

# Incorporating Augmented Reality to Enhance Learning for Students with Learning Disabilities: A Focus on Spatial Orientation in Physical

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## Abstract

This research endeavors to integrate Augmented Reality (AR) technology into the realm of physical education, with a specific emphasis on improving spatial orientation skills among students with learning disabilities. The study pursues three core objectives: (1) To assess the efficacy of utilizing AR-based instructional tools to enhance spatial orientation abilities; (2) To scrutinize the academic advancements of students with learning disabilities post-AR intervention; (3) To gauge the satisfaction levels of these students with the AR-enhanced learning experience. The study cohort comprises nine students with learning disabilities, drawn from an educational institution situated in Pathum Thani Province, Wat Pathum Nayok school, using a targeted sampling methodology. Data is gathered through immersive AR experiences within the context of physical education, with a focus on spatial awareness. The analytical approach encompasses a diverse array of statistical techniques, including percentages, means, and standard deviations. Furthermore, the t-test is deployed to statistically compare pre and post-learning outcomes, maintaining a significance level of  $\alpha = 0.05$ . The research outcomes substantiate that AR-driven educational activities in physical education effectively enhance spatial orientation skills among students (E1/E2: 82.40/81.33). Preceding the intervention, students recorded an average score of 8.80 with a standard deviation of 2.33, which significantly escalated to 16.27 with a standard deviation of 1.48 following AR-assisted learning. The t-test underscores the statistically significant disparity ( $p < 0.05$ ) in scores prior and subsequent to the AR intervention. Furthermore, students with learning disabilities express considerable satisfaction with the application of AR in physical education, with an average satisfaction rating of 4.51. This research carries substantial implications, particularly within the realm of data science, as it pertains to the collection and analysis of data relating to students' educational achievements and satisfaction levels.

**Keywords:** Augmented Reality Education; Learning Disabilities; Spatial Orientation; Inclusive Learning; AR Enhancement

## 1. Introduction

Learning Disabilities (LD) pose unique challenges to students, and the field of data science offers an exciting opportunity to enhance their educational experience through Augmented Reality (AR). AR has the potential to revolutionize data-driven education by simplifying complex concepts and catering to individual learning needs. This study explores the integration of AR into data science education and its impact on students with LD.

AR leverages immersive experiences that engage multiple senses and promote visual learning by interacting with three-dimensional models and real-world data, making it an ideal tool for students who struggle with abstract concepts. In recent years, the integration of Information and Communications Technology (ICT) into education has gained significant attention and support. However, its application in the realm of data science education for students with LD remains underexplored.

This research investigates the effects of AR-based training on data science education, particularly focusing on spatial orientation. Through a quantitative study involving 140 high school students, strong correlations were identified, with particular significance found in the motivation factor. However, it is noteworthy that the ratings given by educators were comparatively lower, highlighting an area for improvement.

The study aims to bridge the gap in data science education for students with LD by harnessing the potential of AR. By transforming educational content into interactive, game-like experiences equipped with accessibility features such as

text-to-speech and speech-to-text functionality, AR can not only engage students but also improve their comprehension and retention of data-driven concepts.

Furthermore, this research evaluates the impact of combining real and virtual aspects in data science education for students with unique learning challenges. The findings indicate that AR technology is effective in aiding the learning process for these students, with students expressing a willingness to embrace this technology due to its engaging nature.

## 2. Literature Review

### 2.1. Augmented Reality Game: Bridging the Virtual and Real Worlds

AR games have emerged as a fascinating fusion of technology and reality, reshaping how we interact with digital content. Unlike virtual reality, which immerses users entirely in a simulated world, AR enhances the real world by overlaying digital elements onto it. This discussion explores the evolving landscape of AR games, highlighting their impact on entertainment, education, healthcare, and beyond.

First and foremost, AR games have revolutionized the entertainment industry. Games like Pokémon GO took the world by storm, inviting players to explore their surroundings while capturing digital creatures. This blending of physical and virtual realms offered a novel and engaging experience, encouraging outdoor activity and social interaction. It demonstrated how AR can transform everyday environments into dynamic playgrounds, bridging the gap between the screen and the real world.

In the realm of education, AR games have introduced innovative approaches to learning. Educational apps and games use AR to make abstract concepts tangible, allowing students to interact with 3D models or historical artifacts. For instance, students can dissect virtual frogs or explore ancient civilizations from their classrooms. AR fosters active participation and deeper understanding, making learning more immersive and enjoyable.

Moreover, AR games have found applications in healthcare. Surgeons can use AR to overlay medical images directly onto a patient's body during surgery, enhancing precision and reducing risks. In rehabilitation, AR-based exercises can make therapy sessions more engaging and motivating. Patients recovering from injuries can see their progress in real-time through gamified experiences, turning rehabilitation into a rewarding journey.

Beyond entertainment, education, and healthcare, AR games are making their mark in various industries. In architecture and interior design, AR allows clients to visualize projects in their actual spaces before construction begins. In retail, AR enables customers to try on clothes virtually or visualize how furniture would fit in their homes. These applications demonstrate the versatility of AR in enhancing user experiences and aiding decision-making.

In conclusion, AR games have transcended mere entertainment to become powerful tools with broad-reaching implications. They merge the digital and physical worlds, offering unique experiences in entertainment, revolutionizing education, improving healthcare, and transforming various industries. As technology continues to advance, the potential of AR games to reshape our interaction with the world around us remains a promising and exciting prospect.

### 2.2. Enhance Learning for Students

Enhancing learning for students is a multifaceted endeavor that involves various strategies and approaches aimed at optimizing the educational experience. These efforts are not only essential for academic success but also contribute to the overall personal and intellectual growth of students. In this discussion, we will explore five key aspects of enhancing learning for students.

Firstly, engaging and dynamic teaching methods play a pivotal role in enhancing student learning. Educators who incorporate interactive activities, real-world examples, and technology into their lessons capture students' attention and make the learning process more enjoyable and effective. When students are actively engaged in their studies, they are more likely to retain information and develop a deeper understanding of the subject matter.

Secondly, personalized learning is an increasingly important approach to cater to the diverse needs of students. Recognizing that each student has unique strengths, weaknesses, and learning styles, educators are increasingly tailoring their teaching methods to accommodate individual differences. This might involve providing additional support for struggling students or offering advanced materials for those who excel, ensuring that every student can progress at their own pace.

Thirdly, fostering a supportive and inclusive learning environment is crucial. Students learn best when they feel safe, valued, and respected in their classrooms. In such an environment, they are more likely to ask questions, express their opinions, and collaborate with peers. This not only promotes academic growth but also cultivates essential life skills, such as effective communication and empathy.

Fourthly, the integration of technology in education has revolutionized the learning process. Digital tools, online resources, and educational apps offer students opportunities for self-directed learning and exploration. Moreover, technology allows for the creation of immersive and interactive educational experiences, making complex concepts more accessible and engaging.

Lastly, assessment and feedback mechanisms are essential components of enhancing student learning. Regular assessments, both formative and summative, help educators gauge the progress of their students and identify areas that may need additional attention. Constructive feedback provides students with valuable insights into their strengths and areas for improvement, empowering them to take ownership of their learning journey.

In conclusion, enhancing learning for students requires a holistic approach that combines effective teaching methods, personalized learning, a supportive environment, technology integration, and thoughtful assessment and feedback. By addressing these aspects, educators can create an enriching and empowering educational experience that equips students with the knowledge, skills, and confidence needed to succeed in an ever-evolving world. Ultimately, the goal is to instill a love for learning and a lifelong commitment to personal and academic growth in every student.

### 2.3. Learning Disabilities and Augmented Reality

Learning disabilities represent a complex and diverse spectrum of challenges that many students face in their educational journeys. These disabilities can significantly impact a student's ability to grasp certain subjects, such as mathematics, which often involves abstract concepts and complex problem-solving. In recent years, technology, particularly AR, has emerged as a promising tool to address the educational needs of students with learning disabilities. This discussion delves into the intersection of learning disabilities and AR, exploring how AR technology can be harnessed to provide tailored support and enhance the learning experience for these students.

AR offers a dynamic and interactive platform that overlays digital content onto the physical world. This immersive technology has the potential to create engaging learning environments that cater to the diverse needs of students with learning disabilities. For instance, AR can visualize abstract mathematical concepts through interactive 3D models, making them more tangible and accessible to students who may struggle with traditional methods of instruction. By providing multisensory experiences, AR can cater to different learning styles, accommodating the varied needs of students with disabilities.

One of the key advantages of AR is its adaptability. Educational content can be personalized and scaffolded to meet individual students' needs, allowing them to progress at their own pace. This is particularly beneficial for students with learning disabilities who may require additional time and support to master certain skills. AR applications can provide immediate feedback and adapt the level of difficulty based on a student's performance, fostering a supportive and inclusive learning environment.

Furthermore, AR can address the issue of motivation and engagement among students with learning disabilities. Traditional learning methods can often become monotonous and frustrating for these students, leading to disinterest and low self-esteem. AR's immersive and interactive nature can make learning more enjoyable and meaningful. Gamification elements in AR applications can incentivize students to actively participate and persist in their learning, which is crucial for their academic success.

While AR holds significant promise in addressing the educational needs of students with learning disabilities, challenges remain. Access to AR technology and appropriate resources can be a barrier for some schools and students. Moreover, it is essential to ensure that AR applications are designed with a deep understanding of the specific needs and challenges of students with learning disabilities to maximize their effectiveness.

In conclusion, AR has the potential to revolutionize the way students with learning disabilities approach their education. By providing immersive, personalized, and engaging learning experiences, AR technology can help bridge the gap in understanding and achievement for these students. As technology continues to advance, further research and development in this field can unlock new possibilities for inclusive and effective education, ensuring that all students have the opportunity to thrive academically.

### **3. Methodology**

#### **3.1. Research Design**

This study utilized the One Group Pretest-Posttest Design research pattern to assess the effectiveness of an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for primary 4 students with learning disabilities.

#### **3.2. Population and Sample**

**Population:** The population for this research consisted of primary 4 students in the Salarat network group under the Office of Pathum Thani Primary Educational Service Area 2 during the academic year 2022. This population comprised 7 schools, seven classrooms, and 77 students.

**Sample:** The sample group used for this research was drawn from primary 4 students at Wat Pathum Nayok School, which is part of the Salarat Network Group under the Pathum Thani Primary Educational Service Area Office, Area 2, for the Academic year 2022. This sample group comprised one school, one classroom, and 9 learning disability students. Purposive sampling was employed to select this sample group based on the criteria of low achievement in Mathematics subject in addition and subtraction of numbers up to a hundred thousand.

#### **3.3. Research Tools**

The research tools used in this study included:

- (1) Teaching activity application based on an AR game activity.
- (2) Pretest-posttest to measure student learning outcomes.
- (3) Assessment form for student satisfaction with the AR game activity.

#### **3.4. Creation of Research Tools**

**Teaching Activity Application:** The teaching activity application was developed based on a conceptual framework that included a manual and lesson plan for teachers and a student handbook. It was designed to address the research objectives and included content such as explanations, lesson plans, knowledge sheets, activity sheets, pretest-posttests, and answers to department activities.

**Opinion Questionnaire for Experts:** An opinion questionnaire for experts was developed to assess the quality of the teaching activity application. The questionnaire was created based on concepts, theories, and principles related to AR game activities in Mathematics for primary 4 students with learning disabilities. Three experts in educational or information technology reviewed and provided feedback on the application.

**Pretest-Posttest:** Pretest and posttest assessments were created to measure student learning outcomes. These assessments were analyzed for content validity using the Index of Item Objective Congruence (IOC) criteria.

### 3.5. Data Collection

Data were collected through experimental models using the teaching activity application. The process involved coordination with the graduate studies faculty at Rajamangala University of Technology Thanyaburi, where the experiment was conducted at Wat Pathum Nayok School. The sample group consisted of 9 primary 4 students who participated in the AR game activity.

### 3.6. Curriculum Analysis

The study focused on the objectives of the curriculum related to Mathematics, specifically addition and subtraction of numbers up to a hundred thousand. Behavioral objectives were developed based on Bloom's learning theory. The curriculum analysis informed the development of the teaching activity application.

### 3.7. Data Analysis

Data collected from the pretest and posttest assessments were analyzed statistically using mean and standard deviation to evaluate the impact of the AR game activity on student learning outcomes.

## 4. Result

An AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. The results of the test scores of the primary 4 students of 9 students, representing an average percentage of 82.40, and an average of the percentage of posttest scores of 81.33, indicating that the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students efficiency criterion is 80/80, i.e., E1/E2 is equal to 82.40/81.33. Therefore, this is based on the assumption.

**Table. 1.** Effectiveness of AR Math Game for Primary 4 LD Students

| Total score list         | Scores | Mean  | Percentage | Criteria standard. | E1/ E2 |
|--------------------------|--------|-------|------------|--------------------|--------|
| Grades during class      | 50     | 41.20 | 82.40      | 80                 | 82.40  |
| Test scores after school | 20     | 16.27 | 81.33      | 80                 | 81.33  |

Using the application of teaching activities according to an AR game activity [10-12] on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students in the pretest the average score is 8.80, the SD. value is 2.33 after students have learned through the application. Teaching activities according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. Elementary school year 3 and taking the test after class Students have higher grade point averages. The mean score was 16.27; the SD. value was 1.48. The t-test analysis between before and after school was 20.68. There was a statistically significant difference at the .05 level.

**Table. 2.** Pretest-Posttest Comparison for AR Math Game in Primary 4 LD Students

| Test     | Scores: Full | Scores | SD.  | t     | Sig.(2-tailed) |
|----------|--------------|--------|------|-------|----------------|
| Pretest  | 20           | 8.80   | 2.33 | 20.68 | .00            |
| Posttest | 20           | 16.27  | 1.48 |       |                |

Satisfaction of primary 4 students towards the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. Students total 9 people overall, there was a high level of satisfaction with an overall average of 4.51, with the highest satisfaction in helping learners study content anywhere, anytime with an average of 4.70 and did not find the item that the primary 4 students had the lowest level of satisfaction. Assessment results of primary 4 students'

satisfaction with the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. Student satisfaction with applying basic the Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students was high, with 4.51.

## 5. Conclusion

This research study on the development of teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, which has research objectives were to (1) develop and find the effectiveness of the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students., (2) compare the learning achievement of the students who learned with the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, and (3) find students' satisfaction towards application for teaching activities based on an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students [13-15]. The sample group used in this research was primary 4 students at Wat Pathum Nayok School. Under the district office Pathum Thani Primary Education Area, District 2, 9 people by using a method of selecting a specific sample Purposive Sampling, there were tools used in the experiment, namely, the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students pretest and after studying is a parallel exam.

Multiple choice, 4 choices, 20 questions each, and the student satisfaction assessment form with the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. The results can be summarized, discussion of results, and research recommendations as follows; (1) survey the problem of data collection in Wat Pathum Nayok School under the Pathum Thani Elementary Education Service Area Office, Region 2, to find the cause of primary 4 students who have problems with Mathematics subject in addition and subtraction of numbers up to a hundred thousand and the media that teachers use in educational institutions is not enough, (2) study the Mathematics subject in addition and subtraction of numbers up to a hundred thousand group curriculum according to the Core Curriculum of Basic Education B.E. 2551, (3) to study the concepts, principles, and theories related to the Development of teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, (4) analysis of content, structure, and guidelines for teaching and learning management, (5) determine the main objectives of the research, (6) formulate the structure of the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, (7) make an application according to the structure of the content defined by adhering to the core curriculum for learning the an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, (8) make a test and the satisfaction assessment form of grade 4 students towards the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students to use as a research tool, (9) bring the application created by the researcher to the experts for review. To find the consistency between the content, language used, questions, teaching and learning activities to create and find the effectiveness of the tool with three measurement and evaluation experts, and then use it to improve and correct errors to be utterly correct as experts recommend in all respects, (10) bring the application to demonstrate how to use it with students in schools other than the sample group, to determine the performance of the application and make improvements until the efficiency is acceptable, (11) bring the application to demonstrate how to use it with a sample group, namely primary 4 students at Wat Pathum Nayok School. Under the Office of Pathum Thani Primary Education Area 2, 9 people to determine the efficiency of the application, E1/E2 was determined to equal 80/80. The standard deviation was determined using SD [16-18]. an AR game activity on

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Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students was compared using mean and t-test [19].

Summarize the research findings in analyzing all the previous data above. The researcher summarized the research results according to the objectives set as follows; (1) the effectiveness of the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities Primary 4 students that were created and developed with efficiency according to the 80/80 criterion, i.e., the percentage of the score during the study was 82.40 (E1), and the percentage of score from the posttest was equal to 81.33 (E2)., (2) Comparison of pretest- posttest achievement scores found that the scores after learning from the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students are higher than pre-semester grades. With statistical significance at the .05 level, (3) the study results on the satisfaction of primary 4 students found a high level of satisfaction. Discussion of the research results on the development of teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students. Corresponding to strategies and activities encourage students to self-understand by working and forming ideas along with their ability to learn on their own. Students can learn by themselves by completing the learning activity sheet for each subject. It was found that the students were more interested in learning and more active.

Teachers will help encourage students to have knowledge, understanding, thinking for themselves through the context of creating wisdom and self-knowledge [9] which the discussion results The objectives and hypotheses of the research were as follows; (1) Teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities Primary 4 students focuses on teaching activities on reading words with rhymes and reading words with unvoiced consonants and vowels which the content is consistent with the core curriculum, B.E. 2551 from the development of teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students to be effective according to the 80/80 criteria. Students who study through the application of teaching activities based on an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, before using the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities Primary 4 students In teaching and learning, students take pretests. Has an average score of 20 full marks equal to 8.80 from a total of 9 students. After completing the pretest, the researcher applied the teaching activity application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students who have been designed to be used in teaching and learning by setting activities for students to learn in which students are enthusiastic more interested in learning The results of the grades during the course were recorded, and the results of the grades during the studies were taken to find the average. The percentage is equal to 82.40. After the students have learned through the application of teaching activities based on an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students, then have students take the test after class. It was found that the average posttest scores were 81.33%, indicating that learning through the teaching activities application according to an AR game activity on Mathematics subject in addition and subtraction of numbers up to a hundred thousand for learning disabilities primary 4 students created by the researcher were as effective as 82.40/81.33.

According to the specified criteria, the efficiency is 80/80, consistent with the research of teachers planning together with students to challenge, motivate, encourage, advise, give advice, and seek the right knowledge. Recommendations In this research, the researcher, has suggestions for applying the research results; (1) the equipment should be prepared. Moreover, internet signal before teaching every time., (2) students should prepare by practicing the application usage skills according to the detailed instruction manual for every step of the learning activities [20-22]. Suggestions for further research from the results of the research that were summarized and discussed, The researcher has the following



ideas as suggestions; (1) should study more content on Mathematics subject in addition and subtraction of numbers up to a hundred thousand., (2) should construct a software program covering the area of mathematics, including addition and subtraction of numbers up to one hundred thousand, so that they can progress., (3) should develop an application on the subject of mathematics, including addition and subtraction of numbers up to one hundred thousand, in addition to organizing various learning styles such as TAI (Team Assisted Individualization), STAD (Student Team Achievement Division), and others. This study should make use of multimedia games as instruments for critical thinking activities based on the Self-Regulated Learning (SRL) framework. These activities should be supported by achievement tests and questionnaires that are administered via student-directed instructional design online, in which the students' guide makes some input into their learning processes. The high degree of student satisfaction achieved via the application of the SRL framework for learning is indicative of the usefulness of the SRL framework for problem-solving in the contexts of both classroom instruction and career development. The entirety of the many teaching styles, such as the constant concentration, orientation, or intent, comprised the various patterns of teaching behaviors. According to the findings of this study, a self-directed learner can be considered to be self-managing in an environment in which the individual is participating in student-centered education [23].

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