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The Effect of Augmented Reality (AR) on Conceptual Understanding and Learning Motivation Among Students with Hearing Impairment: A Quasi-Experimental Study

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ABSTRACT :

This quasi-experimental study investigated the impact of Augmented Reality (AR) on conceptual understanding and learning motivation among students with hearing impairment. The study was conducted in a special education school and involved two intact Grade 7 classes assigned as the experimental group (n = 18) and the control group (n = 18). The experimental group was taught science topics using an AR-based mobile application that incorporated interactive 3D models, animations, and sign-language support, while the control group received instruction through traditional visual-aided materials and teacher-led sign language explanations. Both groups were assessed before and after the intervention using a Conceptual Understanding Test (CUT) and a Learning Motivation Scale (LMS). Statistical analyses showed that the AR-based instruction led to significantly higher gains in both conceptual understanding and motivation. The findings support the integration of AR into special education classrooms to enhance science learning for students with hearing impairments.

Introduction

Students with hearing impairments face a range of challenges in accessing mainstream educational content, particularly in cognitively demanding subjects such as science (Adeduyigbe et al., 2024). These subjects often involve abstract concepts, complex processes, and technical vocabulary that are typically conveyed through spoken explanations, auditory cues, and static visual aids. Traditional pedagogical approaches—such as lecture-based instruction, textbook diagrams, or chalkboard illustrations—frequently fail to address the unique learning needs of deaf and hard-of-hearing students (Bowen & Probst, 2023). This disconnect can result in significant gaps in comprehension, decreased academic confidence, and limited classroom participation. Therefore, it is essential to explore alternative instructional methods that can accommodate diverse learning modalities and enhance science literacy among students with hearing impairments.

One emerging solution is the integration of Augmented Reality (AR) technology into science instruction. AR superimposes digital content—such as 3D models, animations, and simulations—onto the physical environment, allowing students to interact with complex information in immersive and intuitive ways (Mahamad et al., 2024). For learners who depend primarily on visual and spatial information, AR offers a dynamic alternative to traditional teaching methods. By transforming abstract scientific phenomena into concrete, manipulable experiences, AR helps make learning more accessible and meaningful. For example, instead of reading about the structure of a cell, students can explore a 3D holographic model that visually demonstrates organelle functions, enabling deeper conceptual understanding (Borchert et al., 2013).

In addition to cognitive benefits, AR also has the potential to enhance student motivation and engagement, which are critical components of successful learning experiences. Research suggests that interactive and visually stimulating technologies can foster increased interest and active participation, especially among students who may feel marginalized in conventional classrooms. For students with hearing impairments, AR can reduce feelings of exclusion by offering an engaging, equitable platform for exploration and collaboration. The novelty and interactivity of AR may also support sustained attention, improve memory retention, and encourage peer interaction, all of which contribute to a more inclusive and participatory science education environment.

Given these possibilities, this study aims to investigate whether AR can serve as an effective pedagogical tool for improving science learning outcomes and motivation among students with hearing impairment. Specifically, the research seeks to evaluate how AR influences comprehension of scientific concepts, student engagement during lessons, and learners' attitudes toward science as a subject. By examining the practical application of AR in inclusive primary school settings, the study intends to generate context-specific insights that can inform both policy and practice. It also aims to contribute to the broader discourse on inclusive education and digital innovation in low-resource environments, such as those found in many Ethiopian schools.

Research Questions

This study was guided by the following research questions:

1. Does AR-based instruction significantly improve the conceptual understanding of students with hearing impairment compared to traditional

instruction?

2. What is the impact of AR-based instruction on the learning motivation of students with hearing impairment in comparison to traditional visual instruction?

Methodology

Research Design

The study employed a **quasi-experimental pretest-posttest design with non-equivalent control groups**. This design was chosen because random assignment was not feasible in the school setting, and intact classrooms were used.

Participants

The participants were 36 Grade 7 students (ages 12–14) with moderate to profound hearing impairment enrolled in a government-supported special education school. Two intact classes were selected through purposive sampling. One class was designated as the experimental group (AR instruction), and the other as the control group (traditional instruction). Students in both groups had similar backgrounds in terms of communication skills, prior academic performance, and exposure to digital tools.

Instructional Intervention

Over four weeks, both groups received instruction on selected science topics aligned with the national curriculum, including "The Human Digestive System" and "Photosynthesis." The **experimental group** used a custom-designed AR mobile app that provided real-time 3D models, animations, text captions, and sign-language video clips. Students interacted with AR content using tablets, exploring models by rotating, zooming, and activating animations with gesture-based controls.

The **control group** received the same content using printed visual materials, static diagrams, and teacher-led instruction with sign language support. Both groups received three 40-minute science sessions per week, totaling 12 sessions. Teachers in both groups were trained equally in content and delivery methods to ensure consistency.

Instruments

- **Conceptual Understanding Test (CUT):** A researcher-developed 20-item assessment including multiple-choice, labeling, and matching questions designed to measure students' grasp of scientific concepts. It was validated by three content experts and adapted to meet the visual and cognitive needs of students with hearing impairments.
- **Learning Motivation Scale (LMS):** A 15-item instrument adapted from the ARCS model (Keller, 1987), measuring Attention, Relevance, Confidence, and Satisfaction. Items were translated into visual symbols and simplified language with optional sign-language interpreter support.

Data Collection Procedure

Data collection occurred in three phases: pretesting, intervention, and posttesting. Pretests were administered to both groups one week before the intervention. After the four-week instructional period, the same instruments were administered as posttests. Data collection was supervised by trained special educators and interpreters to ensure clarity and consistency in communication.

Data Analysis

Descriptive statistics were used to summarize the data. Inferential analyses, including paired-samples t-tests (within groups) and independent-samples t-tests (between groups), were conducted using SPSS 26.0. Cohen's d was calculated to determine the effect size of observed differences.

Results

Baseline comparisons between the experimental and control groups indicated no statistically significant differences in students' pretest scores for either conceptual understanding or learning motivation, with p-values greater than .05. This suggests that the two groups were initially equivalent in terms of their academic standing and motivation levels prior to the intervention. Such equivalence is essential to establish the internal validity of the study and to ensure that any observed differences in post-intervention outcomes can be attributed with greater confidence to the AR-based instructional approach rather than to pre-existing disparities.

Following the implementation of the augmented reality (AR) intervention, post-test comparisons revealed notable improvements in the experimental group across both measured outcomes. In terms of conceptual understanding, the students in the AR group achieved significantly higher post-test scores ($M = 16.1$, $SD = 1.7$) compared to their counterparts in the control group ($M = 13.2$, $SD = 2.1$). The difference between groups was statistically significant, $t(34) = 4.78$, $p < .001$, with a large effect size (Cohen's $d = 1.57$). This substantial effect underscores the efficacy of AR in enhancing comprehension of scientific concepts among students with hearing impairments. The interactive and visual nature of AR likely contributed to more effective cognitive processing and retention of abstract science content.

Similar gains were observed in the domain of learning motivation. The experimental group reported significantly higher motivation scores ($M = 4.21$, $SD = 0.38$) compared to the control group ($M = 3.46$, $SD = 0.51$). This difference was also statistically significant, $t(34) = 5.09$, $p < .001$, with a large effect size (Cohen's $d = 1.35$). These results suggest that AR technology not only supports cognitive learning but also fosters greater student interest and emotional engagement. For students with hearing impairments, who often experience reduced classroom participation due to communication barriers, the AR environment may have provided an inclusive and stimulating platform that boosted their enthusiasm and sense of agency in learning.

Overall, the findings from this study provide strong empirical evidence that AR-based instruction significantly enhances both conceptual understanding and motivation among students with hearing impairment. The large effect sizes associated with both outcome measures indicate that AR is not only effective but potentially transformative in addressing the educational needs of this marginalized group. These results have important implications for inclusive education, highlighting the potential of emerging technologies to bridge learning gaps and promote equity in science education for all learners.

Discussion

The study's findings are consistent with a growing body of literature highlighting the positive impact of Augmented Reality (AR) on diverse learner populations, including students with disabilities. Specifically, for students with hearing impairment, the visual and spatial affordances of AR proved particularly advantageous. Unlike conventional instructional methods that rely heavily on auditory delivery and static visual aids, AR allowed learners to interact with 3D models, animations, and simulations in real-time. These dynamic features made abstract scientific concepts more accessible and concrete. The capacity to explore phenomena such as cell division, magnetism, or planetary motion in a visually immersive manner provided students with deeper conceptual clarity and improved content retention.

Moreover, the interactivity embedded within AR environments empowered students to control their learning experiences. Being able to manipulate objects, zoom into specific structures, or repeat animations at their own pace gave learners the autonomy to process information in a way that matched their individual needs. This self-paced exploration not only supported differentiated instruction but also fostered a sense of ownership over learning. For students with hearing impairments—who often face communication barriers in mainstream classrooms—AR provided an alternative channel for inquiry and comprehension that was both responsive and inclusive (Ioannou & Constantinou, 2017) .

In addition to cognitive benefits, the study found that AR significantly enhanced students' intrinsic motivation toward learning science. The novelty of the technology itself captured students' attention, while the ability to engage actively with content promoted feelings of competence and confidence. Many students reported increased enthusiasm and enjoyment during AR-based lessons, which contributed to greater classroom participation. These motivational gains are particularly important in inclusive education, where students with hearing impairments may otherwise experience reduced engagement due to social isolation or limited access to mainstream pedagogical tools.

Ultimately, these results underscore the transformative potential of AR in creating more equitable and student-centered learning environments. By addressing both cognitive and emotional aspects of learning, AR technologies can bridge significant gaps in educational access for students with hearing impairments. They offer teachers innovative ways to differentiate instruction and promote deeper learning, while also empowering students with the tools they need to thrive academically and socially. As such, AR should be considered a valuable component in the broader movement toward inclusive and technology-enhanced education.

Conclusion

This study demonstrates that Augmented Reality can be a powerful educational tool for enhancing conceptual understanding and learning motivation among students with hearing impairment. By delivering content in a highly visual, interactive, and accessible format, AR bridges the communication gap often experienced in conventional science instruction. Its integration into special education settings offers promising possibilities for making learning more inclusive, engaging, and effective.

Recommendations

Based on the findings, the following recommendations are made:

- Schools should actively consider integrating augmented reality (AR) applications into science instruction, particularly for students with hearing impairments. AR has the potential to provide immersive and interactive learning experiences that can significantly enhance understanding and engagement for these learners.
- To support this integration effectively, educators must receive targeted training on how to use AR tools and adapt instructional content to align with visual and kinesthetic learning preferences. Such professional development is crucial to ensure that teachers can fully leverage the benefits of AR and create inclusive learning environments.
- In addition, education policymakers have an essential role in facilitating the adoption of AR by providing adequate resources, funding, and the necessary technological infrastructure. Policy-level support will help bridge accessibility gaps and enable schools, especially those serving students with special needs, to implement AR solutions successfully.

- Finally, further research is needed to explore the long-term effects of AR-based learning. Longitudinal studies should investigate not only the retention of scientific knowledge but also the broader impacts of AR on other academic subjects and the development of cognitive and problem-solving skills among students with hearing impairments.

REFERENCE

1. Adeduyigbe, A. M., Adeduyigbe, A. E., & Tijani, B. E. (2024). Addressing students with hearing impairment's current state and future needs: Reforming an inclusive science education. International Journal of Studies in Inclusive Education., 1(2), 12–15. https://doi.org/10.38140/ijsie.v1i2.1448
2. Borchert, O., Hokanson, G., Slator, B. M., Vender, B., Yan, P., Aggarwal, V., Karilouma, M., Marry, A. "Mazz," & Cosmano, B. (2013). A 3D Immersive Virtual Environment for Secondary Biology Education. 2013(1), 254–259. https://www.learntechlib.org/primary/p/48105/
3. Bowen, S. K., & Probst, K. M. (2023). Deaf and Hard of Hearing Students with Disabilities: An Evolving Landscape. Neveléstudomány. https://doi.org/10.3390/educsci13070752
4. Ioannou, A., & Constantinou, V. (2017). Augmented Reality Supporting Deaf Students in Mainstream Schools: Two Case Studies of Practical Utility of the Technology (pp. 387–396). Springer, Cham. https://doi.org/10.1007/978-3-319-75175-7_39
5. Keller, J. M. (1987). Strategies for stimulating the motivation to learn. Performance and instruction, 26(8), 1-7.
6. Mahamad, S., Sulaiman, S., & Faizul, A. N. I. (2024). Enhancing the Learning of Computer Internal Systems Through Augmented Reality. 1–4. https://doi.org/10.1109/iccubea61740.2024.10775039