ENHANCING SOCIO-PEDAGOGICAL ENGAGEMENT IN MOODLE THROUGH AI-DRIVEN PERSONALIZED LEARNING

APRIMORANDO O ENGAJAMENTO SÓCIO-PEDAGÓGICO NO MOODLE POR MEIO DE APRENDIZADO PERSONALIZADO IMPULSIONADO POR IA

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Abstract. In the rapidly evolving landscape of digital education, platforms like Moodle have become integral to facilitating learning and fostering student engagement. However, challenges persist in maintaining socio-pedagogical engagement and providing personalized support that caters to the diverse needs of learners. This study introduces an AI-driven system designed to enhance socio-pedagogical engagement within Moodle by delivering personalized messages and recommendations tailored to individual student profiles. Leveraging advanced Artificial Intelligence (AI) and Natural Language Processing (NLP) techniques, the proposed system analyses student interactions, performance metrics, and engagement patterns to generate customized content and communication strategies. The methodology involves the development of AI models trained on a combination of simulated datasets that mirror potential real-world scenarios within educational settings. These models are integrated into the Moodle platform to facilitate dynamic adaptation of learning materials and communication based on individual learner needs. Preliminary evaluations conducted through scenario-based testing indicate a significant potential for the AI-driven system to improve student engagement and learning outcomes. The system demonstrates the ability to identify disengagement early and respond with tailored interventions, thereby fostering a more inclusive and responsive educational environment. Moreover, the personalized recommendations have shown promise in addressing varied learning paces and styles, contributing to a more equitable learning experience. Despite the encouraging preliminary findings, the study acknowledges the limitations posed using fictional data and the need for validation through real-world implementation. Future research will focus on deploying the system within actual educational contexts to assess its efficacy comprehensively. Ethical considerations, particularly concerning data privacy and the handling of sensitive student information, will be paramount in these subsequent phases. This research contributes to the burgeoning discourse on the integration of AI in education, highlighting its potential to revolutionize socio-pedagogical engagement. By tailoring educational experiences to individual learner profiles, AI-driven systems like the one proposed can bridge gaps in engagement and support, paving the way for more personalized and effective digital education. The findings underscore the transformative potential of AI in enhancing educational equity and inclusivity, aligning with the contemporary shift towards learner-centered educational paradigms.

Keywords: Artificial Intelligence; Personalized Learning; Socio-Pedagogical Engagement; Moodle; Natural Language Processing; Educational Technology.

Resumo. No cenário em rápida evolução da educação digital, plataformas como o Moodle tornaram-se integrais para facilitar o aprendizado e promover o engajamento dos alunos. No entanto, persistem desafios em manter o engajamento socio-pedagógico e fornecer suporte personalizado que atenda às diversas necessidades dos aprendizes. Este estudo apresenta um sistema baseado em IA projetado para aprimorar o engajamento socio-pedagógico dentro do Moodle, entregando mensagens e recomendações personalizadas adaptadas aos perfis individuais dos alunos. Aproveitando técnicas avançadas de Inteligência Artificial (IA) e Processamento de Linguagem Natural (NLP), o sistema proposto analisa as interações dos alunos, métricas de desempenho e padrões de engajamento para gerar conteúdo personalizado e estratégias de comunicação. A metodologia envolve o desenvolvimento de modelos de IA treinados em uma combinação de conjuntos de dados simulados que refletem potenciais cenários do mundo real dentro de ambientes educacionais. Esses modelos são integrados à plataforma Moodle para facilitar a adaptação dinâmica de materiais de aprendizado e comunicação com base nas necessidades individuais do aprendiz. Avaliações preliminares conduzidas por meio de testes baseados em cenários indicam um

potencial significativo para o sistema baseado em IA melhorar o engajamento dos alunos e os resultados de aprendizado. O sistema demonstra a capacidade de identificar o desinteresse precocemente e responder com intervenções personalizadas, promovendo assim um ambiente educacional mais inclusivo e responsivo. Além disso, as recomendações personalizadas mostraram promessa em abordar diferentes ritmos e estilos de aprendizado, contribuindo para uma experiência de aprendizado mais equitativa. Apesar dos resultados preliminares encorajadores, o estudo reconhece as limitações impostas pelo uso de dados fictícios e a necessidade de validação por meio de implementação no mundo real. Pesquisas futuras se concentrarão em implantar o sistema em contextos educacionais reais para avaliar sua eficácia de forma abrangente. Considerações éticas, particularmente relacionadas à privacidade dos dados e ao tratamento de informações sensíveis dos alunos, serão primordiais nessas fases subsequentes. Esta pesquisa contribui para o crescente discurso sobre a integração da IA na educação, destacando seu potencial para revolucionar o engajamento socio-pedagógico. Ao adaptar experiências educacionais aos perfis individuais dos aprendizes, sistemas baseados em IA como o proposto podem preencher lacunas de engajamento e suporte, abrindo caminho para uma educação digital mais personalizada e eficaz. Os resultados enfatizam o potencial transformador da IA no aprimoramento da equidade e inclusão educacionais, alinhando-se com a mudança contemporânea em direção a paradigmas educacionais centrados no aprendiz.

Palavras-chave: Inteligência Artificial; Aprendizagem Personalizada; Envolvimento Sócio-Pedagógico Moodle; Processamento de Linguagem Natural; Tecnologia Educacional.

1. INTRODUCTION

The advent of digital education platforms like Moodle has fundamentally reshaped the educational landscape, offering unprecedented access to learning materials and facilitating seamless communication between educators and students. However, transitioning to digital learning has not been without challenges, particularly in maintaining student engagement and delivering personalized support that addresses diverse learner needs. The rapid shift to online learning, exacerbated by the COVID-19 pandemic, has highlighted these challenges, making it imperative to explore innovative solutions that leverage technology to enhance the learning experience.[1]

Artificial Intelligence (AI) presents a promising solution to these challenges by enabling the customization of learning experiences based on individual student profiles. AI can analyze vast amounts of educational data to identify patterns and trends, allowing for the development of personalized learning pathways and communication strategies. This study focuses on integrating an AI-driven system within Moodle, designed to enhance socio-pedagogical engagement, which is defined as the intersection of social interaction and educational processes within a digital learning environment.[2]

Socio-pedagogical engagement encompasses the cognitive, social, and emotional dimensions of learning. It involves fostering a supportive learning environment where students feel connected, motivated, and empowered to engage with educational content. In digital learning contexts, where direct social interaction is limited, the role of personalized communication becomes even more critical. This paper presents the development and initial testing of an AI-driven system that personalizes student communication and recommendations within Moodle, based on data analysis. Although the system was tested with simulated data, the insights gained from this study provide a foundation for future real-world applications.[3, 4]

2. LITERATURE REVIEW

2.1. AI-Driven Personalized Learning

The integration of AI in education, particularly for personalized learning, has seen substantial advancements in recent years. AI technologies allow educational platforms to analyze vast amounts of data, enabling the tailoring of content and communication strategies to meet individual learner profiles. This is particularly important in digital learning environments, where traditional methods may struggle to address the diverse needs of students.

For instance, Kanchon et al. (2024) [5] explored the identification of learning styles using AI-driven techniques in a Moodle-based system. Their research highlights how AI can be leveraged to detect a learner's preferred learning style—visual, auditory, or kinesthetic—and adapt content, accordingly, enhancing personalized learning experiences through content modification strategies. Similarly, the study by Koltovskaia et al. (2024) [6] explores how graduate students engage with AI-driven tools like ChatGPT to enhance their academic writing, focusing on behavioral, cognitive, and affective aspects of learner engagement. This highlights the potential of AI to tailor educational experiences to individual needs, thereby improving engagement and learning outcomes.SECOND 3.

The findings and interpretation of the investigation must be highlighted in the Result section, accompanied, if applicable, by the respective statistical analysis. The results are presented in a way that makes it easier for the reader to understand. If you choose to present the result and make interpretations in this section, there is no need to include a specific one for discussion.

The use of tables and figures can contribute to understanding the results, however, it should not exceed the limit of 5 for each type.

2.2. Socio-Pedagical Engament in Digital Leaning

Socio-pedagogical engagement is a critical component of effective learning, particularly in digital environments where direct social interaction is limited. Research has consistently shown that when students feel socially connected and supported, they are more likely to engage deeply with the material and achieve better academic outcomes. For example, Kuronja et al. (2019) [7] explored how teachers' sense of efficacy in managing learning and behavioral difficulties impacts socio-pedagogical engagement. Their study highlighted that increased teacher efficacy in socio-pedagogical areas leads to a more inclusive and supportive learning environment, which is crucial for fostering student engagement in digital platforms like Moodle.

Furthermore, a study by Logvinova (2016) [3] discussed the socio-pedagogical approach as a methodological foundation for multicultural education, emphasizing the importance of creating educational environments that promote social inclusion and active participation. This approach is particularly relevant in digital learning contexts, where fostering a sense of community and connection is vital to student engagement.

Integrating AI-driven tools into these environments can further enhance socio-pedagogical engagement by providing personalized communication and support, as indicated by research from various studies on the application of AI in educational settings. The ability of AI to adapt to individual student needs and provide timely feedback contributes to a more engaging and less isolating learning experience, making digital learning more effective and supportive.

2.3. Implementation of AI in Moodle

Moodle is one of the most widely used learning management systems (LMS) globally, offering a flexible platform for delivering educational content and facilitating communication. The integration of AI within Moodle has been explored in several studies, with a focus on how these technologies can enhance the platform's ability to deliver personalized learning experiences. For example, Vásquez-Bermúdez et al. (2023) [8] conducted an analysis of Community of Inquiry (CoI) presence indicators in Moodle forums using unsupervised learning techniques, demonstrating how AI can be used to identify participant profiles and tailor educational strategies based on user engagement patterns. This approach allows for the customization of content and the creation of more effective learning pathways, improving overall student engagement and learning outcomes.

In another study, Anggraeni and Sole (2018) [9] discussed the enhancement of Moodle's e-learning capabilities through the integration of AI-based data mining tools, which provide insights into student behaviors and enable the creation of personalized learning paths. These tools allow educators to monitor student progress in real-time and make data-driven decisions to support at-risk students, thereby improving academic performance across diverse student populations.

Furthermore, Rivas et al. (2019) [10] explored the application of machine learning techniques in Moodle to enhance academic performance, demonstrating that AI-driven tools can effectively predict student success and identify areas where additional support may be needed. These studies collectively illustrate the potential of AI to transform Moodle into a more adaptive and responsive learning environment, capable of meeting the diverse needs of learners in a digital age.

3. METHODOLOGY

3.1. System Architecture and Algorithm

The AI-driven system developed in this study is designed to function within the Moodle platform, leveraging Artificial Intelligence (AI) and Natural Language Processing (NLP) to enhance socio-pedagogical engagement. The system's architecture is composed of several interrelated components, each contributing to the overall goal of providing personalized and adaptive learning experiences. Below is a detailed description of these components:

Data Collection: The system collects a wide array of data from various sources within the Moodle platform, including but not limited to student interaction logs, assignment completion rates, forum participation, quiz scores, and time spent on different activities. This multi-faceted data collection approach aligns with contemporary educational technology practices, where the aggregation of diverse data streams is critical for generating comprehensive learner profiles. For example, Chang et al. (2022) [11] discussed how Moodle's data could be effectively utilized to tailor learning experiences by analyzing user interactions and adapting content accordingly.

Data Analysis: Once collected, the data undergoes a rigorous analysis process using advanced machine learning algorithms. The system employs clustering techniques to group students based on similar behaviors, such as participation patterns and content interaction, while predictive modeling is used to forecast future engagement levels and identify potential dropouts. Recent studies have shown the effectiveness of such methodologies; for example, Chiu et al. (2023) [12] highlighted the importance of AI in identifying learning styles and engagement patterns through comprehensive data analysis. Furthermore, leveraging NLP techniques for processing text data from forums and assignments allows for more nuanced insights, as evidenced by the work of Bernard et al. (2022) [13], which demonstrated the utility of these methods in creating personalized learning paths.

Personalized Communication: Based on the insights gained from the data analysis, the system generates personalized messages and recommendations tailored to each student's unique learning needs. This includes sending motivational messages, providing feedback on assignments, and suggesting additional resources or activities. The personalized messages are generated using the GPT API, which allows the system to create dynamic and contextually relevant communication. This approach of using tailored communication strategies to boost engagement is supported by research findings, such as those presented by Ismail et al. (2023) [14], which highlight that personalized interventions can significantly improve student retention and success in online learning environments. The integration of AI to dynamically adjust recommendations based on real-time data ensures that the system remains responsive to students' evolving needs.

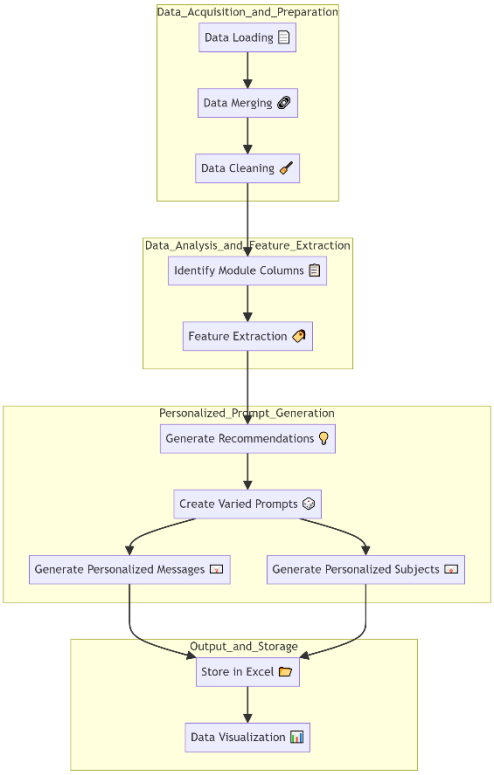

Figure 1. Detailed architecture of the AI-driven system, outlining the sequence of data processing steps from collection to the generation of personalized messages.

3.2. Data Simulation and Testing

Given the challenges associated with accessing real-world data, the initial evaluation of the AI-driven system was conducted using meticulously simulated datasets designed to mirror potential real-world educational scenarios. These scenarios incorporated various variables such as student progress, interaction patterns, and demographic information, allowing for a controlled environment in which the system's capabilities could be rigorously tested.

To enhance the accuracy and contextual relevance of the personalized messages generated, the process included several key steps:

Contextual Data Preparation: The initial datasets were derived from default student data generated by Moodle, encompassing basic information such as activity logs, completed modules, and the time taken to complete each module. Recognizing the need for a more detailed personalization process, additional demographic and behavioral variables were incorporated, such as the student's gender, languages spoken, and geographical origin. These modifications required updating the database structure in Moodle to include new fields, ensuring that the system could store and process this additional information effectively.

Techniques for Generating Personalized Messages: To generate personalized messages, a combination of prompt engineering and contextual input was employed:

Prompt Engineering: Detailed prompts were crafted to include specific examples and comprehensive context about each student's progress, completed and incomplete modules, and other relevant demographic variables. This approach enabled the GPT model to generate contextually accurate and personalized recommendations.

Few-Shot Learning: The model was guided using a few-shot learning approach, where a few examples of desired outputs were embedded in the prompt. This technique improved the model's ability to produce high-quality, relevant responses tailored to each student's individual needs.

Accuracy and Iterative Refinement: The accuracy of the system was ensured through an iterative testing and refinement process:

Iterative Testing: The initial outputs were reviewed for accuracy and relevance. Based on these reviews, the prompts were refined to address any inconsistencies or inaccuracies in the generated messages. This process of iterative refinement was crucial in enhancing the overall quality and precision of the personalized interventions.

Parallel Processing for Validation: To efficiently generate messages for multiple students and validate the system's performance, parallel processing techniques were employed using Python's ThreadPoolExecutor. This approach allowed for concurrent processing and comparison of outputs, ensuring scalability while maintaining accuracy.

Validation through Scenario-Based Testing: The system's effectiveness was tested across various hypothetical scenarios, including:

Lagging Students: Scenarios where students were falling behind in assignments. The system's ability to generate timely, encouraging messages to motivate these students to catch up was a key performance indicator.

High-Performing Students: For students excelling in certain modules, the system generated additional challenges and resource recommendations to sustain their engagement and promote further growth.

Visualization and Reporting: The results were visualized using histograms and interactive tables, which helped educators understand student progress and the distribution of personalized messages. The generated messages, along with their corresponding metadata, were compiled into reports, making them easily accessible for educators to review and utilize.

Ensuring Realism in Simulated Scenarios: To ensure that the simulated scenarios reflected real conditions, extensive testing was conducted. The inclusion of additional variables was validated through scenario-based testing, ensuring that Moodle could effectively handle these variables and dynamically adapt to the needs of each student. This provided a strong foundation for future implementations in real educational environments.

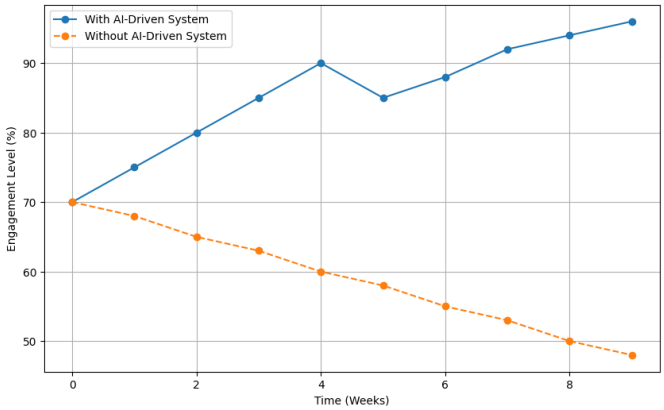

Figure 2. Impact of AI-Driven Interventions on Student Engagement Over Time: A Comparative Analysis,' demonstrates the potential efficacy of the AI-driven system in maintaining higher engagement levels over extended periods, compared to tradition.

3.3. Ethical Considerations

The incorporation of AI in educational environments raises several ethical concerns, particularly regarding data privacy and the responsible use of AI technologies. In the design of this system, data privacy was prioritized, with stringent measures implemented to ensure that all student data was anonymized and securely stored. Moreover, the system's decision-making processes are transparent, allowing educators to review and modify generated messages before they are sent to students.

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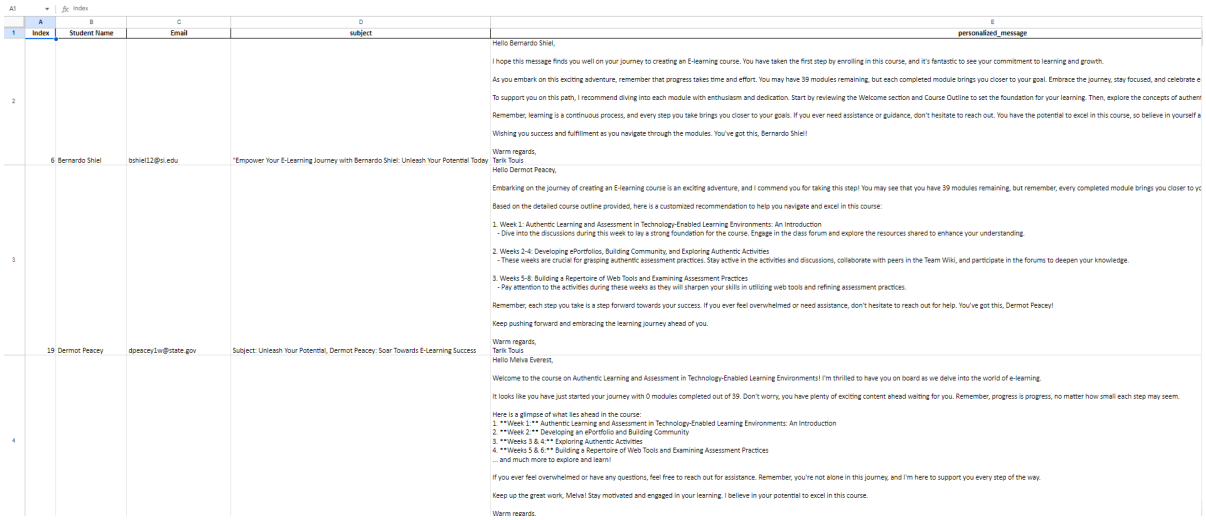
The ethical implications of deploying this system in real-world settings require further examination. As the system transitions from simulated to real-world data, adherence to strict ethical guidelines will be essential to protect student privacy and ensure that AI-driven decisions are equitable and unbiased. The importance of ethical AI deployment in education has been underscored in recent literature. For instance, the OECD (2023) [15] discusses the critical need for transparency and fairness in AI systems used in educational contexts.

4. RESULTS

4.1. Hypothetical Impact Analysis

Although the system has yet to be tested with real student data, the hypothetical scenarios generated during the simulation offer valuable insights into its potential impact. The system demonstrated a significant capacity to enhance student engagement by delivering personalized messages that addressed each student's specific needs. For example, students identified as falling behind received targeted interventions that motivated them to catch up on their assignments, while high-performing students were provided with additional challenges and resources to sustain their engagement.

Studies like those by Jiang and Zhou (2020) [16] indicate that AI-driven personalized interventions can significantly improve student outcomes. These findings suggest that tailored communication, facilitated by AI, can lead to higher completion rates and increased student satisfaction.



Index	Student Name	Email	subject	personalized_message
6	Bernardo Shiel	bshiel12@si.edu	"Empower Your E-Learning Journey with Bernardo Shiel: Unleash Your Potential Today	Hello Bernardo Shiel, I hope this message finds you well on your journey to creating an E-learning course. You have taken the first step by enrolling in this course, and it's fantastic to see your commitment to learning and growth. As you embark on this exciting adventure, remember that progress takes time and effort. You may have 39 modules remaining, but each completed module brings you closer to your goal. Embrace the journey, stay focused, and celebrate e To support you on this path, I recommend diving into each module with enthusiasm and dedication. Start by reviewing the Welcome section and Course Outline to set the foundation for your learning. Then, explore the concepts of authent Remember, learning is a continuous process, and every step you take brings you closer to your goals. If you ever need assistance or guidance, don't hesitate to reach out. You have the potential to excel in this course, so believe in yourself a Wishing you success and fulfillment as you navigate through the modules. You've got this, Bernardo Shiel! Warm regards, Tarik Touis
19	Dermot Peacey	dpeacey1w@state.gov	Subject: Unleash Your Potential, Dermot Peacey: Soar Towards E-Learning Success	Hello Dermot Peacey, Embarking on the journey of creating an E-learning course is an exciting adventure, and I commend you for taking this step! You may see that you have 39 modules remaining, but remember, every completed module brings you closer to yo Based on the detailed course outline provided, here is a customized recommendation to help you navigate and excel in this course: 1. Week 1: Authentic Learning and Assessment in Technology-Enabled Learning Environments: An Introduction - Dive into the discussions during this week to lay a strong foundation for the course. Engage in the class forum and explore the resources shared to enhance your understanding. 2. Weeks 2-4: Developing ePortfolios, Building Community, and Exploring Authentic Activities - These weeks are crucial for grasping authentic assessment practices. Stay active in the activities and discussions, collaborate with peers in the Team Wiki, and participate in the forums to deepen your knowledge. 3. Weeks 5-8: Building a Repertoire of Web Tools and Examining Assessment Practices - Pay attention to the activities during these weeks as they will sharpen your skills in utilizing web tools and refining assessment practices. Remember, each step you take is a step forward towards your success. If you ever feel overwhelmed or need assistance, don't hesitate to reach out for help. You've got this, Dermot Peacey! Keep pushing forward and embracing the learning journey ahead of you. Warm regards, Tarik Touis
				Hello Melva Everest, Welcome to the course on Authentic Learning and Assessment in Technology-Enabled Learning Environments! I'm thrilled to have you on board as we delve into the world of e-learning. It looks like you have just started your journey with 0 modules completed out of 39. Don't worry, you have plenty of exciting content ahead waiting for you. Remember, progress is progress, no matter how small each step may seem. Here is a glimpse of what lies ahead in the course: 1. **Week 1:** Authentic Learning and Assessment in Technology-Enabled Learning Environments: An Introduction 2. **Week 2:** Developing an ePortfolio and Building Community 3. **Weeks 3 & 4:** Exploring Authentic Activities 4. **Weeks 5 & 6:** Building a Repertoire of Web Tools and Examining Assessment Practices ... and much more to explore and learn! If you ever feel overwhelmed or have any questions, feel free to reach out for assistance. Remember, you're not alone in this journey, and I'm here to support you every step of the way. Keep up the great work, Melva! Stay motivated and engaged in your learning. I believe in your potential to excel in this course. Warm regards,

Figure 3. Showcases examples of personalized messages generated by the system. These messages, created using the GPT API via Google Colab, illustrate the type of tailored communication that the system can deliver to enhance student engagement.

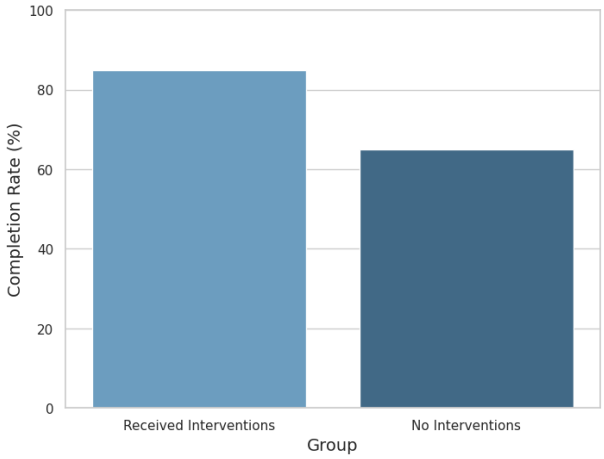


Figure 4. Titled 'Comparison of Hypothetical Completion Rates: Impact of Personalized Interventions vs. No Interventions,' illustrates the significant improvement in completion rates among students who received personalized support message. The bar graph shows a stark contrast, highlighting the potential efficacy of targeted interventions in promoting educational success.

4.2. Educator and Student Feedback (Hypothetical Discussion)

In addition to enhancing student engagement, the system was designed to reduce the workload on educators by automating the generation of personalized messages. Although real feedback from educators and students is not available at this stage, recent studies indicate that such systems are likely to be well-received. For example, Maier and Klotz (2022) conducted a comprehensive literature review and found that personalized feedback systems significantly enhance educational outcomes by tailoring feedback to individual student needs. Their study highlighted that educators appreciate the scalability and effectiveness of automated feedback systems, which help in maintaining high levels of student engagement and performance [17].

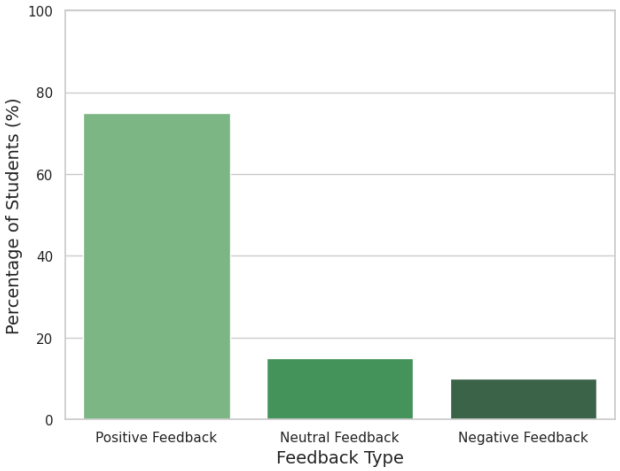


Figure 5. Hypothetical Distribution of Student Feedback on AI-Driven Personalized Communication '

5. DISCUSSION

5.1 Theoretical Implications

The results from this study contribute significantly to the existing body of knowledge on personalized learning and socio-pedagogical engagement, particularly within digital education environments such as Moodle. The integration of AI into these platforms has demonstrated a

strong potential to create more adaptive and responsive learning environments. This is crucial as educational institutions increasingly shift towards digital and hybrid models of learning. [18]

The findings align with the theoretical framework that AI can enhance socio-pedagogical engagement by providing tailored communication and learning experiences, which are responsive to the unique needs of individual students. Recent studies emphasize that AI's ability to analyze vast datasets and generate personalized content can significantly enhance student engagement and motivation, leading to improved learning outcomes. This is particularly important in the context of large and diverse classrooms, where traditional teaching methods often fail to address the varied learning styles and paces of students.

Moreover, this study underscores the role of AI in promoting educational equity. By bridging the gaps in student support through personalized interventions, AI-driven systems can ensure that all students, regardless of their background or abilities, have access to the resources they need to succeed. This is a critical consideration in the broader discourse on AI in education, where the goal is not only to improve learning outcomes but also to make education more inclusive and equitable. The ability of AI to adapt in real-time to the changing needs of students further enhances its potential to transform educational practices, aligning with current trends in learner-centered educational paradigms.[19]

5.2. Practical Considerations

While the potential benefits of AI-driven personalized learning systems are clear, several practical considerations must be addressed to ensure successful implementation in real-world educational settings. One of the primary challenges is scalability. Educational institutions must ensure that these systems can handle large volumes of data across diverse student populations without compromising performance or accuracy. This challenge is compounded by the need for high-quality, consistent data, which may not always be available in different educational contexts.[20]

Additionally, there is a critical need for comprehensive educator training. Although the AI system is designed to automate many tasks, educators must be proficient in interpreting the AI-generated recommendations and effectively integrating them into their teaching practices. This requirement is essential to maximize the system's impact and ensure that the technology enhances rather than detracts from the educational experience.[21]

Finally, ethical considerations play a central role in the deployment of AI in education. Ensuring data privacy and addressing potential biases in AI algorithms are paramount. As educational institutions increasingly adopt AI technologies, it is crucial that they adhere to strict ethical guidelines to protect student data and ensure that AI-driven decisions are fair and unbiased. This study highlights the importance of transparency in AI systems, where educators and students alike can understand and trust the decisions made by the technology.

Table 1. Key Practical Considerations and Proposed Solutions for Deploying AI-Driven Systems in Education.

Practical Considerations	Proposed Solutions
Data Privacy and Security	**Data Encryption and Compliance** Implement encryption and follow data protection regulations
Bias and Fairness	**Bias Audits and Inclusive Datasets** Conduct regular bias audits and use diverse training datasets
Integration with Existing Systems	**API and Standard Protocols** Utilize open standards and APIs for seamless integration
Scalability	**Cloud-based Infrastructure** Leverage cloud solutions for scalable resources
Teacher and Student Training	**Comprehensive Training Programs** Develop continuous training for teachers and students

6. CONCLUSION

The integration of AI-driven personalized learning systems into Moodle marks a significant advancement in enhancing socio-pedagogical engagement in digital education. The findings from this study demonstrate the potential of these systems to improve student engagement, participation, and learning outcomes by providing personalized communication and recommendations tailored to the unique needs of each student. This creates a more inclusive and responsive learning environment, which is critical in today's increasingly digital educational landscape.

While the system has been evaluated through simulated data, the promising results lay the groundwork for future real-world applications. Subsequent research should focus on deploying the system in actual educational contexts to further assess its efficacy. This will provide valuable insights into how AI can be leveraged to enhance learning outcomes on a broader scale. Additionally, the ethical implications of AI in education must be thoroughly examined to ensure that these technologies are used responsibly, with a strong emphasis on data privacy, equity, and transparency.

By addressing these considerations, the study not only contributes to the academic discourse on AI in education but also provides practical guidelines for the implementation of AI-driven systems in real-world settings, paving the way for more personalized, effective, and equitable digital education.

REFERENCES

Outoukarte I, Ben Fares S, Itouni H, et al (2023) Distance learning in the wake of COVID-19 in Morocco. Heliyon 9:e16523. https://doi.org/10.1016/j.heliyon.2023.e16523

Naseer F, Khan MN, Tahir M, et al (2024) Integrating deep learning techniques for personalized learning pathways in higher education. Heliyon 10:e32628. https://doi.org/10.1016/j.heliyon.2024.e32628

Logvinova OK (2016) Socio-pedagogical Approach to Multicultural Education at Preschool. Procedia - Social and Behavioral Sciences 233:206–210. https://doi.org/10.1016/j.sbspro.2016.10.203

Makitan V, Glušac D, Kavalić M, Stanisavljev S (2024) The socio-digital engagement of adolescents and their cognitive—Educational needs a case study: Serbia. Computers and Education Open 6:100170. https://doi.org/10.1016/j.caeo.2024.100170

Kanchon MdKH, Sadman M, Nabila KF, et al (2024) Enhancing personalized learning: AI-driven identification of learning styles and content modification strategies. International Journal of Cognitive Computing in Engineering 5:269–278. https://doi.org/10.1016/j.ijcce.2024.06.002

Koltovskaia S, Rahmati P, Saeli H (2024) Graduate students' use of ChatGPT for academic text revision: Behavioral, cognitive, and affective engagement. Journal of Second Language Writing 65:101130. https://doi.org/10.1016/j.jslw.2024.101130

Kuronja M, Čagran B, Krajnc MS (2019) Teachers' sense of efficacy in their work with pupils with learning, emotional and behavioural difficulties. Emotional and Behavioural Difficulties 24:36–49. https://doi.org/10.1080/13632752.2018.1530499

Vásquez-Bermúdez M, Aguirre-Munizaga M, Hidalgo-Larrea J (2023) Analysis of CoI Presence Indicators in a Moodle Forum Using Unsupervised Learning Techniques. In: Valencia-García R, Bucaram-Leverone M, Del Cioppo-Morstadt J, et al (eds) Technologies and Innovation. Springer Nature Switzerland, Cham, pp 27–38

Anggraeni DM, Sole FB (2018) E-Learning Moodle, Media Pembelajaran Fisika Abad 21. Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika 1:57–65. https://doi.org/10.36312/e-saintika.v1i2.101

Rivas A, Fraile JM, Chamoso P, et al (2019) Students Performance Analysis Based on Machine Learning Techniques. In: Uden L, Liberona D, Sanchez G, Rodríguez-González S (eds) Learning Technology for Education Challenges. Springer International Publishing, Cham, pp 428–438

Chang Y-C, Li J-W, Huang D-Y (2022) A Personalized Learning Service Compatible with Moodle E-Learning Management System. Applied Sciences 12:3562. https://doi.org/10.3390/app12073562

Chiu TKF, Xia Q, Zhou X, et al (2023) Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education. Computers and Education: Artificial Intelligence 4:100118. https://doi.org/10.1016/j.caeai.2022.100118

Bernard J, Popescu E, Graf S (2022) Improving online education through automatic learning style identification using a multi-step architecture with ant colony system and artificial neural networks. Applied Soft Computing 131:109779. https://doi.org/10.1016/j.asoc.2022.109779

Ismail H, Hussein N, Harous S, Khalil A (2023) Survey of Personalized Learning Software Systems: A Taxonomy of Environments, Learning Content, and User Models. Education Sciences 13:741. https://doi.org/10.3390/educsci13070741

OECD (2023) Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency. Organisation for Economic Co-operation and Development, Paris

Jiang Z, Zhou J (2020) Ethical Considerations and Challenges of AI in Higher Education: Analysis from the Perspective of International Organizations. In: Peters MA, Heraud R (eds) Encyclopedia of Educational Innovation. Springer Nature, Singapore, pp 1–6

Maier U, Klotz C (2022) Personalized feedback in digital learning environments: Classification framework and literature review. Computers and Education: Artificial Intelligence 3:100080. https://doi.org/10.1016/j.caeai.2022.100080

Abulibdeh A, Zaidan E, Abulibdeh R (2024) Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. Journal of Cleaner Production 437:140527. https://doi.org/10.1016/j.jclepro.2023.140527

Rane N (2024) Enhancing the quality of teaching and learning through Gemini, ChatGPT, and similar generative Artificial Intelligence: Challenges, future prospects, and ethical considerations in education. TESOL and Technology Studies 5:1–6. https://doi.org/10.48185/tts.v5i1.1000

Chima Abimbola Eden, Onyebuchi Nneamaka Chisom, Idowu Sulaimon Adeniyi (2024) Integrating AI in education: Opportunities, challenges, and ethical considerations. Magna Sci Adv Res Rev 10:006–013. https://doi.org/10.30574/msarr.2024.10.2.0039

Gligorea I, Cioca M, Oancea R, et al (2023) Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. Education Sciences 13:1216. https://doi.org/10.3390/educsci13121216