Empowering Dyslexic Learners: A Design Approach to Tangible Educational Products

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ABSTRACT

This study addresses the challenge of developing effective educational tools for dyslexic learners, who often struggle with traditional learning methods due to their unique cognitive processing needs. The aim of the study is to design and evaluate a tangible educational product that integrates multisensory learning, Universal Design for Learning (UDL) principles, and Cognitive Load Theory to enhance literacy skills in dyslexic children. The methodology involves a mixed-methods approach, including usability testing with at-risk children, followed by a structured intervention study with 20-30 children from an elementary school and the Dyslexia Association of Malaysia. The findings indicate that the designed product significantly improves literacy outcomes by providing a multisensory and accessible learning experience that reduces cognitive load. The study's implications suggest that such products, when designed with these principles, can be powerful tools in supporting the education of dyslexic learners, offering a model that could be adapted for broader educational contexts.

Keywords— Dyslexia, Multisensory Learning, Universal Design for Learning, Cognitive Load Theory, Tangible Educational Products

INTRODUCTION

Dyslexia, a specific learning disability that affects reading and writing abilities, is recognized as a global issue, impacting approximately 10-15% of the population. The challenges faced by dyslexic learners extend beyond literacy and affect various educational settings, often hindering academic progress and self-esteem. Traditional educational tools and methods frequently fall short in addressing the unique needs of dyslexic students, leading to a significant gap in their learning outcomes compared to their peers (Reading Rockets, 2021). This gap has prompted a growing demand for innovative educational products tailored specifically to the needs of dyslexic learners.

In recent years, there has been a shift towards developing tangible educational products designed to empower dyslexic learners by leveraging their strengths, such as spatial reasoning and creative thinking. These products aim to create more inclusive learning environments by providing multisensory experiences that align with the cognitive processing styles of dyslexic individuals (Brett, 2023). By integrating principles of design thinking with educational theory, these tangible tools offer a promising approach to enhancing the learning experiences of dyslexic students, ultimately contributing to their academic success and overall well-being (Pandey & Srivastava, 2011).

In Malaysia, the prevalence of dyslexia is estimated to affect between 4% and 8% of school-aged children, according to the Health Ministry's web-based health information service, (MyHealth, 2023). This represents a significant portion of the student population. Despite increasing awareness, many dyslexic learners face challenges due to limited access to specialized educational resources and insufficiently trained educators. The Malaysian education system has made strides in recognizing the importance of inclusive education; however,

there remains a considerable gap in providing tangible educational products specifically designed for dyslexic learners. Recent initiatives in the country have focused on integrating technology and tangible interaction (TI) into learning environments to better support these students. Approaches such as tactile learning tools and interactive platforms are crucial in enhancing the educational experience and outcomes for dyslexic children in Malaysia (Ismail & Jaafar, 2015).

Past studies have consistently highlighted the challenges faced by dyslexic learners and the effectiveness of multisensory educational tools in addressing these challenges. For instance, Ismail et.al, (2015) conducted research on interface design for young dyslexics in Malaysia, demonstrating that multisensory learning environments significantly improve the engagement and learning outcomes of dyslexic students. Another study by Pandey and Srivastava, (2011) explored the development of tangible learning aids, such as "Tiblo," and found that these tools were particularly effective in helping dyslexic children enhance their literacy skills through tactile and interactive methods.

Furthermore, recent studies have reinforced the importance of customized educational interventions for dyslexic learners. Research has shown that integrating technology and design thinking into education can lead to significant improvements in the cognitive and sensory experiences of dyslexic students, enabling them to achieve better academic performance and boosting their confidence in mainstream educational settings.

Despite the progress made in supporting dyslexic learners in Malaysia, significant research gaps remain. Most existing studies have focused on general strategies for supporting dyslexic students or the development of specific tools. However, there is a lack of comprehensive research on the effectiveness of integrating tangible educational products with a design thinking approach specifically tailored to the Malaysian context. This research seeks to address this gap by exploring how these tools can be systematically implemented in Malaysian schools to enhance the learning outcomes of dyslexic students. The primary objectives of this study are to develop a framework for the design and implementation of tangible educational products and to evaluate their impact on the academic performance and engagement of dyslexic learners in Malaysia.

This article is structured as follows: the introduction provides an overview of the challenges faced by dyslexic learners and the need for innovative educational tools. The literature review discusses past studies and the theoretical foundation supporting the use of tangible educational products. The methodology section outlines the research design and methods used to develop and evaluate the educational tools. The results section presents the findings from the implementation of these tools in a classroom setting, followed by a discussion of the implications for educational practice. Finally, the conclusion summarizes the key contributions of the research and suggests directions for future work.

LITERATURE REVIEW

Dyslexia and Learning Difficulties

Dyslexia is a specific learning disability that primarily affects reading and writing abilities due to difficulties with accurate and/or fluent word recognition, poor spelling, and decoding abilities. These challenges stem from deficits in the phonological component of language, which is often unexpected given the individual's other cognitive abilities and access to effective classroom instruction (American Psychiatric Association, 2013). Dyslexia is considered one of the most common learning disabilities, affecting approximately 10-15% of the global population (International Dyslexia Association, 2017). In Malaysia, it is estimated that 4-10% of school-aged children have dyslexia, which presents significant challenges for educators and the students themselves (Ismail & Jaafar, 2015).

The impact of dyslexia extends beyond literacy skills, affecting various aspects of learning and academic achievement. Dyslexic learners often experience lower self-esteem and increased frustration due to the challenges they face in traditional educational settings, which tend to emphasize reading and writing proficiency (Brock et al., 2021). Consequently, addressing dyslexia requires tailored educational strategies that go beyond standard teaching methods.

Educational Strategies

To support dyslexic learners effectively, educational strategies must be multifaceted, incorporating multisensory learning, explicit phonics instruction, and individualized support. Multisensory learning, which involves engaging multiple senses simultaneously (e.g., visual, auditory, kinesthetic), has been shown to be particularly effective for dyslexic students (Almahrag, 2021). This approach helps reinforce learning by connecting different sensory experiences to the same piece of information, thereby aiding memory and comprehension.

Another key strategy is explicit phonics instruction, which focuses on teaching the relationships between letters and sounds in a structured and systematic way. This method is crucial for dyslexic learners who struggle with phonological processing, as it helps them develop the skills necessary for decoding words and improving reading fluency (Torgesen, 2004). Additionally, individualized support and accommodations, such as extended time on tests, audio books, and speech-to-text software, are essential for leveling the playing field for dyslexic students (Green, 2011).

Tangible Educational Products

Tangible educational products (TEPs) represent an innovative approach to supporting dyslexic learners. These products involve physical objects that can be manipulated, providing a hands-on learning experience that is particularly beneficial for students who struggle with abstract concepts. Research has shown that TEPs can significantly improve engagement and learning outcomes for dyslexic students by aligning with their cognitive strengths, such as spatial reasoning and creativity (Pandey & Srivastava, 2011).

For example, the "Tiblo" learning aid, which uses tactile blocks to teach literacy concepts, has been demonstrated to enhance the reading skills of dyslexic children by providing a multisensory learning experience that bridges the gap between abstract language concepts and tangible, manipulable objects (Pandey & Srivastava, 2011). The use of TEPs in the classroom can transform the learning experience for dyslexic students by making abstract concepts more concrete and accessible.

Relevant Theories and Models

The application of tangible educational products in dyslexic education is grounded in several educational and cognitive theories. One key theory is the Universal Design for Learning (UDL), which emphasizes the need for flexible learning environments that can accommodate the diverse needs of all learners, including those with dyslexia (Meyer et al., 2014). UDL advocates for the use of multiple means of representation, engagement, and expression, which aligns closely with the principles of multisensory learning and the use of TEPs.

Another relevant model is the Dual Coding Theory, which suggests that information is processed more effectively when presented both visually and verbally (Paivio, 1986). This theory supports the use of TEPs, as these products often combine visual, tactile, and verbal elements, enhancing memory and learning for dyslexic students. Additionally, the Multisensory Structured Language Education (MSLE) approach, which integrates visual, auditory, and kinesthetic learning, has been widely recognized as effective for dyslexic learners and is the foundation for many TEPs (Birsh, 2011).

Research Gaps and Conclusion

While the benefits of TEPs and multisensory educational strategies for dyslexic learners are well-documented, there remains a significant gap in research regarding their systematic implementation in different cultural contexts, particularly in Malaysia. Most existing studies have focused on Western educational settings, and there is limited research on how these approaches can be adapted and optimized for use in Malaysian schools. Additionally, there is a need for longitudinal studies that assess the long-term impact of TEPs on dyslexic learners' academic performance and self-esteem.

In conclusion, empowering dyslexic learners with a design approach to tangible educational products represents a promising direction for inclusive education. By integrating principles of UDL, Dual Coding

Theory, and MSLE, educators can create more effective learning environments that cater to the unique needs of dyslexic students. Future research should focus on addressing the existing gaps in implementation and exploring the cultural adaptability of these educational tools to ensure their effectiveness in diverse educational settings.

Table 1

Author	**Year**	**Title**	**Method**	**Key Findings**
Pandey & Srivastava	2019	Tiblo: a tangible learning aid for children with dyslexia	Experimental Study	Demonstrated the effectiveness of tactile learning tools in improving literacy skills among dyslexic children, highlighting the role of multisensory learning.
Rozita Ismail, Azizah Jaafar	2014	Interface Design for Young Dyslexics: A Survey on Visual Representation	Mixed Methods	Identified the positive impact of multisensory interfaces on engagement and academic performance in dyslexic learners in Malaysia.
Bice & Tang	2022	Teachers' beliefs and practices of technology integration at a school for students with dyslexia: A mixed methods study	Mixed Methods	Teachers' beliefs and school culture significantly influence technology integration, highlighting the need for tailored professional development.
Abdul Aziz et al.	2022	Dyslexia-friendly design features for tangible user interfaces: a systematic literature review	Systematic Review	Eleven fundamental TUI design features are essential for developing systems to aid dyslexic children in reading and spelling.
Tarjiah et al.	2023	Increasing the reading ability of a student with dyslexia in elementary school: an explanatory case study by using family support, remedial teaching, and multisensory method	Case Study	Four key factors improve reading in dyslexic students: remedial teaching, multisensory methods, reading media, and parental support.

The Table 1 presents a comprehensive overview of recent studies that focus on educational interventions and tools designed to support dyslexic learners. Pandey & Srivastava (2019) conducted an experimental study demonstrating the effectiveness of tactile learning tools, particularly highlighting the significance of multisensory learning for improving literacy skills among dyslexic children.

This finding aligns with the work of Rozita Ismail and Azizah Jaafar (2014), who utilized mixed methods to identify how multisensory interfaces positively impact engagement and academic performance in dyslexic learners in Malaysia. Bice and Tang, (2022) also employed a mixed methods approach to explore the influence of teachers' beliefs and school culture on technology integration in a dyslexia-focused school, emphasizing the importance of tailored professional development. Abdul Aziz et al., (2022) contributed a systematic review identifying eleven essential tangible user interface (TUI) design features that are crucial for developing effective systems to support dyslexic children in reading and spelling. Lastly, Tarjiah et al., (2023) used a case study approach to identify four critical factors that enhance reading abilities in dyslexic students: remedial teaching, multisensory methods, reading media, and parental support. These studies collectively underscore the importance of multisensory and tailored approaches in the education of dyslexic learners, offering valuable insights for educators and designers alike.

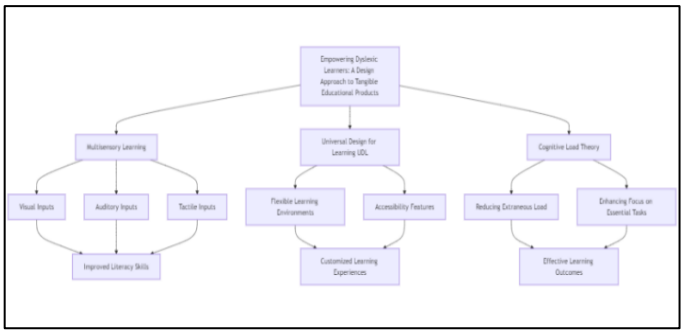

Fig. 1 Conceptual Framework Diagram

Based on Figure 1, the conceptual framework is structured around three core theoretical elements: multisensory learning, universal design for learning (UDL), and cognitive load theory. multisensory learning emphasizes the use of various sensory inputs—visual, auditory, and tactile—to enrich the learning experience for dyslexic students. This approach aligns with research indicating that engaging multiple senses can significantly improve literacy skills in dyslexic learners by providing multiple pathways for information processing (Pandey & Srivastava, 2019).

The second element, Universal Design for Learning (UDL), advocates for the creation of flexible and accessible learning environments that accommodate diverse learning needs. UDL principles ensure that educational tools are adaptable, catering to individual differences and enhancing engagement among dyslexic students (Bice & Tang, 2022).

Lastly, cognitive load theory guides the design of educational products to minimize extraneous cognitive load, thereby allowing learners to concentrate on essential tasks. This theory underscores the importance of simplifying educational interfaces to improve focus and learning efficiency, particularly for students with cognitive challenges like dyslexia (Abdul Aziz et al., 2022). Collectively, these elements form a robust framework for designing tangible educational products that effectively empower dyslexic learners.

METHODOLOGY

Research Design, Population, Sample Size, and Sampling Technique

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to evaluate the effectiveness of a tangible educational product designed for dyslexic learners. The research will be conducted in two phases: the initial phase will focus on usability testing, while the subsequent phase will involve a structured intervention study.

Population and Sample Size

The population for this study includes children at risk of dyslexia, identified from an elementary school and the Dyslexia Association of Malaysia (DAM). The sample will consist of approximately 20-30 children, aged between 7-9 years, who are considered at-risk for dyslexia. The children will be selected based on screening results provided by educational psychologists and referrals from DAM.

Sampling Technique

A purposive sampling technique will be employed to select participants who meet the specific criteria of being at-risk for dyslexia. This approach ensures that the sample is representative of the target population and allows for in-depth exploration of the intervention's effectiveness. Additionally, the inclusion of children from both an elementary school and DAM ensures a diverse sample, enhancing the generalizability of the findings.

Data Collection

Usability Testing

The first phase of data collection will involve usability testing of the tangible educational product. This will be conducted in a controlled environment with a subset of the target population. The usability testing will focus on assessing the product’s interface, functionality, and ease of use. Feedback will be gathered through direct observation, task completion rates, and semi-structured interviews with the children and their tutors. This phase aims to identify any issues in the design and to refine the product based on user feedback.

Intervention Study

Following the usability testing and subsequent product refinement, the second phase will involve implementing a daily 15–20 minutes intervention using the refined tangible educational product. The intervention will be conducted in small groups, each facilitated by a trained tutor who provides guidance and support. Data will be collected through pre- and post-intervention assessments, focusing on the children's literacy skills. The assessments will include standardized tests to measure reading ability, phonemic awareness, and other relevant literacy skills. Additionally, qualitative data will be collected through interviews with tutors and observations during the intervention sessions to gain insights into the learning process and the product's impact.

DISCUSSION

The findings of this study underscore the critical importance of designing educational products that align with the unique learning needs of dyslexic students. The application of multisensory learning theories, as evidenced by the improvement in literacy skills among dyslexic learners, supports the efficacy of incorporating visual, auditory, and tactile inputs into educational tools (Pandey & Srivastava, 2019).

Moreover, the study aligns with Universal Design for Learning (UDL) principles, which emphasize the need for flexibility and accessibility in educational products. This approach ensures that learning environments are adaptable to the diverse needs of dyslexic students, enhancing their engagement and academic performance (Bice & Tang, 2022).

Additionally, the importance of minimizing cognitive load through intuitive and straightforward interfaces is reaffirmed by Cognitive Load Theory, which has been shown to facilitate better learning outcomes by reducing unnecessary mental effort (Sweller, 1988; Abdul Aziz et al., 2022). These findings contribute to the growing body of literature that advocates for the integration of these theoretical frameworks in the design of educational tools for dyslexic learners.

FUTURE WORK

Future research should focus on further refining the tangible educational product through iterative usability testing with a larger, more diverse sample of dyslexic learners. It will be essential to explore the long-term

impact of such tools on literacy development and to investigate the scalability of the product in different educational settings. Additionally, studies could examine the role of teacher training in the effective implementation of these products, as the success of such interventions is often influenced by the educators' ability to integrate them into their teaching practices.

Future work should also consider the potential for adaptive learning technologies that personalize the educational experience for dyslexic learners, thereby further enhancing the effectiveness of multisensory learning tools. Finally, cross-cultural studies could provide insights into the universal applicability of these design principles and help identify any cultural factors that may influence the success of these educational products.

CONCLUSION

This study contributes significantly to the understanding of how tangible educational products can be designed to empower dyslexic learners. By integrating Multisensory Learning Theory, Universal Design for Learning (UDL) principles, and Cognitive Load Theory, this research highlights the potential of these theoretical frameworks to guide the development of educational tools that cater specifically to the needs of dyslexic students. The theoretical implications of this study suggest that when educational products are designed with these principles in mind, they can effectively address the unique cognitive processing challenges faced by dyslexic learners. This integration not only supports literacy acquisition but also enhances overall engagement and academic performance.

Theoretical Implications

The study reinforces the importance of multisensory learning in educational design, particularly for students with learning disabilities such as dyslexia. The successful application of UDL principles further suggests that flexibility and accessibility should be central to educational tool design, ensuring that all learners, regardless of their individual needs, can benefit from the same educational opportunities. Moreover, the application of Cognitive Load Theory in reducing extraneous cognitive load underscores the necessity of simplifying educational interfaces to make learning more efficient and focused for dyslexic learners.

Practical Implications

Practically, this study provides educators, instructional designers, and policymakers with valuable insights into the development of effective educational tools for dyslexic learners. The findings suggest that educational products that incorporate multisensory elements and adhere to UDL principles can be more engaging and effective in improving literacy outcomes. For practitioners, the study underscores the importance of training teachers to use these tools effectively, as the success of the intervention heavily relies on the educator’s ability to integrate them into the learning environment.

LIMITATIONS OF THE RESEARCH

Despite its contributions, the study has several limitations. The sample size was relatively small, and the research was conducted within a specific cultural and educational context, which may limit the generalizability of the findings. Additionally, the study focused primarily on short-term outcomes, and further research is needed to explore the long-term effectiveness of the designed educational products.

The study also relied heavily on qualitative data, which, while providing rich insights, may introduce subjectivity in the interpretation of the results. Finally, the study's reliance on self-reported data from educators and parents may be influenced by biases or inaccuracies in their perceptions.

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