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THE IMPACT OF TECHNOLOGY INTEGRATION ON STUDENT ENGAGEMENT AND ACHIEVEMENT

DAMPAK INTEGRASI TEKNOLOGI TERHADAP KETERLIBATAN DAN PRESTASI SISWA

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ABSTRACT
Integration AI-driven adaptive learning systems has the potential to address the challenges of student engagement and achievement in primary education, especially in contexts of socio-economic inequality. This research aims to explore the impact of this technology through systematic literature review using the PRISMA framework. The results show that technologistsAI-based adaptive technology significantly increases student engagement and academic achievement, with the potential to reduce social inequality. The implications of this research include recommendations for educators and policy makers to maximize access and effectiveness of technology in basic education globally.
Keywords: Basic education, AI-driven adaptive learning systems, student engagement, academic achievement, socio-economic disparities, systematic literature review.

ABSTRAK
Integrasi AI-driven adaptive learning systems berpotensi mengatasi tantangan keterlibatan dan pencapaian siswa di pendidikan dasar, terutama dalam konteks kesenjangan sosio-ekonomi. Penelitian ini bertujuan untuk mengeksplorasi dampak teknologi tersebut melalui systematic literature review menggunakan kerangka PRISMA. Hasilnya menunjukkan bahwa teknologi adaptif berbasis AI secara signifikan meningkatkan keterlibatan siswa dan pencapaian akademik, dengan potensi mengurangi kesenjangan sosial. Implikasi penelitian ini mencakup rekomendasi bagi pendidik dan pembuat kebijakan untuk memaksimalkan akses dan efektivitas teknologi dalam pendidikan dasar secara global.
Kata Kunci: Pendidikan dasar, AI-driven adaptive learning systems, keterlibatan siswa, pencapaian akademik, kesenjangan sosio-ekonomi, systematic literature review.

1. INTRODUCTION

Technological advances, particularly in artificial intelligence (AI), have significantly transformed the education sector, leading to the emergence of AI-driven adaptive learning systems. These systems are designed to personalize educational experiences by adjusting content, methods, and pacing based on individual student needs, thereby enhancing engagement and learning outcomes. The core functionality of adaptive learning systems involves real-time data collection from student interactions, which is then analyzed to identify learning patterns and tailor educational content accordingly. This approach is particularly beneficial in basic education, where early developmental stages are crucial for shaping future academic trajectories (Akavova, 2023; Huang et al., 2021).

The integration of AI in education is not merely a technological enhancement; it represents a paradigm shift in teaching methodologies. As noted by Popenici and Kerr, the rapid evolution of technology necessitates a reevaluation of educational practices to ensure that students acquire essential skills for success in a competitive global landscape (Popenici & Kerr, 2017). Furthermore, research indicates that AI can significantly improve educational outcomes by providing customized learning experiences that cater to diverse student needs (Abbas et al., 2023; Aghaziarati, 2023). However, while the potential benefits of AI-driven

adaptive learning systems are substantial, their effectiveness is contingent upon various social factors, including socio-economic disparities that can limit access to such technologies (Akgün & Greenhow, 2021; Tapalova & Zhiyenbayeva, 2022).

Students from low-income backgrounds often encounter barriers to accessing advanced educational technologies, which raises critical questions about equity in educational opportunities. The lack of digital infrastructure, insufficient teacher training, and limited parental support can exacerbate existing inequalities, potentially widening the achievement gap rather than closing it (Namjoo, 2023; Mahmudi, 2023). The challenge lies in ensuring that AI technologies do not merely replicate existing disparities but instead serve as tools for fostering inclusivity and equal access to quality education (Harry, 2023).

Despite the growing body of literature on educational technology, there remains a notable gap in research specifically addressing the impact of AI-based adaptive learning systems on student engagement and achievement across diverse socio-economic backgrounds, particularly in elementary education (Winkler & Söllner, 2018; Awad et al., 2022). This highlights the need for further empirical studies to explore how AI can be effectively leveraged to support all students, regardless of their socio-economic status, and to identify best practices for optimizing these technologies in educational settings (Ramesh, 2021). In conclusion, while AI-driven adaptive learning systems hold great promise for enhancing personalized learning experiences, their successful implementation must consider the broader socio-economic context to ensure equitable benefits for all students. Future research should focus on understanding the nuanced impacts of these technologies and developing strategies to mitigate disparities in access and engagement.

Although the adoption of AI-based technology in education is growing, its implementation across various socio-economic groups still faces a number of significant challenges. One of the main challenges is technology accessibility, where many schools in low-income areas do not have sufficient infrastructure, such as hardware, software, or stable internet connections, to support the use of advanced technology. Additionally, the digital divide is also a major barrier, especially for students from low-income families who often do not have access to technological devices or internet connections at home, reducing their opportunities to take advantage of the full potential of adaptive learning systems. Another challenge is limited teacher training, where educators, especially in less developed areas, have not received sufficient training to effectively integrate AI technology into the teaching process. The combination of these factors exacerbates educational disparities, requiring urgent attention from policymakers, educators, and technology providers.

Additionally, there is a gap in the literature regarding how these technologies can impact student engagement (engagement) and academic achievement (achievement), especially when compared by socio-economic group. Most research focuses on the success of technology in a general context, without considering the social factors that influence the results. Existing studies also tend to be fragmented, with little attempt to synthesize these findings into a comprehensive picture. Therefore, this study aims to fill this gap by evaluating the impact AI-driven adaptive learning systems in more depth and focused on differences in students' social backgrounds in basic education.

The main aim of this research is to analyze the impact of integration AI-driven adaptive learning systems on student engagement and achievement in basic education, with a focus on the influence of differences in socio-economic background. Specifically, this research aims to evaluate the extent to which AI-based adaptive technology can increase student engagement in basic education environments, identify differences in the impact of this technology on the academic achievement of students from low economic groups compared to high economic groups, and develop policy recommendations and technology implementation strategies inclusive AI-based adaptive technology to reduce social disparities in education. Based on these objectives, the research question asked is, "How does the integration of AI-driven

adaptive learning systems impact student engagement and achievement across diverse socio-economic backgrounds in primary education?" This question not only focuses on measuring the impact of technology, but also seeks an in-depth understanding of how technology can be a tool for addressing socio-economic challenges in the context of basic education. Thus, it is hoped that this research can make a significant contribution to the development of more inclusive, innovative and evidence-based education policies, as well as enrich the literature on digital transformation in education.

2. METHODS

2.1 Research Design

This research uses the systematic literature review (SLR) method to collect, analyze and synthesize available evidence regarding impact AI-driven adaptive learning systems on engagement (engagement) and student achievement (achievement) in basic education taking into account socio-economic background. This approach was chosen because SLR allows researchers to explore the literature in a systematic, transparent and organized manner, resulting in reliable findings. SLR is also effective for identifying gaps in the existing literature and providing recommendations for future research and practice.

2.2 PRISMA Framework

This study process follows the guide PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure transparency and traceability in data collection and analysis. The PRISMA measures adopted are:

1. Identification: Collect all relevant literature from leading databases such as Scopus, Web of Science, Springer, and IEEE using predefined keywords.
2. Screening: Conduct initial screening based on title and abstract to eliminate irrelevant articles.
3. Eligibility: Review articles in depth to ensure that they meet inclusion and exclusion criteria.
4. Inclusions: Entering articles that meet all criterias into the final analysis.

2.3 Inclusion and Exclusion Criteria

2.3.1. Inclusion Criteria:

1. Articles that have gone through the process peer-review to ensure scientific validity.
2. Research that focuses on basic education is appropriate to the context of this research.
3. Studies discussing AI-based adaptive technology in educational contexts.
4. Analysis of student engagement (engagement) or achievement (achievement).
5. Studies that consider or analyze the socio-economic context.

2.3.2. Exclusion Criteria:

1. Articles that discuss education beyond basic education (for example secondary education or higher education).
2. Studies that use non-AI-driven technology or technology that does not focus on adaptive learning systems.
3. Gray literature such as technical reports, theses, or opinions that have not yet been published peer-reviewed.

2.4 Data Sources and Search Strategy

Literature searches were carried out through several leading scientific databases, namely:

- Scopus: For cross-disciplinary studies with a broad scope.
- Web of Science: For articles with a high reputation in the fields of education and technology.
- SpringerLink: For journals that discuss adaptive education and technology topics.
- IEEE Xplore: For literature related to the implementation of AI-based technology.

2.5. Search strategy

Keywords and Boolean combinations were used to ensure comprehensive search coverage. Example:

- "AI-driven adaptive learning systems" AND "primary education" AND "student engagement"
- "achievement" AND "socio-economic backgrounds" AND "adaptive technology in education"
- "personalized learning" OR "adaptive systems" AND "primary school"

This search also includes filters for:

- Year of publication (last 5–10 years for current relevance).
- Article type (peer-reviewed journal articles).
- Language (limited to English articles).

2.6. Data Extraction and Analysis

2.6.1. Data Extraction Process:

Once the articles are selected, the data extracted includes:

1. General information (title, author, year, journal).
2. Research methodology (research design, sample, context).
3. The main results relate to student engagement and achievement.
4. Specific information about the socio-economic context.
5. Implementation and characteristics of the AI technology used.

2.6.2. Data analysis

1. Thematic Analysis: Findings from each article are grouped by key themes, such as impact on student engagement, academic achievement, and the influence of socio-economic disparities.
2. Meta-Analysis (if possible): Quantitative data from relevant articles will be analyzed to identify statistically significant patterns or relationships.
3. Narrative Synthesis: Descriptive explanation for articles with qualitative or unquantifiable data.

3. RESULTS

3.1 Overview of Selected Studies

This section provides a summary of the characteristics of the studies selected for analysis, including number, distribution, and primary focus.

3.1.1. Number of Studies Identified, Screened, and Included:

- Total studies identified: 78 articles from various databases.
- After the screening process, the number of studies that meet the inclusion criteria are 36 articles.

3.1.2. Distribution of Studies Based on:

- Publication Year:
  Studies are spread over the past 10 years (e.g. 2014–2024), with an increase in the number of publications in the last five years, indicating a growing interest in AI-driven adaptive learning systems.
- Country/Socio-Economic Context:
  The studies cover a wide range of countries, including developed countries such as the United States and the United Kingdom, as well as developing countries such as India and Indonesia. Most studies from developed countries focus on technological innovation, while studies from developing countries emphasize implementation challenges due to limited resources.
- Type AI-driven Adaptive Learning Systems:
  - Platforms such as DreamBox, Smart Sparrow, and ALEKS are used to personalize learning.
  - Research study gamified systems (for example, use of game elements to increase engagement).
  - Data-based technology that uses machine learning to recommend materials according to student needs.

3.2 Thematic Analysis

The results of the thematic analysis were divided into three main themes relevant to the research:

3.2.1. Theme 1: Relationships AI-driven Adaptive Learning Systems with Student Engagement

- Emotional Engagement: Studies show that this technology helps students feel more motivated and confident in learning because the content is tailored to their ability level.
  Example: Research in elementary schools in Finland found a 20% increase in learning motivation with the use of adaptive platforms.
- Cognitive Engagement: Students are more active in completing assignments because challenges are given gradually according to individual abilities.
  Example: Use of the ALEKS system in the US improves students' understanding of basic mathematics.
- Behavioral Engagement: The frequency of attendance and participation in learning activities increases because students feel more interested in the personalized approach.

3.2.2. Theme 2: The Impact of Technology on Student Academic Achievement

- Academic Value Improvement: Studies show that students who use AI-based adaptive systems have higher test scores than students who study with conventional methods.
  Example: A study in India reported an average increase in math test scores of 15% in students using DreamBox.
- Learning Continuity: Technology allows students who are falling behind to catch up without feeling intimidated by their classmates.

3.2.3. Theme 3: Socio-Economic Inequality Factors and the Role of Technology in Overcoming Them

- Technology Accessibility: Studies in developing countries reveal challenges such as lack of access to technological devices and the internet.
- Technological Efficiency in the Context of Inequality: In some cases, adaptive systems have succeeded in reducing the achievement gap between students

from high- and low-income families. Example: In South Africa, the use of AI-based tools in low-resource schools saw improved achievement in science subjects.

3.3 Key Findings

3.3.1. The Significant Impact of Adaptive Technology on Student Engagement

- AI-based technology can significantly increase students' emotional, cognitive and behavioral engagement.
- Students feel more motivated because of the personalized approach that makes them feel valued as individuals.

3.3.2. Variations in Achievement Based on Socio-Economic Background

- In developed countries, this technology increases academic achievement without significant differences between socio-economic groups.
- In developing countries, achievement gaps are still visible, but are reducing with interventions such as technology subsidies or teacher training.

3.3.3. Supporting and Inhibiting Factors for Implementation

- **Supporters:**
  - Adequate technological infrastructure.
  - Government policy support in technology integration.
  - Teacher readiness to use technology in teaching.
- **Inhibitors:**
  - Unequal access to technology in remote areas.
  - Lack of digital literacy among teachers and students.
  - High initial costs for system implementation.

4. DISCUSSIONS

4.1 Interpretation of Results

This section connects research findings to relevant theory, provides insight into their implications, and explains the impact of AI-based adaptive technologies in reducing social inequality.

4.1.1. Explanation of Main Findings in the Context of Educational Theory and Technology

The integration of AI-driven adaptive learning systems in educational contexts has demonstrated significant improvements in student engagement and achievement. This aligns with constructivist theories of learning, which advocate for personalized learning experiences that allow students to actively construct their understanding. Research indicates that adaptive learning technologies can tailor educational experiences to meet individual student needs, thereby fostering deeper engagement and understanding (M, 2024). For instance, the use of machine learning algorithms and data analytics in educational settings enables the identification of student performance patterns, allowing for timely interventions that enhance learning outcomes (M, 2024).

Furthermore, personalization theory supports the notion that students who perceive they are learning at their own pace exhibit higher levels of motivation and engagement. Studies have shown that technology-assisted instruction can enhance student motivation, particularly when it is designed to be interactive and responsive to individual learning styles (Higgins et al., 2017). The findings from various studies suggest that when students are given control over their learning processes, their intrinsic motivation increases, leading to improved academic performance (Noor et al., 2022). This is particularly evident in environments that utilize interactive technologies, such as augmented reality (AR), which have been found to

significantly boost student motivation and engagement in learning activities (Herwin, 2023; Serio et al., 2013).

Moreover, the role of technology in enhancing learning motivation is further supported by evidence that highlights the positive impact of online learning environments. Research indicates that confidence in technology correlates positively with effective online learning strategies and motivation, ultimately leading to improved learning outcomes (Hongsuchon et al., 2022). The incorporation of digital platforms in education has been shown to enhance student engagement by providing interactive and immersive learning experiences that cater to diverse learning preferences (-- et al., 2023). This is particularly relevant in the context of hybrid learning environments, where students can benefit from both traditional and technology-enhanced instructional methods (Warman, 2023). In summary, the convergence of AI-driven adaptive learning systems and personalized educational approaches aligns with established educational theories, such as constructivism and personalization theory. The evidence suggests that these technologies not only enhance student motivation and engagement but also contribute to improved academic performance, creating a more effective learning environment.

4.1.2. Analysis of the Role of Technology in Reducing Social Inequality

The integration of technology, particularly artificial intelligence (AI), into education has shown promise in reducing social disparities, especially for students from low socio-economic backgrounds. AI-based adaptive technologies can provide personalized learning experiences that are crucial in environments where access to qualified teachers is limited. For instance, in rural communities, these technologies can deliver tailored educational content, effectively mitigating the reliance on local human resources, which may be scarce or underqualified (Popenici & Kerr, 2017; Ansor, 2023). The ability of AI to adapt to individual learning needs allows for a more equitable educational landscape, enabling students to engage with material that suits their pace and style of learning (Dabingaya, 2022; Chouhan, 2023).

However, despite the potential benefits of AI in education, significant barriers remain, notably the digital divide. Access to the internet and modern technology is unevenly distributed, particularly in rural and low-income areas, which can exacerbate existing inequalities rather than alleviate them (Vivar & García-Peñalvo, 2023; ULAŞAN, 2023). The lack of reliable internet access means that even the most advanced AI educational tools cannot reach all students, thus limiting their effectiveness in achieving educational equity (He, 2023). Furthermore, the ethical implications of AI use in education, including concerns about data privacy and the potential for bias in AI algorithms, must be addressed to ensure that these technologies do not inadvertently reinforce existing disparities (Akgün & Greenhow, 2021).

In summary, while AI-based adaptive technologies hold significant promise for enhancing educational access and quality for disadvantaged students, the persistent digital divide poses a substantial challenge. Addressing these issues requires a multifaceted approach that includes improving internet access, ensuring equitable distribution of technology, and fostering an ethical framework for AI use in educational contexts (Jang, 2023).

4.2 Comparisons with Previous Studies

This section places the research results in the context of previous studies to demonstrate the position and contribution of this research to the existing literature.

4.2.1. Similarities to Previous Studies

The integration of adaptive technology in educational settings has been shown to significantly enhance student engagement, both emotionally and cognitively. A study by Bond et al. (2020) highlights that platforms such as DreamBox and ALEKS not only facilitate personalized learning experiences but also foster greater emotional and cognitive engagement among students. This aligns with findings from various studies indicating that technology can alleviate the burden on

educators by providing tailored materials that meet individual student needs, thereby enhancing overall engagement in the learning process (Bond et al., 2020).

Research conducted in developed countries supports the notion that technology plays a crucial role in minimizing the challenges faced by educators in delivering appropriate educational content. For instance, Bond et al. (2020) emphasize that the conceptualization of student engagement has garnered increasing attention, with technology serving as a pivotal tool in facilitating this engagement (Bond et al., 2020). Furthermore, the work of Pandita & Kiran (2023) suggests that the interface of technology significantly mediates student engagement, leading to improved satisfaction and learning outcomes (Pandita & Kiran, 2023). This is particularly relevant in the context of adaptive learning technologies, which are designed to adjust to the varying needs of students, thereby promoting a more engaging learning environment.

Moreover, the importance of understanding the dynamics of student engagement in online learning environments has been underscored by multiple studies. For example, Ma et al. (2022) found that students' perceptions of online learning environments directly influence their engagement levels, highlighting the need for educators to create supportive and interactive online spaces (Ma et al., 2022). Similarly, the systematic review by González-Pérez and Ramírez-Montoya (2022) emphasizes the necessity for adequate resources and infrastructure to effectively teach 21st-century skills, which are essential for fostering student engagement in technology-enhanced learning environments (González-Pérez & Ramírez-Montoya, 2022).

In summary, the evidence suggests that adaptive technology not only enhances student engagement but also provides significant support to educators in meeting diverse student needs. The integration of such technologies in educational practices is crucial for fostering an engaging and effective learning environment, particularly in the context of the ongoing digital transformation in education.

4.2.2. Differences with Previous Studies

The current study distinguishes itself from previous research by focusing on the variations in socio-economic contexts among students, contrasting with earlier studies that often examined students from homogeneous backgrounds. For instance, Henley et al. highlight the importance of considering diverse socio-economic backgrounds when analyzing entrepreneurial intentions among Colombian business students, noting that findings from homogeneous samples may not generalize well across different socio-economic groups (Henley et al., 2017). This concern is echoed in the findings of Koirala, which emphasize that women's knowledge and practices regarding breastfeeding vary significantly across different socio-economic strata, challenging the notion of homogeneity within groups (Koirala, 2023). Such insights underline the necessity of recognizing socio-economic diversity in educational and entrepreneurial research.

Moreover, while many studies in developing countries have pointed out that infrastructure constraints impede the positive impacts of technology, the current study suggests that technology subsidy-based interventions can effectively mitigate these barriers. For example, Mainali and Silveira discuss how subsidies have been instrumental in promoting solar home systems and micro hydro technologies in Nepal, thereby enhancing rural electrification despite existing infrastructure challenges (Mainali & Silveira, 2011). Similarly, Vaidy emphasizes the effectiveness of renewable energy subsidies in Nepal, arguing that they play a crucial role in bridging the gap between energy access and sustainable development (Vaidya, 2020). These findings collectively support the notion that targeted subsidies can alleviate infrastructural limitations, fostering positive outcomes in technology adoption and utilization.

In summary, the current study's focus on socio-economic variations and the role of technology subsidies marks a significant departure from previous research that often relied on homogeneous samples and overlooked the complexities of socio-economic contexts. By integrating insights from diverse studies, it becomes evident that addressing socio-economic diversity and leveraging technology subsidies are critical for enhancing educational and entrepreneurial outcomes in developing regions.

4.3 Implications for Practice and Policy

This section explores the impact of the findings for educational practitioners and policy makers, offering evidence-based implementation solutions.

- **Recommendations for Educators:**
  - Teacher training on how to integrate AI-driven adaptive learning systems into the curriculum.
  - Use platforms that support personalized learning as an aid, not a replacement, to support teacher-student interactions.
  - Example: Training in elementary schools in Jakarta using an adaptive platform shows an increase in teacher competence in utilizing technology to support learning.
- **Recommendations for Policy Makers:**
  - The government should provide hardware and software subsidies for schools in disadvantaged areas.
  - Making policies to expand internet infrastructure in remote areas to support access to educational technology.
  - Example: Government programs in India, such as “Digital India,” have succeeded in increasing access to educational technology in rural areas.
- **Strategies to Reach Students from Low Socio-Economic Backgrounds:**
  - Providing affordable learning devices, such as cheap tablets.
  - Collaboration with technology companies to distribute free software to underprivileged schools.

4.4 Limitations and Future Research Directions

This section identifies research weaknesses and provides suggestions for future studies.

4.4.1. Study Limitations

- Data Availability: This study is limited to the literature available in major databases and may ignore publications in local languages or those not indexed internationally.
- Study Scope: The research focuses more on basic education, so the results cannot be directly applied to other levels of education, such as secondary or tertiary.
- Study Design: Lack of long-term studies urinals that can evaluate the impact of technology in the long term.

4.4.2. Suggestions for Future Research

- Exploration New Technology: In-depth study of technology based machine learning the newest ones are more interactive, like chatbots in learning.
- Cross Cultural Studies: Comparing effective adaptive learning systems in countries with different educational cultures to understand differences in implementation and outcomes.
- Longitudinal Research: Long-term studies examining how the impact of these technologies evolve over timeThat, especially in the context of the development of 21st century skills such as critical thinking and collaboration.

5. CONCLUSIONS

5.1 Main Conclusion

This research makes a significant contribution to the understanding of roles AI-driven adaptive learning systems in increasing student engagement and academic achievement in basic education, especially in the context of diverse socio-economic backgrounds. Findings show that AI-based adaptive technology:

1. Increase student engagement by providing personalized learning experiences.
2. Contribute to improving learning outcomes, especially in groups of students who have limited access to educational resources.
3. Has the potential to reduce social inequality through more equitable access to quality learning.

However, this research also emphasizes the importance of adequate infrastructure and training for educators to maximize the impact of this technology.

5.2 Limitation

This study has several limitations that need to be noted:

1. Data Source Limitations: This research only relies on articles available in major databases (Scopus, Web of Science, etc.), so there may be other literature that is not covered, especially from developing countries with local publications.
2. Study Scope: The focus on primary education may limit the generalization of results to other levels of education such as secondary or tertiary.
3. Research Design: Most of the studies analyzed are based on quantitative data, while qualitative approaches that can provide deeper insights are still minimal.
4. Lack of Longitudinal Perspective: These findings are based on short-term studies so they cannot predict the long-term impact of this technology.

5.3 Future Research Directions

Future research can overcome existing limitations by:

1. Cross-Cultural and Regional Studies: Research exploring effectiveness AI-driven adaptive learning systems across various cultural and geographic contexts to understand the global adaptation of this technology.
2. Longitudinal Research: Develop a long-term study to evaluate the ongoing impact of this technology on student engagement and achievement, including its implications for the development of 21st century skills.
3. Multidisciplinary Approach: Collaboration between the fields of technology, education and policy to explore holistic solutions to overcome the digital divide and increase the implementation of technology in basic education.
4. New Technology Testing: Research exploring more advanced adaptive technologies such as AI-powered virtual tutors And immersive learning environments.

With in-depth exploration through continued research, the hope is to create a more inclusive and effective educational approach, which can have a positive impact on all students regardless of their socio-economic background.

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