to improve student engagement and learning outcomes compared to traditional methods. This assertion is supported by the analysis of cognitive differences observed among students exposed to AR versus those who were not. The findings suggest that AR facilitates a more interactive and adaptable learning environment, which aligns with the principles of constructivist learning theory ((Dalim et al., 1970)). This is particularly relevant for future primary school teachers, as it underscores the potential of AR to create dynamic learning experiences that cater to diverse student needs.

Furthermore, the article discusses the accessibility of AR technology for educators, noting that even those without prior experience can successfully implement AR in their teaching practices. This finding is crucial for teacher training programs, as it suggests that future educators can be equipped with the necessary skills to utilize AR technologies effectively in their classrooms. The flexibility afforded to learners in manipulating virtual objects within an augmented environment is highlighted as a significant advantage, fostering deeper understanding and retention of knowledge ((Dalim et al., 1970)).

The article "Making it real: exploring the potential of Augmented Reality for teaching primary school science" by (Kerawalla et al., 2006) provides a comprehensive examination of the integration of Augmented Reality (AR) technologies within educational contexts, specifically in teaching primary school science. The authors effectively introduce the concept of AR, distinguishing it from Virtual Reality by emphasizing its capacity to enhance real-world experiences with virtual elements. This distinction is crucial for educators and future primary school teachers as it informs the potential applications of AR in classroom settings.

The study employs a comparative analysis of teaching methodologies, focusing on the dialogue employed by teachers when discussing celestial bodies such as the earth, sun, and moon. By utilizing video recordings of teaching sessions and audio interviews with educators, the authors present valuable qualitative data that highlights teachers' perceptions of AR's benefits. The findings suggest that educators are optimistic about AR's potential to make complex scientific concepts more accessible and engaging for young learners. This insight aligns with the notion that interactive and visually stimulating content can significantly enhance learning experiences for primary school students.

However, the article also identifies critical limitations in the current applications of AR in education. The authors argue that existing AR technologies lack sufficient interactivity and flexibility. For instance, the ability for both teachers and students to manipulate digital augmentations—such as pausing animations to foster inquiry—remains underdeveloped. This point raises important considerations for the design and implementation of AR resources in educational settings. Future developments in AR must prioritize user control to facilitate deeper exploration and understanding of the subject matter.

The authors note that the use of AR in formal education is still in its early stages, suggesting that there is ample room for growth and innovation. This observation is particularly relevant for future primary school teachers, who will need to be equipped with the skills and knowledge to harness AR technologies effectively. As AR continues to evolve, it is essential for educators to stay informed about advancements in this field, ensuring that they can integrate these tools into their teaching practices in a meaningful way.

The article "Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade" by (Quintero et al., 2019) provides a comprehensive examination of the role of augmented reality (AR) in fostering inclusive educational environments. The authors systematically analyze various studies from the past decade, highlighting the innovative applications of AR technology aimed at addressing the diverse needs of students, particularly those with disabilities.

One of the key insights from the article is the emphasis on the importance of utilizing multiple resources in educational settings, particularly for teaching students with hearing impairments. For instance, the application developed by Almutairi and Al-Megren for teaching Arabic to deaf children demonstrates a practical approach to enhancing learning through AR. This application not only aids comprehension but also engages both teachers and parents, indicating a collaborative effort in the educational process ((Quintero et al., 2019)).

Furthermore, the authors discuss the creation of a storybook by Abas and Zaman, which serves as a motivational tool for reading among students. This aligns with the broader objective of AR technologies to create engaging and interactive learning experiences that cater to various learning styles. The combination of AR with audio and video, as explored by Mirzaei et al., exemplifies how multimedia resources can enhance the learning experience for deaf individuals, thereby reinforcing the idea that inclusive education can be significantly enriched through technology.

The article also highlights the development of specific applications, such as "Paint-cAR" by Bacca et al., which targets students with diverse educational needs. This particular application illustrates how AR can be tailored to foster creativity and engagement among learners with varying abilities. Similarly, the digital game designed by Tobar-Muñoz et al. focuses on developing logical skills in mathematics, showcasing the versatility of AR in different subject areas.

Despite the thorough exploration of AR applications in education, (Quintero et al., 2019) note a critical gap in the literature regarding the current state of knowledge on AR's role in promoting educational inclusion. While many studies highlight the potential of AR in enhancing learning experiences, there is a lack of comprehensive analysis on its effectiveness in addressing the specific needs of diverse learners. This gap underscores the necessity for further research to evaluate and refine AR applications, ensuring they effectively support inclusive education initiatives.

The article "XR-Ed Framework: Designing Instruction-driven and Learner-centered Extended Reality Systems for Education" by (Yang et al., 2020) presents a comprehensive analysis of the application of extended reality (XR) technologies in educational settings. The authors conducted a thorough literature scan across three databases, employing a range of keywords related to XR technologies such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), in conjunction with terms like education and learning. This methodological approach ensured a robust selection of peer-reviewed studies that focus on the educational use of XR technologies.

The research process involved a two-round analytical framework. In the first round, the researchers evaluated various studies based on criteria such as educational goals, learning sciences theories, research questions, and the characteristics of the users involved. This foundational analysis allowed for a detailed categorization of the existing literature, highlighting the diverse applications of XR in education. The second round of analysis delved deeper into the specific mechanisms through which XR technologies facilitated the learning of domain knowledge, culminating in the identification of higher-level themes across different studies.

A significant contribution of the article is the development of the XR-Ed framework, which encompasses six dimensions aimed at guiding the design and implementation of XR systems in educational contexts. This framework not only provides a structured approach for educators and developers but also emphasizes the importance of aligning XR applications with instructional goals and learner needs. The thematic analysis employed by the researchers is particularly noteworthy, as it offers insights into commonalities in XR usage that can inform future educational practices.

However, while the article presents a solid foundation for understanding the role of XR technologies in education, it could benefit from a more explicit discussion on the practical implications of the XR-Ed framework for future primary school teachers. The framework's dimensions could be elaborated upon with specific examples of how they can be operationalized in classroom settings, particularly in the context of preparing future educators to integrate these technologies effectively. Additionally, a consideration of potential challenges and limitations in the adoption of XR technologies in primary education would enhance the article's critical evaluation of the current landscape.

In the article "Augmented Reality and Gamification: A Framework for Developing Supplementary Learning Tool" by (H. Godoy, 2021) (2021), the author presents a comprehensive examination of how game-based learning, particularly through the lens of Augmented Reality (AR), can enhance the educational experiences of students in primary education. The main thrust of Godoy's argument is that integrating AR into educational frameworks can significantly address the issues of student motivation and engagement, which have been notably declining in various learning contexts.

Godoy articulates a clear connection between the principles of gamification and the cognitive, social, and emotional development of students. This connection is critical, as it underscores the multifaceted benefits of employing AR games in educational settings. The article posits that AR-based games not only make learning more interactive but also foster a collaborative environment where students can engage with content in a meaningful way. This engagement is vital for future primary school teachers to understand, as they will be tasked with implementing such innovative teaching strategies.

A significant aspect of the article is the proposed development of an AR-based mobile application, ScavengEarSci. Godoy outlines a conceptual framework and methodology that will guide the development of this application, ensuring that it meets educational standards and effectively addresses the needs of learners. The emphasis on a structured development process is commendable, as it highlights the importance of systematic planning in educational technology projects. Furthermore, the intention to evaluate the application using ISO 25010 standards reflects a commitment to quality assurance, which is essential for the successful deployment of educational tools.

The article also invites further exploration into the iterative nature of application development, as Godoy notes that post-evaluation improvements will be based on expert assessments. This iterative feedback loop is crucial in educational technology, as it allows for continuous refinement and adaptation of resources to better serve the educational landscape.

The article "An exploration into the impact of augmented reality on EFL learners' Reading comprehension" by (Ebadi & Ashrafabadi, 2022) (2022) provides a comprehensive examination of the role augmented reality (AR) plays in enhancing the educational experience, particularly in the context of English as a Foreign Language (EFL) learners. The authors trace the origins of AR back

to the 1960s, emphasizing its evolution into a multi-sensorial simulator that integrates computer-generated virtual information with the real environment. This integration is pivotal in enriching the learning experience and fostering increased engagement among students.

One of the key insights of the article is the interactive nature of AR, which allows learners to engage with virtual content in real-time while remaining anchored in their physical environment. This characteristic of AR is particularly beneficial in educational settings, where it can create immersive hybrid learning environments. The authors argue that such environments not only enhance academic achievement but also make the learning process more engaging ((Ebadi & Ashrafabadi, 2022)). This assertion is supported by evidence indicating that students exhibit a positive attitude towards AR-enhanced learning, perceiving it as an effective tool for improving their academic performance.

Moreover, the article highlights the cognitive benefits of AR, particularly its ability to lower cognitive load. The authors suggest that well-designed AR systems can alleviate cognitive overload, thereby facilitating better learning outcomes. This is a crucial point, as it underscores the importance of thoughtful implementation of AR technologies in educational contexts. The reduction of cognitive load can lead to enhanced motivation and satisfaction among learners, further promoting their understanding of complex concepts.

The authors also discuss the collaborative aspect of AR, which fosters critical thinking and problem-solving skills through interactive group activities. This collaborative interaction is essential for the development of future primary school teachers, as it prepares them to utilize AR technologies effectively in their own teaching practices.

3. Conclusion

The exploration of Augmented Reality (AR) in education has garnered considerable attention, highlighting its potential to transform teaching and learning experiences. The foundational work by (Dalim et al., 1970) establishes that AR fosters a constructivist learning environment, where active engagement with virtual objects leads to improved understanding and learning outcomes. This early insight serves as a catalyst for subsequent research that delves deeper into AR's application in educational contexts.

(H. Godoy, 2021) expand on this foundation by examining the use of AR in primary school science education. Their study underscores the importance of interactivity in AR applications, revealing that while educators appreciate AR's potential, there is a need for enhancements in user engagement. This observation points to the current limitations of AR technologies and the necessity for further development to fully realize their educational benefits.

(Quintero et al., 2019) contribute to the discourse by analyzing AR's role in promoting inclusive educational environments. Their systematic review identifies successful AR applications designed for students with disabilities, emphasizing the need for continued innovation in AR resources to address diverse learning needs. However, they also highlight a significant gap in the literature regarding the understanding of AR's effectiveness in fostering inclusivity, suggesting that further research is essential.

(Yang et al., 2020) introduce the XR-Ed framework, which guides the design of extended reality systems in education. This framework emphasizes the alignment of technology with educational goals, offering a structured approach for future research and application of XR in educational contexts. The framework's development is crucial for preparing future primary school teachers to integrate AR technologies effectively into their teaching practices.

In the realm of gamification, (H. Godoy, 2021) discusses the integration of AR with game-based learning, proposing the mobile application ScavengEarSci as a tool to enhance student engagement and motivation. This study highlights the potential of AR to create interactive and enjoyable learning experiences, addressing the challenges of declining student motivation in educational settings.

(Ebadi & Ashrafabadi, 2022) further explore the impact of AR on English as a Foreign Language (EFL) learners, demonstrating its effectiveness in improving reading comprehension and overall academic achievement. Their findings indicate that AR not only enhances engagement but also reduces cognitive load, facilitating a more effective learning process. This versatility of AR illustrates its potential to transform various educational domains.

Collectively, these studies illustrate the multifaceted applications of AR in education, from fostering inclusivity to enhancing engagement and comprehension. The literature reflects a trajectory of increasing sophistication in AR applications, underscoring the need for continued research and development to maximize the benefits of AR for future primary school teachers.

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