

AI-POWERED INSTRUCTIONAL INTERVENTIONS FOR STRUGGLING READERS: EFFICACY AND BEST PRACTICES

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Abstract

This paper provides a comprehensive review of AI-powered instructional interventions for struggling readers, focusing on their efficacy and best practices. Struggling readers, who face significant difficulties in acquiring and mastering reading skills, often encounter challenges that extend beyond English studies, affecting their overall academic performance. The paper explores various AI technologies, including machine learning, natural language processing and speech recognition, that offer personalized, real-time feedback and adaptive learning experiences to support struggling readers. The literature review highlights studies demonstrating the positive impact of AI-powered interventions on reading fluency, comprehension and engagement. The paper discusses the efficacy of these interventions, emphasizing the importance of strategic planning, professional development for educators, data privacy and ethical considerations. Successful implementations of AI-driven platforms in different educational contexts are presented, showcasing significant improvements in student performance and engagement. Despite the promising potential, the paper also addresses the challenges and limitations, such as equity and access, ethical concerns, pedagogical limitations, and implementation challenges. The conclusion underscores the need for ongoing research and development to maximize the benefits of AI-powered instructional interventions while addressing the associated challenges. Part of the recommendations suggested were teachers' support in the area of training, equity and access to all students without any bias, data privacy and ethics guidelines should be provided and many more.

Keywords: Machine Learning, Language Processing, Comprehension

Introduction

Struggling readers are students who face challenges and considerable difficulties in acquiring and mastering reading skills expected of their grade level which cause their reading to be at frustration level. A significant number of secondary school students encounter challenges with reading that extend beyond the confines of English studies. These difficulties transcend into various subjects, impairing their ability to understand even basic notes provided to them (Lawal, 2020). Inability to read and comprehend simple instructions has

resulted into failure in their external examinations. Struggling readers are found at every stage of learning, even adults are not left out (Nwosu, 2020). Reading difficulty is a common issue that affects readers at any level and anywhere. Reading problems can occur at any grade level due to faulty foundation which may occur as a result of wrong teaching techniques and strategies used for teaching reading (Nalisa, Chataa & Maemeco, 2019). Instructional intervention is a systematic approach used in education to provide targeted support and assistance to students who

may be struggling academically or who have specific reading needs.

As education evolves in a quickly changing technological environment, AI-powered instruction is emerging as an essential tool for modern classrooms. Traditional educational approaches, while effective in their day, frequently fail to suit the different demands of today's students. The demand for customized, adaptable, and data-driven education methodologies is increasing and Artificial Intelligence (AI) is well positioned to meet these problems. Integrating AI-powered education in schools is vital for multiple reasons: it may improve individualized learning, increase teacher efficiency, assist students with various learning requirements, and nurture critical 21st-century skills and reading challenges (Pedro et al., 2019).

The following advantages of AI-powered instructional intervention can be received, according to the National Institute of Child Health and Human Development (2000) and the International Literacy Association (2020):

- Preventing problems with reading
- Improving the results of reading
- Reducing achievement inequalities
- Improving reading abilities
- Encouraging student achievement
- Early intervention for reading difficulties
- Focused assistance
- Increased efficacy of teachers.

Artificial Intellect (AI) is the replication of human intellect in computers that have been designed with human-like thought and learning processes. These systems are capable of carrying out operations like speech recognition, visual perception, decision-making and language translation that

normally demand for human intelligence (Muhamad, 2024).

Important Aspects of AI:

Machine Learning (ML) is a branch of artificial intelligence that uses statistical models and algorithms to help computers get better at tasks over time (Luckin, Holmes, Griffiths, & Forcier, 2016).

Natural Language Processing (NLP) is an area of artificial intelligence that focuses on how computers and human language interact to allow machines to comprehend, translate and produce human language (Luckin, Holmes, Griffiths, & Forcier, 2016).

Computer Vision is an area of Artificial Intelligence that allows machines to analyse and decide on the basis of visual information from the environment (Luckin, Holmes, Griffiths, & Forcier, 2016).

Robotics is the field of technology concerned with the creation, maintenance, use and application of robots. These machines frequently use artificial intelligence (AI) to carry out activities on their own (Luckin, Holmes, Griffiths, & Forcier, 2016).

AI-Powered Reading Interventions:

Artificial Intelligence (AI)-powered reading interventions are instructional tools and platforms that use AI technology to support and improve students' reading abilities, especially those who have difficulty in reading. AI is being used in these interventions to give real-time feedback, tailor learning experiences and adjust to the requirements of specific students (Muhamad, 2024).

Kinds of Instructional Interventions Driven by AI:

Adaptive Educational Resources: These systems tailor reading materials and exercises to each learner's progress and ability using AI algorithms. They modify the material and degree of difficulty in real time to meet the demands of every learner. Individualized reading activities catered for each person's skill, which is available through platforms such as DreamBox Learning (Luckin, Holmes, Griffiths, & Forcier, 2016).

Intelligent Tutoring System (ITS): ITS offers one-on-one tutoring sessions that mimic human instructors using artificial intelligence. They engage in conversation with students by posing queries, providing clarifications and providing comments. Despite being primarily a math resource, Carnegie Learning's MATHia serves as an excellent example of how ITS may be applied in education ((Goksel, & Bozkurt, 2019).

Natural Language Processing Tools (NLP): NLP technologies assist writing and reading comprehension by analysing and comprehending human language. They offer comments on syntax, grammar and meaning. Grammarly helps individuals improve their writing by delivering real-time corrections and suggestions ((Goksel, & Bozkurt, 2019).

Speech Recognition and Text-to-Speech Systems: These tools translate spoken words into written words and vice versa again, helping children who struggle with reading by giving them hearing assistance with reading and comprehension. Both Google Text-to-Speech and Dragon NaturallySpeaking assist pupils by transcribing spoken words and reading aloud from texts.

Reading Analytics: AI-powered systems for reading analytics monitor and evaluate students' engagement, comprehension and reading habits. On

the basis of the information gathered, they provide analysis and recommend focused interventions. Analytics are used by learning management systems, such as Moodle and Canvas, to track and assist students' progress (Goksel, & Bozkurt, 2019).

Potential Benefits

Personalisation: It increases the efficacy of learning by adjusting reading strategies and materials to the needs of each individual student (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Real-time feedback: It gives students access to timely remedial feedback right away, enabling them to keep learning and getting better (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Engagement: Through participatory and adaptable factors, engagement and motivation are increased (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Accessibility: Provides support and other formats to meet a range of learning requirements, including those of students with reading problems (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Data-Driven Decisions: Assists educators in making well-informed choices by utilising comprehensive analytics and data on student performance (Holmes, Bialik, & Fadel, 2019).

The struggle to acquire and master reading skills affects millions of student worldwide, with far-reaching consequences for their academic performance and lifelong learning. AI-powered instructional interventions offer a promising solution, leveraging cutting-edge technologies to provide personalized, adaptive learning experiences. This paper provides a

comprehensive review of AI-powered instructional interventions for struggling readers, exploring their efficacy, best practices and challenges. AI-powered instruction is not just a futuristic concept; it is a necessary evolution in the educational system that addresses the diverse and complex needs of today's learners. AI represents a transformative force in education because of its ability to personalize learning on a large scale, improve teacher efficiency, support students with diverse learning needs and prepare them for their future. As technology continues to advance, the adoption of AI in schools will be crucial in fostering more effective, equitable and forward-thinking learning environments. By leveraging the power of AI, educators can better equip students with the knowledge and skills needed to thrive in an increasingly digital world.

Research Questions

1. What are the most effective AI-powered instructional interventions for struggling readers?
2. How can educators be supported in integrating AI-powered tools into their teaching practices?
3. How can AI-powered instruction be tailored to meet the diverse needs of struggling readers?
4. What are the long-term benefits and challenges of implementing AI-powered instructional interventions?
5. How can policymakers and educators balance the benefits of AI-powered instruction with potential pedagogical limitations?
6. Are there successful examples of countries that have implemented AI-powered instruction?

Literature Review

According to research, reading fluency and personalised learning may significantly improve students' performance in a variety of areas, including reading comprehension. Artificial Intelligence is a booming technological domain capable of altering every aspect of our social interactions. In education, AI has begun producing new teaching and learning solutions that are now undergoing testing in different contexts (Pedro et al. 2019). Muhamad, 2024's study found that the students who used the AI-based platform had significantly higher reading comprehension scores than those who did not, indicating that the platform effectively enhanced reading comprehension. Educators and administrators should consider incorporating AI-based personalised reading platforms into their teaching strategies to improve students' reading skills. Amit, Sanjeev, and Manpreet, (2023) researched on the Impact of AI-Driven Personalisation on Learners' Performance. This study explores the impact of AI-driven personalization on learners' performance. Through quantitative and qualitative analysis, the research demonstrates a positive correlation between personalized AI-based adaptive learning and improved academic achievement, engagement, and satisfaction. The findings highlight the potential of AI-driven personalization to enhance learners' performance and transform education practices. The literature reviewed underscores the transformative potential of AI-based personalized learning platforms in education. The studies by Muhamad (2024) and Amit, Sanjeev, and Manpreet (2023) provide evidence that these platforms can significantly enhance reading comprehension, academic

achievement and student engagement. As a result, there is a strong case for educators and administrators to integrate AI-driven personalized learning solutions into their teaching practices to foster better learning outcomes. In the words of Bali (2024), many educational installations, tablets have largely replaced books in the learning process and internet-based learning has grown increasingly frequent. Digital technologies have altered education, making it more engaged and independent. New technology has also altered the way people share information, so teachers must discover new ways to motivate students and adapt to the new century (Bali, 2024). AI provides various benefits to the Nigerian educational system. It personalizes learning, increases student engagement and delivers real-time feedback to improve overall educational achievements. If AI is incorporated into the educational system, schools will handle contemporary educational challenges more effectively.

Different research works have been done in this area of study. Borbajo, Malbas, and Dacanay (2023) investigated the global impact of incorporating Artificial Intelligence (AI) into education and its implications for educational improvement. A thorough meta-analysis of papers from Scopus-indexed journals is used to investigate the effects of AI on student learning results, instructional methods, pedagogical techniques and educational policy. The findings imply that incorporating AI into the classroom has the potential to greatly improve student learning outcomes. AI-powered adaptive learning platforms and intelligent tutoring systems offer individualized training and differentiated learning experiences, according to each student's

unique requirements and learning style. AI integration also improves data-driven decision making, allowing instructors to make educated instructional decisions based on student data analysis.

Ciroma (2024) proposed leveraging artificial intelligence (AI) to address Nigeria's out-of-school children issue. Quality teachers and instructional materials are crucial. AI-driven solutions include smart devices, virtual tutors, offline educational chatbots, digital libraries and language learning tutors. These tools can provide personalized learning experiences, improve educational outcomes and increase accessibility.

Efficacy of AI-Powered Instructional Interventions

To make sure AI-powered instructional interventions achieve learning objectives and provide students with quantifiable benefits, it is imperative to measure their effectiveness. Strategic planning and adherence to best practices that guarantee the interventions are also morally and environmentally required for the successful implementation of AI-powered instructional interventions (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019). Below are some measures:

Assessment of Needs and Establishing Objectives: Perform a comprehensive needs assessment to determine the precise reading difficulties that pupils are facing prior to putting AI solutions into practice. Establish quantifiable, explicit goals for the intervention (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Professional Development and Training for Teachers

Be certain that educators and teachers receive in-depth instruction on how to use AI tools. To keep educators abreast of current developments and best practices, educators should have access to ongoing professional development (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Student-Centered Approach: When creating AI interventions, keep each student's needs in mind. Tailoring instruction to each student's specific needs and learning preferences is essential too (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Security and Privacy of Data

Put strong data security and privacy procedures in place to safeguard student information. Verify adherence to pertinent laws and regulations, including FERPA and GDPR (FERPA -Family Educational Rights and Privacy Act: A US law that protects the privacy of student education records while GDPR-General Data Protection Regulation: A European Union law that regulates the processing of personal data ((National Center for Education Statistics, 2020).

Blending with the Current Curriculum

Align AI-powered interventions with the current teaching methods and curriculum. This promotes the overall learning objectives and guarantees coherence (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Constant Observation and Assessment

Continue to track and assess the AI initiatives' efficacy. Analyse student success using data analytics, then make the required modifications (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Establish Explicit Evaluation Metrics

Determine precise, unbiased criteria to assess how the intervention affects reading abilities. Reading comprehension, engagement levels and fluency are a few examples of metrics (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Assessments before and after the intervention

Conduct assessment before and after the intervention to track improvement. To measure efficacy, compare baseline data to post-intervention results (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Use of Control Groups

Wherever possible, establish control groups to compare the outcomes of students receiving AI interventions to those getting traditional education (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019).

Guidelines for assessing the efficacy of AI-powered reading interventions-

- *Ethical Considerations in Evaluation:*
Equity and Access- Make sure that AI-powered solution is available to all students, regardless of financial position or geographical location. Address the digital gap challenges. Data breaches, unlawful access and the misuse of personal information, all may pose threats (Benedict, 2023).
- *Bias in AI Algorithms.*
Regularly assess AI algorithms for bias and take efforts to reduce any found biases that may harm particular learning groups (Benedict, 2023).

- *Transparency*
Maintain transparency about how AI systems make judgments and give learner, parents and educators detailed explanations of how the technology works (Benedict, 2023).
- *Student Autonomy*
Empower students by including them in learning decisions and ensuring that AI technologies complement, not replace, human teachers (Benedict, 2023).
- *Privacy and Data Security*
Prioritise the privacy and security of student information. Implement strong data protection procedures and acquire informed permission for data collection and usage (National Center for Education Statistics, 2020).
- *Accountability*
Create explicit lines of responsibility for the deployment and effectiveness of AI-powered instructional initiatives. Make sure that educators and developers are accountable for the ethical usage of AI (Benedict, 2023).

Examples of Successful Implementations

New Town High School sought to improve engagement and learning results in STEM disciplines, where students frequently struggle with difficult subjects and receive insufficient customised attention owing to high class numbers. The school introduced "Maths Pathway," an AI-driven platform that employs artificial intelligence to individualise maths instruction for each student's learning pace and style. The platform continually monitors student progress and modifies the content as needed, giving individualised modules and instant feedback to students. The implementation of Maths Pathway

resulted in a significant improvement in student mathematics performance, with more engagement and higher test scores recorded. Teachers were able to better detect and address individual learning gaps, resulting in more timely and relevant interventions (Digital Defynd, (2024) <https://digitaldefynd.com/IQ/ai-in-schools-case-studies/>)

Singapore's Ministry of Education (MOE) recognised the issue of offering tailored learning experiences to a varied student population. Traditional teaching approaches frequently appeal to the average learner, leaving faster students undisturbed while slower students struggle to keep up. Furthermore, grading and feedback procedures were time-consuming and sometimes lacking in individualisation. To address these difficulties, the MOE has developed a number of AI-driven solutions at various schools. Notable among these is the use of computerised English marking systems for elementary and secondary levels. These AI-powered systems are intended to evaluate open-ended, short-answer questions and essays, focusing on grammar, spelling and syntax problems while freeing teachers to focus on higher-level elements of marking such as fundamental terms, creative thinking and argumentation.

Teachers no longer have to work hard to grade assignment, gives them more time to design lessons and engage directly with students. Instead of wasting a lot of time on repetitive marking, teachers may now concentrate more on helping students improve their critical thinking and creative abilities. Because adaptive learning systems are designed to meet the specific needs of each student, they have shown to be beneficial in individual learning. While slower learners receive the extra time and resources they need to understand

complicated ideas without feeling pressured, fast learners may advance at a pace that keeps them interested. (Digital Defynd, (2024) <https://digitaldefynd.com/IQ/ai-in-schools-case-studies/>)

In order to promote an inclusive learning environment that meets the unique requirements of all students, including those with special needs, Japan has begun implementing AI technology. The LEAF system, which incorporates BookRoll and LogPalette, is a noteworthy application. BookRoll has features like text highlighting and note annotations that make it possible to browse digital learning resources. By analysing and visualising learning data from BookRoll, LogPalette offers insights into the comprehension and engagement of students. The use of AI systems like LEAF has made it possible to provide greater personalised learning opportunities. Teachers may gain a deeper understanding of each student's unique learning process and modify their teaching strategies accordingly by examining the extensive data gathered from students' interactions with digital content. Students with exceptional educational needs, who frequently need more specialised teaching methods, can benefit from this (Digital Defynd, (2024) <https://digitaldefynd.com/IQ/ai-in-schools-case-studies/>).

Also, in Nigeria, Lagos State Government, led by Governor Babajide Sanwo-Olu, initiated the EKO Excellence in Child Education and Learning (EKOEXCEL) initiative to transform the state's public education system. This government-funded project seeks to empower 500,000 students throughout 1,016 public elementary schools by offering extraordinary learning experiences. At the core of EKOEXCEL is the purpose of assisting teachers, who are

critical to improved learning outcomes. To do this, nearly 14,000 existing government teachers are getting re-training and utilizing technology to increase their teaching abilities and motivation. EKOEXCEL bridges the gap between developed and poor nations, delivering significant learning gains and moving Lagos State to educational levels equivalent to those of more developed, higher-income countries. The programme gives teachers the tools and training they require to succeed, such as access to digital resources and continual professional development.

Osun State's initiative in using digital platforms for learning in secondary schools during Governor Aregbesola's tenure was quite impressive. The state government launched the "Opon Imo" initiative, which aimed to provide digital tablets to secondary school students. This initiative was designed to enhance digital education and provide students with access to quality educational resources. The Opon Imo initiative demonstrated Governor Aregbesola's commitment to leveraging technology to improve education in Osun State. The initiative called 'opon imo' has the following features

- Digital Tablets: Distribution of digital tablets to secondary school students to facilitate e-learning.
- Computer Classrooms: Establishment of computer classrooms in schools to promote digital literacy.
- Teacher Training: Training for teachers to effectively integrate digital media into their teaching methods.

The integration of Artificial Intelligence (AI) in education has transformed learning environments globally. Examples from foreign

countries and Nigeria demonstrate AI's potential in promoting inclusive learning. The successes of these initiatives underscore the importance of embracing AI in education. As Nigeria continues to grapple with challenges in its education sector, lessons from these case studies can inform policy decisions and strategic investments in AI-powered education solutions

Challenges and Limitations

AI-powered instructional intervention holds great promise in addressing literacy challenges, but they also come with significant challenges and limitations such as:

1. Equity and Access:

One of the primary challenges is the digital divide, which refers to the gap between individuals who have access to modern information and communication technology and those who do not. This divide can limit the effectiveness of AI interventions, particularly in under-resourced schools or communities where students may lack reliable internet access or necessary devices. Socio-economic Barriers: Students from low-income families may not have the financial means to afford devices or stable internet connections. This disparity can make worse existing educational inequalities, as those who could benefit the most from AI interventions might be the least to access them.

Geographical Disparities: Rural areas often face additional challenges, such as poor internet infrastructure, which further limits access to AI-powered tools and this can lead to uneven educational outcomes between urban and rural

students (Van Deursen, & van Dijk, 2019).

2. Ethical Considerations

Data Privacy and Security: AI interventions often require the collection and analysis of vast amounts of personal data. Ensuring the privacy and security of this data is a significant ethical concern. There are risks associated with data breaches, unauthorised access and misuse of personal information.

Bias and Fairness: AI systems can perpetuate and even amplify existing biases if they are trained on biased data sets. This can lead to unfair treatment of certain groups of students. For instance, if the training data predominantly represents certain demographics, the AI might not perform as well for students from lessened backgrounds (Friedman, & Nissenbaum, 1996).

Transparency and Accountability: AI systems are often criticized for their "black box" nature, where the decision-making process is not transparent. This lack of transparency can lead to accountability issues, as it may be challenging to understand why a particular intervention is recommended or why a student received a specific outcome (Friedman, & Nissenbaum, 1996).

2, Pedagogical Limitations

Personalisation vs. Standardisation:

While AI can offer personalised learning experiences, there is a risk of over-reliance on standardised algorithms that may not fully account for individual learning styles, needs and contexts. Effective education often requires a nuanced approach that AI might not be able to provide (Zawacki-Richter, Marin, Bond, & Gouverneur, , 2019).

Teacher Role and Human Interaction:

AI interventions can sometimes undermine the crucial role of teachers

and the value of human interaction in education. Effective instructional interventions often rely on the relational and motivational aspects of teaching, which AI cannot replicate (Friedman, & Nissenbaum, 1996).

Long-term Dependency:

There is a concern that students might become overly reliant on AI tools, potentially hindering the development of independent learning skills. It is essential to strike a balance between using AI as a supportive tool and fostering self-sufficiency in students (Selwyn, 2019).

4. Implementation Challenges

Cost and Resources:

Implementing AI-powered interventions can be costly, requiring significant investment in technology, training for teachers and ongoing maintenance. Schools in economically disadvantaged areas may struggle to afford these costs, further widening the educational gap (Friedman, & Nissenbaum, 1996).

Professional Development:

Effective use of AI in education requires teachers to be adequately trained in using these tools. There may be resistance or a steep learning curve associated with integrating AI into existing teaching practices. Continuous professional development is necessary to ensure that teachers can effectively utilize AI interventions (Friedman, & Nissenbaum, 1996).

Scalability:

Ensuring that AI-powered instructional interventions scaled effectively across diverse educational settings is a significant challenge. Different schools and districts have varying needs, resources and constraints, making it difficult to implement a one-size-fits-all solution (MIT Sloan Teaching and Learning Technologies, 2024).

Conclusion

The use of AI-powered instructional interventions presents a transformative approach to supporting struggling readers by providing personalized, real-time feedback and adaptive learning experiences. These technologies have shown significant potential in improving reading fluency, comprehension, and overall student engagement. However, the successful implementation of AI interventions requires careful consideration of several factors, including strategic planning, professional development for educators, data privacy, and ethical concerns. While the benefits are substantial, challenges such as equity and access, ethical issues, pedagogical limitations, and implementation difficulties must be addressed to ensure the widespread efficacy of these interventions. Continuous research and development, along with targeted support for educators and students, are essential for maximizing the potential of AI in education. By addressing these challenges, AI-powered instructional interventions can play a crucial role in bridging the literacy gap and fostering an inclusive and effective learning environment for all students.

Recommendations

To effectively incorporate AI-powered instruction for struggling readers, a complete approach is required. Begin by offering specialized professional development for teachers so that they can properly use AI tools. Create specific, planned strategies for incorporating these resources into classroom practices, ensuring that they are consistent with established instructional practices. Then, addressing equity and access challenges is essential for ensuring that all students benefit from AI assistance as is implementing robust data privacy and

ethical norms that protect student information. Employ AI's ability to create individualized, adaptive learning experiences and encourage continuing research to assess and improve the target intervention. Assess their lasting benefits, their impact on reading abilities across several languages and different backgrounds and their efficacy when combined with human instruction. Investigate AI-driven assessments for reading skills and their relevance in tailored learning for students with challenges. Document and share successful case studies to promote broader adoption of AI powered instruction and illustrate the benefits of AI approach to learning.

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