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Conceptual Model of Augmented Reality-Based Inclusive Learning for Students with Dyslexia

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ABSTRACT

Inclusive education for dyslexic students in Muhammadiyah schools still faces significant challenges, especially in strengthening literacy and numeracy. The lack of learning approaches that are appropriate to the cognitive characteristics of dyslexic students and the limited integration of digital-based educational technology are the main obstacles in the effective learning process. This study aims to formulate a conceptual model of inclusive learning based on Augmented Reality (AR) through philosophical, theoretical, empirical, and legal analysis, as well as exploring the perspectives of educational stakeholders in Ponorogo Regency. This study uses a qualitative approach with a Forum Group Discussion (FGD) involving school principals, inclusive teachers, representatives of the education office, and the Dyslexia Education Service Center team from 15 Muhammadiyah schools (elementary to high school/Islamic high school). Data were analyzed using opinion analysis techniques, respondent attitudes, discussion patterns, and general conclusions. The research findings indicate a pressing need for an adaptive multisensory learning model integrated with AI-based AR, underpinned by Muhammadiyah's philosophical values of inclusive and equitable education, and recommend integrating it into the local curriculum. The research findings form the basis for developing models and media for inclusive AR-based learning, as well as policy recommendations for improving teacher capacity and supporting technology in Muhammadiyah schools.

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1. INTRODUCTION

In Muhammadiyah primary and secondary schools, especially those that are not inclusive, such as SD and MI Muhammadiyah in Ponorogo, education for dyslexic students faces significant systemic challenges. Although these schools do not officially accept children with special needs (ABK) during the New Student Admission Process (PPDB), in practice, students with cognitive disabilities, including dyslexia, are still identified during the learning process. This indicates a gap between admission policies and reality on the ground, forcing schools to deal with conditions for which they are not institutionally prepared.

Meanwhile, Muhammadiyah junior high schools and Islamic junior high schools in Ponorogo, which directly announced that they would accept students with dyslexia in the PPDB, have not yet maximised the use of learning media that supports the learning process, especially through the relevant education office (Putra *et al.*, 2024). In general, dyslexic students in these schools experience various serious obstacles, such as basic difficulties in reading, writing, and understanding questions, which hinder their academic development. They often lag behind their peers, have difficulty expressing their thoughts in writing, and have difficulty focusing during learning (Primasari & Supena, 2021). This condition is exacerbated by an unsupportive social response, where dyslexic students are often shunned by their peers for being hyperactive or unable to sit still, resulting in barriers to social interaction, low self-confidence, and feelings of frustration.

Nationally, dyslexia is part of a broader educational context characterised by low literacy and numeracy skills. Data from the Programme for International Student Assessment (PISA) (Siler, 2025). Show that Indonesia ranks 74th out of 79 participating countries, with an average reading score of 371, which is well below the international average. This situation creates additional pressure for students who already face learning barriers such as dyslexia. The prevalence of dyslexia in Indonesia is estimated to be between 3% and 10% of the student population, which means that in a typical class of 25 students, an estimated 2 to 3 students have dyslexia (Hasibuan, 2021).

To make matters worse, many of these students are not diagnosed early, so they grow up with the stigma that they are 'stupid' or 'lazy', which leads to problems with motivation, low self-esteem, bullying, and even depression (Hanny & Dahlan, 2023). The core nature of dyslexia is an imbalance between normal intellectual potential and underachievement, especially in reading, which, if not properly addressed, can have a domino effect on all other subjects, including numeracy (Amidi, 2024; Hasibuan, 2021).

Previous research has provided important insights into effective strategies for overcoming the learning challenges of dyslexic students. In their research Amidi (2024) they found that a multisensory approach that actively involves the senses of sight, hearing, and movement in the learning process is the most effective strategy for improving the reading, writing, and spelling abilities of dyslexic children. On the other hand, McDowall & Kiseleva (2024) developed an intervention that combined flashcards and the token economy principle, which proved effective in improving early reading skills in children with dyslexia. Attractive visual flashcards that facilitate multisensory learning, combined with a positive reinforcement system through token economy, successfully increased the motivation and reading skills of the research subjects (Hasibuan, 2021). Both studies consistently emphasise the importance of a multisensory and tailored learning approach, as well as the use of rich visual media as a bridge between information and understanding for dyslexic students.

Although previous studies have identified the effectiveness of multisensory approaches and visual media, there is a significant gap in the application of cutting-edge technologies

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such as Augmented Reality (AR) and Virtual Reality (VR) in the context of inclusive education in Indonesia, especially for dyslexic students. Most local research still focuses on traditional methods or simple technologies such as basic Android applications and printed flashcards (Sutrisno *et al.*, 2025). Meanwhile, international research Soutthaboualy *et al.* (2022) has demonstrated the tremendous potential of AR in supporting dyslexia learning through its ability to 'bring to life' static text with animations, sounds, and interactive prompts that help students visualise and understand difficult words. However, to date, there has been no study that comprehensively designs, develops, and tests a contextual, easy-to-implement, and affordable AR-based learning model for use in schools, including those under large organisations such as Muhammadiyah. This gap is not only a lack of research, but also represents a missed opportunity to utilise technology that can provide mass personalised learning solutions in accordance with the principles of Universal Design for Learning (UDL) (Kelly *et al.*, 2022).

The second, more fundamental research gap is the absence of a holistic conceptual framework that explicitly integrates the four basic pillars: philosophical, theoretical, empirical, and juridical in the context of developing technology-based learning models for dyslexia (Åsberg Johnels *et al.*, 2022). Most previous studies have been fragmentary, focusing only on technological or psychological aspects, but have not yet integrated them with basic local educational values (in this case, Muhammadiyah values), national education policies, and empirical field results simultaneously.

The development of the AR model must not only be justified by cognitive theoretical frameworks such as multisensory learning and embodied cognition, but must also be in line with Muhammadiyah's educational philosophy, which emphasises humanism, modernity, and empowerment that inherently supports inclusion. Legally, this model must be in line with the Ministry of Education and Culture Regulation on Inclusive Education, the Joint Ministerial Decree of 3 Ministers, and the child protection law (Baro'ah *et al.*, 2023). Without the integration of these four foundations, the development of the model risks becoming a 'technocentric' innovation that is difficult to accept, implement, and scale within the existing education system.

Based on an in-depth analysis of the challenges at the Muhammadiyah school level and in the national context, this study identifies two key gaps: the lack of contextual integration of Augmented Reality (AR) technology and the absence of a comprehensive conceptual framework for inclusive learning (A'isyah & Lessy, 2022). The study aims to formulate a robust conceptual foundation for developing an AR-Based Inclusive Learning Model designed to enhance the literacy and numeracy skills of students with dyslexia. The research question is: How can an AR-based learning model be effectively implemented to support the learning needs of students with dyslexia?

2. METHODS

This study utilised a qualitative approach with a qualitative study design based on structured Focus Group Discussions (FGDs). The purpose of this approach was to explore in depth the perspectives, opinions, and attitudes of stakeholders regarding the needs, challenges, and potential for developing an inclusive learning model based on Augmented Reality (AR) for dyslexic students in Muhammadiyah schools. Qualitative research was chosen because it provides a rich and in-depth contextual understanding of the social, pedagogical, and institutional realities encountered in the field.

This study employs a qualitative approach, with the main instrument being a structured Focus Group Discussion (FGD) guide. This instrument has been validated by a team of

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experts in the field of educational technology and learning to ensure the quality and relevance of the data collected (Pregoner, 2025). The FGD guide was designed to explore the four main dimensions that form the focus of the research, namely: 1) Participants' understanding and experiences of dyslexia; 2) Challenges faced in literacy and numeracy learning; 3) Readiness and potential for the integration of Augmented Reality (AR) technology into the learning process; 4) Local and philosophical values of Muhammadiyah that support educational inclusion.

Data collected through the FGDs comprised participants' narrative accounts of their experiences, their views on learning barriers, technological readiness, and their interpretation of relevant local values within the context of educational inclusion. The FGDs were conducted in parallel across 15 Muhammadiyah schools covering primary (SD), lower secondary (SMP/MTs), and upper secondary (SMA/MA) levels in Ponorogo Regency. Discussion participants comprised various stakeholders, including school heads, inclusion teachers, representatives from the district education office, and the education office's service team. The involvement of these various parties aimed to ensure representation from different levels of decision-making and pedagogical practices in the field. Data collection procedures were carried out in accordance with research ethics, including participant consent and the confidentiality of information shared during the FGDs.

The FGD data were analysed using qualitative thematic analysis techniques, including analysis of opinions, attitudes, discussion patterns, and general conclusions from each session. The analysis process was conducted iteratively through transcription, codification, theme categorisation, and triangulation of findings across institutions. This technique enabled researchers to identify consensus, discrepancies, and critical insights that formed the basis for developing the conceptual foundation of the model. The validity of the findings was reinforced through source triangulation and member checks with key participants. The results formed a solid, participatory, and contextual conceptual foundation for the future development of an AR-based inclusive learning model.

3. RESULTS AND DISCUSSION

3.1. Results

This study identified the need and feasibility of developing an Augmented Reality (AR)-based inclusive learning model for dyslexic students at Muhammadiyah Ponorogo School. Through in-depth interviews with 35 respondents from four groups of informants and structured Focus Group Discussions (FGDs), strong but conditional support for the implementation of AR technology was found. The main findings show that AR-based learning models are considered highly relevant pedagogically, but their success depends on three critical factors: comprehensive teacher training, availability of technological infrastructure, and a participatory approach to model development.

Results of In-Depth Interviews with Respondents School principals expressed a strong commitment to inclusive education as part of Muhammadiyah's social mission. However, they identified significant challenges in programme execution. Of the 15 respondents, 13 mentioned budget constraints that had not been allocated for adaptive learning for students with special needs.

Their attitude towards AR can be described as enthusiastic but cautious, with the main concerns being infrastructure readiness and teacher capacity. 'We fully support inclusion, but I'm sorry, if the model is only good technology without accompanying training and support, it will actually become a burden. We need practical and proven solutions on a small scale first.' Principal of SMP 2 Muhammadiyah Pororogo. The general conclusion from this

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group shows a willingness to support the implementation of the AR model as long as it is accompanied by intensive training and a guarantee of program sustainability.

Meanwhile, in-depth interviews with inclusive teachers revealed a high level of frustration due to the lack of standard guidelines for teaching dyslexic students. Twelve out of 15 teachers rely on improvisation and personal experience, which is often exhausting. Their response to the concept of AR was very positive, with an emphasis on the need for visual and auditory representation in learning. 'Children with dyslexia need to "see" words, not just read them. If we could create an animation of the word "car" that appears and moves directly from the book using a mobile phone, it would really help them understand and remember.' Teacher at MA Muhammadiyah 1 Ponorogo. The general conclusion of the inclusive teachers shows an urgent need for teaching aids that are easy to use, integrated with lesson plans, and specifically designed to assist the word decoding process for students with dyslexia.

Meanwhile, according to the Education Office representative, the inclusion programme has not been running optimally due to a lack of synchronisation and technical assistance. They expressed openness to technological innovations that are in line with the independent learning programme, but on the condition that the model is proven effective through limited trials and can be replicated. The general conclusion from this group is that full support will be given, both in terms of policy and budget, if the AR-based learning model is successful in the trial phase and is accompanied by comprehensive implementation guidelines.

Based on the opinions of the Ponorogo Regency Dyslexia Expert Team, they provided a very valuable clinical perspective. They expressed concern that early identification of dyslexia is still very minimal, causing many students to be newly diagnosed at the secondary level. They strongly support multimodal learning media such as AR because it has been clinically proven to help dyslexia therapy. The general conclusion of this dyslexia expert team emphasises that the development of an AR-based model is a highly relevant strategic step and should be an integral part of a community-based inclusive education ecosystem.

3.2. Discussion

3.2.1. Conceptual Framework for Developing an Augmented Reality-Based Inclusive Learning Model

The FGD results revealed strong consensus among stakeholders regarding the potential of Augmented Reality (AR) in supporting dyslexic students' learning. These findings align with multimodal learning theory Fatima & Ali (2025), which asserts that information presented through multiple modalities (visual, auditory, kinesthetic) enhances retention and comprehension for students with learning difficulties, particularly dyslexia.

Inclusive education teachers participating in the FGD noted that "interactive 3D visuals help dyslexic students grasp abstract concepts that are challenging to comprehend through conventional text." Previous research on the effectiveness of multimedia in dyslexia education has shown significant results (Roberts, 2026). These findings reinforce the justification for using AR as an inclusive learning medium. Furthermore, the Universal Design for Learning principles Kelly *et al.* (2022) serve as a relevant theoretical foundation, where AR enables multiple means of representation, expression, and engagement as desired by FGD participants.

The positive attitude demonstrated by the school principal and education department representatives during the FGD reflects institutional readiness to adopt technological innovations. This aligns with the Technology Acceptance Model (TAM) concept, where

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perceived usefulness and perceived ease of use serve as key determinants of technology adoption in education (Podding *et al.*, 2024). The implementation of the AR learning model in the educational context at Muhammadiyah schools in Ponorogo demonstrates a strong alignment with local characteristics and Muhammadiyah values. Interviews with the relevant education department revealed that the need for learning media that is "contextual with local culture and easily accessible to schools in the region" is a top priority (Magdalena *et al.*, 2021). The developed AR model can integrate Ponorogo cultural elements such as batik, shadow puppetry, and local folklore to enhance student relevance and engagement.

3.2.2. Contributions to the Future Development of AI-Based AR Media

The development of AR learning models for dyslexic students paves the way for integrating more advanced Artificial Intelligence (AI) technologies. Recent research findings indicate that AI can aid in early dyslexia detection through handwriting analysis (Hayati & Ushalli, 2024). Eye-tracking technology combined with AI also shows significant potential in identifying early signs of dyslexia (Hasibuan, 2021).

In the future, the developed AR models can be enhanced with AI capabilities for Adaptive Learning Personalization, Learning Analytics for Educators, and Machine Learning-Based Early Detection (Juliantri *et al.*, 2026). The models should also consider sustainability and scalability aspects. Collaboration between Muhammadiyah schools, local tech developers, and academic institutions can create an independent and sustainable innovation ecosystem. The role of relevant education authorities as facilitators and evaluators will ensure effective implementation of the models, tailored to local needs.

Therefore, it can be concluded that the development of an AR-based inclusive learning model for dyslexic students is not only supported by a strong theoretical foundation but also highly relevant to the local context of Ponorogo and Muhammadiyah values. Future AI integration will further enhance the effectiveness of this model through personalization, early detection, and deeper learning analytics. The successful implementation of this model can serve as an example for other regions in developing technology-based, inclusive education that aligns with local identity.

4. CONCLUSION

An inclusive learning model based on Augmented Reality is essential to meet the needs of students with dyslexia who face challenges in processing conventional textual information. The integration of visual, auditory and kinesthetic elements in learning has been proven to significantly improve comprehension and retention among students with dyslexia. Strong support from teachers, headteachers, parents, and technology developers for the use of Augmented Reality (AR) as a learning medium demonstrates the potential of this technology to present content in a visual and interactive manner. AR helps to make abstract concepts concrete and engaging, in line with the learning styles of students with dyslexia, whilst also boosting their motivation to learn.

The development of this AR-based inclusive learning model is also in line with the philosophical values of Muhammadiyah, namely the principles of renewal (tajdid) and justice (al-'adl), which emphasise inclusive education and sustainable innovation grounded in Islamic values. As a next step, it is recommended that an AR-based inclusive learning model be developed that is integrated with artificial intelligence (AI) to enable adaptive and optimal personalised learning. This model should be designed in accordance with national

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curriculum standards and local contexts, ensuring it is relevant and can be implemented sustainably.

These findings have significant implications for inclusive education practices in Indonesia and support policies on the integration of technology in special needs education. Further research is recommended to strengthen the design framework of AR-based inclusive learning models as a foundation for further development.

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