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essential for educational institutions to fully realize their potential in expanding and democratizing educational opportunities globally.

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Impact of Augmented Reality while Teaching English Alphabet to a Child with Moderate Intellectual Disability: A Case Study Conducted in Kerala

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Abstract

Children with ID have low learning capabilities, they need extra care and support in their learning process. This paper describes a case study conducted using Augmented Reality-based intervention, to teach the English alphabet to a child with moderate ID. The participant was a 12-year-old boy with a mental age of 5 and the study observed the impact of AR in the learning process of this child. The methodology was a pretest-posttest intervention. During the intervention, three parameters - interest, attention, and engagement - of the participant were assessed and found that AR-based training made a positive change on these parameters. After the intervention, a posttest was conducted to assess his memory retention and learning outcome and found that the AR intervention was effective in improving both these parameters. Hence, the results of this study warrant further exploration of AR in the learning process of children with ID.

Keywords: Intellectual disability, augmented reality, moderate id, attention, english literacy, memory retention, engagement

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Introduction

Intellectual disability (ID) is a neurodevelopmental condition characterized by limitations in intellectual functioning and adaptive behavior, which become apparent during the developmental period. These limitations often result in significant challenges in learning, communication, and independent living skills. The severity of intellectual disability is commonly classified based on the IQ score as mild (IQ 50–70), moderate (IQ 35–49), severe (IQ 20–34), and profound (IQ below 20).

A couple of studies have indicated that early intervention and the use of educational technology can significantly enhance the learning experiences and outcomes for children with ID (Ilomäki & Lakkala, 2018; Istenic Starcic & Bagon, 2014). Digital tools, especially those incorporating visual and interactive features, can provide engaging learning environments that cater to the diverse needs of these learners. Augmented Reality (AR), which integrates virtual elements with the physical environment, has a considerable potential in inclusive education (Savitha, K. K., & Renumol, V. G., 2023b). By offering interactive and immersive experiences, AR helps sustain attention, motivate learners, and enhance memory retention (Lin et al., 2021). While AR has been integrated in teaching various subjects and skills to children with Special Educational Needs (SEN), limited research exists on its application for foundational literacy skills, particularly letter recognition, phonological awareness, and handwriting among children with ID. These skills form the basis of reading and writing, as they require children to connect visual letter forms to their sounds, a process known as phonics, and to build decoding ability for word recognition (Snow & Juel, 2005). Learning to read and write requires a blend of visual

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recognition, phonetic decoding, and fine motor skills; and children with ID often struggle in these areas. AR-based tools, with their multisensory feedback and interactive elements, may support these skill areas more effectively than traditional methods.

This paper describes a case study that aimed to explore the impact of an AR-based intervention while teaching the English alphabet to a child with moderate intellectual disability. Children with moderate ID typically face difficulties in cognitive and academic tasks and require specialized support from educators, caregivers, and therapists. The objective of this case study was to investigate the impact of AR on the key parameters such as attention, interest, engagement, letter recognition, phonemic awareness, and writing ability of the participant.

Related Works

In recent years, researchers identified that digital technology has a significant role in educational transformation (Savitha & Renumol, 2019; John & Renumol, 2022) especially for SEN children. Even in the 21st century, the usage of digital technology in the educational process has not been fulfilled completely (Ilomäki & Lakkala, 2018). In India, among the 31 million individuals with ID, 35.29% are children and only 1% of these children have access to schools (Singh, 2014). Compared to their peers with other disabilities, children with ID have more serious learning challenges (Savitha & Renumol, 2023b). The population of children with ID is more when compared to children with other disabilities (Widodo et al., 2019). Along with intellectual disability, these children may also have other physical disabilities. This situation denies social life to such children (Ditchman et al., 2016; Scior et al., 2015; Savitha & Renumol,

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2023b). Children with ID get less learning opportunities due to the low level of acceptance in the social and educational environments. Children with ID require more professional support from special educators (Keskinova & Ajdinski, 2018). According to various studies, children with ID greatly benefit from technology integration in their education (Savitha & Renumol, 2020; Istenic & Bagon, 2014; Yakubova et al., 2022).

Bridges et al. proposed an AR-based intervention to teach daily living skills to children with ID (Bridges et al., 2020). The study results highlighted that the children could do the tasks more independently with the AR compared to their baseline histories. Another case study was conducted among three junior high school children to teach daily life skills using AR (Kang, Y. S., & Chang, Y. J., 2020). Their results proved that AR games helped to teach ATM skills to children with ID. (Rogers et al., 2021) supported the suggestions presented by Lee et al. (2020) in their study that information technology has a potential to enable parents and professionals to provide educational support for children with ID at their homes. From the literature, it is understood that digital technology has the potential to support children with ID in their learning process. This motivated us to conduct a case study to explore the impact of an AR-based educational application to teach English alphabets to a child with moderate ID of mental age 5 and this paper explains that case study.

Methodology

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This case study employed a single-subject design to evaluate the effectiveness of an AR-based intervention in improving basic literacy skills in a child with moderate ID. In this design, the first phase was the pretest, the second phase was the intervention using AR-based educational tools, and the third phase was the posttest. The study involved both pretest and posttest assessments to measure the participant's progress across several key learning parameters such as interest, attention, engagement, memory retention, and learning outcome.

Participant: The participant was a 12-year-old boy diagnosed with moderate ID. His mental age was five years. After the preliminary data collection about him it has been revealed that he had issues like hyperactivity, speech problems, behavioral issues, mood swings, continuously sitting in a cross-legged position on a chair, a tendency to poke into his nose and mouth, and being angry in the classroom. Before the experiment, the experimenter obtained permission from the District Program Officer (DPO) of Ernakulam, Kerala. His parents and teachers were informed about the objective of the study. A signed consent letter was collected from the parents to confirm their willingness to allow their child to participate in the study.

Tools and Materials: Two AR-based applications were used in the experiment - *Animal 3D Safari* and *Journals alive. Animal 3D Safari* was used during the ice-breaking session to build a rapport with the participant and *Journals alive* was used to teach the English alphabet.

Procedure: The procedure was conducted in three stages: pretest, intervention, and posttest.

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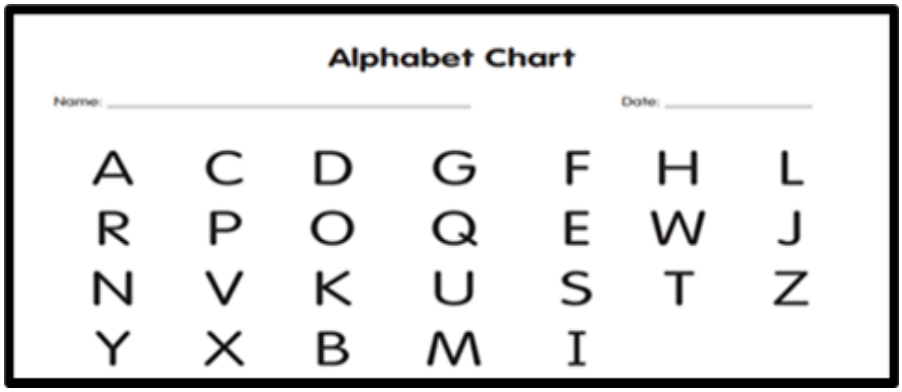
Pretest: The child was assessed using a printed alphabet chart (Fig.1) and was asked to identify the English letters, letter names, and letter sounds.

Figure 1

English Alphabet Chart used for Conducting Pretest and Posttest



Intervention: A commercially available AR application named *Journals alive* was used to teach the English alphabet (Oranç & Küntay, 2019), including identification of the English letters, letter names, letter sounds, and letter writing, using 3D animal models triggered by specific markers. Training sessions using this application were delivered over a period of 26 days, introducing one letter per day. Each session lasted approximately 30 minutes. Activities included letter recognition, phonemic awareness, and tracing tasks using the AR interface. Indirect parameters such as interest, attention span, and engagement were assessed during the intervention using a structured observation sheet.

Posttest: After the intervention period, the child was assessed again using the same procedures as in the pretest to assess the parameters such as memory retention and learning outcome.

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Intervention And Results

Typically, in Kerala the special educators use conventional learning materials to teach children with ID (Savitha & Renumol, 2023a). From the interaction with the special educators and psychologists, the authors understood that the children with ID have complicated problems in their daily life and academic activities. It is more challenging when the children with ID also have hyperactive issues. Teachers mentioned that the combination of these two conditions can create a complex set of difficulties while teaching them.

Since the literature in this area has mentioned that digital technology has the potential to support children with ID in their learning process, the authors decided to conduct studies using AR tools to see their impact on the teaching-learning process of children with ID. The participant was a boy with a mental age of 5 with moderate ID. The task was to teach him the English alphabet, phonics sounds, and writing of letters using an existing AR tool.

Before the experiment, the experimenter collected initial data about the participant. Then a pretest was conducted to determine the participant's current understanding of the English alphabet. Presented with an alphabet chart as shown in Figure 1, with the help of the experimenter, he could identify 7 letters and 8-letter names. He could not recognize any of the letter sounds. In the writing test, he wrote only 7 letters (D, N, L, E, S, V, A) correctly as shown in Figure 2.

Figure 2

Letter Writing Assessment of the Participant During the Pretest

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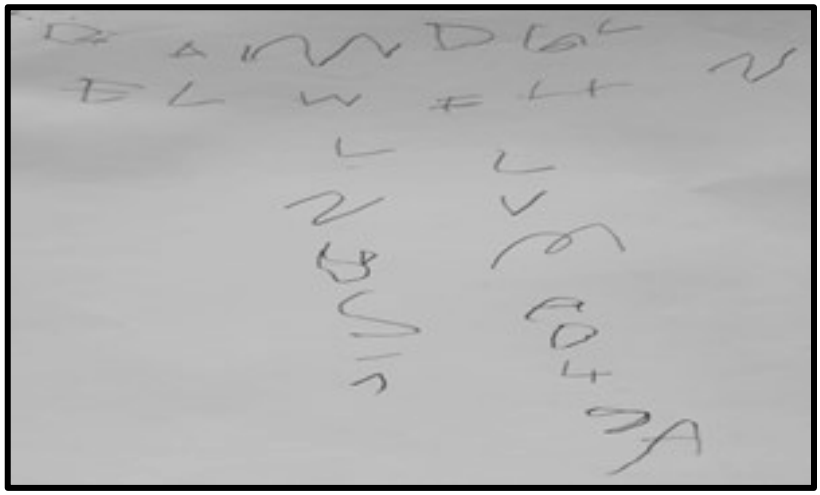

The following day, an ice-breaking session, using *Animal 3D Safari* was conducted to establish a rapport with the participant and to introduce the AR technology to him. This app features interactive, realistic 3D animal models, allowing the student to explore and engage. The participant demonstrated visible enjoyment during this introductory AR experience in the ice-breaking session.

The next day, the scheduled training sessions for English alphabet learning were initiated, using the *Journals alive* application, focusing on letter identification, naming, phonics, and writing. The application used 26 designated markers for activation, which were sourced from aLive Studio in the United States. Upon scanning a letter's marker, the corresponding 3D animal model appears. Figures 3a and 3b provide examples of the letter 'B' interface, demonstrating features like animal name display, image capture, 3D rotation and movement, and audio playback of animal sounds. There are 3 types of interfaces - animal mode, letter mode and letter trace mode. When the learner selects the letter mode (Figure 3c), the interface shows options like: change to animal mode, change the cases of letters, hear letter name, hear letter sound,

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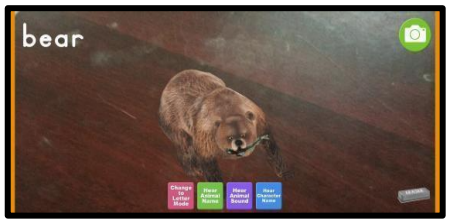
switch to the tracing mode and an eraser icon to erase the animal and to return back to the scanner mode. The tracing mode (Figure 3d) helps the kids to trace through the path of each letter with the help of AR hand tracking. Here the student can switch between the upper and lower cases, and practice repeatedly by refreshing and tracing the patterns. A timer is displayed in the corner to show the time taken for the tracing activity. Learners can choose the pencil color from the color palette displayed on the left side of the tracing interface.

Figure 3

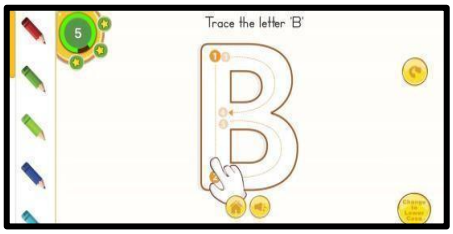
Marker and Interfaces for the Letter 'B' in the 'Journals alive' AR Application

a. Marker of Letter 'B'.



b. Animal mode of Letter 'B'.

c. Letter Mode of 'B'.



d. Tracing mode of Letter 'B'

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One session lasted for 30 minutes for teaching a single alphabet. His parents said that initially he was not interested in coming for the training. But he was excited while seeing the AR experience like the animals' movement and their activities on the mobile phone. He tried to catch the animals displayed on the mobile screen and expressed his happiness while using the animal mode of the application, where he can hear the animal sounds, and see the animal activities. Every time he enjoyed playing hide and seek with the animals displayed on the mobile screen. Gradually he started independently opening the application and scanning the marker to see the animals. While writing, initially he was not interested in tracing the letters. But after some days, he started to trace the letters and gave a high-five when he traced fast and correctly. He expressed his happiness with a loud noise and laughter. Sometimes he was hitting on the table happily. Eventually, he played with the experimenter to compete and check who will write fast. His teachers observed a noticeable change in his attention span. It was approximately 5-10 minutes in the conventional classroom. But, during the AR-based training he was engaged in the learning process for 30 minutes. At the initial stage of training, he was not happy to sit and was not interested in learning. Figure 4 shows the photos taken by the experimenter at the initial stage of training. But, after some days of training, he enjoyed and was attentive to the activities shown in the AR application, as shown in Figure 5.

Figure 4

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Participant was Not Interesting and Not Manageable at the Initial Days of Training

Figure 5

Participant was Interested in Learning using the Journals alive AR Application

The impact of the AR-based intervention on the learning process of this child was assessed by measuring the parameters such as interest, engagement, attention, memory retention, and learning outcomes. Interest, attention, and engagement were assessed during the intervention based on a framework provided by Rajabalee et al, 2020, while the parameters memory retention and learning outcomes were evaluated from the pretest and posttest results. During each of the 26 intervention sessions, the experimenter recorded observed behaviors on a data sheet, assigning scores from 0 to 5 for each direct parameter (boredom, anger, happiness, excitement, curiosity, responses to educational questions, learning involvement, completed learning activities,

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academic performance, attendance percentage, learning effort, diligence towards learning). These values were used to calculate the indirect parameters- *Interest, Attention, and Engagement.*

Interest was measured in terms of direct parameters boredom, anger, happiness, excitement, and curiosity, by using the formula: ((Boredom × -1) + (Anger × -1) + Happiness + Curiosity + Excitement).

Attention was evaluated using the formula:

responses_to_educational_questions+learning_involvement+interest +*Interest*.

Engagement was calculated using the formula:

(completed_learning_activities+

academic_performance+attendance_percentage+learning_effort+

diligence_towards_learning+ *attention*).

The data sheet is available at https://tinyurl.com/3d5d3cvp.

After the intervention, the data sheet and the recorded sessions were shown to a psychologist for an expert opinion. The expert's evaluation, along with the experimenter's observations, were used to assess the changes in these 3 parameters before and during the intervention. The analysis of the direct and indirect parameters revealed significant improvements in the participant's interest, attention, and engagement compared to his previous behavioral patterns, as illustrated in the graph in Figure 6.

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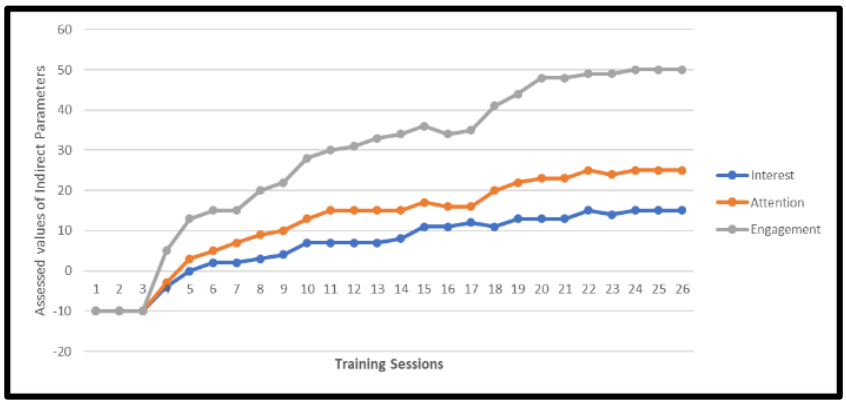
Figure 6

Graph showing Indirect Parameters interest, attention, and engagement of Participant



After the intervention, a posttest was conducted to evaluate the parameters memory retention and learning outcome, using the same pattern as the pretest and allotted 30 minutes for the participant to attend the posttest. During the posttest, he identified all 26 letters, letter names, and letter sounds. In the writing test, he wrote all 26 letters as shown in Figure 7.

Figure 7

Letter Writing Assessment of the Participant During the Posttest

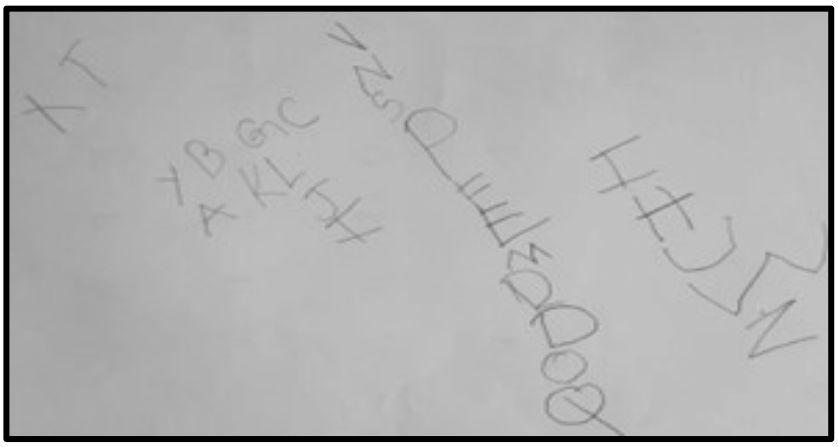


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Table 1 shows his pretest and posttest scores of letter identification, letter name, letter sound, and letter writing. From the results it is obvious that the participant has achieved significant improvements in these parameters, which is the direct indication of the impact of the AR tool on his learning process.

Table 1

Pretest and Posttest Data of the Participant

Variables	Pretest Scores	Posttest Scores
Letter Identification	7	26
Letter Name	8	26
Letter Sound	0	26
Writing Letters	7	26

Conclusion

This case study aimed to investigate the impact of an AR-based educational application while teaching English alphabet to a child with moderate ID. The participant was a boy with mental age 5 from Kerala, India. An AR intervention was used to teach him English alphabet identification, naming, letter sounds, and writing of alphabets. As part of the experiment, the parameters such as interest, engagement, attention span during intervention were observed. The parameters - memory retention and learning achievement were assessed by pretest and posttest. From the observation as well as from the pretest and posttest results, it has been identified that the participant got a remarkable learning outcome and improvements in all the parameters, when

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compared to his performance in the conventional classroom. Initially his parents and teachers were concerned about his academic and behavioral issues. After the intervention, they were happy to see his improvements in learning as well as behavioral aspects. From the result analysis we conclude that the AR tool and its real time visual interactive features helped our participant to achieve a better learning outcome and social interaction, compared to the conventional method of teaching. This study warrants further exploration of AR as an educational tool for children with ID, necessitating further research to fully understand the benefits of AR in the education of children with ID.

Acknowledgment

We express our gratitude to the participant and his parents. Also, to the District Program Officer, Ernakulam, Kerala, and the school authorities for the arrangements made to conduct the study.

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