

# A Novel Framework Incorporating Augmented Reality and Pedagogy for Improving Reading Comprehension in Special Education

Andrianthi KAPETANAKI <sup>a</sup>, Akrivi KROUSKA <sup>a,1</sup>, Christos TROUSSAS <sup>a</sup> and Cleo SGOUROPOULOU <sup>a</sup>

<sup>a</sup>*Department of Informatics and Computer Engineering University of West Attica, Greece*

**Abstract.** Augmented Reality (AR) is an emerging technology thriving in recent years. The implementation of AR in education offers great opportunities to enhance educational environments achieving better learning outcomes. As students with learning disabilities struggle with reading comprehension, an AR learning environment provides them support to better understand texts they actually read. Even though few studies have tried to explore the impact of AR technology to reading comprehension for students with learning disabilities in Secondary Education, there is a lack of research grounded in the incorporation of learning theories and personalization technologies. The goal of this paper is to present an AR educational environment capable of supporting meaningful learning outcomes by taking into consideration each student special educational needs and learning style. The novelty of this study lies in the student-centered and personalized design, which leads to improved understanding, student interaction and self-learning.

**Keywords.** Augmented Reality, Educational Technology, Learning Disabilities, Personalized Learning, Reading Comprehension, Special Education.

## 1. Introduction

One of the main goals of education is to help students develop knowledge, skills and strategies, in order to become proficient and independent readers who read with meaning. The activity of reading includes seeing, perceiving, understanding, vocalizing and mentally constructing through the combined use of eyes, ears and brain [1]. However, students with learning disabilities struggle with reading comprehension which may be due to not only word recognition skills that are not automatic, but also to problems with working memory or to the fact that they may have difficulty in applying metacognitive strategies while reading a text [2].

Reading comprehension intervention can be provided by using a gamified approach and Augmented Reality (AR). Augmented Reality is a rapidly emerging technology that supplements the real world with virtual objects that appear to coexist in the same space as the real world [3]. AR books link text, image, sound and movement

---

<sup>1</sup> Corresponding Author, E-mail: akrouska@uniwa.gr.

as AR application on the mobile phone tracks images in the printed book and overlays virtual content onto them [4]. AR provides a multisensory learning environment with active students' involvement during the reading session [5]. Studies indicate that multisensory approach is the most effective teaching method for students with learning disabilities as it incorporates several learning pathways in the brain at the same time so that opportunities for memory and learning are increased [6].

The purpose of this paper is to investigate the exploitation of augmented reality in order to help students with learning disabilities to better understand texts in a meaningful student-centered learning environment.

## 2. Literature Review

According to the literature review, Augmented Reality is mainly applied in the field of Science [7, 8]. This may be related to the fact that AR learning environments facilitate comprehension of science concepts with the help of 3D models, improving students' laboratory skills [9, 10]. In the field of Social Sciences and Humanities, AR is mainly used in second language learning [11].

Although many studies have been conducted on AR use in education, only few of them are related to special education [12]. However, there is a growing interest in designing AR learning environments to support students with special educational needs. Researchers studied its affordance in skill acquisition of individuals with intellectual disabilities [13], autism spectrum disorder (ASD) [14], learning disabilities [7], hearing [15] and visual impairments [16]. It is remarkable that studies have shown that AR enables students with special educational needs to gain independent life skills, reduce behavioral problems and increase their level of academic achievements, enthusiasm and readiness by bringing them in real-life experiences [17].

In view of the above, the design and development of an AR system incorporating learning theories and personalization techniques targeting to enhancement of students' with learning disabilities reading comprehension skills is crucial. Student-centered and personalized design is expected to promote student interaction and self-learning and achieve better learning outcomes.

## 3. Research Methodology

AR application is mainly focused on STEM education, while there are only few studies in Social Sciences and Humanities. Furthermore, research in AR targeting in reading comprehension for students with learning disabilities in Secondary Education is limited, while there is a lack of research grounded in learning theories, which could provide evidence how AR learning environments should be designed in order to improve learning outcomes. Additionally, AR systems designed are not personalized and not adapted in special educational needs of each particular student. Hence, within this context the research questions addressed by this study are the following:

RQ1: Does AR technology leads students with learning disabilities to the enhancement of their reading comprehension?

AR technology offers great opportunities to enrich learning procedure. Students who use AR material have a better performance in reading comprehension and learning

permanency compared to students who read with traditional methods [18]. Therefore, it would be quite interesting to investigate the effect of an AR environment on students with learning disabilities in Secondary Education.

RQ2: How could the pedagogical affordance of an AR system in special education be enhanced?

Many studies have been conducted in order to explore the impact of AR in education. However, only few of them implemented pedagogical theories. To optimize learning outcomes the incorporation of learning theories is needed in order to design a meaningful educational AR environment [19, 20].

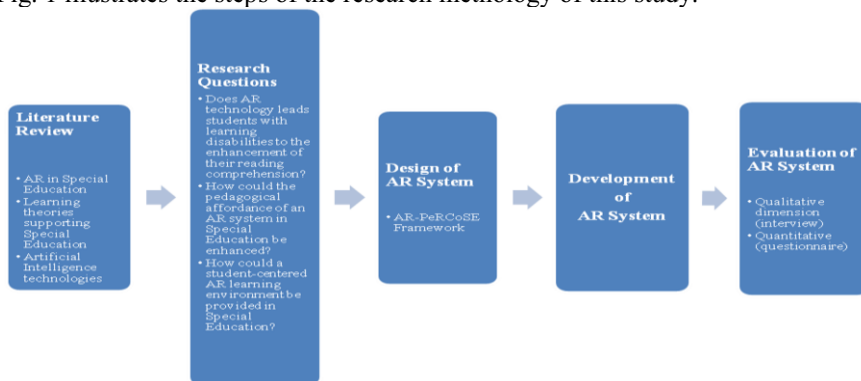
RQ3: How could a student-centered AR learning environment be provided in special education?

A student-centered learning environment is focused on students' interests, abilities and learning styles [21, 22]. It is quite challenging to design a student-centered framework by using artificial intelligence techniques, in order to adjust the AR system to specific needs of students in special education. In that way, personalized learning is provided, satisfying the demand for inclusion and enabling students with special educational needs to take over an active role in learning process.

In view of the above, this paper proposes the design and development of an AR system with the aforementioned features, namely the incorporation of learning theories and personalization techniques, for supporting students with learning disabilities in reading comprehension.

In order to examine whether the use of AR may have a positive impact on this field, quasi-experimental design and a mixed method, combining the collection of both qualitative and quantitative data, will be used for evaluating the developed AR system. Qualitative data will be collected by interviews, while quantitative data will be collected by Likert-scale questionnaire. The sample will be composed of students with learning disabilities in Secondary Education. The experimental group will participate in reading activities of textbooks using AR application, while traditional methods will be used for control group.

Fig. 1 illustrates the steps of the research methodology of this study.



**Figure 1.** Research design of the study

#### 4. The AR-PeRCoSE Framework : Augmented Reality and Pedagogy in Reading Comprehension in Special Education

This study introduces a novel framework, called AR-PeRCoSE, which uses AR technology in conjunction with pedagogical theories and AI techniques for promoting reading comprehension in Special Education. To this direction, school books will be used and enriched with AR content by providing real-time visual and audio feedback. Personalized AR content, consisted of image, audio, video and text, will be prepared, in order to allow multiple entry point to process learning and demonstrate understanding for each particular student. AR technology will be based on markers and a tablet will scan book pages and detect markers via an AR application. Markers and multimedia objects will be designed and saved in system's database in the cloud, so as to enable tablet's camera tracking. AR content will be designed taking into consideration domain model, pedagogical model by integrating learning and special education theories, student model, Augmented Reality (AR) and Artificial Intelligence (AI) techniques. As tablet's camera tracks the markers, the display will show supplemental material from which every student can choose what to use according to its needs and learning style. Interactivity between students and the device is expected to stimulate their interest and encourage them to study efficiently texts at their own pace.

Fig. 2 presents the proposed AR-PeRCoSE framework.

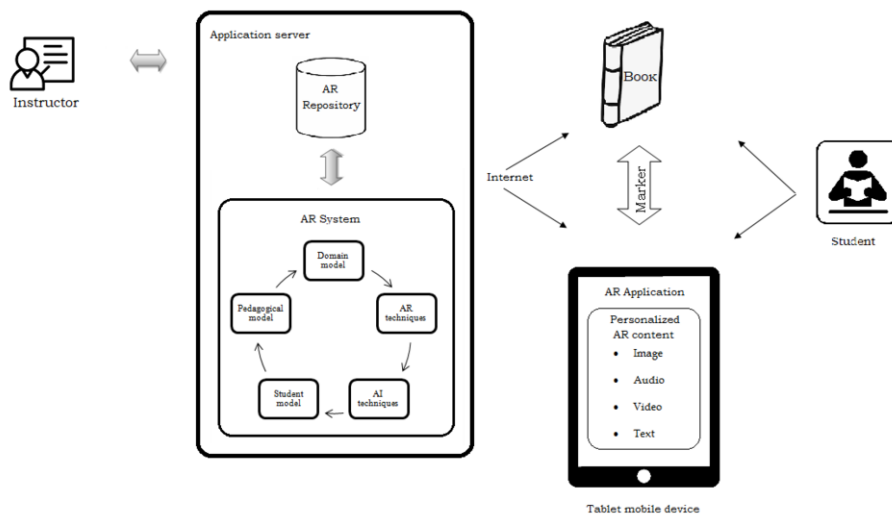


Figure 2. Augmented Reality and Pedagogy in Special Education Framework

#### 5. Conclusion and Future Work

This paper introduces a novel framework which uses AR technology incorporating pedagogical theories and personalization techniques in order to enhance students' with learning disabilities reading comprehension skills. The main aim of this framework is to foster personalized student-centered learning environment and achieve better learning outcomes.

In addition, future studies need to use this framework so as to compare its feasibility to diverse groups of special educational needs, examine its usability and affordance to each particular group and detect potential gaps for its improvement. Furthermore, AR use could be further expanded for other skills acquisition for students in Special Education.

## References

- [1] Palani, K. (2012). Promoting Reading Habits and Creating Literate Society. *Researchers World*, 3, 90.
- [2] Jitendra, A. & Gajria, M. (2011). Reading Comprehension Instruction for Students with Learning Disabilities. *Focus on Exceptional Children*. 43 (8). 1-16. <https://doi.org/10.17161/foec.v43i8.6690>
- [3] Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. *Computer Graphics and Applications IEEE*, 21(6), 34-47.
- [4] Billinghamurst, M. & Duenser, A. (2012). Augmented Reality in the Classroom. *Computer*, 45(7), 56–63. <https://doi.org/10.1109/MC.2012.111>
- [5] Abas, H., & Zaman, H.B. (2011). Scaffolding models for remedial students in using augmented reality storybook. *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics*, 1-5.
- [6] Algrni N.S. (2020). The Effectiveness of Using Multisensory Approach in Enhancing Achievement and Retention of English Vocabulary Amongst Intermediate Female Students with EFL Learning Disabilities. *Journal of Education and Practice*. 11 (9).
- [7] Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented Reality Trends in Education: A systematic review of research and Applications. *Educational Technology & Society*, 17 (4), 133–149.
- [8] Papakostas, C., Troussas, C., Krouska, A., & Sgouropoulou, C. (2021). Exploration of Augmented Reality in Spatial Abilities Training: A Systematic Literature Review for the Last Decade. *Informatics in Education*, 20(1), 107-130.
- [9] Papakostas, C., Troussas, C., Krouska, A., & Sgouropoulou, C. (2021). User acceptance of augmented reality welding simulator in engineering training. *Education and Information Technologies*, 1-27.
- [10] Akçayır, M., Akçayır, G., Pektaş, H. M., & Ocak, M. A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, 57, 334–342.
- [11] Liu, Y., Holden, D., & Zheng, D. (2016). Analyzing students' language learning experience in an augmented reality mobile game: an exploration of an emergent learning environment. *Procedia-Social and Behavioral Sciences*, 228, 369-374. <https://doi.org/10.1016/j.sbspro.2016.07.055>
- [12] Sirakaya, M., & Alsancak Sirakaya, D. (2018). Trends in Educational Augmented Reality Studies: A Systematic Review. *Malaysian Online Journal of Educational Technology*, 6(2), 60-74.
- [13] McMahon, D. D., Smith, C. C., Cihak, D. F., Wright, R., & Gibbons, M. M. (2015). Effects of digital navigation aids on adults with intellectual disabilities:

- Comparison of paper map, Google maps, and augmented reality. *Journal of Special Education Technology*, 30(3), 157-165.
- [14] Bhatt, S., De Leon, N., & Al-Jumaily, A. (2014). Augmented reality game therapy for children with autism spectrum disorder. *International Journal on Smart Sensing and Intelligent Systems*, 7 (2), 519-536.
- [15] Mirzaei, M. R., Ghorshi, S., & Mortazavi, M. (2014). Audio-visual speech recognition techniques in AR environments. *The Visual Computer*, 30, 245–257.
- [16] Albouys-Perrois, J., Laviole, J., Briant, J., & Brock, A. (2018). Towards a multisensory augmented reality map for blind and low vision people: A participatory design approach. In *CHI 2018, Conference on Human Factors in Computing Systems*, 21 - 26 April 2018, Montréal, Canada: ACM.
- [17] Cakir, R., & Korkmaz, O. (2019). The Effectiveness of Augmented Reality Environments on Individuals with Special Education Needs. *Education and Information Technologies*, 24(2), 1631–1659. <https://doi.org/10.1007/s10639-018-9848-6>
- [18] Bursali, H., & Yilmaz, R., (2019). Effect of augmented reality applications on secondary school students' reading comprehension and learning permanency, *Computers in Human Behavior*, 95, 126-135. <https://doi.org/10.1016/j.chb.2019.01.035>
- [19] Krouska A., Troussas C., & Virvou M. (2019). Computerized Adaptive Assessment Using Accumulative Learning Activities Based on Revised Bloom's Taxonomy. In: Virvou M., Kumeno F., Oikonomou K. (eds) *Knowledge-Based Software Engineering: 2018. JCKBSE 2018. Smart Innovation, Systems and Technologies*, vol 108. Springer, Cham. [https://doi.org/10.1007/978-3-319-97679-2\\_26](https://doi.org/10.1007/978-3-319-97679-2_26)
- [20] Krouska, A., Troussas, C., & Virvou, M. (2017, August). Social networks as a learning environment: Developed applications and comparative analysis. In *2017 8th International Conference on Information, Intelligence, Systems & Applications (IISA)* (pp. 1-6). IEEE.
- [21] Troussas, C., Krouska, A., & Virvou, M. (2020). Using a multi module model for learning analytics to predict learners' cognitive states and provide tailored learning pathways and assessment. In *Machine Learning Paradigms* (pp. 9-22). Springer, Cham.
- [22] Troussas, C., Krouska, A., & Sgouropoulou, C. (2021). Impact of social networking for advancing learners' knowledge in E-learning environments. *Education and Information Technologies*, 1-21.