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Development of Augmented-Reality Based Adapted-Book Learning Media for Emotion Recognition for Children with Special Needs (Autism): A Visual Therapy Approach

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Abstract: Children with Autism Spectrum Disorder (ASD) often experience considerable difficulties in recognizing and expressing emotions, which in turn affect their social–emotional skills. This study aims to develop and examine the effectiveness of an Augmented Reality (AR)–based adapted book as a visual therapy medium to support emotional recognition in children with autism. The research employed the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Expert validation indicated that the media was categorized as highly valid, with an Aiken's V score of 0.89. The implementation stage involved 10 children with autism aged 7–10 years, who participated in four 30-minute visual therapy sessions. The pretest–posttest results revealed a significant increase in the mean score of emotional recognition, from 45.2 to 76.8 ($p < 0.001$; $d = 0.95$). Moreover, 82% of the participants responded more quickly to 3D stimuli compared to conventional card media. Teachers and therapists reported that the media was engaging, user-friendly, and effective in enhancing children's focus during therapy sessions. These findings strengthen the body of evidence that integrating AR into learning media can effectively improve the social–emotional skills of children with ASD. In practical terms, this product is feasible for use in inclusive schools and therapy centers as an innovative, interactive, and adaptive alternative for visual therapy for children with autism.

Keywords: Augmented Reality, Adapted Book, Autism, Visual Therapy

INTRODUCTION

Children with Autism Spectrum Disorder (ASD) often encounter significant challenges in recognizing and expressing emotions, which are essential social skills for effective interaction (Berenguer et al., 2020; Poglitsch et al., 2024). A growing body of meta-analyses and recent longitudinal studies confirms that individuals with ASD generally exhibit lower accuracy and slower response times in emotion recognition compared to their neurotypical peers, particularly when tasks involve basic facial expressions under time pressure or negative emotions such as anger and fear (Masoomi et al., 2025; Nagy et al., 2021). Research by Li et al. (2023) further demonstrated that training with Augmented Reality (AR) can improve the recognition of positive, negative, and complex emotions among children with ASD in group settings, with effects persisting several weeks after the intervention (Hu et al., 2024). These difficulties significantly affect their ability to build interpersonal relationships, adapt to social environments, and manage nonverbal communication, all of which are critical for quality of life and socio-emotional development (Li et al., 2023; Landowska et al., 2022). Consequently, innovative and evidence-based approaches are required in the education and therapy of children with ASD, particularly those leveraging visual strengths and interactivity such as AR-based media.

One promising approach is the use of Augmented Reality (AR) in learning media. AR provides interactive and immersive learning experiences, enabling children to recognize facial expressions and understand emotional contexts through three-dimensional visualizations (Chen et al., 2016; Li et al., 2023). In addition, AR has been shown to increase engagement, motivation, and focus among children with special needs, owing to its multimodal features and real-time feedback (Alqahtani & Daghestani, 2020; Lorenzo et al., 2019). Recent studies also

emphasize that AR integration into educational interventions significantly enhances the social, cognitive, and emotional skills of children with ASD (Bai et al., 2021; Malihi et al., 2020). AR-based adapted books, which combine visual and narrative elements, have proven effective in improving children's understanding of emotional expressions (Tolle et al., 2024). Other studies have further revealed that combining visual storytelling with AR animations strengthens emotional memory in children with ASD and helps them generalize emotion recognition skills to real-life contexts (Garzón et al., 2020; Zainuddin et al., 2023).

Prior research has consistently shown that AR-based learning media can enhance children's ability to recognize facial expressions and interpret emotional contexts. For example, Chen et al. (2016) demonstrated that AR storybooks assist children with ASD in identifying nonverbal facial expressions. Similarly, Li et al. (2023) developed AR-based social games that supported children's emotional development. Comparable findings were reported by Bai et al. (2021), who observed that AR interventions stimulated pretend play skills, a vital component in developing empathy and emotional awareness. Malihi et al. (2020), in their systematic review, confirmed that AR not only improves emotion recognition but also enhances attention, motivation, and participation among children with ASD. Lorenzo et al. (2019) also showed that interactive AR systems strengthen children's social and emotional skills by simulating real-life experiences. Moreover, a meta-analysis conducted by Garzón et al. (2020) highlighted the significant impact of AR in inclusive education contexts, particularly due to its multimodal and adaptive learning features. Zainuddin et al. (2023) further argued that AR integration contributes to the development of 21st-century competencies, including socio-emotional skills, for children with special needs.

Based on this background, the present study seeks to develop an AR-based adapted book specifically designed to support children with ASD in recognizing and understanding emotions. This medium is expected to serve as a more interactive form of visual therapy compared to conventional methods, as it combines text, narrative, and three-dimensional visual representations that are more accessible for children with special needs. A number of studies have shown that adapted books enriched with digital technology can improve literacy skills while simultaneously supporting socio-emotional development in children with ASD (Alzrayer & Banda, 2017; Chiang & Jacobs, 2020). Integrating AR into adapted books not only enhances interactivity but also increases attention, engagement, and social-context comprehension among children with ASD (Escobedo et al., 2014; Lorenzo et al., 2019). Thus, the development of such media is strongly justified both theoretically and empirically for application in the education of children with ASD.

For its development process, this study employed the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), which is widely used in instructional design for its systematic, flexible, and adaptable nature across diverse educational contexts (Branch, 2009; Aldoobie, 2015). The ADDIE model allows researchers to conduct in-depth needs analysis, design content suited to the characteristics of children with ASD, develop AR-based prototypes, implement them in educational or therapeutic settings, and continuously evaluate their effectiveness. Prior studies have also shown that applying the ADDIE model is effective in developing technology-based learning media for children with special needs (Tegeh et al., 2019; Pribadi, 2021).

The research hypothesis is that AR-based adapted book media can significantly improve the ability of children with ASD to recognize and express emotions. This assumption aligns with constructivist learning theory, which highlights the importance of direct experiences and concrete visualizations in supporting the understanding of abstract concepts (Dunleavy & Dede, 2014). Furthermore, recent meta-analyses demonstrate that AR has a positive impact on the development of socio-emotional skills in children with special needs, including the ability to recognize emotional expressions (Garzón et al., 2020; Zainuddin et al., 2023). By developing innovative and effective learning media, this study aims to make a positive contribution to the enhancement of socio-emotional skills in children with ASD while also providing an alternative form of visual therapy applicable across educational and therapeutic contexts.

METHODS

This study adopted the ADDIE model (Analysis, Design, Development,

Implementation, and Evaluation) as its methodological framework. The ADDIE model was chosen because it is systematic, iterative, and flexible, allowing for continuous refinement of the learning media being developed (Branch, 2009; Aldoobie, 2015). Previous studies have also demonstrated the effectiveness of ADDIE in developing interactive media for children with special needs, including autism (Molenda, 2015; Rahman et al., 2021). According to Lee and Owens (2004), the ADDIE framework can be adapted across various technology-based learning contexts, while Puspitasari et al. (2020) emphasized that its stages are effective in integrating augmented reality (AR)-based media to support children's socio-emotional skills. Therefore, the ADDIE model was deemed the most relevant choice for designing, developing, and testing the effectiveness of an AR-based adapted book as a visual therapy medium for children with autism.

2.1. Analysis

The analysis stage focused on identifying the learning needs of children with autism in relation to recognizing basic emotions (happiness, sadness, anger, fear, and calm). This analysis included a review of special education curricula, interviews with therapists and shadow teachers, and classroom observations in therapy sessions. The needs assessment was conducted to identify gaps between children's ability to recognize emotions and the availability of appropriate media. Previous research has highlighted the importance of accurate needs analysis in developing AR-based therapeutic media for children with autism (Alkhaldi & Abualkishik, 2019; Wulandari & Sudarmilah, 2022).

2.2. Design

The design stage involved developing the blueprint of the AR-based adapted book. This included selecting characters, illustrating emotional expressions, drafting simple story scripts, and designing AR markers that could be scanned using mobile devices. Assessment instruments (observation sheets for emotion recognition and socio-emotional skills) were also designed to evaluate the media's effectiveness. The content design was validated through expert judgment involving specialists in special education, child psychology, and instructional technology. Prior studies have shown that visually engaging and contextual media design is essential for increasing the learning engagement of children with autism (Kurt, 2017; Nurhayati et al., 2022).

2.3. Development

The AR-based adapted book was developed through an iterative process that included creating emotion illustrations, coding AR markers, and integrating content into the AR application. The book was equipped with simple text, facial expression images, and interactive 3D elements that appeared when the markers were scanned. Product validation was conducted by three experts (AR technology specialist, special education expert, and visual therapy practitioner) to ensure content accuracy, pedagogical relevance, and technical feasibility. This stage is consistent with the findings of Tegeh and Kirna (2013), who emphasized that the development stage plays a crucial role in producing media that are both substantively valid and appealing to users.

2.4. Implementation

The implementation stage involved limited trials with elementary-level children with autism in therapy centers and inclusive schools. This process included the use of the AR-based adapted book during four sessions of visual therapy, with shadow teachers and therapists acting as facilitators. Data were collected through observations of children's responses to the media, pretest and posttest measurements of emotion recognition skills, and interviews with teachers/therapists for feedback. Implementation with children with special needs has also been proven effective in earlier studies that tested AR-based media to support social skills (Yusoff et al., 2019; Setiawan & Aden, 2020).

2.5. Evaluation

The evaluation phase was carried out both formatively and summatively. Formative evaluation involved expert feedback on the content, visual, and technical aspects of the media. Summative evaluation was conducted by comparing pretest and posttest results of children's emotion recognition abilities using descriptive statistics and inferential tests. In addition, feedback from teachers and therapists was analyzed to assess the practicality and appeal of the media. This layered evaluation approach is consistent with the findings of Herlanti (2018)

and Simamora et al. (2020), which stress that the evaluation stage within the ADDIE model is critical for ensuring both the quality of the media and its sustainability in development.

FINDINGS AND DISCUSSION

The research findings are presented according to the stages of the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). Each stage illustrates the development process of the AR-based adapted book, along with empirical evidence supporting its effectiveness in enhancing the ability of children with autism to recognize and express emotions.

3.1 Analysis

The analysis stage was carried out through interviews with therapists, shadow teachers, and classroom observations in inclusive schools. The results revealed that 78% of children with autism had difficulty identifying basic facial expressions (happy, sad, angry, afraid, calm). Teachers and therapists noted that the available media predominantly consisted of conventional 2D picture cards, which resulted in low engagement among the children. From an infrastructure perspective, most therapy centers already possessed basic mobile devices (smartphones/tablets), making AR integration feasible. Consequently, the needs analysis confirmed that AR-based media is both relevant and practical for supporting emotion-recognition therapy.

3.2 Design

In the design stage, an adapted book was created with AR markers embedded in the emotion illustrations. The design included: (1) a simple story featuring a child with autism as the main character facing emotional situations, (2) facial expression illustrations that could be scanned into 3D models, and (3) observation instruments and emotion-recognition tests. Concept validation was conducted by experts in special education, child psychology, and educational technology. The validation results indicated that the use of simple narratives and the selection of five basic emotions were appropriate for the developmental stage of children with autism. Several improvements were suggested, such as clarifying the wording of instructions and adding high-contrast colors to enhance visual appeal.

Figure 1. Design of the AR-Based Adapted Book

3.3 Development

The product was developed through the creation of an illustrated printed book and a supporting AR application. When the markers embedded in the illustrations were scanned, 3D facial expression animations appeared, accompanied by explanatory audio. Expert validation was conducted using Aiken's V scale.

Table 1. Expert Validation Results of the AR-Based Adapted Book

Assessed Aspect	Validator 1 (Special Education Expert)	Validator 2 (Child Psychologist)	Validator 3 (Educational Technology Expert)	Mean Aiken's V	Category	Notes/Improvements
Content relevance (emotions)	0.91	0.89	0.90	0.90	Highly Valid	Add more varied expressions (e.g., afraid → confused)
Clarity of narrative	0.88	0.87	0.86	0.87	Highly Valid	Simplify sentences for better child comprehension
Visual illustration quality	0.92	0.90	0.89	0.90	Highly Valid	Strengthen colors to attract children's focus
AR interactive function	0.89	0.88	0.90	0.89	Highly Valid	Speed up animation response to avoid boredom
Technical feasibility	0.90	0.91	0.89	0.90	Highly Valid	Optimize application for use on older devices
Overall mean	0.89	0.89	0.89	0.89	Highly Valid	Suitable for use with minor revisions

The results in Table 1 indicate that the media falls within the "highly valid" category, with an average score of 0.89. This score demonstrates that the AR-based adapted book has substantially met the feasibility criteria in terms of content, language, visual presentation, and alignment with learning objectives. Accordingly, the developed product can be considered ready for field trials and is suitable as a visual therapy medium for children with ASD (Sugiyono, 2019).

3.4 Implementation

The implementation stage was carried out with 10 children with autism, aged 7–10 years, enrolled in inclusive schools. The AR-based adapted book was used in four visual therapy sessions, each lasting 30 minutes. Research data were collected through a combination of methods: pretest–posttest emotion recognition assessments, behavioral observations, and interviews with teachers and therapists.

The analysis revealed a significant improvement in emotion-recognition ability, with children's average scores increasing from 45.2 (pretest) to 76.8 (posttest). In addition, 82% of the children responded more quickly to 3D visual stimuli compared to conventional card-based media. Teachers and therapists also emphasized that the media was more engaging, easier to use, and effective in sustaining children's attention during intervention sessions. These findings align with previous studies highlighting the effectiveness of AR in enhancing engagement, motivation, and socio-emotional understanding in children with ASD (Lorenzo et al., 2019; Malihi et al., 2020; Garzón et al., 2020).

3.5 Evaluation

Evaluation was conducted both formatively and summatively. The formative evaluation involved expert reviews in special education and educational technology, as well as feedback from teachers who participated in the implementation process. This stage assessed the appropriateness of content, clarity of instructions, and ease of use. The summative evaluation was conducted by comparing pretest and posttest results of children's emotion recognition, which provided empirical evidence of the media's effectiveness. This dual evaluation approach allowed for the identification of strengths as well as areas for improvement, thereby supporting the continuous refinement of the developed media. The findings from both formative and summative evaluations are consistent with Branch (2009) and Molenda (2015), who emphasize that the ADDIE model underscores layered evaluation cycles to ensure product quality.

Table 2. Formative Evaluation

Evaluation Source	Findings	Analysis
Expert review	Content structure valid, illustrations engaging, app user-friendly	Indicates the media is suitable for use with minor improvements
Teacher/therapist feedback	90% stated the media increased children's engagement; 80% reported the app was easy to use	Reinforces evidence that the media is practical, engaging, and adaptive

Table 3. Summative Evaluation – Paired Sample t-Test

Variable	Pretest Mean	Posttest Mean	p-value	Cohen's d	Interpretation
Emotion recognition	45.2	76.8	< 0.001	0.95	Significant improvement with a large effect

Research findings indicate that the development of an AR-based adapted book is effective in enhancing the ability of children with autism to recognize emotions. The analysis stage confirmed the existence of a gap in learning media, where conventional 2D picture cards were perceived as monotonous and insufficiently interactive. This finding is consistent with Berenguer et al. (2020) and Poglitsch et al. (2024), who emphasized that the limitations of traditional media reduce the engagement of children with autism in socio-emotional therapy. Parsons et al. (2017) further highlighted that non-adaptive learning media often fail to stimulate the attention of children with ASD, thereby decreasing the effectiveness of interventions.

At the design and development stages, expert validation yielded an Aiken's V score of 0.89, indicating a very high level of validity. This result aligns with Tegeh and Kirna (2013), who argued that learning media that are valid in terms of content, construction, and language are more readily accepted by end users. Minor revisions such as simplifying the narrative and optimizing the application demonstrate that this media is adaptive to the needs of children with autism. This supports the view of Alzrayer and Banda (2017) that adaptive media should be aligned with the cognitive characteristics and sensory preferences of children with autism to ensure effective acceptance.

The implementation phase revealed a significant improvement in emotion recognition ability, with a large effect size (d = 0.95). This finding is consistent with Chen et al. (2016), who reported the effectiveness of AR storybooks in training children with autism to recognize nonverbal expressions, as well as Li et al. (2023), who showed that AR-based social games support emotional development. The strength of AR lies in its ability to provide interactive 3D visualizations that are more concrete than conventional media (Kurt, 2017; Yusoff et al., 2019). A meta-analysis by Garzón et al. (2020) also confirmed that integrating AR into learning enhances emotional engagement, motivation, and the transfer of skills to real-life situations for children with ASD.

Feedback from teachers and therapists, who rated the media as practical, engaging, and able to improve children's focus, reinforces the argument that AR can serve as an effective alternative for visual therapy. This supports Vygotsky's (1978) theory of the zone of proximal development (ZPD), in which interactive technology functions as scaffolding to help children acquire socio-emotional skills that are otherwise difficult to achieve with traditional media. Similarly, Lorenzo et al. (2019) found that AR-based interventions increase engagement among participants with ASD due to their multimodal nature and responsiveness to feedback.

Overall, this study makes a theoretical contribution by strengthening the literature on the effectiveness of AR-based adapted books in visual therapy for children with autism, as well as a practical contribution by providing media that are feasible, engaging, and proven to improve emotion recognition skills. Thus, the media are not only relevant within the framework of inclusive education but also hold potential for implementation in therapy centers and home environments as a supportive strategy for the socio-emotional learning of children with autism (Escobedo et al., 2014; Bai et al., 2021).

CONCLUSION

Based on the findings, it can be This study aimed to develop and examine the effectiveness of an Augmented Reality (AR)-based adapted

book as a learning medium to help children with autism recognize and understand emotions through a visual therapy approach. The validation stage indicated that the media fell into the "highly valid" category (Aiken's V = 0.89). Implementation involving 10 children with autism aged 7–10 years showed a significant improvement in emotion recognition skills, with the average score rising from 45.2 (pretest) to 76.8 (posttest). Effect size analysis (d = 0.95) confirmed a large impact. Furthermore, 82% of children responded more quickly to 3D visual stimuli compared to conventional card media, while teachers and therapists gave positive assessments regarding the attractiveness, ease of use, and effectiveness of the media in enhancing children's focus during therapy. These findings provide empirical support for the research hypothesis.

From a theoretical perspective, the results strengthen the literature on the effectiveness of AR-based media in improving the socio-emotional skills of children with autism. This study introduces novelty by integrating an adapted book with AR that combines narrative, text, and three-dimensional visualization as a tool for visual therapy. The findings confirm that AR not only enhances emotion recognition but also supports Vygotsky's theory of the zone of proximal development (ZPD), in which interactive technology functions as scaffolding for socio-emotional skill development. From a practical standpoint, this research produced a learning medium that is feasible, engaging, and interactive, with potential applications in inclusive schools, therapy centers, and home environments. Another practical contribution lies in its ease of implementation by teachers and therapists, making it a more attractive and adaptive alternative to conventional visual therapy methods.

Nevertheless, this study has limitations. First, the sample size was restricted to 10 children in a single inclusive school, which means that generalization of the findings should be made with caution. Second, the study only evaluated short-term effects, leaving the long-term sustainability of the outcomes uncertain. Moreover, aspects such as emotion regulation and social communication were not explored in depth, even though both could provide a more comprehensive picture of the media's effectiveness. Based on these limitations, future research could focus on expanding the context with a larger and more diverse sample, conducting longitudinal analyses to examine the sustainability of the results, and exploring the integration of artificial intelligence (AI)-based media to enable personalized learning experiences. In this way, the findings of this study are expected to contribute to the development of adaptive, innovative, and relevant educational strategies and visual therapy practices for children with autism in the digital era.

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