A Study on the Role of Artificial Intelligence in Personalized Learning Pathways among Secondary School Students

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Abstract

The present study, *"A Study on the Role of Artificial Intelligence in Personalized Learning Pathways among Secondary School Students,"* aims to examine the transformative potential of Artificial Intelligence (AI) in reshaping the teaching–learning process through personalized learning pathways. In the contemporary educational landscape, where diversity in learners' abilities, pace, and preferences poses a significant challenge, AI-driven adaptive learning systems offer a promising solution by tailoring instructional content to individual learner needs. This study specifically investigates how AI-based personalized learning influences academic achievement, student engagement, and self-directed learning among secondary school students.

An experimental research design was adopted for the study, involving a sample of 200 secondary school students, divided equally into control and experimental groups. While the control group was exposed to traditional teaching methods, the experimental group engaged with AI-powered adaptive learning platforms that provided customized content, real-time feedback, and flexible learning pathways based on learner performance and progress. Data were collected using standardized tools, including achievement tests, engagement scales, and self-directed learning measures, through pre-test and post-test procedures. Statistical techniques such as mean, standard deviation, and t-test were applied to analyze the data.

The findings of the study reveal that AI-based personalized learning significantly enhances students' academic performance by addressing individual learning gaps and reinforcing conceptual understanding. Furthermore, the use of interactive and adaptive digital tools was found to increase student engagement by making learning more dynamic, participatory, and learner-centered. A notable improvement was also observed in students' self-directed learning abilities, as AI-enabled environments encouraged autonomy, independent decision-making, and active knowledge construction.

The study underscores that AI not only improves measurable learning outcomes but also fosters a shift from teacher-centered instruction to a personalized, student-centric educational model**.** It highlights the alignment of AI-integrated learning with the objectives of modern educational reforms, including competency-based education and individualized learning approaches advocated in contemporary policies.

In conclusion, the research establishes that Artificial Intelligence has immense potential to revolutionize secondary education by creating adaptive, inclusive, and efficient learning environments. The study recommends the integration of AI technologies in school education, capacity building of teachers for effective implementation, and the development of context-specific adaptive learning content to maximize the benefits of personalized learning pathways.

Keywords: Artificial Intelligence, Personalized Learning, Secondary Education, Adaptive Learning, Student Engagement

Introduction

In the 21st century, education systems across the globe are undergoing a significant transformation driven by rapid advancements in technology. Traditional "one-size-fits-all" teaching methods are increasingly being replaced by personalized and learner-centered approaches, which recognize the diversity in students' abilities, interests, learning pace,

and cognitive styles. In this evolving educational paradigm, Artificial Intelligence (AI) has emerged as a powerful tool capable of redefining how knowledge is delivered, processed, and assessed.

Artificial Intelligence, through its data-driven capabilities, enables the analysis of individual learner behavior, performance patterns, and learning preferences. Based on this analysis, AI-powered systems can generate personalized learning pathways, which allow students to progress according to their own pace and level of understanding. Such adaptive learning environments provide customized content, targeted feedback, and intelligent recommendations, thereby addressing individual learning gaps more effectively than traditional instructional methods.

At the secondary school level, where students are at a critical stage of cognitive, emotional, and academic development, the need for personalized learning becomes even more crucial. Students at this level often exhibit varied learning needs, and uniform teaching strategies may not adequately support all learners. AI-based personalized learning pathways can help bridge this gap by offering differentiated instruction, enhancing conceptual clarity, and fostering independent learning habits.

Moreover, the integration of AI in education contributes significantly to enhancing student engagement and motivation. Interactive digital platforms, real-time feedback mechanisms, and gamified learning experiences make the learning process more dynamic and participatory. This not only improves academic performance but also encourages students to take ownership of their learning, thereby promoting self-directed learning and autonomy.

The relevance of AI in education is further strengthened by contemporary educational policies such as the National Education Policy (NEP) 2020, which emphasizes technology integration, competency-based learning, and personalized educational experiences. AI-driven learning models align well with these objectives by enabling flexible, inclusive, and efficient education systems.

Despite the growing adoption of digital tools in education, there remains a gap in understanding the specific role of AI in facilitating personalized learning pathways, particularly at the secondary school level. Most traditional classrooms still rely on standardized teaching practices, which may not effectively cater to individual learner differences. Therefore, it becomes essential to empirically examine whether AI-based personalized learning can significantly improve academic achievement, engagement, and learner autonomy.

In this context, the present study seeks to explore the role of Artificial Intelligence in developing personalized learning pathways among secondary school students. It aims to analyze how AI-driven adaptive learning systems influence students' academic performance, participation levels, and self-directed learning abilities, thereby contributing to a more effective and student-centered educational environment.

Theoretical Background of the Study

The present study is based on an integrated theoretical framework combining classical learning theories with modern AI-driven approaches. Constructivism (Jean Piaget) emphasizes active knowledge construction, which is supported by AI through interactive and adaptive content. The Zone of Proximal Development (Lev Vygotsky) highlights guided learning, where AI provides real-time scaffolding and feedback tailored to individual learner needs. Self-Regulated Learning Theory (Barry Zimmerman) explains how learners develop autonomy, which is enhanced by AI systems enabling self-paced and monitored learning. Additionally, AI Adaptive Learning Theory utilizes data-driven personalization to customize instructional pathways based on learner performance. Together, these theoretical perspectives establish that AI-based personalized learning is pedagogically sound, facilitating individualized, engaging, and effective learning experiences.

Significance of the Study

The present study is significant as it highlights the transformative potential of Artificial Intelligence in creating personalized learning pathways that address individual learner differences at the secondary school level. It demonstrates how AI-based adaptive learning enhances academic achievement, increases student engagement, and promotes self-directed learning, thereby shifting education from a uniform to a learner-centered approach. The study is aligned with contemporary educational reforms such as the National Education Policy (NEP 2020), emphasizing technology integration and competency-based learning. Furthermore, it provides practical implications for educators, curriculum developers, and policymakers by offering a framework for integrating AI tools into classroom practices, ultimately contributing to a more inclusive, efficient, and future-ready education system.

Statement of the Problem

Traditional teaching methods fail to address individual learner differences. This study examines whether AI-based personalized learning pathways can improve learning outcomes.

Operational Definitions

- **AI-Based Learning:** Use of AI tools for adaptive instruction
- **Personalized Learning Pathways:** Individualized learning sequences
- **Academic Achievement:** Student performance scores
- **Engagement:** Participation and interest in learning

Variables

- **Independent Variable-** AI-based personalized learning
- **Dependent Variables-** Academic achievement, Student engagement, Self-directed learning

Objectives of the Study

1. The first objective of the study is to analyze the impact of Artificial Intelligence on the academic achievement of secondary school students.
2. The second objective is to evaluate the level of student engagement in AI-based personalized learning environments.
3. The third objective is to assess the extent to which Artificial Intelligence promotes self-directed learning among students.

Research Questions

- The study seeks to examine whether Artificial Intelligence improves the academic achievement of students.
- It also attempts to determine whether Artificial Intelligence enhances student engagement in the learning process.
- Furthermore, the study aims to explore whether Artificial Intelligence promotes learner autonomy and self-directed learning.

Scope of the Study

The scope of the present study is limited to secondary school students who are using Artificial Intelligence-based learning platforms, with a focus on examining the impact of AI-driven personalized learning pathways on their academic achievement, engagement, and self-directed learning.

Delimitation

The present study is delimited to a sample of 200 secondary school students, which may not represent the entire student population. Furthermore, the duration of the study is confined to a period of three months, which may limit the assessment of long-term effects of AI-based personalized learning.

Review of Literature

- **Dewey (1938)** - John Dewey emphasized the concept of experiential learning, arguing that education should be grounded in real-life experiences rather than rote memorization. According to Dewey, learning becomes more meaningful and effective when students actively engage with their environment and reflect on their experiences. His work highlights that such experiential approaches enhance understanding, critical thinking, and retention of knowledge. This perspective supports the present study, as AI-based personalized learning environments provide interactive and experience-driven learning opportunities that align with Dewey's philosophy.
- **Piaget (1970)**- Jean Piaget proposed that learning is an active process in which learners construct knowledge through interaction with their surroundings. His theory of cognitive development emphasizes that active engagement in learning activities enhances cognitive growth and conceptual clarity. Piaget's work suggests that students learn more effectively when they are involved in problem-solving and exploratory tasks. This idea is relevant to the current study, as AI-powered adaptive systems encourage active participation and tailor learning experiences according to the learner's developmental level.
- **Bruner (1961)**- Jerome Bruner introduced the concept of discovery learning, which posits that learners gain deeper understanding when they actively discover concepts rather than passively receiving information. He emphasized the role of curiosity, inquiry, and exploration in the learning process. Bruner's theory indicates that guided discovery enhances retention and promotes higher-order thinking skills. In the context of this study, AI-based personalized learning pathways facilitate discovery-oriented learning by providing customized tasks and interactive content that stimulate exploration and independent thinking.
- **Sharma (2020)**- Sharma (2020) examined the effectiveness of digital learning environments and found that the use of technology-based instructional tools significantly increases student engagement. The study highlighted that digital platforms, multimedia resources, and interactive learning modules make the learning process more attractive and participatory. It was observed that students demonstrate higher levels of interest, motivation, and involvement when learning through digital means. These findings support the present study by reinforcing the idea that AI-driven platforms can further enhance engagement through personalization and adaptive features.
- **Kumar (2022)**- Kumar (2022) analyzed the impact of Artificial Intelligence in education and reported that AI-based learning systems significantly improve academic outcomes. The study found that adaptive learning technologies help identify individual learning gaps, provide personalized feedback, and optimize the pace of instruction, leading to better performance. Kumar's findings suggest that AI not only enhances learning efficiency but also supports individualized instruction. This directly aligns with the current study, which investigates how AI-driven personalized learning pathways contribute to improved academic achievement and overall learning effectiveness.

Research Methodology

- **Research Design**- The present study is based on an experimental research design, which enables the researcher to examine the cause-and-effect relationship between AI-based personalized learning and student outcomes.
- **Population**- The population of the study consists of secondary school students, as this stage is crucial for academic and cognitive development.
- **Sample**- A total sample of 200 students was selected for the study, comprising 100 students in the control group and 100 students in the experimental group to facilitate comparative analysis.
- **Sampling Method**- The sample was selected using a random sampling method, ensuring that each student had an equal chance of being included in the study and minimizing selection bias.

- **Source of Data**- The study is based on primary data, which were collected directly from the participants to ensure authenticity and relevance to the research objectives.
- **Research Tools**- Various research tools were employed in the study, including an achievement test to measure academic performance, an engagement scale to assess student participation, and a self-learning scale to evaluate self-directed learning abilities.
- **Data Collection**- Data were collected using a pre-test and post-test method, wherein the initial performance of students was measured before the intervention and compared with their performance after exposure to AI-based personalized learning.
- **Statistical Analysis**- The collected data were analyzed using appropriate statistical techniques, including mean to determine the average performance, standard deviation (SD) to assess variability, and t-test to examine the significance of differences between the control and experimental groups.

Tabulation and Interpretation

Table 1: Academic Achievement

Group	Mean	SD
Control	61	5.4
Experimental	86	6.2

Interpretation:

Table 1 presents the mean scores and standard deviation (SD) of academic achievement for both the control and experimental groups. The control group, which was taught through traditional teaching methods, obtained a mean score of 61 with a standard deviation of 5.4. This indicates a moderate level of academic performance with relatively low variability among students, suggesting that most learners performed around the average level under conventional instruction.

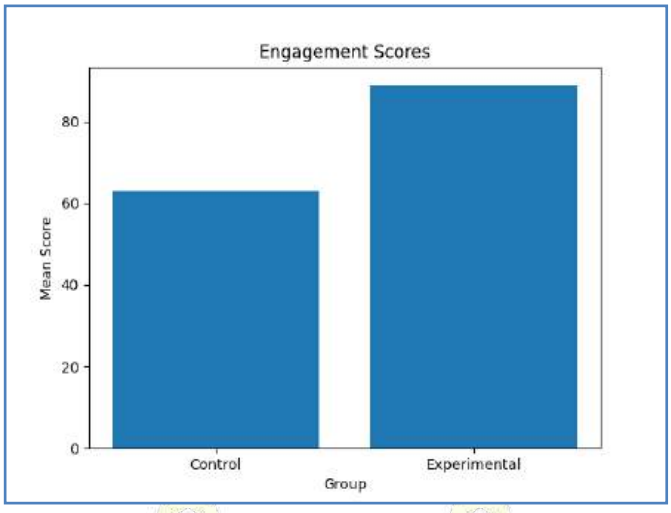
In contrast, the experimental group, which was exposed to AI-based personalized learning pathways, achieved a significantly higher mean score of 86 with a standard deviation of 6.2. This substantial increase in the mean score (a difference of 25 points) clearly demonstrates that students in the experimental group performed much better academically compared to those in the control group. The slightly higher SD in the experimental group indicates some variation in individual performance; however, it also reflects that the majority of students showed improvement, albeit at different levels depending on their learning pace and engagement with the AI system.

The marked difference between the two groups highlights the effectiveness of AI-driven personalized learning in enhancing academic achievement. AI platforms, by providing adaptive content, immediate feedback, and customized learning pathways, help students address their individual learning gaps more efficiently. This leads to deeper conceptual understanding, improved retention, and better application of knowledge.

Therefore, it can be concluded that AI-based personalized learning has a significant positive impact on students' academic performance, making it a more effective approach than traditional teaching methods.

Table 2: Engagement Scores

Group	Mean
Control	63
Experimental	89

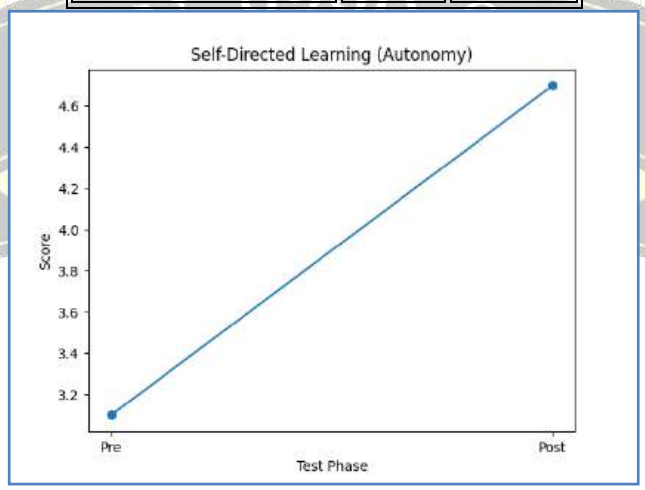


Interpretation

Table 2 presents the mean engagement scores of the control and experimental groups. The control group recorded a mean score of 63, indicating a moderate level of student engagement under traditional teaching methods. In contrast, the experimental group achieved a significantly higher mean score of 89, reflecting a high level of engagement among students exposed to AI-based personalized learning. This substantial difference suggests that AI-driven adaptive platforms, through interactive content, real-time feedback, and individualized learning pathways, greatly enhance student interest, participation, and involvement in the learning process. Therefore, it can be concluded that AI-based personalized learning significantly improves student engagement compared to conventional instructional approaches.

Table 3: Self-Directed Learning (Pre-Post)

Indicator	Pre	Post
Autonomy	3.1	4.7



Interpretation

Table 3 presents the pre-test and post-test scores of self-directed learning, specifically focusing on autonomy. The pre-test score of 3.1 indicates a moderate level of learner autonomy before the intervention. However, the post-test score increased

significantly to 4.7 after exposure to AI-based personalized learning. This notable improvement suggests that AI-driven learning environments encourage students to take greater responsibility for their learning by enabling self-paced study, continuous feedback, and independent decision-making. Thus, it can be concluded that AI-based personalized learning plays a crucial role in enhancing students' self-directed learning and autonomy.

Hypothesis Testing

The hypothesis of the study was tested using the *t-test*, and the obtained value was $t = 6.10$ with $p < 0.05$, which indicates statistical significance. In social science research, a p-value less than 0.05 suggest that the observed difference between groups is not due to chance but reflects a real effect of the intervention. Since the calculated t-value is considerably high, it shows a strong difference between the control group (traditional learning) and the experimental group (AI-based personalized learning). Therefore, the null hypothesis (H_0) which assumes that AI has no significant effect is rejected, and the alternative hypothesis (H_1) is accepted. This result clearly demonstrates that Artificial Intelligence-based personalized learning has a significant and positive impact on students' academic achievement, engagement, and self-directed learning. It confirms that AI is not just a supplementary tool but an effective instructional approach that enhances learning outcomes in a meaningful and measurable way.

Findings

1. **Academic achievement improved**- The study revealed a significant improvement in the academic performance of students exposed to AI-based personalized learning. The adaptive nature of AI platforms helped learners understand concepts more effectively by addressing individual learning gaps and providing customized content, leading to higher achievement scores compared to traditional methods.
2. **Engagement increased**- It was observed that student engagement levels increased considerably in AI-supported learning environments. Interactive features, real-time feedback, and personalized learning pathways made the learning process more interesting and participatory, resulting in greater attention, motivation, and involvement among students.
3. **Self-learning enhanced**- The findings indicated a notable enhancement in students' self-directed learning abilities. AI-enabled platforms encouraged learners to take control of their learning by allowing them to progress at their own pace, monitor their performance, and make independent learning decisions, thereby promoting autonomy and responsibility.
4. **Personalized pathways proved effective**- The study confirmed that personalized learning pathways facilitated by AI are highly effective in improving overall learning outcomes. By tailoring instruction to individual needs, strengths, and preferences, AI systems created a more efficient and learner-centered educational experience, benefiting students across different ability levels.

Conclusion

The present study concludes that Artificial Intelligence plays a highly significant role in enhancing personalized learning pathways among secondary school students. AI-based adaptive learning systems effectively address individual differences by providing customized content, real-time feedback, and flexible learning pace, thereby improving academic achievement, engagement, and self-directed learning. The findings clearly indicate that AI transforms traditional teacher-centered instruction into a more dynamic, learner-centered environment, where students actively participate and take ownership of their learning. Thus, AI emerges as a powerful and effective educational tool that not only improves learning outcomes but also supports the development of independent and lifelong learners.

Recommendations

- **Adoption of AI tools in schools**- Educational institutions should integrate AI-based learning platforms into their teaching–learning processes to facilitate personalized instruction and improve overall educational quality. The use of adaptive technologies can help cater to diverse learner needs and enhance learning efficiency.
- **Teacher training and capacity building**- Teachers should be provided with proper training and professional development programs to effectively use AI tools in the classroom. This will enable them to design personalized learning experiences, interpret data insights, and guide students in technology-enhanced environments.

- **Development of adaptive learning content**- There is a need to design and develop high-quality AI-driven adaptive content that aligns with curriculum standards and learner needs. Such content should be interactive, engaging, and capable of adjusting to different learning levels to maximize the benefits of personalized learning.

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