International Journal of Recent Research and Review, Special Issue 2, 2026

ISSN 2277 – 8322

A Comprehensive Assessment of AI-Based Learning Style Recognition in Adaptive Higher Education Systems

Priyanka Bhasin

Assistant Professor, Department of Computer Science Engineering, Apex University, Jaipur, Rajasthan, India

bhasinpriyanka65@gmail.com

Abstract: Artificial Intelligence (AI) has significantly transformed modern educational systems, particularly in higher education, by enabling personalized and adaptive learning environments. This study presents a comprehensive assessment of AI-based learning style recognition in adaptive higher education systems. The research examines how AI techniques can identify individual learning preferences and dynamically adjust instructional content, assessment strategies, and learning pathways to enhance student engagement and academic performance. The primary objective is to analyze the role of AI in recognizing diverse learning styles and integrating them into adaptive learning frameworks for improved teaching and learning outcomes. A qualitative research methodology, based on audience analysis within higher education contexts, is employed to evaluate the effectiveness of AI-driven adaptive systems. The findings highlight that AI-based learning style recognition enables more efficient knowledge delivery, supports individualized learning experiences, and improves evaluation and grading processes. Furthermore, the study emphasizes the importance of incorporating ethical considerations, such as data privacy, fairness, and transparency, in the deployment of AI technologies in education. The results indicate that integrating AI-based adaptive learning systems into higher education can equip students with relevant skills for future careers while enhancing overall educational efficiency. The study concludes that higher education institutions must actively adopt and implement AI-driven adaptive learning solutions to meet the evolving demands of modern education and workforce readiness.

Keywords: Artificial Intelligence, Adaptive Learning Systems, Learning Style Recognition, Higher Education, Personalized Learning, Educational Technology, Machine Learning, Student Engagement, AI in Education.

1. Introduction

ISSN 2277 – 8322

Artificial Intelligence (AI), a broad and rapidly evolving area of computer science, aims to develop intelligent systems capable of performing tasks that typically require human cognition, such as learning, reasoning, problem-solving, and decision-making. Over the past decade, AI has emerged as a transformative technology across multiple domains, including healthcare, finance, transportation, and education. Common applications of AI include conversational agents, email spam filtering systems, recommendation engines, virtual assistants, and autonomous vehicles. These applications demonstrate the growing capability of AI systems to replicate and, in some cases, surpass human performance in specific tasks [1], [2].

In recent years, AI has gained significant momentum globally, particularly during the COVID-19 pandemic, when digital transformation accelerated across sectors. In the field of education, AI played a crucial role in ensuring the continuity of learning by enabling online education, automated assessments, and intelligent tutoring systems. Organizations such as the UNESCO highlighted the importance of AI in supporting remote learning, maintaining educational access, and assisting institutions in adapting to unprecedented disruptions. AI-driven tools helped educators and learners interact effectively in virtual environments, thereby sustaining educational systems during challenging times.

Higher education, in particular, has witnessed a growing integration of AI technologies to enhance teaching, learning, and administrative processes. AI enables personalized learning experiences by analyzing student behavior, preferences, and performance, thereby allowing institutions to tailor content and assessment methods according to individual needs [3]. Digital platforms such as Google Scholar, YouTube, and various online learning management systems have significantly improved access to knowledge and research resources. Additionally, AI-powered systems are widely used for automating routine tasks such as grading, content recommendation, and communication, improving efficiency within educational institutions [2], [4].

Despite its numerous advantages, AI also raises important concerns and challenges. While AI systems are highly effective in performing specific, well-defined tasks often referred to as “narrow” or “brittle” AI they still lack the general intelligence and adaptability of human cognition [5], [6]. Moreover, the increasing reliance on AI in education necessitates careful consideration of ethical issues such as data privacy, algorithmic bias, transparency, and accountability. Prominent thinkers such as Stephen Hawking,

ISSN 2277 – 8322

Elon Musk, and Bill Gates have expressed both optimism and caution regarding the future impact of AI, emphasizing the need for responsible development and deployment [7].

Furthermore, AI has the potential to be both beneficial and disruptive, depending on its application and governance. While it can enhance learning outcomes, improve accessibility, and equip students with future-ready skills, it may also lead to challenges such as reduced human interaction, over-reliance on automation, and potential job displacement [2]. Therefore, it is essential for higher education institutions to strategically integrate AI into their curricula while ensuring ethical and responsible usage.

This study aims to examine the impact of AI on teaching and learning processes in higher education by drawing on existing research, as well as the perspectives and experiences of stakeholders. It seeks to explore how AI influences instructional methods, student engagement, evaluation systems, and overall academic performance. By critically analyzing both the opportunities and challenges associated with AI, the study contributes to a deeper understanding of its role in shaping the future of higher education.

2. AI-Based Learning Style Recognition in Adaptive Higher Education Systems

The integration of Artificial Intelligence (AI) into adaptive learning systems has significantly enhanced the capability of higher education institutions to deliver personalized learning experiences. One of the key aspects of adaptive learning is the identification and utilization of individual learning styles, which allows educational content to be tailored according to students' preferences, cognitive abilities, and learning behaviors. AI-based learning style recognition plays a crucial role in achieving this personalization by analyzing large volumes of student data and dynamically adjusting instructional strategies.

A. Concept of Learning Styles in Education

Learning styles refer to the preferred ways in which individuals acquire, process, and retain information. Traditional models categorize learners based on visual, auditory, and kinesthetic preferences, among others. While these models provide a theoretical foundation, their practical implementation in large-scale educational environments has been challenging. AI overcomes these limitations by enabling data-driven identification of learning patterns rather than relying solely on predefined classifications.

B. Role of Artificial Intelligence in Learning Style Recognition

AI techniques, including machine learning, deep learning, and natural language

ISSN 2277 – 8322

processing, are widely used to identify learning styles based on student interactions with digital platforms. These systems collect data from various sources such as:

- Learning Management Systems (LMS)
- Online assessments and quizzes
- Interaction logs (clicks, time spent, navigation patterns)
- Discussion forums and textual inputs

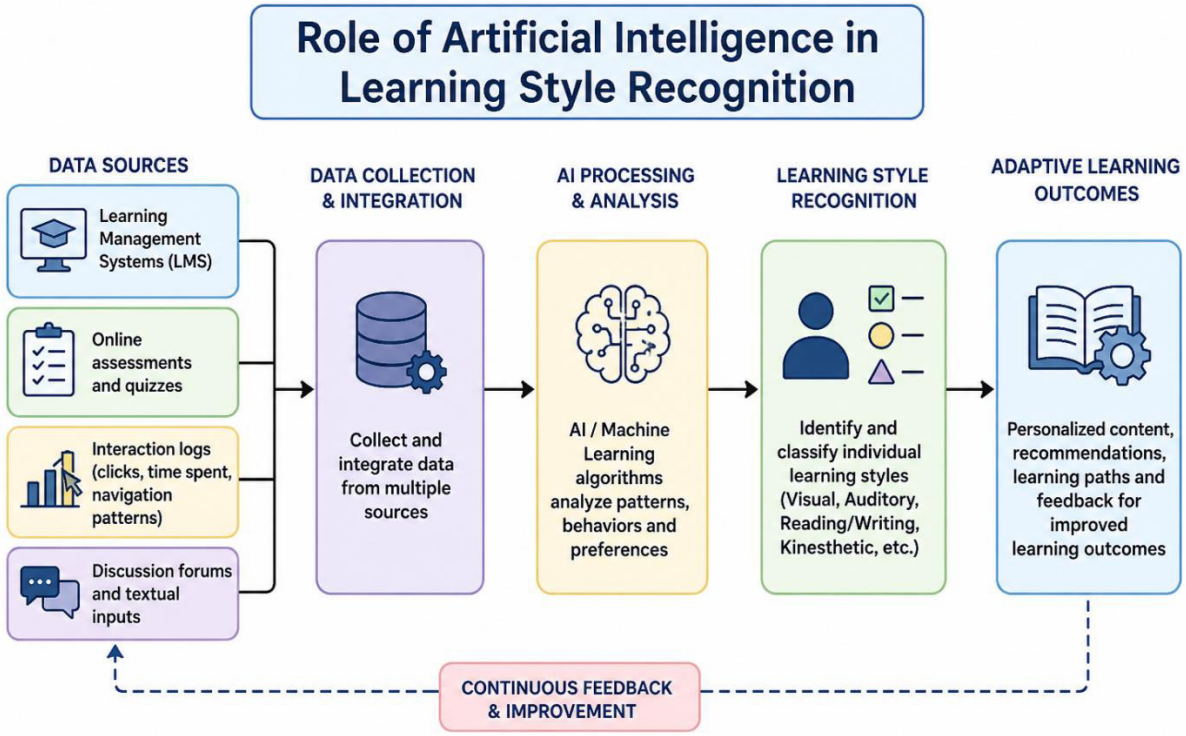

Figure 1: Role of Artificial Intelligence in Learning Style Recognition

By analyzing these data points, AI models can detect behavioral patterns and infer learning preferences. For example, a student who frequently engages with video content may be categorized as a visual learner, while one who performs better with interactive simulations may exhibit kinesthetic learning characteristics.

Advanced models such as neural networks and clustering algorithms enable continuous learning and adaptation, allowing systems to refine their predictions over time. This dynamic approach ensures that learning style recognition remains accurate and relevant.

C. Adaptive Learning Systems and Personalization

Adaptive learning systems utilize the insights gained from AI-based learning style recognition to modify instructional content in real time. These systems adjust various elements of the learning process, including:

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- Content format (text, video, interactive modules)
- Difficulty level and pacing
- Assessment methods and feedback mechanisms
- Learning pathways and recommendations

Such personalization improves student engagement, enhances knowledge retention, and supports diverse learning needs. It also enables educators to monitor student progress more effectively and provide targeted interventions when necessary.

D. Benefits in Higher Education

The application of AI-based learning style recognition in higher education offers several advantages as shown in the figure 2.

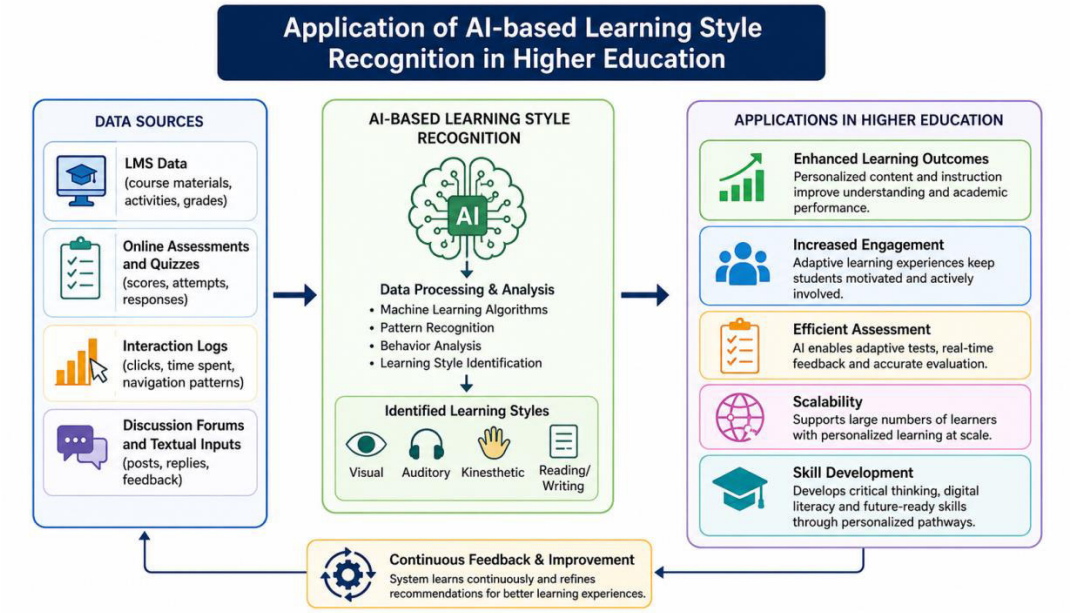

Figure 2: Application of AI-based Learning Style Recognition in Higher Education

- **Enhanced Learning Outcomes:** Tailored instruction improves comprehension and academic performance.
- **Increased Engagement:** Personalized content keeps students motivated and actively involved.
- **Efficient Assessment:** AI enables automated and adaptive evaluation methods.
- **Scalability:** Large numbers of students can be supported without compromising personalization.
- **Skill Development:** Students acquire self-paced and technology-driven learning skills relevant to modern careers.

E. Challenges and Limitations

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Despite its potential, AI-based learning style recognition faces several challenges as shown in figure 3.

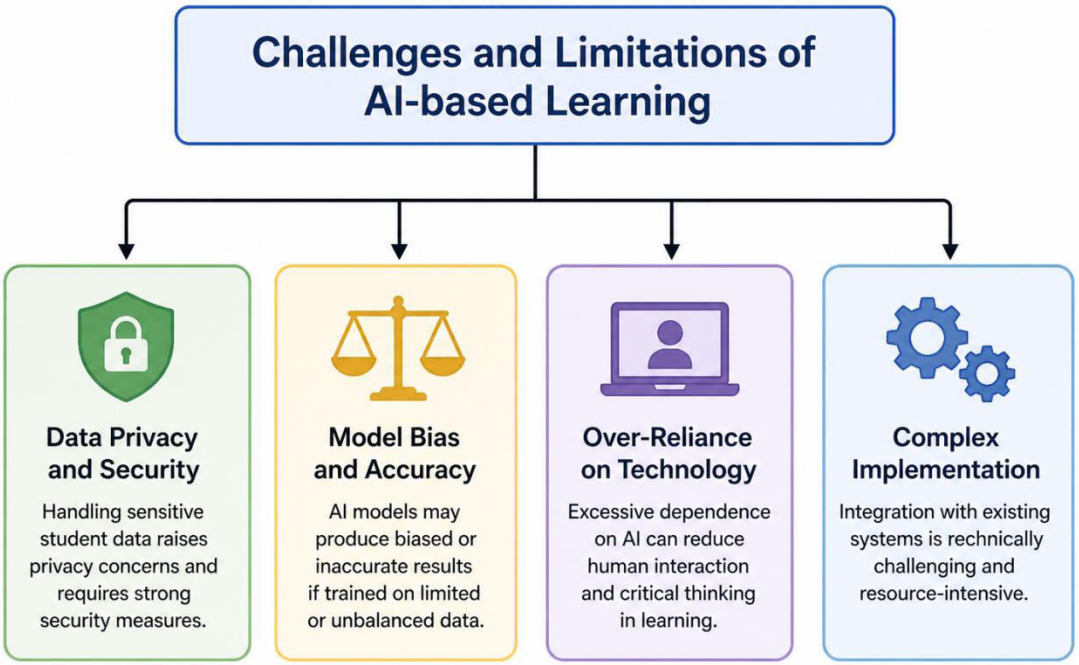

Figure 3: Challenges and Limitations of AI-based Learning

- **Data Privacy and Security:** Handling sensitive student data requires strict ethical and legal compliance.
- **Model Bias and Accuracy:** AI systems may produce biased or inaccurate predictions if trained on limited or unbalanced datasets.
- **Over-Reliance on Technology:** Excessive dependence on AI may reduce human interaction in education.
- **Complex Implementation:** Integration with existing educational systems can be technically demanding and costly.

F. Ethical Considerations

The use of AI in education raises important ethical concerns. Institutions must ensure transparency in AI algorithms, fairness in decision-making, and protection of student data. Additionally, students should be informed about how their data is used and how AI influences their learning experience. Ethical AI implementation is essential for building trust and ensuring the responsible use of technology in education.

3. Literature Review

Recent advancements in Artificial Intelligence (AI) and adaptive learning technologies have significantly transformed higher education by enabling personalized, efficient, and scalable learning environments. Several studies have

ISSN 2277 – 8322

explored the role of AI in learning style recognition, adaptive systems, and intelligent educational platforms.

Yuensook et al. (2026) investigated the implementation and impact of AI-driven adaptive learning systems in higher education through a PRISMA-based systematic review of 15 empirical studies. Their findings indicate a rapid increase in research output after 2022, with machine learning, natural language processing, and hybrid systems being the most commonly used AI technologies. The study reports improvements in academic performance (15–25%) and learner engagement (up to 40%). Despite these benefits, challenges such as infrastructure limitations, faculty readiness, ethical concerns, and limited adoption in non-STEM disciplines persist.

Luo et al. (2025) conducted a systematic review of 63 peer-reviewed articles to evaluate the design and impact of AI-based learning tools in higher education. The study categorizes AI applications into three major roles: assessment and evaluation, personalized feedback, and intelligent tutoring systems. While AI tools show significant improvements in cognitive and affective learning outcomes, their effectiveness in developing higher-order cognitive skills remains inconsistent. The authors also emphasize the need for better design frameworks and implementation strategies.

Hariyanto et al. (2025) examined AI-powered adaptive learning technologies through a large-scale systematic review of 142 studies (2015–2025). Their research highlights the use of supervised, unsupervised, and reinforcement learning techniques in personalized education. Multimodal approaches integrating behavioral, affective, and biometric data were found to enhance learning personalization significantly. However, challenges such as model interpretability, data privacy, scalability, and ethical considerations remain critical barriers to widespread adoption.

Strielkowski et al. (2024) conducted a comprehensive bibliometric analysis of 3518 publications (1990–2024) using VOSviewer to examine the evolution of AI-driven adaptive learning. Their study highlights a substantial growth in research, especially after the COVID-19 pandemic, which accelerated digital transformation in education. The findings emphasize that adaptive learning technologies enhance personalization by catering to individual learning styles and abilities, thereby contributing to sustainable development through improved educational outcomes.

Essa et al. (2023) performed a systematic literature review focusing on AI-based

personalized adaptive learning systems. The study analyzed works published between 2015 and 2022 and identified key trends in learning style (LS) detection using machine learning techniques. The authors reported a growing adoption of artificial neural networks for automatic and dynamic learning style identification. However, they noted limited comparative studies on deep learning models, suggesting the need for further research in evaluating advanced AI techniques for improved adaptability and performance.

Kabudi et al. (2021) presented a systematic mapping study of AI-enabled adaptive learning systems by analyzing 147 publications from 2014 to 2020. Their work identifies various AI-based learning interventions and highlights the growing interest in intelligent learning platforms. The study also points out the gap between research and practical implementation, noting that relatively few systems are designed to address real-world student challenges effectively.

The reviewed studies collectively demonstrate that AI-based adaptive learning systems have evolved from traditional static models to highly dynamic and personalized frameworks. Machine learning and deep learning techniques play a crucial role in identifying learning styles and improving educational outcomes. Despite notable advancements, several challenges persist, including data privacy concerns, lack of interpretability, infrastructure limitations, and the need for robust comparative studies of advanced models.

This review highlights the necessity for developing hybrid, scalable, and interpretable AI-based learning systems that can effectively address real-world educational challenges while ensuring ethical and inclusive implementation in higher education.

4. Conclusion

This study highlights the significant role of AI-based learning style recognition in enhancing adaptive learning systems in higher education. AI enables personalized learning by analyzing student behavior and dynamically adjusting content, which improves engagement, learning outcomes, and assessment efficiency. However, challenges such as data privacy, model bias, system complexity, and ethical concerns must be carefully addressed. Despite these limitations, AI-driven adaptive learning offers a scalable and effective solution for modern education. Overall, the integration of AI in higher education has strong potential to create intelligent, personalized, and future-ready learning environments, provided it is implemented responsibly and ethically.

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