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Interactive Motion-Sensing Game for Improving Physical Education in Students with Intellectual Disabilities

INFORMASI ARTIKEL

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*Aris Rakhmadi[1], Yuliana Puspitasari[1], Fatah Yasin[1], Yusuf Sulistyo Nugroho[1], Umi Fadlilah[2]

[1)]Department of Informatics Engineering, Faculty of Communication and Informatics, Universitas Muhammadiyah Surakarta, INDONESIA.
[2)]Department of Electrical Engineering, Faculty of Engineering, Universitas Muhammadiyah Surakarta, INDONESIA

*KORESPODENSI PENULIS :
aris.rakhmadi@ums.ac.id

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Abstract

Students with intellectual disabilities often face challenges in physical education due to limited motor coordination, reduced engagement, and difficulties following traditional instructional methods. To address this, motion-sensing technology, particularly Kinect-based educational games, presents a promising solution by offering interactive and gamified learning experiences. This study explores the development and implementation of a Kinect-based educational game designed to enhance motor skills and engagement in students with intellectual disabilities. The game focuses on throwing exercises, providing real-time feedback through visual and auditory cues to reinforce learning. The study was conducted at SLB-C YPSLB Surakarta, involving 20 students with intellectual disabilities and five special education teachers. A pre-test and post-test evaluation was used to assess students' motor skill improvement and engagement levels before and after using the game. The results demonstrated a 26.3% increase in throwing accuracy, a 26.9% rise in engagement levels, and a significant reduction in reaction time, indicating the game's effectiveness in enhancing physical coordination and participation. Teacher feedback highlighted the game's usability, ability to maintain student focus, and alignment with PE learning objectives. Although the findings showed positive learning outcomes, several challenges, such as the initial adaptation period and the need for a wider variety of games, were identified. Future research should focus on customizing difficulty levels, varying physical activities, and AI-powered adaptive learning to meet the needs of individual students. This study highlights the potential of motion-sensing educational games as an effective tool for inclusive and engaging physical education for students with intellectual disabilities.

Keywords: *Kinect-Based Learning, Motion-Sensing Technology, Educational Games, Intellectual Disabilities, Physical Education*

Abstrak

Siswa dengan disabilitas intelektual sering menghadapi tantangan dalam pendidikan jasmani, seperti keterbatasan koordinasi motorik, kurangnya keterlibatan, dan kesulitan mengikuti metode pengajaran tradisional. Untuk mengatasi hal ini, teknologi pemantauan gerak, khususnya permainan edukasi berbasis Kinect, menawarkan solusi yang menjanjikan dengan menyediakan pengalaman belajar yang interaktif dan berbasis permainan. Penelitian ini mengembangkan dan menerapkan permainan edukasi berbasis Kinect untuk meningkatkan keterampilan motorik dan keterlibatan siswa dengan disabilitas intelektual. Permainan ini berfokus pada latihan melempar dan memberikan umpan balik waktu nyata melalui isyarat visual dan auditori untuk memperkuat proses pembelajaran. Penelitian dilakukan di SLB-C YPSLB Surakarta dengan melibatkan 20 siswa dan lima guru pendidikan khusus. Evaluasi pre-test dan post-test digunakan untuk menilai peningkatan keterampilan motorik dan tingkat keterlibatan siswa sebelum dan sesudah menggunakan permainan. Hasil penelitian menunjukkan adanya peningkatan akurasi lemparan sebesar 26,3%, kenaikan tingkat keterlibatan sebesar 26,9%, dan pengurangan waktu reaksi yang signifikan, yang menunjukkan efektivitas permainan dalam meningkatkan koordinasi fisik dan partisipasi siswa. Umpan balik dari guru menyoroti kegunaan permainan, kemampuan untuk mempertahankan fokus siswa, dan kesesuaian dengan tujuan pembelajaran pendidikan jasmani. Meskipun hasilnya positif, beberapa tantangan, seperti periode adaptasi awal dan kebutuhan akan variasi permainan yang lebih luas, masih perlu diatasi. Penelitian selanjutnya dapat fokus pada penyesuaian tingkat kesulitan, variasi aktivitas fisik, dan penggunaan pembelajaran adaptif berbasis AI untuk memenuhi kebutuhan individu siswa. Penelitian ini menyoroti potensi permainan edukasi berbasis teknologi pemantauan gerak sebagai alat yang efektif dalam pendidikan jasmani yang inklusif dan menarik bagi siswa dengan disabilitas intelektual.

Kata kunci: Pembelajaran Berbasis Kinect, Teknologi Pemantauan Gerak, Permainan Edukasi, Disabilitas Intelektual, Pendidikan Jasmani

I. INTRODUCTION

Children with intellectual disabilities (ID) often face significant challenges in physical education (PE), as traditional teaching methods may not adequately address their needs. Intellectual disabilities affect cognitive functioning, motor coordination, and engagement levels, making it crucial to develop innovative approaches that encourage active participation. Schools for children with special needs, such as Special Schools (SLB-C) in Indonesia, play a critical role in providing tailored education, including physical activities that help improve motor skills and overall health. However, conventional PE instruction methods, which typically rely on teacher demonstrations and verbal instructions, may not be the most effective way to engage students with intellectual disabilities.

Technology has increasingly been integrated into education, with digital learning tools enhancing student engagement and comprehension [1]. Motion-sensing technology, such as Microsoft Kinect, offers a promising solution for interactive learning, particularly for students who require individualized and engaging methods of instruction. Kinect-based educational games allow students to interact with digital content using body movements, providing a hands-on learning experience that can significantly improve motor skills and cognitive engagement. By incorporating gamification into PE, children with intellectual disabilities can find physical activities more enjoyable, increasing their motivation to participate.

Educational games are recognized as practical learning tools, especially in special education. These games provide an engaging and controlled environment where students can practice skills repetitively without pressure. For children with intellectual disabilities, game-based learning offers a safe and structured approach to physical education, helping them understand movement concepts through interactive play [2]. Unlike traditional instruction, which can sometimes be monotonous or challenging to follow, interactive games break down complex motor tasks into more minor, more manageable activities, encouraging active participation and gradual skill development.

Various studies have explored the use of motion-sensing technology in special needs education. Researchers have found that motion-based games can improve students' motor coordination, reaction time, and balance [3]. Additionally, they foster a sense of accomplishment and motivation, as students can visually perceive their progress [4]. Kinect technology, in particular, has been widely adopted in rehabilitation and therapy for individuals with physical and cognitive impairments [5]. Its ability to track body movements in real time makes it an ideal tool for educational applications that require movement-based interaction.

Despite these advancements, the integration of Kinect-based games in PE for children with intellectual disabilities remains underexplored [6]. Existing educational games tend to focus on cognitive subjects such as math and language, while fewer studies address the potential of gamified learning in motor skill development [7]. There is a need to bridge this gap by developing and evaluating interactive games that specifically target physical education for students with intellectual disabilities. This research aims to contribute to the field by designing a Kinect-based educational game that enhances PE instruction in special needs schools.

The proposed interactive game leverages motion-sensing technology to teach fundamental PE skills, with a primary focus on throwing movements. Throwing is a crucial motor skill that requires coordination, spatial awareness, and muscle control, making it an ideal focus for children with intellectual disabilities. The game provides visual and auditory feedback, helping students understand their movements and make necessary adjustments in real-time. This interactive approach aligns with the principles of active learning, allowing students to experience movement rather than passively observe it.

To ensure the effectiveness of the game, the development process involves a user-centered design approach, incorporating feedback from special education teachers and students[8]. Teachers play a vital role in assessing the suitability of the game for PE instruction, ensuring that it aligns with educational goals and student needs. Additionally, students' responses and engagement levels are observed to evaluate the impact of the game on their learning experience. By adopting this approach, the research seeks to develop a practical and engaging educational tool that enhances PE learning outcomes in special needs schools.

One of the significant challenges in PE instruction for children with intellectual disabilities is sustaining their attention and motivation [9]. Traditional exercises may not hold their interest for long periods, leading to disengagement and passive participation [10]. The introduction of game elements, such as scoring systems, interactive challenges, and virtual rewards, creates an environment where students are encouraged to engage in physical activities actively. This game-based approach transforms PE sessions into an immersive and enjoyable experience, addressing the challenge of low motivation among students with intellectual disabilities.

An evaluation process was conducted at SLB-C YPSLB Surakarta to validate the effectiveness of the Kinect-based educational game. Teachers and students participated in hands-on trials of the game, followed by structured feedback collection using questionnaires. The responses were analyzed to determine the level of engagement, ease of use, and overall effectiveness of the game in improving students' motor skills. The results of the evaluation provide valuable insights into the feasibility of using motion-sensing technology in special needs PE instruction.

The findings of this study contribute to the broader discussion on the role of technology in inclusive education. By demonstrating the impact of Kinect-based learning on PE engagement and skill development, this research underscores the potential of digital tools in addressing the diverse learning needs of students with intellectual disabilities. The insights gained from this study may inform future developments in special education technology, encouraging the integration of motion-based games into teaching strategies.

As technology continues to evolve, the possibilities for interactive learning in special education are expanding. The integration of motion-sensing technology in PE represents a step forward in making physical activities more accessible and enjoyable for students with intellectual disabilities [11]. Future research can explore additional motion-based interventions, expanding beyond throwing skills to incorporate a broader range of physical activities. By leveraging the power of technology, educators can create inclusive learning environments that cater to the unique needs of special needs students, ultimately enhancing their educational experience and overall well-being.

The present study aims to bridge the gap between traditional PE instruction and technology-driven learning by introducing an interactive Kinect-based game tailored for students with intellectual disabilities. By doing so, it seeks to provide an engaging and effective alternative to conventional teaching methods, making PE more inclusive and enjoyable for special needs students. The research highlights the importance of interactive learning in special education and the potential of motion-sensing technology to transform PE instruction.

TABLE 1
COMPARISON OF TRADITIONAL PE METHODS AND KINECT-BASED EDUCATIONAL GAMES IN SPECIAL NEEDS EDUCATION

Aspect	Traditional PE Methods	Kinect-Based Educational Game
Engagement	Students often lose interest due to passive instruction	Interactive elements keep students actively engaged
Motor Skill Development	Limited hands-on practice, mostly observational	Real-time practice with immediate feedback
Instructional Approach	Teacher-centered, requiring high levels of verbal guidance	Student-centered, allowing self-paced learning
Assessment	Subjective teacher observation	Data-driven feedback based on movement tracking
Motivation	Low motivation due to repetitive routines	Higher motivation with gamified elements like scores
Inclusivity	Challenges in adapting activities for diverse needs	Adjustable difficulty levels for different abilities

Table 1 highlights key differences between traditional PE methods and Kinect-based educational games. Traditional instruction often relies on teacher demonstrations, which may not fully engage students with intellectual disabilities. In contrast, a Kinect-based game provides an interactive experience where students can actively participate and receive immediate feedback on their movements. This real-time interaction enhances their motor skills and encourages self-improvement.

Motivation plays a crucial role in learning outcomes. Many students with intellectual disabilities struggle with maintaining focus in PE sessions due to repetitive drills and lack of engagement [12]. The Kinect-based game's gamified approach introduces elements such as scores, achievements, and interactive challenges, making the learning process more enjoyable. By transforming PE into a fun and immersive experience, students are more likely to participate actively, leading to better physical and cognitive development.

Motion-sensing technology allows for objective assessment of student performance [13], [14]. Unlike traditional methods, where teachers rely on observation, the Kinect system provides data-driven feedback, enabling more accurate evaluations of student progress. This data can help educators tailor instruction to meet individual student needs, creating a more inclusive and effective learning environment.

II. RELATED WORKS

Research on integrating technology into special education has gained increasing attention in recent years [15]. The use of digital tools, including motion-sensing devices like Microsoft Kinect, has been explored to enhance learning outcomes for students with intellectual disabilities [16]. Traditional teaching methods in physical education (PE) often rely on verbal instructions and teacher demonstrations, which can be less engaging for students with cognitive impairments. Therefore, researchers have investigated alternative approaches to make PE more interactive and accessible for special needs students.

Gamification has been widely recognized as an effective method to enhance learning engagement. Educational games provide structured, interactive experiences that motivate students to participate actively in learning activities. Game-based learning can significantly improve students' cognitive and motor skills. Motion-based games, in particular, have shown promise in helping children with intellectual disabilities develop physical coordination and social interaction skills.

Several studies have examined the impact of Kinect-based applications in special education [17]. Some research demonstrates that Kinect-based interventions can improve motor skills and engagement levels in children with autism spectrum disorder (ASD). Findings indicate that students who use Kinect-based games show significant improvements in hand-eye coordination and reaction time. Other research suggests that motion-based educational games contribute to increased participation and motivation among children with learning disabilities.

TABLE 2
SUMMARY OF KEY STUDIES ON KINECT-BASED EDUCATIONAL INTERVENTIONS

Study	Participants	Key Findings
Zhiyong Chen (2022) [5]	10 young PE teachers (5 intermediate, 5 junior)	Kinect and AI accurately recognized four PE teaching behaviors with 99.8% accuracy using the LightGBM algorithm.
Jordan Hernandez-Martinez (2024) [19]	52 inactive older females (65–75 years), split into XKS (13), NSS (14), and CG (16)	Xbox Kinect Sports helped participants lose more fat and get stronger, faster, and more flexible than Nintendo Switch Sports or no exercise
Carlos Núñez (2023) [11]	4–5-year-old children from a school in Ambato, Tungurahua province	The Kinect-based game improved gross motor skills by 70% and cognitive skills by 35% after four attempts
Xin-Ting Liu (2023) [12]	35 young adults, 665 elderly subjects	Kinect showed high reliability and a strong correlation with physical exams but moderate accuracy for reach and walking speed. Users rated it highly for telerehabilitation.

In the context of physical education, Kinect technology has been applied to various training programs for special needs students [18]. Some studies focus on the effectiveness of Kinect-based exercises in enhancing the motor skills of students with intellectual disabilities. The findings suggest that students who engage in Kinect-based activities exhibit better balance, coordination, and overall physical performance compared to those who follow traditional PE methods. The importance of interactive feedback is also emphasized, allowing students to adjust their movements in real time, leading to more effective skill acquisition. Table 2 summarizes key studies on Kinect-based educational interventions for students with special needs.

Table 2 highlights the effectiveness of Kinect-based learning interventions in improving various aspects of physical and cognitive development among children with special needs. Each study provides empirical evidence supporting the integration of motion-sensing technology into educational practices. The results consistently indicate that Kinect-based applications offer a more engaging and practical approach compared to traditional learning methods.

While previous research has demonstrated the potential benefits of Kinect-based games, challenges remain in their practical implementation [19]. One significant issue is customizing learning activities to meet the diverse needs of students with intellectual disabilities. Unlike traditional PE methods, which teachers can adapt in real-time, motion-based games require precise programming and game design to accommodate different learning abilities. This limitation has led to further studies on adaptive learning mechanisms in game-based education.

TABLE 3
COMPARISON OF STATIC AND ADAPTIVE KINECT-BASED EDUCATIONAL GAMES

Feature	Static Kinect-Based Games	Adaptive Kinect-Based Games
Learning Adaptability	Fixed difficulty levels, not personalized	Adjusts difficulty based on user performance
Engagement	It can become repetitive over time	Higher engagement due to dynamic challenges
Motor Skill Improvement	Progress may be slow due to fixed learning paths	Faster skill improvement with personalized feedback
Usability	Requires manual adjustments by teachers	Automated adjustments enhance usability
Student Motivation	Motivation may decrease due to a lack of progression	Higher motivation due to gradual skill development

Several studies have explored adaptive motion-sensing games that dynamically adjust difficulty levels based on student performance. Some research has developed Kinect-based games that automatically modify task complexity based on player movements and reaction times. The findings indicate that students who use adaptive games experience greater engagement and improvement in motor skills compared to those who use static, pre-set game levels. This suggests that incorporating artificial intelligence (AI) and machine learning (ML) techniques into Kinect-based educational games can enhance learning outcomes. Table 3 provides a comparison between static and adaptive Kinect-based educational games, focusing on their impact on student performance and engagement.

Table 3 demonstrates the advantages of adaptive Kinect-based educational games over static ones. One key benefit of adaptive games is their ability to modify difficulty levels dynamically, ensuring that students remain challenged without becoming frustrated. In contrast, static Kinect-based games have pre-set difficulty levels, which may not accommodate the varying abilities of students with intellectual disabilities.

Another critical aspect of adaptive Kinect-based games is their ability to provide real-time, personalized feedback. Unlike static games, where students follow the same instructional patterns regardless of their performance, adaptive games analyze user interactions and adjust gameplay accordingly. This feature enhances learning efficiency and keeps students motivated to continue engaging with the educational content.

These comparative studies suggest that future research should focus on the development of AI-powered Kinect-based educational games tailored to special needs education. By leveraging advanced algorithms, these games can create individualized learning experiences that cater to each student's specific needs. Additionally, further investigation is needed to assess the long-term impact of adaptive learning technologies on motor skill development and cognitive abilities in children with intellectual disabilities.

Existing research supports the integration of Kinect-based educational games in special needs education, highlighting their effectiveness in enhancing motor skills, engagement, and learning motivation. However, to maximize the benefits of motion-sensing technology, it is essential to explore adaptive learning mechanisms that cater to diverse student needs. The current study builds upon previous research by designing a Kinect-based educational game specifically for physical education, incorporating features that promote engagement, real-time feedback, and personalized learning experiences for students with intellectual disabilities.

III. RESEARCH METHODOLOGY

The development of the Kinect-based educational game for students with intellectual disabilities followed a structured approach using the System Development Life Cycle (SDLC) methodology. This approach provided a systematic framework for analyzing, designing, implementing, and evaluating the game to ensure its effectiveness in improving physical education learning [20]. The study began with a needs analysis, where the requirements of students with intellectual disabilities and the constraints of traditional physical education methods were identified [21]. Observations and discussions with teachers at SLB-C YPSLB Surakarta helped shape the fundamental objectives of the game, ensuring that it addressed the specific motor skill challenges faced by students.

The game was developed using Unity 3D, a powerful game engine suitable for creating interactive 3D environments. Programming was done using C#, allowing seamless integration with Microsoft Kinect, which enabled motion tracking and real-time user interaction. Additional tools such as 3Ds Max were used for 3D character modeling, Adobe Photoshop CS3 for graphic design, and Cool Edit for sound editing. The game was designed to provide three different play styles, each focusing on throwing exercises, which are essential for improving motor coordination in students with intellectual disabilities. The gameplay mechanics encouraged students to interact with the virtual environment by physically throwing virtual objects into designated targets.

The game design incorporated real-time feedback mechanisms, where students received immediate auditory and visual responses upon successful or incorrect movements. This interactive approach aimed to increase engagement and provide students with a clear understanding of their progress. Each game session was designed to last approximately 30 minutes, with students engaging in structured activities that guided them through progressive challenges. The interface was intentionally designed to be simple and intuitive, ensuring that students could navigate the game independently or with minimal assistance from teachers.

Following the development phase, the game was tested with first-grade students at SLB-C YPSLB Surakarta. The participants were selected based on specific criteria, including their cognitive abilities and ability to interact with motion-sensing technology. Special education teachers facilitated the testing sessions, ensuring that students could engage with the game in a safe and controlled environment. The game was introduced as part of the physical education curriculum, allowing students to experience it within a structured learning context.

The evaluation phase involved both quantitative and qualitative data collection methods. Quantitative data was gathered by assessing students' motor skill improvements using pre-test and post-test evaluations. Teachers observed and recorded students' ability to perform throwing movements before and after using the game, allowing for a measurable comparison. In addition, game performance logs were collected to track students' accuracy, response time, and frequency of successful throws.

Qualitative data was obtained through teacher feedback questionnaires and direct student observations. Teachers were asked to evaluate the game’s effectiveness based on engagement levels, ease of use, and its potential as a teaching aid. Students’ behaviors, enthusiasm, and level of participation were also observed to assess how well they adapted to the game. This combination of qualitative and quantitative analysis provided a comprehensive understanding of the game's impact on students’ physical education learning.

To ensure the reliability of the findings, the study incorporated statistical analysis of student performance before and after using the game. A paired sample t-test was conducted to determine whether there was a significant improvement in students' throwing skills after interacting with the Kinect-based game. Additionally, thematic analysis was applied to teacher feedback to identify recurring patterns regarding usability, effectiveness, and engagement.

Ethical considerations were carefully addressed throughout the study. Parental consent was obtained before including students in the research, ensuring that all participants and their guardians were fully informed about the study’s objectives. Data confidentiality was maintained, and all personal information was anonymized. The game was designed to be non-intrusive and non-strenuous, allowing students to participate in a safe and inclusive learning environment.

Although the Kinect-based game showed promising results in improving student engagement and motor skills, certain limitations were identified. The study was conducted within a single school setting, which may limit the generalizability of the findings. Additionally, the sample size was relatively small, which could affect the statistical significance of the results. Future research could explore the long-term impact of the game on motor development and expand its application to other physical education activities beyond throwing exercises.

IV. RESULTS AND DISCUSSION

The Kinect-based educational game was developed to create an interactive and engaging learning experience for students with intellectual disabilities. One of the key gameplay scenes is activated when the player selects Style 1 from the main menu, as illustrated in Figure 1. In this scene, three family members—the father, mother, and older sibling—each hold a basket, and the player must accurately throw a ball into the designated basket based on the given instructions. Each basket accommodates one ball at a time, and the player is granted five attempts to complete the task. Upon a successful throw, the game displays a "Benar" (Correct) message accompanied by an audio confirmation, reinforcing the correct action. If the player completes all five attempts, they are redirected to the main menu, where they can either progress to the following game style or retry the current stage if they did not complete it successfully.

Fig. 1. Gameplay Scene of Style 1: Ball-Throwing Task with Family Members

In Style 2, the gameplay introduces an additional cognitive challenge, as illustrated in Figure 2. In this scene, three family members—father, mother, and older sibling—are once again holding baskets, but each basket is now labeled with a specific number. The objective of the game is for the player to throw the ball into the basket that corresponds to the correct number based on the given instructions. To execute the throw, the player must first position the cursor over the ball, then drag and release it into the designated basket. If the ball is correctly placed into the numbered basket, the game provides instant feedback, displaying the text "Benar" (Correct) along with an audio confirmation, reinforcing the correct selection.

Fig. 2. Gameplay Scene of Style 2: Numbered Basket Challenge

The scripting and mechanics of Style 2 are built upon the same framework as Style 1, with necessary adjustments to the audio instructions, object detection parameters, and active scripting elements to accommodate the numbered basket feature. These modifications ensure that students engage in a progressively challenging yet structured gameplay experience, enhancing their cognitive processing, hand-eye coordination, and motor accuracy.

The implementation of the Kinect-based educational game at SLB-C YPSLB Surakarta involved 20 students with intellectual disabilities. It aimed to assess the impact of motion-sensing technology on their engagement and motor skill development. The findings were gathered through pre-test and post-test assessments, student performance logs, and teacher feedback. The results indicate that the game-based approach significantly enhanced students' engagement, coordination, and motivation in physical education.

TABLE 4
COMPARISON OF PRE-TEST AND POST-TEST RESULTS

Performance Indicator	Pre-Test Score (Mean)	Post-Test Score (Mean)	Improvement (%)
Accuracy in Throwing	52.3%	78.6%	+26.3%
Student Engagement Level	58.2%	85.1%	+26.9%
Reaction Time (in seconds)	3.8s	2.5s	-1.3s
Number of Successful Throws	4.2	7.8	+3.6

The pre-test observations revealed that many students had difficulties performing controlled throwing movements, struggled with hand-eye coordination, and displayed low enthusiasm for traditional PE activities. Some students lost focus quickly, while others required repeated instructions to complete simple throwing exercises. However, after playing the Kinect-based game, noticeable improvements were observed in engagement levels, motor coordination, and reaction times.

Table 4 demonstrates that students significantly improved their motor skills after using the game. Throwing accuracy increased by 26.3%, indicating that students developed better hand-eye coordination through interactive gameplay. Additionally, the engagement level increased by 26.9%, suggesting that the game's interactive nature successfully encouraged students to participate actively in the learning process. Another key finding was the improvement in reaction time, where students responded faster to game instructions, reflecting enhanced cognitive processing and motor planning.

During gameplay, students were more willing to repeat throwing exercises, showing more remarkable persistence and focus compared to their behavior in traditional PE sessions. The immediate feedback provided by the game's visual and auditory responses played a crucial role in reinforcing correct movements, allowing students to learn in a structured and engaging way.

A. *Teacher Feedback and Observations*

The special education teachers at SLB-C YPSLB Surakarta provided valuable insights regarding the usability, engagement, and effectiveness of the Kinect-based game. They observed that students who were usually less motivated in traditional PE activities became more enthusiastic and engaged when interacting with the game.

One of the key advantages highlighted was the game's ability to maintain student focus. Unlike conventional instruction methods that rely on verbal explanations and repetitive drills, the motion-based approach encouraged active learning through real-time interaction. Teachers also noted that students who typically struggled to follow instructions showed better understanding when engaging with visual and movement-based learning elements.

Another significant observation was the positive impact of real-time feedback. The game provided instant auditory and visual responses, which helped students recognize successful movements and make immediate corrections when necessary. Teachers emphasized that this reinforcement mechanism was particularly beneficial for students with intellectual disabilities, as they often require repetitive and immediate feedback to grasp new concepts.

While the overall response to the game was positive, teachers also identified areas for improvement. Some students required an adaptation period to understand how to interact with the game's motion-tracking system. However, after a few practice sessions, most students could use the game independently. Teachers suggested that future versions of the game should include adjustable difficulty settings to accommodate students with varying skill levels. Additionally, they recommended introducing more activity variations, such as jumping, catching, and balancing exercises, to complement the throwing-based gameplay.

B. Engagement and Motivation Levels

In addition to motor skill development, the game significantly improved student motivation. Many students expressed excitement about participating in PE sessions, which contrasted with their previous lack of interest in traditional exercises. The use of game-based challenges, scoring systems, and rewards created a sense of achievement, which encouraged students to remain actively involved in the learning process.

TABLE 5
STUDENT ENGAGEMENT INDICATORS BEFORE AND AFTER USING THE KINECT-BASED GAME

Engagement Factor	Before Playing the Game	After Playing the Game
Willingness to Participate in PE	Low	High
Ability to Follow Instructions	Moderate	Improved
Response to Feedback	Limited	Positive
Focus During Activities	Inconsistent	Sustained
Enjoyment Level	Low	High

Table 5 confirms that students were more engaged and willing to participate in physical education lessons after using the game. Their ability to follow instructions improved, and they showed more excellent responsiveness to real-time feedback. The game also helped maintain sustained focus, as students were motivated to complete in-game challenges rather than disengaging from physical activities.

These results suggest that gamified learning can transform the way students with intellectual disabilities engage with physical education, making lessons more accessible, enjoyable, and effective. The interactive nature of the Kinect-based game created a positive learning environment that encouraged active participation rather than passive observation.

C. Challenges and Future Improvements

Although the study demonstrated successful outcomes, some challenges were identified. One key issue was the initial adaptation phase required for students to become comfortable with the game mechanics. While most students adapted quickly, a few needed additional guidance before they could effectively interact with the motion-sensing system.

Another limitation of the study was the relatively small sample size. Since the research was conducted in a single school, the findings may not be fully generalizable to other educational settings. Future research should consider expanding the study to multiple schools and increasing the number of participants to validate the results further.

Additionally, teachers suggested incorporating more diverse movement-based activities to expand the scope of the game beyond throwing exercises. Including jumping, balancing, or group-based physical activities could further enhance the educational impact of motion-sensing technology in special needs education.

D. Implications for Special Needs Education

The results of this study provide strong evidence that Kinect-based educational games can serve as an effective alternative to traditional physical education methods for students with intellectual disabilities. The combination of motion-based interaction, gamification, and real-time feedback contributes to a more engaging and practical learning experience.

By integrating technology into special needs education, educators can enhance the way students develop motor skills, improve engagement levels, and foster a positive learning environment. As motion-sensing technology continues to advance, there is potential for further innovations in game-based learning to support diverse educational needs.

V. CONCLUSION

This study demonstrated the effectiveness of a Kinect-based educational game in enhancing physical education for students with intellectual disabilities. By integrating motion-sensing technology, the game provided an interactive and engaging learning experience that significantly improved motor skills, coordination, and student engagement. The findings indicate that gamified learning approaches, particularly those incorporating real-time feedback and motion-based interactions, can serve as effective alternatives to traditional PE methods for students with special needs. The results showed a notable increase in throwing accuracy, engagement levels, and reaction time, reinforcing the game's positive impact on motor skill development.

Teacher feedback further supported the game's usability and effectiveness, highlighting its ability to maintain student focus, provide immediate feedback, and align with physical education learning objectives. The study also revealed that students who typically struggled with traditional PE lessons became more enthusiastic and motivated when using the game. However, some challenges were identified, including the adaptation period required for students to familiarize themselves with motion controls and the need for additional gameplay variations to cater to different skill levels. These insights suggest that future improvements should focus on customizable difficulty settings, expanded movement-based activities, and potential multiplayer modes to enhance collaborative learning experiences.

Although the study yielded promising results, its scope was limited to a single school setting with a relatively small sample size. Future research should expand the study to multiple institutions and diverse participant groups to further validate its effectiveness. Additionally, incorporating artificial intelligence (AI)-powered adaptive learning could allow for personalized gameplay experiences, catering to the unique abilities of each student. By leveraging motion-sensing technology and game-based learning, this research contributes to the ongoing development of inclusive and engaging educational tools for students with intellectual disabilities. The findings support the broader integration of interactive learning methods in special needs education, paving the way for more accessible, immersive, and effective physical education programs.

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