International Journal of Research Studies in Computer Science and Engineering (IJRSCSE)
Volume 9, Issue 2, 2023, PP 45-49
ISSN 2349-4840 (Print) & ISSN 2349-4859 (Online)
https://doi.org/10.20431/2349-4859.0902005
www.arcjournals.org

Effects of Mobile Augmented Reality Apps in Science Education on Austrian Secondary School Students' Health

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Abstract: *The implementation of Mobile Augmented Reality (mAR) apps in Austrian secondary science education has demonstrated enhanced learning outcomes, increased engagement, and improved spatial understanding. However, this practice presents challenges, including infrastructure constraints, addictive behavior concerns, and potential health impacts on the students. This mini-review investigates the effects of mAR apps on the health of students, addressing issues like addictive usage, motion sickness, and psychological implications. It highlights the importance of a balanced approach, suggesting strategies to mitigate risks and proposing future research to assess long-term (m)AR implications on well-being and academic performance. Furthermore, it emphasizes the need for guidelines to regulate mAR app usage in education and advocates for exploring alternative teaching methods to minimize excessive screen time and potential addiction.*

Keywords: *Mobile Augmented Reality, Apps, AR, Science Education, Student Health*

1. Introduction

Augmented reality (AR) overlays digital content onto the real world, enhancing user experiences (Craig, 2013). Mobile augmented reality (mAR), a subset of AR, uses mobile devices such as smart phones and tablets for "on-the-go" AR experiences. Currently, mAR is one of the fastest-growing segments in this field, seamlessly integrating AR into various global locations, such as the educational field. The increasing power and affordability of mobile devices are propelling the rapid evolution of this technology (Craig, 2013). In European classrooms, educational applications, including mAR, are increasingly popular (Fernandez, 2017; Tobinski and Cyra, 2021), especially in science lessons (Schmidthaler, 2023a, 2023b), because AR is viewed as a very promising educational tool in modern science education (Saidin et al., 2015, Çakır et al., 2021; Kalana et al., 2020). In addition, Austrian science curricula suggest the use of the latest educational applications or technologies, like mAR (BMBWF, 2019). 2022 and 2023 studies showed that the most common learning apps with (m)AR in Austrian science education are *Merge Cube, Anatomyka, Geogebra, Flora Incognita, Insight Heart, Anatomy 3D Atlas, Seek by iNaturalist,* and *Atlas der Humananatomie (Visible Body*) (Schmidthaler, 2023a, 2023b).

2. Advantages and Issues in Science Education

Numerous recent case studies with students showed diverse benefits of AR and mAR in science education: (1) *Learning Enhancement and Motivation*: Increase in learning outcome (Wahyu et al., 2020), boosted motivation, and enhanced interest in STEM (Mystakidis et al., 2022). (2) *Collaboration and Engagement*: Improved collaboration, fostered cooperation, and increased engagement (Ajit et al., 2021). (3) *Enhanced Learning Experience*: Improved spatial awareness (Bogomolova et al., 2020), heightened contextual understanding of science (Yapıcı and Karakoyun, 2021), and better visualization of complex biological content (Saidin et al.,2015; Celik et al., 2020; Schmidthaler et al., 2023a; 2023b). (4) *Convenience and Accessibility*: Simple usability (Çakır et al., 2021), accessibility anytime, anywhere (even after school), and elimination of the need for other analog materials for instruction (Papadakis, 2021). Furthermore, Schmidthaler et al, (2023b) showed that mAR is perceived by science teachers as an innovative and creative educational tool, which changes the design of a lecture.

It seems that mAR is the solution for modern science education, but the successful implementation of mAR also has disadvantages and needs additional resources (Radu, 2012; 2014): (1) *School Environment and Technical Infrastructure:* Lack of budget, devices, and WIFI. (2) *Student Issues and Concerns*: Lack of competencies, difficult usability, advertisements, In-App purchases, lack of smartphones, increased distraction (e.g., social media) (Schmidthaler et al, 2023a; 2023b). (3) *Faculty Challenges and Needs*: Lack of money, school rules (e.g., no smartphones allowed in class) (Schmidthaler, 2023a; 2023b). (4) *Educational Practitioners' Perspectives*: Rules for smartphone utilization at home, additional costs, concern for distraction and overload (Melzer, 2019; Schmidthaler, 2023a; 2023b); Papadakis and Kalogiannakis, 2017), impaired concentration (Billhurst et al., 2003) and ineffective or lack of learning outcomes (Kerawalla et al, 2006). (5) *Application Functionality and Integration*: Wrong or age-inadequate apps' content, and technical dysfunctionality (e.g. AR is not correctly working) (Billhurst et al., 2003, Schmidthaler et al., 2023a, 2023b, Papadakis and Kalogiannakis, 2017; Dong et al., 2020). Some studies suggest that while low- and average-achieving students may benefit from AR, high-achievers may not, and students with lower reading abilities might not benefit from certain aspects of the AR experience (Freitas & Campos, 2008). Regarding equipment and infrastructure, in 2023, not all Austrian schools will have the same level of technical equipment. There are still educational institutions with inadequate WLAN, and not all students and educators have digital devices throughout, despite Austrian-wide device initiatives (e.g., provided notebooks or tablets for all 5th-graders) (BMBWF, 2021; OeAD, 2021) and financial support options at all school locations. In addition, not all educators and students are in possession of smartphones: 90% of all people older than 15 years own a smartphone (Statistics, 2023a). The analysis of parental perspectives on AR implementation for early childhood education reveals positive perceptions regarding its benefits, including enhanced motivation, knowledge acquisition, reading and writing skills, creativity, and overall satisfaction (Cascales et al., 2013; Shaharom & Halim, 2016). However, there are concerns among educators, students, and parents regarding the potential impact of integrating mobile apps with AR technology. They fear that it might hinder concentration, attention tunneling and cause distractions, both during learning sessions and within the classroom (Tang et al, 2003, Billhurst et al, 2003, Schmidthaler et al., 2023a, 2023b). Consequently, the significant apprehension revolves around the potential for addictive and detrimental usage.

3. Advantages and Issues in Health

Since AR technology is still very young, there is a lack of studies on the long-term use of mobile AR technologies, especially in school contexts with students and children. However, in terms of human health care and clinical potential, AR is nowadays also used in extinction-based therapies (e.g., anxiety, stress) and addiction treatment (smoking, substance use disorders) (Vinci, et al, 2020; Yang et al., 2022). Furthermore, the psychological impact of AR can trigger long-lasting effects in us as they engage our nervous system. A Stanford (2019) study showed, just like other real-world stimuli, those stimuli trigger our primitive fight-or-flight response when experiencing Virtual Reality (VR) and AR applications. Human brains behave the same way toward immersive virtual experiences as they do toward real-life experiences. This can also change how we perceive stimuli in the real physical environment (Miller et al, 2019). Additionally, to influences on neurobiology, other studies also show effects on physical well-being. Research shows that VR can cause motion sickness (Chattha et al, 2020). This manifests itself as nausea, confusion, vomiting, dizziness, and cold sweats after the VR experience. However, a recent study from 2022 also shows that optical see-through AR can also cause severe motion sickness (Kaufeld et al., 2022).

4. Methods and Research Aim

This mini-review highlights the possible benefits and disadvantages of mAR in teaching science classes for secondary school students. The aim is to introduce secondary school students in a healthy way to state-of-the-art computer science (CS) technologies such as mAR and to apply them positively in the classroom.

5. Discussion

Mobile apps are increasingly used in the school context. Moreover, in Austria, 85% of all 11–18-year-olds are using their smartphones on an everyday basis (Statistika, 2023b), and over 50% of the 13-year-olds, and over 70% of all 15-17-year-olds are using their smartphones at least three hours per day

(BMBWF, 2018). This high usage rate among Austrian secondary school students is only problematic if the students' thoughts only revolve around the use of smartphones. According to the HBSC study of the Federal Ministry, 9% of all Austrian students show strong signs of addictive behavior in terms of usage. In addition, more girls than boys and socially and/or income-disadvantaged students with/without a migration background tend to be affected (BMBWF, 2018). These figures must be considered by teachers in science classes. Since AR shows many advantages in science education (Wahyu et al., 2020), however, the risk of addiction and parents' concerns need to be considered by science teachers. Alternative forms of learning individualized and differentiated teaching with a wide variety of methods and different media could help all students equally, and possibly reduce increased screen/smartphone usage and the potential for addiction or possibly addictive behavior. Alternatively, within each school community, science teachers could agree on how often they use which mAR apps so that no peaks occur in terms of implementation in individual classes.

6. Conclusion and Outlook

In conclusion, the integration of mAR applications in science education has demonstrated various advantages, such as enhanced learning outcomes, improved spatial awareness, and heightened interest in STEM subjects. Despite these benefits, the successful implementation of mAR is impeded by various challenges, including limited technical infrastructure, concerns about potential addiction, and disparities in access to digital devices. Moreover, the potential adverse effects of mAR on students' focus and well-being, as evidenced by the increasing concern about smartphone addiction among Austrian students, cannot be overlooked. The mAR implementation in science must be accompanied by a balanced approach that considers the potential drawbacks and incorporates strategies for mitigating risks associated with potential excessive screen time, motion sickness and addictive behavior. Future research in this field should focus on addressing the challenges associated with the integration of mAR in Austrian science education. Further research efforts should also be directed towards developing guidelines and policies that regulate the use of mAR apps in educational settings, taking into consideration the concerns of educators, students, and parents. Furthermore, investigations into the long-term effects of mAR on students' cognitive development, social behavior, and psychological well-being are warranted. Additionally, studies should explore alternative pedagogical approaches that integrate various teaching methods and media to promote a holistic learning experience while mitigating the risks associated with prolonged smartphone usage.

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Citation: *Eva Schmidthaler. "Effects of Mobile Augmented Reality Apps in Science Education on Austrian Secondary School Students' Health" International Journal of Research Studies in Computer Science and Engineering (IJRSCSE), vol 9, no. 2, 2023, pp. 1-5. DOI: https://doi.org/10.20431/2349-4859.0902001.*