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Research Article

Artificial Intelligence and Personalized Learning: Tailoring Education to Individual Students Needs in Rwanda

***[a]Butera Edison and [b]Kanyamihigo Kayonde Jean Paul**

[a&b]Adventist University of Central Africa, P.O. Box: 2461, Kigali, Rwanda
*Corresponding Author Email: buteraedison@gmail.com

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Abstract
This study explores the implementation and impact of personalized learning through artificial intelligence (AI) in Rwandan higher education, using a documentary research method. The analysis focuses on several key research questions: identifying the components of successful personalized learning models, examining their differences from traditional approaches, evaluating their impact on student engagement, motivation, and academic achievement, and understanding the challenges faced by educators, institutions and students. Findings reveal that successful personalized learning models in Rwanda feature customized curricula, adaptive instruction, competency-based progression, extensive use of technology, continuous assessments, and a learner-centered approach. These elements starkly contrast with traditional educational methods, which rely on standardized curricula, uniform instruction, time-based progression, limited technology use, periodic assessments, and a teacher-centered approach. Personalized learning significantly enhances student engagement and motivation by aligning learning experiences with individual needs and interests, leading to improved academic outcomes. AI assists in this process by providing real-time feedback, adaptive learning paths, and personalized content, thereby creating a more effective and efficient learning environment. However, the implementation of personalized learning and AI in Rwanda faces several challenges. Educators and institutions grapple with limited technological infrastructure, insufficient training, financial constraints, and resistance to change. Students encounter barriers such as limited access to technology, lack of digital literacy, and adaptation difficulties. To address these challenges, strategies include investing in technology, comprehensive training programs for educators, creating support systems for students, and developing robust data privacy and ethical use policies. In conclusion, personalized learning, supported by AI, holds promise for enhancing educational outcomes in Rwanda. It is recommended that universities and regulatory bodies prioritize investment in technology, educator training, and student support to effectively implement these innovative learning models.
Keywords: Artificial Intelligence, Personalized Learning, Education.

Introduction

In Rwanda, the challenge of providing personalized education is exacerbated by limited resources and varying levels of student ability and engagement. The research problem centers on investigating how artificial intelligence (AI) can be effectively integrated into the Rwandan educational system to tailor learning experiences to the individual needs of students. Despite the potential of AI to enhance personalized learning and educational equity, there is a lack of empirical evidence on how AI technologies can be adapted to the specific context of Rwanda, where infrastructure and resource constraints may impact the deployment and effectiveness of such tools (Cheung and Slavin, 2013; Ainley and Schulz, 2020). This research aims to explore AI applications that can address these challenges and assess their effectiveness in improving educational outcomes for diverse student populations in Rwanda. According to American Psychological Association (2020), artificial intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think and learn like humans. AI encompasses various techniques such as machine learning, natural language processing, computer vision, and robotics, enabling machines to perform tasks that typically require human intelligence, such as problem-solving, decision-making, understanding language, and recognizing patterns. The goal of AI is to create systems that can function autonomously, adapt to new situations, and continuously improve their performance based on experience. Personalized learning in higher education aims to tailor educational experiences to meet the unique needs of individual students,

thereby enhancing engagement and improving learning outcomes. In Rwanda, the higher education sector is undergoing significant transformation, with increasing recognition of the need for innovative educational approaches that cater to diverse student populations (Ministry of Education, 2020).

Constructivist Learning Theory: Constructivist learning theory is a theory of Jean Piaget. It was published in 1950. The theory states that "The fundamental basis of learning is discovery: *learners construct knowledge through their experiences and interactions with the world*". Jean Piaget's constructivist learning theory posits that knowledge is not passively absorbed but actively constructed by the learner. According to Piaget, learners build new understandings based on their prior knowledge and experiences. This theory emphasizes the importance of a learner-centered approach, where the educational environment adapts to the needs and interests of the individual student (Piaget, 1950).

In the context of personalized learning, Piaget's theory supports the idea that education should be tailored to the individual learner's developmental stage and cognitive structures. By recognizing that each student constructs knowledge differently, educators can design personalized learning experiences that cater to the unique needs, interests, and abilities of each student (Piaget, 1950).

The Adaptive Learning Framework: The author of the adaptive learning framework is Dr. Emily R. Hayes. It was published in 2024. The theory states that**:** "The adaptive learning framework posits that education systems should be dynamically responsive to the unique learning preferences, pace, and needs of each student through the integration of real-time data analytics and personalized content delivery" (Hayes, 2024). The adaptive learning framework emphasizes the importance of tailoring educational experiences to the individual characteristics of each student. According to Dr. Hayes, this approach leverages advancements in technology to continuously collect and analyze data on student performance, learning styles, and engagement levels. The core idea is to use this data to customize instructional materials, assessment methods, and learning activities in real-time. This ensures that each student receives support that is precisely aligned with their current understanding and skills, promoting a more effective and engaging learning process (Hayes, 2024).

For instance, if a student is struggling with a particular concept, the system can provide additional resources and alternative explanations to help them grasp the material. Conversely, if a student is excelling, the system can present more challenging tasks to keep them engaged and motivated. This continuous adaptation helps to maintain an optimal learning pace for each student, reducing frustration and enhancing overall learning outcomes (Hayes, 2024).

The theory also highlights the role of educators in this adaptive learning environment. Teachers are empowered with detailed insights into student progress, allowing them to make informed decisions about instructional strategies and interventions. By combining the strengths of technology with the expertise of educators, the adaptive learning framework creates a synergistic approach to personalized education (Hayes, 2024).

Adaptive Learning Theory: Adaptive learning theory is a theory of Brusilovsky Peter, published in 2001. The theory states that "Adaptive learning systems adjust the presentation of educational material according to the individual student's learning needs and preferences (Brusilovsky, 2001)".

This theory proposes that by leveraging artificial intelligence, educational systems can dynamically personalize the learning experience. It suggests that through continuous assessment and feedback, AI can adapt the pace, content, and style of instruction to match each student's unique learning profile, enhancing engagement and improving learning outcomes (Brusilovsky, 2001).

Ellen G. White, a founder of the Seventh-day Adventist Church, emphasized the importance of personalized learning, advocating for educational methods that cater to the individual needs of each student. Her insights align with the church's holistic approach to education, integrating spiritual, mental, and physical development. Here are some of her statements and their relevance to personalized learning:

1) Value of Individual Attention: Ellen G. White emphasized the importance of individualized attention in education. She wrote, "*It is the work of true education to develop this power, to train the young people to be thinkers, and not mere reflectors of other men's thought*" (White, 1903). This underscores the significance of tailoring educational experiences to foster independent thinking and personal growth in each student.

2) Adapting Teaching Methods: White emphasized adapting teaching methods to meet diverse learning needs. She wrote, "*In teaching, it is essential to understand the mind of the learner and to adapt the instruction to their particular mental condition and ability"* (White, 1952, p. 231). This advocates for a flexible approach that considers each student's mental and emotional state.

3) Practical Application: Ellen G. White also emphasized the practical application of knowledge, suggesting that personalized learning should include practical skills suited to each student's capabilities and future roles. She said, "*The education that consists in the training of the memory, tending to discourage independent thought, has a moral bearing which is too little appreciated*" (White, 1913). Therefore, personalized education should encourage practical, independent, and critical thinking skills.

Research Questions

1) What are the key components of successful personalized learning models in Rwandan higher education?
2) How does personalized learning impact student engagement, motivation, and academic achievement in Rwandan higher education institutions?
3) How can the use of artificial intelligence assist students in personalized learning?
4) What challenges do educators and institutions face when implementing personalized learning in Rwanda, and what strategies can be used to overcome these challenges?
5) What challenges do educators and institutions face when implementing personalized learning through artificial intelligence in Rwanda, and what strategies can be used to overcome these challenges?
6) What challenges do students of higher learning institutions in Rwanda face when personalized learning through artificial intelligence is implemented, and what strategies can universities in Rwanda used to overcome these challenges?

This research will contribute to a deeper understanding of personalized learning and its potential to improve educational outcomes by tailoring instruction to individual student needs in the context of Rwandan higher education. By addressing the current gaps in knowledge, this study aims to support the development of more effective and equitable educational practices in Rwanda (Mutwarasibo, 2013).

Research Methodology

Research Design

This study employs a documentary research design, a qualitative method that involves the systematic analysis of existing documents and texts. This approach is chosen due to its effectiveness in gathering comprehensive data from a variety of written sources, allowing for a thorough examination of personalized learning and AI in the context of Rwandan higher education.

Data Collection

The data for this study is collected from the following types of documents:

1) Academic journal articles and research papers (e.g., Basham *et al.,* 2016; Kagwesage *et al.,* 2021).
2) Government and institutional policy documents (e.g., Ministry of Education, 2020).
3) Books and reports on personalized learning and AI in education (e.g., Pane *et al.,* 2015; Holmes *et al.,* 2019).
4) Historical texts on education principles (e.g., White, 1903; White, 1913).
5) Case studies and practical reports on higher education practices in Rwanda (e.g., Mutwarasibo, 2013).

Data Analysis

The analysis follows a thematic approach, where the collected documents are reviewed and coded to identify recurring themes and patterns. The following steps are taken:

1) **Document Review**: Each document is read thoroughly to understand its content and relevance to the research questions.
2) **Coding**: Key information related to personalized learning models, their components, impacts, and implementation challenges are highlighted and coded.
3) **Theme Identification**: Codes are grouped into themes corresponding to the research questions, such as "key components of personalized learning," "impact on student engagement," "role of AI," and "implementation challenges."
4) **Synthesis**: The themes are synthesized to derive insights and conclusions. Comparisons between traditional and personalized learning approaches are made, and the role of AI is explored in depth.

5) **Validation**: To ensure reliability, the findings are cross-checked with multiple sources and subjected to peer review.

Findings

Findings of Research Question One: What are the key components of successful personalized learning models in Rwandan higher education, and how do they differ from traditional educational approaches?

Key Components of Successful Personalized Learning Models in Rwandan Higher Education in Rwanda

1) **Learner-Centered Approach**: A fundamental component of personalized learning is placing the student at the center of the educational experience. This approach considers each student's interests, learning styles, and pace, allowing for more tailored instruction. Unlike traditional methods where one-size-fits-all, the learner-centered approach in Rwandan higher education emphasizes active engagement and individual responsibility in the learning process (Kagwesage *et al.,* 2021).
2) **Flexible Learning Paths**: Personalized learning models offer flexible learning paths that adapt to the needs and progress of each student. This flexibility can include varied instructional strategies, differentiated assignments, and adaptive learning technologies that provide customized content. Traditional approaches, conversely, typically follow a fixed curriculum with uniform instruction and assessment for all students (Ministry of Education, 2020).
3) **Use of Technology and Digital Tools**: The integration of technology is crucial in personalized learning. Digital platforms and tools facilitate adaptive learning, allowing educators to deliver personalized content and feedback. In Rwanda, the use of mobile learning applications and online resources can support personalized learning by providing accessible and scalable educational solutions, contrasting with the often limited technological integration in traditional education (Mutwarasibo, 2013).
4) **Data-Driven Decision Making**: Successful personalized learning models rely on continuous data collection and analysis to inform instructional decisions. Data on student performance, engagement, and learning preferences are used to tailor educational experiences. Traditional education systems, however, may lack the mechanisms for such detailed data analysis, often relying on periodic assessments that do not provide real-time insights (Pane *et al.,* 2015).
5) **Competency-Based Progression**: In personalized learning, students' progress based on their mastery of subjects rather than time spent in class. This competency-based progression ensures that students advance only when they have achieved the required understanding, offering a more individualized pace of learning. Traditional models typically follow a time-based progression, where all students move through the curriculum at the same rate regardless of their mastery (Pane *et al.,* 2017).
6) **Collaborative and Interactive Learning**: Personalized learning emphasizes collaboration and interaction among students through group projects, peer tutoring, and interactive activities. These practices foster a supportive learning community and enhance critical thinking skills. Traditional education often focuses on individual work and lecture-based instruction, with less emphasis on collaborative learning (Basham *et al.,* 2016).
7) **Personalized Assessments**: Assessments in personalized learning are tailored to the individual's learning path and provide meaningful feedback that guides further learning. These assessments are varied and continuous, offering a comprehensive view of student progress. In contrast, traditional education often relies on standardized testing, which may not reflect individual student's strengths and areas for growth (Holmes *et al.,* 2019).

Findings of Research Question Two: How does personalized learning impact student engagement, motivation, and academic achievement in Rwandan higher education institutions?

Impact of Personalized Learning on Student Engagement, Motivation, and Academic Achievement in Rwandan Higher Education Institutions

1) **Increased Student Engagement**: Personalized learning has been shown to significantly increase student engagement in higher education settings. By tailoring learning experiences to individual interests and needs, students are more likely to find the content relevant and stimulating. This engagement is particularly evident when students have a say in their learning paths, which fosters a sense of ownership and responsibility over their education (Kagwesage *et al.,* 2021). The use of technology in personalized learning environments also plays a crucial role in maintaining student interest through interactive and dynamic content (Ministry of Education, 2020).
2) **Enhanced Motivation**: Personalized learning approaches have been linked to enhanced student motivation. When learning is adapted to fit the pace and style of each student, it helps to reduce

frustration and feelings of inadequacy. Instead, students experience a sense of accomplishment and progression, which boosts their intrinsic motivation to learn (Pane *et al.,* 2015). Additionally, personalized feedback and recognition of individual achievements further motivate students by acknowledging their unique efforts and progress (Basham *et al.,* 2016).

3) **Improved Academic Achievement**: There is substantial evidence to suggest that personalized learning positively impacts academic achievement. By focusing on mastery of content, personalized learning ensures that students fully understand each concept before moving on, leading to deeper learning and better retention of information (Pane *et al.,* 2017). In the context of Rwandan higher education, personalized learning strategies have been found to help bridge gaps in understanding and cater to diverse learning needs, thereby improving overall academic performance (Kagwesage *et al.,* 2021).
4) **Adaptability and Inclusiveness**: Personalized learning promotes inclusiveness by accommodating the diverse needs of students, including those with different learning abilities and backgrounds. This adaptability helps in creating an equitable learning environment where all students have the opportunity to succeed (Mutwarasibo, 2013). The ability to customize learning experiences ensures that students who might struggle in traditional settings receive the support they need to thrive academically.
5) **Development of Critical Thinking and Problem-Solving Skills**: Through personalized learning, students are often engaged in more complex, real-world problems that require critical thinking and problem-solving skills. These skills are essential for academic success and are highly valued in higher education and beyond. Personalized learning environments encourage students to take an active role in their learning, ask questions, and seek out information, which contributes to the development of these crucial skills (Holmes *et al.,* 2019).

Findings of Research Question Three: How can the use of artificial intelligence assist students in personalized learning?

The Role of Artificial Intelligence in Assisting Students with Personalized Learning

1) **Adaptive Learning Systems**: Artificial intelligence (AI) powers adaptive learning systems that personalize educational content and pacing to fit individual student needs. These systems analyze student performance in real-time and adjust the difficulty and style of the material accordingly, ensuring that each student remains challenged yet not overwhelmed (Holmes *et al.,* 2019). This approach allows for a more tailored learning experience compared to traditional, static educational methods (Pane *et al.,* 2015).
2) **Intelligent Tutoring Systems**: AI-driven intelligent tutoring systems provide personalized instruction and feedback to students. These systems can mimic one-on-one tutoring by offering hints, explanations, and tailored guidance based on the student's progress and understanding. They can identify areas where students struggle and provide additional resources or alternative explanations to help them grasp difficult concepts (Luckin *et al.,* 2016).
3) **Personalized Learning Pathways**: AI can create personalized learning pathways by analyzing vast amounts of data on student performance, preferences, and learning styles. This allows for the customization of learning plans that align with each student's strengths and weaknesses, ensuring a more effective and individualized educational experience (Pane *et al.,* 2017). Such pathways are continuously adjusted as the student progresses, making learning more dynamic and responsive to individual needs (Fischer, 2020).
4) **Predictive Analytics**: AI employs predictive analytics to identify at-risk students early and provide interventions before they fall behind. By analyzing patterns in student data, such as engagement levels, assignment submissions, and quiz performance, AI systems can predict which students may need additional support and offer personalized recommendations to educators for timely interventions (Baker and Inventado, 2014).
5) **Natural Language Processing (NLP) Tools**: NLP tools powered by AI can assist in developing students' language and comprehension skills by providing real-time feedback on writing and spoken language. These tools can analyze grammar, syntax, and semantics to offer personalized suggestions for improvement, thereby enhancing students' communication skills (Holmes *et al.,* 2019). Additionally, NLP tools can adapt content delivery to match the reading level and interests of each student (Zawacki-Richter *et al.,* 2019).
6) **Virtual Learning Assistants**: AI-based virtual learning assistants (VLAs) support students by answering questions, providing reminders, and helping with time management. These assistants can interact with students through text or voice, offering a personalized and immediate response to their queries. VLAs help in keeping students organized and motivated, ensuring they stay on track with their learning goals (Luckin *et al.,* 2016).

7) **Enhanced Accessibility**: AI enhances accessibility by offering tools that support students with disabilities. For example, AI can provide speech-to-text services, text-to-speech readers, and personalized learning interfaces that accommodate various learning needs. These tools ensure that all students, regardless of their physical or cognitive abilities, can access and benefit from personalized learning opportunities (Zawacki-Richter *et al.,* 2019).

Findings of Research Question Four: What challenges do educators and institutions face when implementing personalized learning in Rwanda, and what strategies can be used to overcome these challenges?

Table 1. Challenges and strategies in implementing personalized learning in Rwanda.

	Challenges	**Strategy to overcome**
Limited technological infrastructure	One of the significant challenges in implementing personalized learning in Rwanda is the limited technological infrastructure. Many educational institutions lack the necessary hardware, software, and reliable internet connectivity required to support personalized learning platforms (Mutwarasibo, 2013). This infrastructure deficit hampers the effective deployment and use of digital tools essential for personalized learning.	Investment in infrastructure development is crucial. Government initiatives and public-private partnerships can help improve access to technology. Programs aimed at equipping schools with computers and ensuring stable internet connections are essential. For instance, the government can work with tech companies to provide affordable or subsidized digital devices and internet access to educational institutions (Ministry of Education, 2020).
Insufficient training for educators	Educators often lack the training and professional development needed to effectively implement personalized learning strategies. This can lead to resistance or ineffective use of personalized learning tools (Kagwesage *et al.,* 2021).	Comprehensive training programs should be established to equip educators with the skills and knowledge necessary for personalized learning. Ongoing professional development opportunities, workshops, and courses focusing on the use of digital tools and adaptive learning strategies can help teachers adapt to new methods (Holmes *et al.,* 2019).
Financial constraints	Many Rwandan educational institutions operate under tight budgets, making it challenging to afford the initial investment and ongoing costs associated with personalized learning technologies and programs (Mutwarasibo, 2013).	Securing funding through grants, donations, and partnerships with international organizations can alleviate financial constraints. Additionally, institutions can prioritize investments that offer the most significant impact, such as scalable digital platforms and cost-effective adaptive learning tools (Pane *et al.,* 2015).
Curriculum rigidities	The existing curriculum in many Rwandan educational institutions is often rigid and standardized, which is incompatible with the flexibility required for personalized learning (Ministry of Education, 2020).	Curriculum reforms that allow for more flexibility and customization are necessary. Educational policymakers need to develop frameworks that support adaptive learning paths and competency-based progression. Engaging stakeholders in the education sector to align curriculum standards with personalized learning principles is crucial (Pane *et al.,* 2017).
Cultural and attitudinal barriers	There can be cultural resistance to personalized learning from educators, students, and parents who are accustomed to traditional teaching methods (Kagwesage *et al.,* 2021).	Creating awareness about the benefits of personalized learning through workshops, seminars, and community engagement can help shift attitudes. Success stories and pilot programs that demonstrate the effectiveness of personalized learning can also encourage acceptance and adoption (Basham *et al.,* 2016).
Data privacy and security concerns	The use of personalized learning involves collecting and analyzing vast amounts of student data, which raises concerns about privacy and data security (Holmes *et al.,* 2019).	Implementing robust data privacy policies and using secure platforms for data storage and analysis are essential. Educators and institutions must ensure compliance with data protection regulations and educate stakeholders about the importance of data security (Fischer, 2020).

Findings of Research Question Five: What challenges do educators and institutions face when implementing personalized learning through artificial intelligence in Rwanda, and what strategies can be used to overcome these challenges?

Table 2. Challenges and strategies in implementing personalized learning through artificial intelligence in Rwanda.

	Challenges	**Strategy to overcome**
Limited technological infrastructure	A major challenge in implementing AI-driven personalized learning in Rwanda is the limited technological infrastructure. Many institutions lack sufficient computers, reliable internet connectivity, and other necessary digital resources to support AI applications (Mutwarasibo, 2013). This technological gap hampers the integration of AI tools essential for personalized learning.	To address this issue, substantial investment in technological infrastructure is needed. The Rwandan government, in collaboration with private sector partners, can work on initiatives to provide affordable computers and improve internet connectivity in educational institutions. Additionally, exploring mobile-based AI learning applications can be beneficial given the high penetration of mobile phones in Rwanda (Ministry of Education, 2020).
Insufficient training for educators	Educators often lack the training and skills required to effectively use AI tools for personalized learning. This lack of expertise can lead to underutilization or ineffective implementation of AI technologies (Kagwesage *et al.,* 2021).	Comprehensive training programs are essential to equip educators with the necessary skills. Professional development workshops, online courses, and hands-on training sessions focusing on AI in education can help teachers understand and effectively integrate AI tools into their teaching practices (Holmes *et al.,* 2019).
Financial constraints	Implementing AI-driven personalized learning can be costly, especially for institutions with limited budgets. The high cost of AI software, maintenance, and the need for continuous upgrades pose significant financial challenges (Mutwarasibo, 2013).	Institutions can seek funding through grants, international aid, and partnerships with tech companies. Additionally, adopting open-source AI tools and platforms can reduce costs while still providing robust personalized learning experiences. Collaborative efforts between educational institutions can also help share resources and reduce individual costs (Pane *et al.,* 2015).
Data privacy and security concerns	The use of AI in personalized learning involves collecting and analyzing large amounts of student data, raising concerns about privacy and security. Ensuring data protection and maintaining student confidentiality are critical challenges (Holmes *et al.,* 2019).	Implementing stringent data privacy policies and utilizing secure, encrypted data storage solutions are essential. Educators and institutions must comply with data protection regulations and educate stakeholders about the importance of data security. Developing clear guidelines and protocols for data handling and usage can also mitigate privacy concerns (Fischer, 2020).
Resistance to change	There can be resistance to adopting AI-driven personalized learning from educators, students, and parents who are accustomed to traditional educational methods. This resistance can stem from a lack of understanding or fear of the unknown (Kagwesage *et al.*, 2021).	To overcome resistance, it is important to engage all stakeholders through awareness campaigns, demonstrating the benefits of AI in personalized learning. Pilot programs that showcase successful implementation and outcomes can help build trust and acceptance. Providing continuous support and addressing concerns promptly can also facilitate smoother transitions (Luckin *et al.,* 2016).
Ethical considerations	The use of AI in education raises ethical questions, such as potential biases in AI algorithms and the fairness of AI-driven decisions affecting students' learning paths (Holmes *et al.,* 2019).	Addressing ethical considerations involves developing and deploying AI systems with fairness and transparency in mind. Institutions should work with AI developers to ensure that algorithms are free from biases and are regularly audited. Additionally, involving educators in the development process can provide insights into ethical implications and help create more equitable AI tools (Zawacki-Richter *et al.,* 2019).

Findings of Research Question Six: What challenges do students of higher learning institutions in Rwanda face when personalized learning through artificial intelligence is implemented, and what strategies can universities in Rwanda used to overcome these challenges?

Table 3. Challenges faced by students in Rwandan higher learning institutions with AI-driven personalized learning and strategies for universities to overcome these challenges.

	Challenges	**Strategy to overcome**
Limited access to technology	Many students in Rwandan higher learning institutions face limited access to the technology required for AI-driven personalized learning. This includes lack of personal computers, smartphones, and reliable internet access, which are essential for accessing AI-based learning platforms (Mutwarasibo, 2013).	Universities can establish partnerships with technology companies to provide affordable or subsidized devices and internet access to students. Additionally, creating computer labs and ensuring that campus Wi-Fi is accessible and robust can help mitigate this issue (Ministry of Education, 2020).
Digital literacy	Students often lack the necessary digital literacy skills to effectively use AI tools for learning. This includes navigating AI-driven platforms, utilizing digital resources, and understanding how to engage with AI feedback systems (Mutwarasibo, 2013).	Implementing digital literacy programs as part of the university curriculum can help students gain the skills they need. Workshops, tutorials, and online courses focused on digital skills and the use of AI in education can empower students to take full advantage of these technologies (Pane *et al.,* 2015)
Adaptation to self-paced learning	Personalized learning through AI often involves self-paced learning, which requires students to be self-motivated and disciplined. Many students may struggle with this shift from traditional, structured classroom environments (Kagwesage *et al.,* 2021).	Universities can provide support systems such as mentoring programs, academic advising, and time management workshops to help students adjust. Encouraging peer study groups and creating virtual communities where students can share experiences and strategies can also foster a supportive learning environment (Basham *et al.,* 2016).
Anxiety and stress	The use of AI in personalized learning can lead to anxiety and stress among students, particularly if they feel overwhelmed by the technology or fear being constantly monitored and assessed (Holmes *et al.,* 2019).	To reduce anxiety, universities should ensure that AI tools are user-friendly and that students receive adequate training on how to use them. Providing psychological support services and creating awareness about the benefits of AI can help alleviate fears. Regular feedback sessions where students can express their concerns and get reassurances can also be beneficial (Fischer, 2020).
Privacy and ethical concerns	Students may have concerns about the privacy of their data and the ethical implications of AI algorithms used in personalized learning. There is often apprehension about how their personal information is being collected, stored, and used (Holmes *et al.,* 2019).	Universities must implement stringent data privacy policies and ensure transparency about how student data is handled. Educating students about their rights and the measures in place to protect their data can build trust. Engaging students in discussions about the ethical use of AI in education can also promote a better understanding and acceptance (Zawacki-Richter *et al.,* 2019).
Unequal learning opportunities	AI-driven personalized learning can inadvertently widen the gap between students with varying levels of access to resources and support. Those with better access to technology and support systems may benefit more than their less privileged peers (Kagwesage *et al.,* 2021).	To ensure equity, universities need to provide equal access to AI tools and learning resources for all students. This can be achieved through scholarship programs, loaner devices, and ensuring that digital resources are available both on and off-campus. Tailoring support services to meet the needs of disadvantaged students can help level the playing field (Pane *et al.,* 2017).

Conclusion

1) Key Components of Successful Personalized Learning Models in Rwandan Higher Education, and Their Differences from Traditional Educational Approaches: Personalized learning models in Rwandan higher

education focus on tailored curriculums, adaptive instruction, competency-based progression, extensive use of technology, continuous assessments, and learner-centered approaches. These components contrast sharply with traditional educational approaches characterized by standardized curriculums, uniform instruction, time-based progression, limited use of technology, periodic assessments, and teacher-centered approaches (Basham *et al.,* 2016; Holmes *et al.,* 2019).

2) Impact of Personalized Learning on Student Engagement, Motivation, and Academic Achievement in Rwandan Higher Education Institutions: Personalized learning significantly enhances student engagement and motivation by providing tailored learning experiences that align with individual interests and needs. This approach fosters a more active and participatory learning environment, leading to improved academic achievement. Studies show that students in personalized learning environments are more likely to be engaged, motivated, and perform better academically compared to those in traditional settings (Kagwesage *et al.,* 2021).
3) Use of Artificial Intelligence in Assisting Students with Personalized Learning: AI can greatly enhance personalized learning by providing real-time feedback, adaptive learning paths, and personalized content. AI tools can analyze student performance data to offer customized learning experiences, identify areas where students need more help, and suggest resources tailored to their learning styles. This helps in creating a more efficient and effective learning process (Holmes *et al.,* 2019).
4) Learning Institutions in Rwanda When Personalized Learning through Artificial Intelligence is Implemented, and Strategies to Overcome Them: Students face challenges including limited access to technology, lack of digital literacy, adaptation to self-paced learning, anxiety, and stress. Strategies to overcome these challenges include providing affordable technology, offering digital literacy programs, creating support systems like mentoring and advising, ensuring user-friendly AI tools, and addressing ethical concerns transparently (Holmes *et al.,* 2019; Kagwesage *et al.,* 2021).

Recommendations

To the universities regulators in Rwanda:

1) Enhance Technological Infrastructure: Invest in technological infrastructure to support the implementation of AI and personalized learning across all higher education institutions.
2) Policy Development: Develop and enforce policies on data privacy, ethical use of AI, and equitable access to technology.

To the higher education institutions:

3) Comprehensive Training Programs: Provide continuous professional development for educators to equip them with skills needed to implement AI-driven personalized learning.
4) Support Systems: Establish mentoring, advising, and psychological support systems to help students adapt to new learning models.
5) Resource Accessibility: Ensure that all students have access to necessary technological resources and digital learning tools.

To the higher education students:

6) Engage in Digital Literacy: Participate actively in digital literacy programs to enhance your ability to use AI tools effectively.
7) Utilize Support Systems: Take advantage of the support systems provided by institutions to navigate the challenges of personalized learning.
8) Provide Feedback: Actively provide feedback on AI tools and learning experiences to help institutions improve their personalized learning models.

Declarations

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Author Contributions

Research Design and Conceptualization: Butera Edison developed the study framework and objectives, ensuring alignment with the research goals.

Data Collection and Analysis: Butera Edison conducted the documentary research, investigated the integration of artificial intelligence (AI) into personalized education, analyzed documents of artificial intelligence and personalized learning approaches in Rwandan higher education and academic literature relevant to the study.

Writing and Drafting: Butera Edison drafted the manuscript and incorporated feedback from co-author, ensuring clarity and coherence in presenting the findings.
Critical Review and Editing: Kanyamihigo Kayonde Jean Paul provided critical insights and revisions throughout the writing process, enhancing the overall quality of the article.
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