**Research Title: "Exploring the Impact of Augmented Reality Technology on Student's Learning Outcomes in Education"**

1. **Introduction**
2. **Objectives**
3. **Scope and Limitation**
4. **Presentation of the Chosen Technology**

**What is Augmented Reality?**

Augmented Reality (AR) is an important technology that provides significant tools to improve the experience of interacting with reality (Garzón, 2019). Numerous literatures, including the writings of Buchner et al. in 2022, described that Augmented Reality must possess three key features. Similarly, Microsoft has expounded on the same three important characteristics of Augmented Reality (AR), namely the merging of digital and physical world, instant interactions in real time, and precise 3D recognition of virtual and physical entities. As a result of these features, Augmented Reality has the potential to provide a more immersive, interactive, and collaborative learning environment, offering a dynamic, experiential, and participatory approach to education that transcends the passive knowledge transfer often associated with traditional learning modalities.

**First Augmented Reality System in Education**

Based on scientific and academic literature databases, it has been reported that the initial development of an augmented reality (AR) system solely intended for educational purposes was aimed at facilitating the teaching of anatomical structures in three dimensions. The system was developed in University of Carolina and was first presented by its innovators to the scientific community during the International Conference on Computer Vision, Virtual Reality, and Robotics in Medicine convened in Nice, France in 1995. Their system employed a process of superimposition and registration to accurately align and depict bone structures in relation to real anatomical counterparts within a human subject. This innovative approach was introduced to facilitate the teaching and learning of anatomy through utilization of a head-mounted display.

**Three Generations of Augmented Reality in Education**

In Garzón’s study on the overview of twenty-five years of Augmented Reality in 2021, he proposed three generations of Augmented Reality technology in education.

**First Generation (1GARE)**

The first generation of Augmented Reality in Education was named 1GARE by Garzón. This period spans from 1995 to 2010, and during these years, AR systems were heavily hardware-based. AR systems during this generation were distinguished by the utilization of high-priced and intricate AR technologies, including head-mounted displays, heads-up displays, and handheld displays. The aforementioned systems were originally developed with an aim to impart knowledge in health, natural sciences, and engineering academic spheres, and catering primarily to undergraduate students. Nevertheless, the utilization of 1GARE applications was hampered by two major constraints, specifically, elevated expenses and difficulties associated with usability. As a consequence of these factors, the application of 1GARE in educational settings did not garner widespread acceptance, resulting in limited dissemination.

Early researchers such as Billinghurst in 2002 and Dunleavy in 2009 have underscored the prospective significance of augmented reality (AR) in the realm of education, with particular emphasis on its capacity to generate seamless interactions between authentic and digital environments. During the early phases of integrating augmented reality (AR) in the realm of education, there were only less instances of the technology being implemented, leading to a lack of comprehensive user assessments. Due to this constraint, their capacity to comprehend the full extent of Augmented Reality's influence on education was restricted during the early period of educational AR technologies.

**Second Generation (2GARE)**

The second generation has witnessed a significant surge in the popularity of augmented reality (AR) systems, with Google Glass and Pokemon GO emerging as two of the most notable commercial products in this era. In the year 2014, Google Glass, representing one of the primary advancements towards augmented reality technology in mainstream markets, presented a version of wearable technology that overlayed digital data onto the physical surroundings of users (Bower, 2016). Although Google Glass fell short of meeting its expected commercial success, it incited vital discussions and explorations concerning the potential of augmented reality (AR) in diverse industries, such as education (Bower, 2016). The experimental utilization of Google Glass within educational settings has illustrated the potential of augmented reality (AR) in promoting personalized learning, augmenting student collaboration, and cultivating an immersive and embodied learning modality, as illuminated by the research endeavors of Al-Emran, Elsherif, and Shaalan in 2016. In contrast, Pokémon Go provided a different effect in the implementation of AR in education. Through its utilization of Augmented Reality (AR) technology, the mobile game emerged as a cultural sensation, thereby showcasing the potential of AR technology to enter the mainstream market. The success of Pokémon Go revealed that augmented reality possesses the potential to be accessible, user-friendly, engaging, and effective in facilitating real-world exploration (Serino, Cordrey, McLaughlin, & Milanaik, 2016). In recent times, the educational community has capitalized on the widespread acceptance of Pokémon Go to incorporate Augmented Reality (AR) technology in teaching and learning techniques. This approach has succeeded in paving the way for developing stimulating and dynamic learning programs that enable learners to immerse themselves in interactive and enjoyable learning experiences (Klopfer & Sheldon, 2010).

The emergence of Google Glass in 2014 and the subsequent success of Pokémon Go in 2016 were crucial factors in acquiring attention from both developers and users of augmented reality (AR) technology, thereby highlighting its status as a significant tool in the field of educational technology.

**Third Generation (3GARE)**

Lastly, the third generation of Augmented Reality in education (3GARE) pertains to the AR systems from 2020 up to the future as stated by Garzón. 3GARE denotes a notable advancement beyond conventional modalities such as head-mounted displays and smartphones. The evolution in the field of augmented reality (AR) can be identified and classified according to three specific trajectories or scenarios, namely smart glasses, WebAR, and the integration of AR technology with Artificial Intelligence (AI) systems.

The initial scenario pertains to smart glasses, including HoloLens, Oculus Rift, as well as the upcoming iGlass. It is predicted that standalone headsets will become progressively prevalent. The International Data Corporation (2017) has projected a remarkable surge in the worldwide shipment statistics of these devices - from 225,000 units in 2017 to an expected total of around 32.7 million units in 2022. This observed growth suggests a prospective adaptation of augmented reality in diverse sectors, indicating a revolutional stance within the realm of education.

The WebAR scenario has been developed as a response to the reluctance of some users to install specialized mobile applications solely for the purpose of accessing augmented reality (AR) content. The utilization of WebAR technology facilitates access to augmented reality (AR) via the internet, which efficiently enhances user involvement with AR by eliminating the need for installation of an application. Despite the current efficiency deficit of WebAR compared to app-based AR, the potential for transformative web interactions and advancement of AR technology is significant (Rauschnabel, Rossmann, & tom Dieck, 2017).

Ultimately, the development of augmented reality (AR) and artificial intelligence (AI) represents the third and final scenario. The integration of Artificial Intelligence (AI) into Augmented Reality (AR) technology facilitates the convergence of physical and digital realms, providing new solutions to a variety of everyday problems. The integration of artificial intelligence (AI) enhances the quality of augmented reality (AR) experiences by facilitating a more realistic and immersive encounter, consequently providing advanced levels of application customization (Billinghurst, Clark, & Lee, 2015). The incorporation of AI integration has the potential to not only broaden the intellectual scope for developers and academics, but it also has the ability to introduce a powerful and revolutionary model for augmented reality in various industries, including education.

1. **Summary**
2. **Conclusion and Recommendation**
3. **References**

Billinghurst, M., Clark, A., & Lee, G. (2015). A survey of augmented reality. Foundations and Trends® in Human–Computer Interaction, 8(2-3), 73-272.

Billinghurst, M. (2002). Augmented reality in education. New horizons for learning, 12(5), 1-5.

Buchner, J., Buntins, K., & Kerres, M. (2022). The impact of augmented reality on cognitive load and performance: A systematic review. Journal of Computer Assisted Learning, 38, 285-303.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. Journal of science Education and Technology, 18, 7-22.

Garzón, J. A., & Acevedo, J. P. (2019). Meta-analysis of the impact of Augmented Reality on students’ learning gains. Educational Research Review, 27, 244–260. https://doi.org/10.1016/j.edurev.2019.04.001

Garzón, J. A. (2021). An Overview of Twenty-Five Years of Augmented Reality in Education. Multimodal Technologies and Interaction, 5(7), 37. https://doi.org/10.3390/mti5070037

Microsoft. (n.d.). What is augmented reality (AR) | Microsoft Dynamics 365. https://dynamics.microsoft.com/en-us/mixed-reality/guides/what-is-augmented-reality-ar/