Effect of Adaptive Learning Technology Use and Academic Achievement of Learners in Public Primary Schools in Rwanda: A Case of Rusizi District

Byimana Dieudonne[1], Dr. Hesbon Andala (PhD)[2] Mr. Letanzio Mugo[3]
1.Mount Kenya University
2.Mount Kigali University.
3.Mount Kigali University

Abstract

This study investigated the effect of adaptive learning technology on academic achievement among learners in public primary schools in Rusizi District, Rwanda. The research aimed to identify adaptive learning tools influencing student performance, assess learners' academic achievement levels, and examine the relationship between technology use and achievement. Employing a descriptive survey design with quantitative and qualitative methods, the study sampled 389 respondents from teachers, students, and headteachers across 29 primary schools using purposive and random sampling. Data were collected via questionnaires, interviews, and observations, then analyzed using SPSS for descriptive and inferential statistics. Results showed a high usage of online textbooks (94.9% agreement) as adaptive tools, and that 94.5% of respondents recognized improved national exam results as evidence of academic achievement. Pearson correlation (r = 0.851) indicated a strong positive relationship between adaptive learning technology use and student achievement. The study recommends further research on adaptive systems' role in motivating learners and aligning with diverse learning styles.

Keywords: *Academic Achievements, Adaptive learning, Educational technology, Elementary Education*

1   Introduction

Adaptive learning is an educational scaffolding strategy designed to benefit all stakeholders in a learning environment, including teachers, students, and school administrators (Castañeda & Selwyn, 2018). This technology supports instructors by saving time and providing valuable data on each student's learning progress and abilities. Acting as an assistive platform, adaptive learning enables educators to design personalized teaching experiences tailored to individual student needs, with customized materials and activities that align with each learner's pace and level. This approach, often referred to as supportive scaffolding, requires teachers to adopt differentiated instruction methods that match the unique learning processes of their students. Globally, research in countries such as India has shown that while educational technology generally has a positive impact on learning outcomes, customizing technology to meet the needs of individual learners remains challenging (Cheung & Slavin, 2020). Adaptive Learning Technology (ALT) is a growing trend within Computer-Assisted Learning (CAL), leveraging artificial intelligence (AI), machine learning, and algorithms to continually adjust digital resources based on students' skill levels and progress (Xie et al., 2019; UDIR, 2018). Recent advances in AI have made it possible to simulate human tutoring processes and deliver personalized education that can significantly enhance student engagement and achievement.

In countries like Norway, digital competence has been recognized as a key skill across all educational levels since 2006, with technology integrated into all subject areas (Krumsvik et al., 2020). Most Norwegian students now have access to personal computers or tablets, facilitating individualized learning experiences. Despite the benefits, challenges remain for teachers in effectively managing digital tools within classrooms, as highlighted in national policy documents. This underscores the need for better integration of ALT in classroom management and teacher training (Honna, 2020). In other regions, such as Japan, the Ministry of Education promotes English as a Foreign Language (EFL) education supported by adaptive technologies to enhance inclusion, especially for students with special needs (Yamada, 2018). Similarly, in South Africa, adaptive technologies like screen readers and magnifiers empower visually impaired learners, as documented in resources by Sensory Solutions Limited (2018) and the South African National Council for the Blind (2015).

In East Africa, studies in Tanzania and Kenya have examined the use of assistive technologies for students with visual and hearing impairments, highlighting both opportunities and barriers (Ampratwum et al., 2016; Kisanga, 2019; Gitari, 2021). However, empirical research on how adaptive learning technologies affect academic achievement in Rwanda remains limited. Rwanda's education system has embraced a competency-based curriculum emphasizing seven core competencies, including ICT skills, literacy, and numeracy, all essential for modern learning (Ntalindwa, 2022). The Education Sector Strategic Plan (2018–2024) aims to improve learning outcomes through the integration of ICT, building infrastructure, teacher capacity, and smart classrooms (Zeitlin, 2018). Despite these initiatives, national exam performance data reveal persistent challenges, with high failure rates reported in recent years (MINEDUC, 2023).

Research indicates that insufficient use of adaptive technologies negatively impacts student achievement (Mungai, 2014; Batanero, 2022). Although the Rwandan Ministry of Education advocates for adaptive technology deployment, cost and accessibility remain barriers (Ministry of Education, 2023). Given the moderate but positive influence of educational technology on learning (Costley, 2020), this study seeks to further explore the impact of adaptive learning technology on the academic achievement of learners in public primary schools in Rusizi District, Rwanda. The general objective of this study is to investigate the effect of adaptive learning technology use on the academic achievement of learners in public primary schools in Rusizi District, Rwanda. The specific objectives are to: i. Identify adaptive learning technology tools that influence academic achievement in these schools, Determine the level of academic achievement among learners using adaptive learning technology, and Examine the relationship between adaptive learning technology use and academic achievement of learners in public primary schools in Rusizi District.

2 Review of Related Literature
2.1 Empirical Literature
Adaptive technology (AT), as defined by the World Health Organization (2018), encompasses all systems and services associated with assistive goods to improve the functionality of individuals, particularly those with disabilities. In the U.S., the Adaptive Technology Act (1998) refers to any equipment or system, whether customized or commercially acquired, that enhances the functional capabilities of individuals with disabilities. Lewis (2020) emphasizes that AT's core purpose is twofold: compensating for impairments and boosting individuals' capacities to thrive.

2.1.1 Adaptive Learning Technology Tools that Influence Academic Achievement
White (2015) explored the integration of learning analytics (LA) and adaptive learning technologies (ALT) in primary schools. The study revealed that although instructors acknowledge the benefits of ALT, its implementation often presents challenges due to technical complexity and limited professional development. Adaptive tools are generally categorized into low-tech and high-tech solutions. Low-tech tools include items like visual aids, pencil grips, or modified learning materials, which are affordable and easy to use. High-tech tools, such as screen readers, speech-to-text software, and AI-driven personalized learning platforms, are more complex and expensive but provide deeper customization and accessibility for learners (Luce & Flecky, 2018; Cook & Hussay, 2021).

According to Bouck et al. (2023), AT enhances learners' independence and learning capacity, provided the tools align with their specific needs and learning contexts. Seok and DaCosta (2020) emphasize that affordability, accessibility, and teacher training are critical for effective implementation. Borg et al. (2018) argue that the

provision of AT should not be influenced by age or gender and must be universal across socio-economic groups. Bağlama (2023) found a strong correlation between teachers' attitudes toward adaptive technologies and their classroom management skills. Positive attitudes enabled better integration of ALT tools, improving both instructional delivery and learner engagement. Culp, Honey, and Mandinach (2015) note that educational technology, including ALT, enhances engagement, develops behavior, and accommodates diverse learning needs, especially in inclusive settings. According to Currie and Drewry (2018), adaptive technologies empower learners to overcome daily learning barriers. Dalton (2018) argues that adaptive tools are essential in fostering equity in education, especially when they are tailored to the learners' abilities and the learning environment. McLeskey and Waldron (2023) advocate for embedding technology into customized learning materials to support learners with special education needs.

2.1.2 Level of Academic Achievement of Learners in Public Primary Schools

Academic achievement can be measured through performance in standardized tests, progression rates, and classroom participation. Adaptive tools play a pivotal role in influencing these outcomes. Reed and Yeager (2018) categorize assistive tools into low, medium, and high-tech devices. These include page turners, smartboards, virtual reality applications, and reading magnifiers. Aleven et al. (2016) highlight that adaptive learning systems range from rule-based to AI-enhanced systems, supporting mastery learning and metacognition.

In Zambia, Megeha (2015) observed that student preferences, including how they engage with visual content, influence how adaptive learning tools should be designed. Osadchyi et al. (2020) show that blended and online environments utilizing ALT improve personalization and engagement. Kasinathan et al. (2017) highlight the use of analytics and machine learning to enhance adaptive content, although challenges in scaling remain.

Njuguna (2022) conducted a study in Kenya's Murang'a South Sub County and found that factors like mother tongue interference, lack of assessment tools, and resource scarcity negatively affected academic performance. Similarly, Chemiat (2020) and Mulwa et al. (2017) found that inadequate teaching resources, poor infrastructure, and teacher shortages are detrimental to student outcomes. Pauline (2020) notes the lack of adapted materials for learners with hearing impairments, reiterating the need for inclusive resource provision. Gurgand (2015) established that boarding status positively affects performance due to reduced domestic distractions. Mulwa et al. (2017) confirmed that school-based variables—such as teacher support, infrastructure, and teaching materials—are directly linked to academic performance and educational waste. Runić-Ristić (2023) affirmed the efficacy of adaptive e-learning in improving learner motivation and performance, especially when compared with traditional systems.

2.1.3 Relationship between Adaptive Learning Technology Use and Academic Achievement

Research strongly supports a positive relationship between the use of adaptive technology and learners' academic achievement. Aslan and Kan (2017) revealed that teachers with favorable attitudes toward AT were more likely to integrate it effectively into their teaching. According to Marzano and Marzano (2020), student success is closely tied to effective classroom management, which is further enhanced by the integration of AT tools. Muñoz (2022) reviewed 9764 publications on ALT in higher education, identifying adaptive feedback, learner traits, and navigational structures as core areas of focus. Despite existing progress, the study identifies research gaps in implementation frameworks and training approaches. Castro (2019) notes that adaptive platforms enable students to receive instruction tailored to their performance, which helps close learning gaps. Fidel (2017) asserts that adaptive learning allows learners to progress at their own pace, providing real-time feedback that builds their competence. According to Aleven et al. (2016), adaptive platforms help teachers personalize learning experiences, reflect on instruction, and adjust delivery methods for maximum effectiveness. Pitts (2022) adds that adaptive systems serve as tools for administrators to boost performance while managing limited budgets.

Maguvhe (2020) analyzed the role of AT in improving learning outcomes for visually impaired students in developed countries. Koch (2017) and Boucher (2018) report widespread use of AT in North America, citing improved communication and self-expression skills. However, Sahin and Yorek (2019) caution that AT access remains low globally, with the WHO (2016) estimating only 10% global access. Kelly et al. (2018) found that fewer than 40% of students in the U.S. had adequate access to ALT, and G3ict (2017) noted that many countries lack digital infrastructure and accessible libraries. Wong (2021) identified teacher attitudes and large class sizes as barriers to effective math instruction using AT. In overcrowded classrooms, student engagement and content mastery suffer. Sahin and Yorek (2019) added that teachers without specialized training struggle to support learners with hearing impairments effectively. Jude (2015) investigated adaptive audio technology's impact on hearing-impaired learners in Jigawa, Kenya. The findings showed that technologies like audio induction loops

significantly improved comprehension and participation. Dalton (2020) highlighted similar barriers in Tanzanian higher education, where poor infrastructure and limited training restrict AT access. Students often rely on peer support and personal resilience to overcome these limitations. Dalton recommends regular AT training and increased funding for equitable access.

2.2 Theoretical Framework

2.2.1 Social Constructivism Theory of Vygotsky

This study is grounded in Vygotsky's Social Constructivism Theory, which emphasizes the fundamental role of social interaction and cultural context in learning. According to Vygotsky (1978), learning occurs most effectively within the Zone of Proximal Development (ZPD), where a learner can achieve higher understanding through guidance or collaboration with more knowledgeable peers or adults. This theory underpins the idea that adaptive learning technologies, when used in public primary schools, can support cognitive development by enabling peer collaboration, differentiated instruction, and play-based learning. Social constructivism advocates for learner-centered environments that encourage discovery learning, inquiry-based methods, and ownership of knowledge construction. Adaptive learning technologies align with these principles by promoting personalized, interactive, and socially engaging educational experiences. As Ntalindwa (2022) notes, adaptive technologies not only improve academic performance but also support collaborative learning, consistent with Vygotsky's vision of education as a socially mediated process of development and knowledge acquisition.

2.3 Conceptual Framework

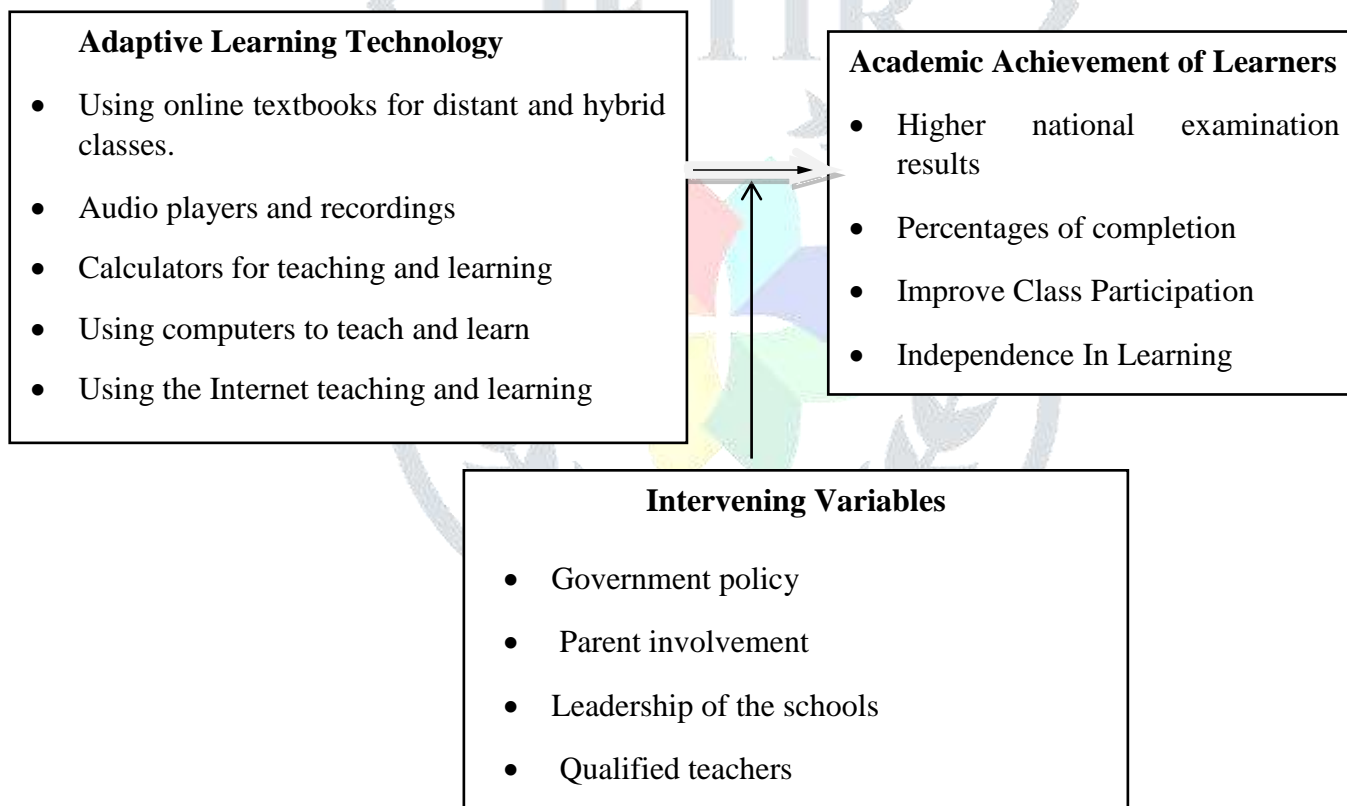**Independent Variable**   **Dependent Variable**

Figure 2.1: Conceptual Framework

Source: Researcher (2024)

Figure 2.1 indicates the independent variable which Adaptive learning technology for students and the dependent variable which is Academic Achievement of Learners as well as the intervening variables.

3. Research Methodology

According to Kothari (2020), research methodology serves as the blueprint that guides the overall research process by identifying the study population, data collection tools, and procedures for analysis. Simon (2016) concurs, stating that the study design outlines the systematic approach adopted to answer the research questions effectively. This study employed a descriptive survey design, integrating both quantitative and qualitative methods**.** The descriptive design allowed the researcher to capture perceptions, attitudes, and behaviors of participants concerning the use of adaptive learning technologies in public primary schools in Rusizi District, Rwanda. Quantitative data were gathered through structured questionnaires, while qualitative insights were derived from interviews.

The target population consisted of 13,643 individuals, including 3,800 teachers, 79 head teachers, and 9,764 students. Sampling was done using Yamane's (1976) formula for determining sample size, which provided a representative sample of 389 respondents. This included 108 teachers, 277 students, and 4 head teachers. Sampling techniques included purposive sampling for selecting teachers and students from schools using adaptive learning technology tools, and simple random sampling for choosing head teachers. Purposive sampling ensured the inclusion of participants who were most knowledgeable and relevant to the research topic.

Data collection tools included self-administered questionnaires for teachers and students, and semi-structured interviews for head teachers. The questionnaire consisted of both open and closed-ended questions. The self-administered approach allowed respondents to complete the questionnaires in their own time and space, increasing the likelihood of honest and independent responses. The researcher also used direct interviews to collect in-depth qualitative data from head teachers, which were recorded in note form during the sessions.Data collection adhered to ethical standards. A recommendation letter from Mount Kenya University was presented to relevant authorities, including head teachers and district education officials. All participants provided informed consent prior to data collection, with students' assent obtained verbally. Data collection was conducted in small group settings (six to ten students) in private rooms to ensure focus and confidentiality. The process lasted approximately one month.

Validity and reliability were emphasized to ensure research rigour. Validity was tested through expert review and a pilot study. The Content Validity Index (CVI) was computed, comparing the number of relevant questions to the total number of questions. A CVI above 0.60 confirmed the validity of the instrument. According to Yamada (2018), a valid tool accurately measures what it is intended to assess and avoids extraneous content. Reliability was tested using the Cronbach's Alpha coefficient, which measures internal consistency. A value above 0.80 indicated acceptable reliability. According to White (2015), this test ensures that the instrument produces stable and consistent results when applied repeatedly under similar conditions.

Data were cleaned and prepared through editing, coding, and tabulation. Quantitative data were analyzed using SPSS version 21.0, with descriptive statistics such as frequencies, percentages, and means computed to interpret responses. Inferential statistics, including correlation and regression analysis, were employed to determine the relationship between adaptive learning technology and academic achievement. Qualitative data from interviews were analyzed thematically and triangulated with quantitative results to ensure a comprehensive understanding of the research problem. Additional information was gathered through library research, including books, journal articles, and policy documents on adaptive learning and inclusive education, to supplement primary data. This triangulated approach strengthened the study's findings and ensured a balanced interpretation of results.

4 Presentation of Results

4.1 Adaptive Learning Technology Tools that Influence the Academic Achievement of Learners

Teachers and students were requested to answer to the questions related to the adaptive learning technology tools that influence the academic achievement of learners in public Primary schools.

Table 4.1 Adaptive Learning Technology Tools that Influence the Academic Achievement of Learners

| Items (n = 385) | Responses | | | | | | | | | | Mean | Std dev |
| | SD | | D | | N | | A | | SA | | | |
	F	%	F	%	F	%	F	%	F	%		
Using online textbooks for distant and hybrid classes indicate the adaptive learning technology tools	0	0.0	0	0	32	7.1	349	90.5	18	4.4	2.93	0.85
Audio players and recordings indicate the adaptive learning technology tools	0	0	0	0	0	0.0	65	16.5	323	83.5	2.63	0.71
Calculators for teaching and learning indicate the adaptive learning technology tools	0	0.0	0	0	5	1.3	245	63.3	138	35.4	3.83	0.53
Using computers to teach and learn indicate the adaptive learning technology tools	0	0.0	0	0	20	5.1	349	90.5	19	4.4	2.24	0.85
Using the Internet teaching and learning indicate the adaptive learning technology tools	6	1.2	0	0	0	0.0	82	21.4	300	77.9	3.07	0.71

Source: Primary Data (2024)

The findings reveal several adaptive learning technology tools being utilized in distant and hybrid learning environments. Online textbooks were widely supported, with 94.9% of respondents either strongly agreeing or agreeing on their usefulness (mean = 2.93, SD = 0.85). This aligns with Dziuban et al. (2016), who highlight that adaptive systems allow learners to progress at their own pace while providing personalized feedback (Bailey et al., 2018). Audio players and recordings also gained strong approval, with 83.5% strongly agreeing and 16.5% agreeing, though 19% strongly disagreed (mean = 2.63, SD = 0.71). Interestingly, calculators were less favored, with 63.3% strongly disagreeing and a higher mean of 3.83 (SD = 0.53), indicating limited perceived usefulness. Computers were positively received by 90.5% of respondents (mean = 2.24, SD = 0.85), while internet-based tools received 77.9% strong agreement (mean = 3.07, SD = 0.71). These findings support Wang et al. (2019), who showed personalized internet resources enhance student engagement.

4.2 Level of Academic Achievement of Learners in Public Primary Schools

The level of achievement of learners was taken into consideration in this research. The results are presented and interpreted in the following table.

Table 4.2 Level of Academic Achievement of Learners in Public Primary Schools

| Items (n = 385 | Responses | | | | | | | | | | Mean | Std dev |
| | SD | | D | | N | | A | | SA | | | |
	F	%	F	%	F	%	F	%	F	%		
Higher national examination results indicate the level of academic achievement of learners	0	0	0	0	21	5.5	243	63.1	121	31.4	2.93	0.85
Percentages of completion indicate the level of academic achievement of	6	1.5	0	0	0	0.0	176	45.0	209	53.5	2.63	0.71

learners											
Improve Class Participation indicate the level of academic achievement of learners	0	0	0	0	5	1.3	223	57.9	157	40.8	3.83	0.53
Independence In Learning indicate the level of academic achievement of learners	0	0	0	0	6	1.558	213	55.3	166	43.12	2.24	0.85

Source: Primary Data (2024)

According to the data, 94.5% of respondents agreed that national examination results indicate the level of academic achievement, supporting Dziuban et al. (2017), who found students rated adaptive learning (AL) highly for improving education and flexibility. Regarding completion percentages, 53.5% agreed and 45.0% strongly agreed, with a mean of 2.63 and standard deviation of 0.71. On class participation, 57.9% agreed and 40.8% strongly agreed (mean = 3.83, SD = 0.53). For independence in learning, 55.3% agreed, 43.1% strongly agreed, and 1.5% disagreed (mean = 2.24, SD = 0.85), highlighting AL's role in enhancing learner autonomy and achievement.

4.3 Relationship between Adaptive Learning Technology, Use and the Academic Achievement of Learners in Public Primary Schools

The Pearson correlation coefficient (r) indicates a strong positive relationship between adaptive learning technology use and academic achievement. As adaptive technology increases, learner achievement also rises. Therefore, the null hypothesis is rejected, confirming a significant positive correlation.

Table 4.3 Adaptive Learning Technology and Use and Academic Achievement of Learners in Public Primary Schools

		Adaptive learning technology and their use	Academic achievement of learner
Adaptive learning technology and their use	Pearson Correlation	1	.851[**]
	Sig. (2-tailed)		.009
	N	385	385
Academic achievement of learner	Pearson Correlation	.851[**]	1
	Sig. (2-tailed)	.009	
	N	385	385

**.Correlation is significant at the 0.01 level (2-tailed).

Source: Primary Data (2024)

The table above reveals that the independent variable, adaptive learning technology and its use, is strongly correlated with the dependent variable, academic achievement of learners. The correlation coefficient of 0.851 falls within the 0.70–0.90 interval, indicating a strong positive relationship between the two variables. This suggests that as the use of adaptive learning technology increases, learners' academic performance also improves. Therefore, the null hypothesis is rejected, confirming a significant and positive relationship in Rwandan public primary schools. Similarly, a study conducted in Pakistan using a sample of 103 respondents found a significant positive correlation (r = 0.287) between adaptive learning technology and academic achievement (Muhammad et al., 2011). However, adaptive learning remains a relatively recent innovation, with limited research on its broader

pedagogical impact. Lim et al. (2022) emphasize the need to examine learner satisfaction, while Raj and Renumol (2022) note that both direct and indirect feedback inform adaptive learning system effectiveness.

5. Discussion of Findings

5.1 Adaptive Learning Technology Tools that Influence the Academic Achievement of Learners

Teachers and students were requested to answer to the questions related to the adaptive learning technology tools that influence the academic achievement of learners in public Primary schools. This aligns with Dziuban et al. (2016), who highlight that adaptive systems allow learners to progress at their own pace while providing personalized feedback (Bailey et al., 2018). Audio players and recordings also gained strong approval, with 83.5% strongly agreeing and 16.5% agreeing, though 19% strongly disagreed (mean = 2.63, SD = 0.71). Interestingly, calculators were less favored, with 63.3% strongly disagreeing and a higher mean of 3.83 (SD = 0.53), indicating limited perceived usefulness. These findings support Wang et al. (2019), who showed personalized internet resources enhance student engagement.

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6 Conclusion and Recommendations

This study, titled "The Effect of Adaptive Learning Technology Use on the Academic Achievement of Learners in Public Primary Schools in Rusizi District, Rwanda," investigated how the use of adaptive learning technologies (ALT) influences learners' academic performance. The study population included 3,800 primary school teachers, 9,764 students, and 79 head teachers, with a total sample size of 389 respondents. The purpose was to design and assess an adaptive learning management system (LMS) based on individual learning styles, aiming to enhance learner outcomes. Findings demonstrated that adaptive learning systems significantly improve learning effectiveness, motivation, and learner satisfaction compared to traditional e-learning platforms. The personalized nature of adaptive systems—providing real-time feedback, increased interactivity, and flexibility—was shown to foster meaningful engagement and higher academic achievement. The study also confirmed a strong positive correlation (r = 0.851) between the use of adaptive learning technology and learners' academic performance.

However, the research had limitations, especially regarding sample diversity and the short-term observation of student outcomes. Additionally, while the current study focused on learning styles, other critical learner characteristics such as prior knowledge, interest, and learning pace were not fully examined. Future research

should investigate the impact of adaptive learning systems tailored to broader learner characteristics, including cognitive abilities, interest areas, and learning speeds. They should conduct long-term evaluations to better understand the sustained effects of adaptive learning technologies on academic achievement and expand research to include the role of personalized adaptive learning in higher education, particularly in relation to engagement and performance.

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