African Journal of Emerging Issues
Peer reviewed | Double blind | Interdisciplinary

African Journal of Emerging Issues (AJOEI)
Online ISSN: 2663 - 9335
Available at: https://ajoeijournals.org

ICT (EDUCATION)

DESIGNING AN OPTIMIZED MODEL FOR ENHANCING SMART CLASSROOM UTILIZATION IN PUBLIC SECONDARY SCHOOLS IN GICUMBI DISTRICT, RWANDA

[1*]Mr. Turinumikiza Maurice, [2]Dr. Mubaraka Conrad Mike, [3]Dr. Paul Ssemaluulu & [4]Assoc. Prof. Businge Phelix Mbabazi

***Email of the corresponding author: tzamaurix@gmail.com**

Publication Date: December 2025

ABSTRACT

The study investigated the key predictors of smart classroom utilization in public secondary schools in Gicumbi District, Rwanda, and developed an evidence-based optimized model to enhance digital learning. The study employed a quantitative correlational design with 175 senior three students selected through purposive sampling from schools with functional smart classrooms. Data were collected via questionnaires and analyzed using multiple regression and binary logistic regression. Findings revealed that interactivity and collaboration were significantly influenced by Technological Infrastructure, Pedagogical Readiness, and Institutional Support, whereas Critical Thinking and Active Engagement were primarily driven by Learning Environment and Learner Commitment. Peer Support and Instructional Proficiency had moderate contributions, and Pedagogical Readiness negatively affected Active Engagement. The results indicate that effective smart classroom utilization depends on a combination of technological, pedagogical, institutional, and learner-related factors. The study concludes that smart classroom utilization in Gicumbi District is driven by interconnected technological, pedagogical, institutional, and learner-related factors, with technological infrastructure, pedagogical readiness, and institutional support strongly influencing interactivity and collaboration, while learning environment and learner commitment mainly shape critical thinking and active engagement. Recommendations include prioritizing teacher professional development, improving technological infrastructure, fostering learner engagement, and establishing supportive institutional policies to maximize the benefits of smart classroom investments, ultimately enhancing digital learning outcomes in rural Rwandan secondary schools.

Keywords: *Designing, optimized model, smart classroom utilization, public secondary schools, Gicumbi District, Rwanda*

INTRODUCTION

The purpose of this study was to examine the relationship between key predictors of smart classroom utilization in public secondary schools in Gicumbi District, Rwanda, and to use these findings to design an optimized model that enhances effective utilization. Although previous research has explored factors such as teacher ICT competence, infrastructure availability, digital pedagogy readiness, and institutional support (Damien & Claire, 2022; Mushimiyimana et al., 2022; Mpumuje, 2024), limited attention has been given to understanding how these predictors interact statistically to influence utilization outcomes. Much of the existing literature tends to examine predictors in isolation, resulting in fragmented interventions that do not provide a cohesive framework for improving technology-enhanced teaching and learning (UNESCO, 2019; World Bank, 2021).

Rwanda has made considerable progress in expanding digital learning infrastructure through programs such as the Smart Classroom Initiative, supported by the ICT in Education Policy (Ministry of education (MINEDUC), 2016), the Smart Rwanda Master Plan (Ministry of ICT(MINICT), 2018), and the ICT Teacher Professional Development Framework (Rwanda Education Board (REB), 2019). These efforts were designed to strengthen digital competence, promote technology integration, and prepare learners for twenty-first-century skills. However, evidence shows that smart classroom utilization in rural districts such as Gicumbi remains below expected levels, with challenges related to limited teacher readiness, insufficient maintenance support, outdated equipment, and weak alignment between infrastructure and classroom practice (de Dieu & de Dieu, 2021; Mushimiyimana, 2021; World Economic Forum, 2020).

This study is guided by the research question: How can an optimized model be designed to support smart classroom utilization in public secondary schools in Gicumbi District, Rwanda? The importance of this research lies in providing empirical evidence on the strength and direction of relationships among technological, pedagogical, environmental, and institutional predictors of smart classroom utilization. By integrating these predictors into a statistically informed and context-appropriate optimized model, the study offers a practical framework that can guide educators, school leaders, and policymakers in maximizing the impact of Rwanda's national ICT investments. The model is further informed by systems-oriented perspectives on technology-enhanced learning, reflecting theoretical insights from scholars who argue that effective digital learning emerges from the interaction of technological tools, pedagogical approaches, and institutional arrangements (Kozma, 2003; Laurillard, 2012).

LITERATURE REVIEW

Previous research has shown that the integration of technology in education enhances teaching effectiveness, learner engagement, and the development of twenty-first-century skills (Kinshuk et al., 2016; Kozma, 2003), but results remain inconsistent, particularly in low-resource and rural contexts. Various theoretical frameworks have been proposed to explain the mechanisms and conditions under which technology integration succeeds. The Technological Pedagogical Content Knowledge (TPACK) framework emphasizes that effective digital instruction requires a balance between teachers' technological knowledge, pedagogical skills, and subject content expertise (Mishra & Koehler, 2006).

The Smart Learning Environment (SLE) theory highlights the interplay between technological infrastructure, pedagogical readiness, learning environment, and institutional support in fostering meaningful learning (Kinshuk et al., 2016). Similarly, the Community of Inquiry (CoI) framework focuses on teaching, social, and cognitive presence as mediators of effective learning in technology-rich environments (Garrison, Anderson, & Archer, 2000). Practical models such as the SAMR model, which includes Substitution, Augmentation, Modification, and Redefinition, (Puentedura, 2006) and Flipped Classroom approaches (Bergmann & Sams, 2012) guide teachers in progressively integrating technology while promoting active, student-centered learning.

Several studies have suggested that technology integration can produce significant gains in student engagement, personalized learning, and digital literacy in technologically advanced contexts (Cha & Ahn, 2020; Kim & Lee, 2012), while others have reported minimal impact in rural settings due to insufficient teacher competence, weak institutional support, unstable infrastructure, and limited curriculum alignment (Mushimiyimana, 2021; Mpumuje, 2024; UNESCO, 2019). Frameworks such as TPACK and SAMR provide valuable perspectives on teacher-centered practices and technology adoption; however, they often assume favorable infrastructural conditions and robust pedagogical support, assumptions that are not consistently met in rural districts such as Gicumbi.

The majority of existing literature has focused on urban or well-resourced schools, leaving rural schools underexplored despite unique challenges such as intermittent electricity, unstable internet connectivity, limited access to devices, and lower teacher readiness (Mushimiyimana, 2021; REB, 2018). Human factors, including teacher training, pedagogical readiness, and ongoing professional development, are critical for effective technology integration (Damien & Claire, 2022; Aashish & Rohit, 2024). Systemic factors, including institutional leadership, governance structures, policy frameworks, and curriculum alignment, are decisive for sustaining digital learning initiatives (Otieno, 2022; Nabushawo & Aguti, 2023).

Recent studies have highlighted the need for context-sensitive, integrated approaches that combine technological infrastructure, pedagogical readiness, learning environment, and institutional support with mediating factors such as instructional proficiency, learner commitment, and peer support (de Dieu et al., 2021; Mpumuje, 2024). Integrating SLE, Digital Learning Environment theory, CoI, and Flipped Classroom principles provides a robust conceptual basis for developing frameworks that address both structural and human dimensions of smart classroom utilization (Kozma, 2003; Kinshuk et al., 2016; Garrison et al., 2000; Bergmann & Sams, 2012).

Global and regional experiences further underscore the importance of holistic and adaptive frameworks. South Korea's Smart Education Strategy demonstrated that combining infrastructure provision with sustained teacher training, parental engagement, and systematic monitoring improves learning outcomes (Cha & Ahn, 2020; Kim & Lee, 2012). India's DIKSHA platform illustrated the value of localized content, hybrid offline-online access, and continuous professional development in resource-constrained settings (Ministry of Education India, 2017; Aashish & Rohit, 2024). In the United Arab Emirates, the Mohammed Bin Rashid Smart Learning Program highlighted structured teacher training and performance monitoring as essential for successful digital transformation (AlGhawi, 2017; Konca et al., 2025). Regionally, Makerere University in Uganda emphasized the role of institutional leadership, ICT policies, and faculty development in sustaining smart classroom use in African contexts (Makerere University, 2022; Nabushawo & Aguti, 2023).

In Rwanda, the National Smart Classroom Initiative illustrates the limitations of focusing primarily on devices without corresponding teacher training, curriculum integration, or institutional support (REB, 2018; Mugisha et al., 2021; Mpumuje, 2024). In rural districts such as Gicumbi, smart classrooms are often underutilized due to low teacher competence, weak leadership, unreliable electricity, and limited access to functional devices (Otieno, 2022; Mushimiyimana, 2021). This review summarizes key findings and identifies the main research gap addressed in this study. While theoretical frameworks and international experiences provide valuable insights, there is currently no integrated, context-specific, theory-informed model for optimizing smart classroom utilization in rural Rwandan secondary schools. Existing studies often treat infrastructure, pedagogy, and institutional support separately, failing to explain how these elements interact to produce meaningful utilization. Addressing this gap requires a holistic, locally grounded, and theory-informed framework to guide sustainable smart classroom implementation in Gicumbi District and similar rural contexts.

RESERCH METHODOLOGY

The study employed a quantitative correlational design to examine how Technological Infrastructure, Pedagogical Readiness, Learning Environment, Institutional Support, Instructional Proficiency, Learner Commitment, and Peer Support predict smart classroom utilization-measured through Interactivity, Collaboration, Critical Thinking, and Active Engagement-among 175 purposively selected Senior Three students in public secondary schools with functional smart classrooms in Gicumbi District, Rwanda. Data were collected using validated structured questionnaires whose reliability and validity were confirmed through KMO, Bartlett's Test, factor analysis, and Cronbach's Alpha, and were administered in person under strict ethical safeguards including dual consent, anonymity, and standardized procedures. Analysis involved descriptive statistics, multiple regression, and binary logistic regression using SPSS v26, supported by collinearity diagnostics and model fit tests, enabling the study to identify the relative contribution of each predictor while upholding rigorous ethical standards throughout the research process.

RESULTS

The results show that several factors are significantly related to smart classroom utilization in public secondary schools in Gicumbi District, Rwanda. The analysis indicates that Interactivity, Collaboration, Critical Thinking, and Active Engagement were influenced by different predictors. Contrary to expectations, some factors, such as Learning Environment on Interactivity, were not found to have a significant effect. The findings are summarized in Table 1 and illustrated in Figures 1 and 2. The main outcome of the study is that smart classroom utilization is driven by a combination of technological, pedagogical, institutional, and learner-related factors.

Interactivity

The results show that Interactivity in smart classrooms is significantly influenced by Pedagogical Readiness ($\beta = .299$, $p < .001$) and Technological Infrastructure ($\beta = .279$, $p <$

.001), indicating that functional digital resources and well-prepared teachers are critical for engaging students interactively. Peer Support (β = .137, p = .032) also showed a positive effect. Institutional Support (β = .180, p = .005) and Instructional Proficiency (β = .121, p = .073) contributed moderately to Interactivity. Contrary to expectations, Learning Environment (β = –.006, p = .922) was not significant, highlighting that environmental factors alone may not directly drive Interactivity without other supporting mechanisms.

Collaboration

The results show that Collaboration is significantly predicted by Technological Infrastructure (β = .202, p = .010), Instructional Proficiency (β = .204, p = .009), Institutional Support (β = .177, p = .015), and Learning Environment (β = .152, p = .038). Pedagogical Readiness (β = .018, p = .808), Learner Commitment (β = .134, p = .099), and Peer Support (β = .052, p = .478) were not significant, suggesting that Collaboration relies more on resources, teacher competence, and supportive institutional structures than on individual student initiative

Critical Thinking

The results show that Critical Thinking is significantly driven by Learner Commitment (β = .303, p < .001), Learning Environment (β = .244, p = .001), and Institutional Support (β = .210, p = .006). Other predictors, including Technological Infrastructure (β = .020, p = .803), Pedagogical Readiness (β = –.068, p = .366), Instructional Proficiency (β = .069, p = .386), and Peer Support (β = .098, p = .197), were not significant, emphasizing that higher-order thinking depends more on student engagement and institutional support than on technology or teacher preparedness alone.

Active Engagement

The results show that Active Engagement is significantly influenced by Peer Support (β = .272, p < .001), Learning Environment (β = .225, p = .003), Instructional Proficiency (β = .193, p = .015), Learner Commitment (β = .183, p = .028), and Institutional Support (β = .157, p = .033). Contrary to expectations, Pedagogical Readiness had a significant negative effect (β = –.166, p = .025), suggesting that overly structured, teacher-centered approaches may reduce active participation. Technological Infrastructure (β = .018, p = .824) was not significant.

Binary Logistic Regression Analysis

The results show that Technological Infrastructure (OR = 2.28), Institutional Support (OR = 2.10), and Learner Commitment (OR = 2.06) significantly increased the likelihood of achieving high smart classroom utilization. The logistic regression model demonstrated good fit with a non-significant Hosmer-Lemeshow test ($\chi^2 = 8.34$, $p = .401$), 73.1% classification accuracy, and an Area Under the Curve (AUC) of 0.78, indicating strong predictive power. Pedagogical Readiness had a positive but marginally non-significant effect (OR = 1.80, $p = .083$), while Learning Environment, Instructional Proficiency, and Peer Support were positive but not significant.

Summary of Findings and Implications for Model Design

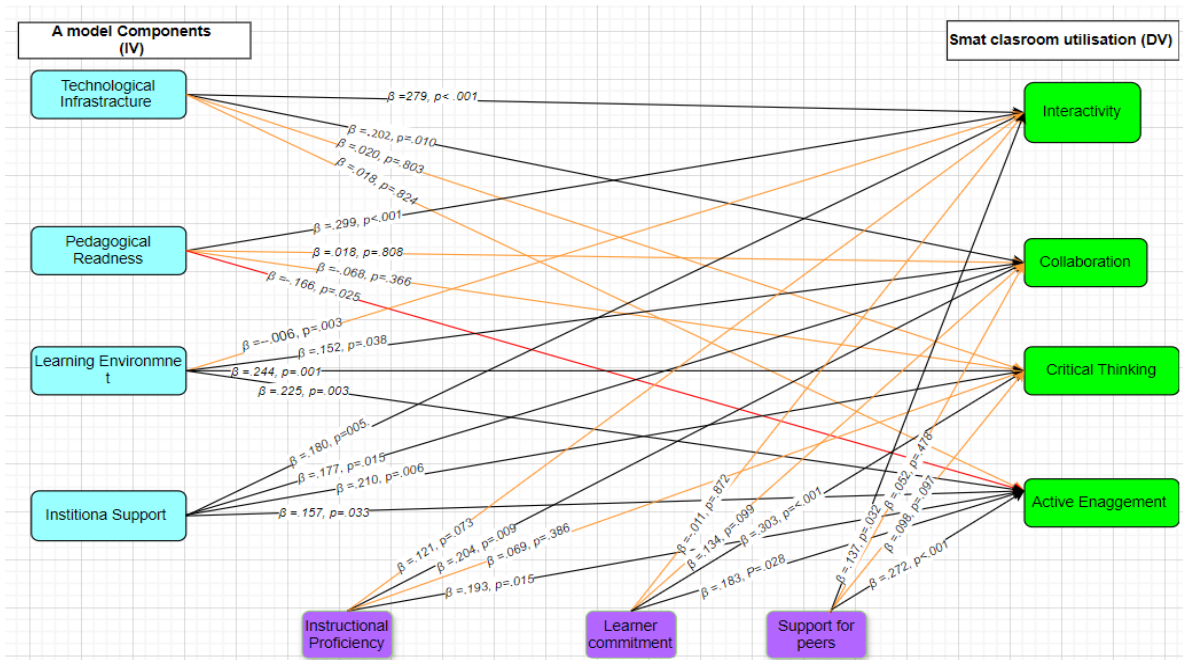
The results show that Interactivity and Collaboration are strongly influenced by Technological Infrastructure, Pedagogical Readiness, and Institutional Support, highlighting the importance of functional technology, well-prepared teachers, and institutional facilitation. Critical Thinking and Active Engagement were primarily driven by Learning Environment and Learner Commitment, emphasizing the role of supportive classrooms and motivated students. Peer Support and Instructional Proficiency contributed moderately, enhancing specific dimensions of engagement and interactivity. The negative effect of Pedagogical Readiness on Active Engagement suggests that overly structured approaches may inadvertently limit student participation. Overall, the findings indicate that smart classroom utilization is driven by a combination of technological, pedagogical, institutional, and learner-related factors. These results provide a robust foundation for designing a comprehensive optimized model that integrates technology, teacher preparedness, learner motivation, supportive learning environments, and institutional backing to achieve maximum utilization and improved learning outcomes in Gicumbi District.

Table 1: Standardized Regression Coefficients for Smart Classroom Utilization

Predictor		Collaboration	Critical Thinking	Active Engagement
Technological Infrastructure	.279*** (< .001)	.202* (.010)	.020 (.803)	.018 (.824)
Pedagogical Readiness	.299*** (< .001)	.018 (.808)	–.068 (.366)	–.166* (.025)
Learning Environment	–.006 (.922)	.152* (.038)	.244** (.001)	.225** (.003)
Institutional Support	.180** (.005)	.177* (.015)	.210** (.006)	.157* (.033)
Instructional Proficiency	.121 (.073)	.204** (.009)	.069 (.386)	.193* (.015)
Learner Commitment	–.011 (.872)	.134 (.099)	.303*** (< .001)	.183* (.028)
Peer Support	.137* (.032)	.052 (.478)	.098 (.197)	.272*** (< .001)

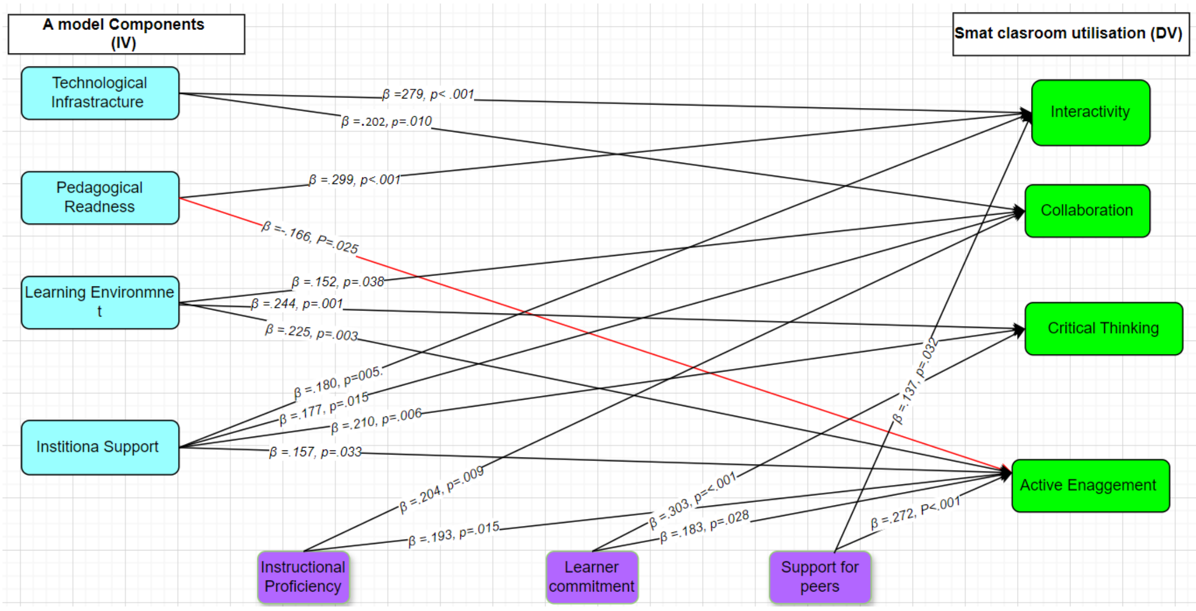
Note. Standardized regression coefficients (β) with p-values in parentheses. *p < .05, **p < .01, ***p < .001.

Figure 1: Conceptual Visualization of Predictors



Note. Solid black lines indicate significant positive relationships, solid red lines indicate significant negative relationships, and solid orange lines indicate non-significant relationships. Predictors include Technological Infrastructure, Pedagogical Readiness, Learning Environment, Institutional Support, Instructional Proficiency, Learner Commitment, and Peer Support. Smart classroom utilization dimensions include Interactivity, Collaboration, Critical Thinking, and Active Engagement.

Figure 2: Optimized Model of Smart Classroom Utilization



Note. The model includes only statistically significant predictors. Positive predictors are represented with solid black arrows, and negative predictors are represented with solid red arrows. The model highlights dimension-specific and cross-cutting drivers of Interactivity, Collaboration, Critical Thinking, and Active Engagement.

DISCUSSION OF THE RESULTS

Interactivity

The results show that interactivity in smart classrooms was significantly related to Pedagogical Readiness, Technological Infrastructure, and Peer Support, while Learning Environment was not significant. These findings are consistent with previous studies that reported teacher preparedness and functional digital resources as critical drivers of interactive learning (Mishra & Koehler, 2006; Kinshuk et al., 2016). The results differ from earlier work, which suggested that physical classroom conditions alone can promote interactivity (Damien & Claire, 2022). One possible explanation for the findings is that students require both competent guidance and peer support to engage interactively, and environmental factors alone are insufficient in rural contexts. The study contributes to the literature by providing new evidence on the limited direct influence of Learning Environment on interactivity in low-resource secondary schools. Implications of the results include prioritizing teacher training and peer collaboration strategies to maximize interactive use of smart classrooms, and they suggest directions for future research on how environmental modifications can complement pedagogical and social supports.

Collaboration

Collaboration was significantly influenced by Technological Infrastructure, Instructional Proficiency, Institutional Support, and Learning Environment. These findings are consistent with studies emphasizing the role of resources, teacher competence, and institutional facilitation in promoting collaborative learning (Mushimiyimana, 2021; Mpumuje, 2024). The results differ from previous work that suggested student initiative alone is sufficient to drive collaboration (de Dieu & de Dieu, 2021). One possible explanation for the findings is that collaborative practices rely heavily on the availability of functional digital tools and structured guidance from teachers supported by the institution. The study contributes to the literature by highlighting the predominant role of systemic factors in enabling collaboration in rural secondary schools. Implications of the results include strengthening institutional policies, investing in teacher professional development, and improving technology access to enhance collaboration, and they suggest future research should explore mechanisms for fostering student-driven collaborative learning in low-resource settings.

Critical Thinking

Critical Thinking was significantly associated with Learner Commitment, Learning Environment, and Institutional Support, while other predictors were not significant. These findings are consistent with prior studies reporting that student motivation and supportive classrooms foster higher-order thinking (Kinshuk et al., 2016; Garrison et al., 2000). The results differ from earlier work that emphasized technology access as the primary driver of critical thinking (Kim & Lee, 2012). One possible explanation for the findings is that in rural contexts, the presence of technology does not automatically translate into enhanced cognitive engagement without motivated students and institutional encouragement. The study contributes to the literature by providing new evidence on the central role of learner engagement and supportive environments in promoting critical thinking. Implications of the results include designing interventions that enhance student motivation and create conducive learning environments, and they suggest directions for future research on the interaction between institutional support and learner engagement.

Active Engagement

Active Engagement was significantly related to Peer Support, Learning Environment, Instructional Proficiency, Learner Commitment, and Institutional Support, while Pedagogical

Readiness had a negative effect. These findings are consistent with studies highlighting the importance of social and motivational factors in promoting engagement (Bergmann & Sams, 2012; de Dieu & de Dieu 2021). The results differ from previous work that suggested teacher preparedness always positively influences engagement (Damien & Claire, 2022). One possible explanation for the findings is that overly structured, teacher-centered approaches may restrict students' active participation, whereas peer collaboration and supportive classrooms encourage engagement. The study contributes to the literature by showing that negative consequences of rigid pedagogical practices can offset the benefits of teacher readiness. Implications of the results include adopting more student-centered teaching strategies and promoting peer-supported learning, and they suggest future research should investigate optimal pedagogical approaches for active engagement in rural digital classrooms.

Overall Predictors and Implications for the Optimized Model

The logistic regression analysis confirms that Technological Infrastructure, Institutional Support, and Learner Commitment substantially increase the probability of achieving high levels of smart classroom utilization. These findings are consistent with prior research emphasizing the importance of infrastructure, institutional facilitation, and learner motivation in driving overall digital learning effectiveness (Mushimiyimana, 2021; Mpumuje, 2024). One possible explanation for the findings is that these factors provide the foundational conditions necessary for successful implementation across multiple dimensions of utilization. The study contributes to the literature by demonstrating the combined predictive power of infrastructure, institutional support, and learner commitment for high smart classroom utilization in low-resource settings. Implications of the results include focusing policy and resources on these key factors to maximize utilization, and they suggest future research should explore the causal mechanisms linking these predictors to learning outcomes.

Overall, the study shows that different dimensions of smart classroom utilization are influenced by distinct but interconnected factors. Interactivity and Collaboration are strongly shaped by Technological Infrastructure, Pedagogical Readiness, and Institutional Support, while Critical Thinking and Active Engagement are primarily determined by Learner Commitment and Learning Environment. Peer Support and Instructional Proficiency contribute moderately, reinforcing the importance of social learning and teacher expertise. The negative effect of Pedagogical Readiness on Active Engagement highlights the potential unintended consequences of rigid teaching practices. The main outcome of the study is that an evidence-based, contextually grounded, and theory-informed model can guide sustainable implementation and improve learning outcomes in rural Rwandan secondary schools, with implications for similar low-resource educational settings. These findings provide clear directions for targeted interventions, resource allocation, and policy formulation.

CONCLUSION

The study concludes that smart classroom utilization in public secondary schools in Gicumbi District is shaped by a combination of technological, pedagogical, institutional, and learner-related factors, with Technological Infrastructure, Pedagogical Readiness, and Institutional Support emerging as significant predictors of Interactivity and Collaboration, while Learning Environment and Learner Commitment primarily drive Critical Thinking and Active Engagement. The unexpected negative relationship between Pedagogical Readiness and Active Engagement suggests that rigid, teacher-centered instructional approaches may suppress student participation, highlighting the need for more balanced, student-centered digital pedagogy. By filling a notable gap in existing research, the study provides a context-specific, evidence-based optimized model tailored for rural Rwandan schools. However, its conclusions are bounded by the focus on a single district and the use of Senior Three students as the sole respondent group, indicating the need for future studies across diverse regions, school categories, and educational levels to validate and extend the applicability of the proposed model.

RECOMMENDATIONS

Recommendations are presented in sections.

Recommendations for School Administrators

School administrators should prioritize the maintenance and optimization of smart classroom infrastructure to ensure reliable and continuous functionality. Regular inspection and timely repair of equipment, including computers, projectors, and internet connectivity, are essential to support uninterrupted digital learning. Administrators are also encouraged to optimize classroom layouts, lighting, and seating arrangements to facilitate collaborative and interactive learning. Establishing monitoring systems and institutional policies that guide and incentivize teachers in the effective use of smart classroom technologies can enhance overall utilization.

Recommendations for Teachers

Teachers should engage in continuous professional development to strengthen pedagogical readiness, digital instructional proficiency, and technology-mediated teaching competencies.

Implementation of student-centered strategies, including collaborative group work, peer-assisted learning, and technology-enhanced activities, is recommended to foster interactivity, critical thinking, and active engagement. Teachers should also promote structured peer support initiatives to enhance learner commitment and collaboration, ensuring that students fully leverage the benefits of smart classrooms.

Recommendations for District Education Authorities

District education authorities are advised to provide sustained technical and financial support to schools for upgrading and maintaining smart classroom infrastructure. Coordinated workshops and training programs should be organized to enhance teachers' pedagogical readiness and instructional proficiency consistently across schools. Authorities should identify, document, and disseminate best practices from high-performing schools to promote the adoption of effective smart classroom utilization strategies within the district.

Recommendations for Policymakers

Policymakers, including the Ministry of Education and the Ministry of ICT, should develop policies and incentive mechanisms that encourage the effective integration of digital learning tools in rural secondary schools. Allocating adequate resources for technological upgrades, teacher training, and school supervision is essential to sustain smart classroom initiatives. Furthermore, policymakers are encouraged to support research-based interventions that continuously monitor, evaluate, and improve smart classroom utilization and its impact on learning outcomes.

Recommendations for Learners

Students are encouraged to actively engage with smart classroom activities, participate in collaborative tasks, and provide constructive feedback to teachers and administrators regarding digital learning experiences. Learners should also take initiative in utilizing available technological resources to enhance understanding, critical thinking, and academic performance. Encouraging self-directed engagement will contribute to maximizing the overall effectiveness of smart classroom utilization.

Acknowledgements

I wish to express my deepest gratitude to all those who supported the completion of this study. I am profoundly grateful to my supervisors, Dr. Mubaraka Conrad Mike, Dr. Paul Ssemaluulu, and Assoc. Prof. Businge Phelix Mbabazi, all of Kabale University, for their expert guidance, constructive feedback, and unwavering support throughout the research process. Their insights greatly strengthened the quality and rigor of this study. I sincerely thank the Senior Three students who actively contributed to designing the optimized smart classroom utilization model, as well as the students, parents, teachers, and school administrators of public secondary schools in Gicumbi District for their willingness to participate, provide information, and share their perspectives. Their cooperation was essential in collecting meaningful data that informed the study's findings and conclusions. Finally, I acknowledge the encouragement and support from my peers and colleagues, whose discussions and suggestions enriched this research.

REFERENCES

Aashish, J., & Rohit, K. (2024). Technologies for quality and sustainable online education in rural India: A comprehensive review. *2024 ITU Kaleidoscope: Innovation and Digital Transformation for a Sustainable World (ITU K)*, 1–8.

AlGhawi, M. A. (2017). Gifted education in the United Arab Emirates. *Cogent Education, 4*(1), 1368891. https://doi.org/10.1080/2331186X.2017.1368891

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day.* International Society for Technology in Education.

Cha, H. J., & Ahn, M. L. (2020). Design and development of a smart-tool prototype to promote differentiated instruction: A user-centered design approach. *Interactive Learning Environments, 28*(6), 762–778. https://doi.org/10.1080/10494820.2019.1682982

de Dieu, M. J., & de Dieu, D. J. (2021). Effect of blended learning on learners' academic performance: Case of Gicumbi District (2015–2020) (No. 2021-40-02).

Damien, N., & Claire, M. M. (2022). Influence of teachers' preparedness on students' academic performance in public secondary schools in Rwanda. *Journal of Education, 5*(2).

Garrison, D. R., Anderson, T., & Archer, W. (2000). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The Internet and Higher Education, 2*(2–3), 87–105. https://doi.org/10.1016/S1096-7516(00)00016-6

Kinshuk, Chen, N. S., Cheng, I. L., & Chew, S. W. (2016). Evolution is not enough: Revolutionizing current learning environments to smart learning environments. *International Journal of Artificial Intelligence in Education, 26*(2), 561–581. https://doi.org/10.1007/s40593-015-0071-8

Kim, S. W., & Lee, M. G. (2012). Utilization of digital textbooks in Korea. *E-books & e-readers for e-learning*, 90.

Kozma, R. B. (2003). *Technology and classroom practices: An international study.* Educational Technology Research and Development, 51(3), 1–16. https://doi.org/10.1007/BF02504550

Laurillard, D. (2012). *Teaching as a design science: Building pedagogical patterns for learning and technology.* Routledge. https://doi.org/10.4324/9780203125083

Makerere University. (2022, September 9). The first smart classroom and robotics technology for teaching in Uganda launched at Makerere University. *College of Computing and Information Sciences*. https://shorturl.at/B72QP

Ministry of Education. (2016). *ICT in education policy.* Government of Rwanda. https://planipolis.iiep.unesco.org/sites/default/files/ressources/rwanda_ict_in_education_.policy_approv ed.pdf

Ministry of Education, Government of India. (2017). *India report: Digital education — Strategy and approach paper (MHRD).* https://www.education.gov.in/sites/upload_files/mhrd/files/India_Report_Digital_Education_0.pdf

Ministry of Information Communication Technology Rwanda (MINICT). (2018). *National ICT policy: Transforming Rwanda into a knowledge-based economy.* Kigali, Rwanda: Government of Rwanda.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467- 9620.2006.00684.x

Mpumuje, M. (2024). Information communication technology (ICT) integration in teaching and learning in selected rural secondary school in Burera District, Rwanda. *African Journal of Empirical Research, 5*(2), 453–461.

Mugisha Ngendabanga, C., Nsanzimana, P., Nduwayezu, F., Umuhoza, V., & Nkurunziza, J. B. (2021). Effect of smart classroom on learners' performance in organic chemistry: A case study of senior five students in Kicukiro District-Rwanda. *GSC Biological and Pharmaceutical Sciences, 16*(2), 204–211.

Mushimiyimana, J. (2021). School management and effective use of smart classroom in teaching and learning process [Working paper].

Mushimiyimana, J. B., Bazimaziki, G., & Tuyishime, D. (2022). ICT integration in educational curriculum in higher education: Challenges and opportunities in the University of Rwanda–College of Education. *International Journal of Humanities and Education Development (IJHED), 4*(2), 118–137.

Nabushawo, H. M., & Aguti, J. N. (2023). Online learning and professional development for faculty and staff at Makerere University in Uganda.

Otieno, F. (2022). *Factors influencing integration of information communication technology in teaching geography in secondary schools in Rachuonyo South Sub-county, Kenya* (Doctoral dissertation, University of Nairobi).

Puentedura, R. R. (2006). Transformation, technology, and education: The SAMR model. *Hippasus Learning Technologies.* http://www.hippasus.com/rrpweblog/

Rwanda Education Board. (2018). *Annual report 2017–2018.* Kigali, Rwanda: Rwanda Education Board.

Rwanda Education Board. (2019). *The national teacher continuous professional development (CPD) framework.* Kigali, Rwanda: Rwanda Education Board. https://www.teachertaskforce.org/sites/default/files/2022-05/2019_REB_The-National-Teacher-CPD-Framework_EN.pdf

UNESCO. (2019). *ICT in education: A roadmap for learning.* https://unesdoc.unesco.org/ark:/48223/pf0000372169

World Bank. (2018). *World development report 2018: Learning to realize education's promise.* https://www.worldbank.org/en/publication/wdr2018

World Economic Forum (2020). COVID-19 has accelerated the digital transformation of higher education. https://www.weforum.org/stories/2020/07/covid-19-digital-transformation-higher-education

Author Biography

Turinumikiza Maurice is an Assistant Lecturer at the University of Kigali, Rwanda. He is currently pursuing a PhD in ICT Education at the Faculty of Education, Kabale University, Uganda. Maurice holds a strong academic background in information and communication technologies with a focus on integrating digital tools in education to enhance teaching and learning processes. His research interests include smart classroom implementation, technology-based education, and sustainable educational development in Sub-Saharan Africa. He has contributed to several studies on ICT adoption in education and is committed to advancing innovative educational technologies to support learner engagement and improve academic outcomes. Maurice can be reached at tzamaurix@gmail.com.

Co-Author Biography

Dr. Mubaraka Conrad Mike is a Lecturer in Computer Education within the Faculty of Education, Department of Open Learning at **Kabale University**, Uganda. He holds a PhD in Information Systems, an MSc in Computer Science, and a BSc in Computer Science with Education. His academic interests focus on e-learning, ICT integration in teacher training, and open distance education. He can be reached at **cmubaraka@kab.ac.ug** or kmikemubeee@yahoo.com.

Dr. Paul Ssemaluulu is a Senior Lecturer in the Department of Computer Science, Faculty of Computing, Library and Information Science at **Kabale University**, Uganda. He holds a PhD in Computer Modeling and Simulation from the University of Groningen (RUG), The Netherlands, an MSc in Computer Science from Makerere University, and a BBA from Makerere University. His research interests include systems modeling, ICT in education, and digital learning environments. He can be reached at pssemaluulu@kab.ac.ug.

Assoc. Prof. Businge Phelix Mbabazi is an Associate Professor in the Department of Computer Science, Faculty of Computing, Library and Information Science at **Kabale University**, Uganda. He holds a PhD and an MSc in Information Systems and is certified in BCI, MCSA, CCNA, HCIA, and HETC. His research covers computer networks, smart learning environments, and ICT-enabled development. He can be reached at pmbusinge@kab.ac.ug.