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Perception of Teachers and Students on the Use of Smart Classroom in Teaching and Learning Mathematics for Rwandan Secondary Schools in Nyarugenge District

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Abstract: *This study assessed the perception of teachers and students on the use of smart classroom in teaching and learning Mathematics for Rwandan secondary schools in Nyarugenge district, with a population 286 students and 12 teachers. As a descriptive, qualitative and quantitative research, its objectives were to assess the perceived usefulness on the use of smart classroom, to assess the challenges affecting the use of the smart classroom and to explore essential Smart Classroom Tools used in teaching and learning. The impetus for this research is driven by the global trend towards digital education and the necessity to assess its effectiveness in varied educational settings. By focusing on Nyarugenge District, this study seeks to provide valuable insights that can guide policymakers, educators, and stakeholders in making informed decisions about the implementation and optimization of smart classroom technologies in Rwandan secondary schools. The findings of this research will contribute to the broader discourse on educational technology, offering evidence-based recommendations for enhancing teaching and learning practices Mathematics. Teachers and students said that ICT tools and online resources stimulate the learners' interest and engagement and help learners to learn more various skills. Smart classrooms increase concentration in learning, facilitate teachers and learners to get easily the content of the lesson and academic resources. Students disagree that they use computers to do group exercises and assignments, they do not use various educational software and search for supplementary reading and learning materials.*

Keywords: *Perception, Smart classroom, Teaching Mathematics, Nyarugenge District, Rwandan secondary schools, Interactive white board, Interactive Display Panels, Speakers, Educational software, Optical Mark Reader.*

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1. Introduction

In the twenty-first century information has advanced tremendously. As the information society grows, information and communication technology (ICT) becomes more widely used, new opportunities for learning and gaining new digital skills and competencies arise (Das, 2019a).

According to Chang and Lee (2010), the smart classroom has gained popularity because it incorporates so many different forms of media and IT technology. In order to address these technological developments in the classroom, the idea of "built pedagogy" was proposed because a smart classroom's design affects the teaching and learning environment.

Students can use ICT as a tool to perform calculations, draw graphs, and help solve problems (Das, 2019b)[i]. The Rwandan government views Information and Communication Technology (ICT) as a key tool for transforming the economy, with the education sector playing an important role in developing the necessary human resources(Were et al., 2011). Since 2000 there has been a big push to introduce computers into schools and integrate ICT into the education curriculum through a range of initiatives (Were et al., 2011). Previous studies have shown that the use of smart classroom technologies can lead to improve student performance and greater teacher satisfaction (Zhou et al., 2022; Singh & Kaur, 2021). Rwanda started integrating technology into classrooms with the One Laptop Per Child initiative in 2008. As of 2023, over 250,000 laptops have been distributed to 933 primary schools (BORGEN). The Smart Classroom program, launched in 2016, extends this initiative to include secondary, vocational, and higher education. It aims to create interactive, technologically enhanced learning environments that go beyond traditional teaching methods (BORGEN).As of 2021, 52% of schools in Rwanda had at least two fully functional smart classrooms. The goal is to have 82% of primary and secondary schools equipped with smart classrooms by 2024 (BORGEN) (The New Times). The government has allocated about 10% of its annual budget to advance education, focusing on building new classrooms and providing electricity to support these technological upgrades (BORGEN).

2. Literature Review

2.1. Theoretical Review

There are different theories related to the use of smart classes in the teaching and learning process. Some of these theories are discussed below.

2.1.1. Theory of planned behavior and technology acceptance model

The theory of planned behavior (TPB), proposed by Ajzen (1991), is the theory that links people's beliefs and behaviors. This theory provides explanations for the factors influencing the decisions of individuals against a particular behavior. This has been found to be an extension of the theory of reasoned action (TRA) and both models were developed in terms of providing and explaining behavioral motivational influences (Rebecca Cameron et al., 2012). According to him, attitudes cause behavior, so the attitudes of teachers could influence their behavior on using smart classes in education. The theory of planned behavior is built on three elements such as individual attitudes concerning behavior, subjective norms, and perceived behavioral control (Rebecca Cameron et al., 2012).

2.1.2. Cognitivist learning theory

According to Jean Piaget (1896-1980), Known for his theory of cognitive development, which outlines how children construct a mental model of the world through stages of development. His work emphasized the importance of active learning and the role of schemas in understanding the world. In this theory, knowledge is seen as a symbolic mental construct in the learner's mind, and learning is the process by which these constructs are committed to memory. In cognitivism, smart devices are taken as a model of processing information where learning is considered as an input that is managed into short-term memory and coded for long-term remembrance (Sweller, 2011)

The use of smart classrooms in teaching and learning, cognitivism theory focuses on the process of delivering content facilitated by technological devices such as audio, videos, and TV. There are different cognitive skills including the ability to conduct research, think critically, plan solutions and solve problems, try out and develop ideas, use the imagination, and think creatively (Maier & Klinker, 2013).

2.1.3. The theory of multimedia learning

According to Richard E. Mayer, the theory of multimedia learning by exploring how different types of media (e.g., text, images, audio, and video) can be effectively combined to enhance learning. Their research provides a foundation for designing educational materials that leverage the strengths of multiple modalities to improve understanding and retention. This study of investigating and analyzing the factors which influence educators to use ICT for improving teaching and learning in secondary schools was guided by the theory of multimedia learning proposed by Mayor (1997). In his theory, he explained that multimedia learning occurs when students receive information presented in more than one mode such as pictures and words. The adoption of this theory is grounded on the fact that Mathematics contains many concepts and phenomena that may be easily understood if presented in different modalities such as using videos, audio, and other forms of multimedia presentation. This will make teaching and learning more motivating and meaningful (Yang et al., 2018).

2.1.4. Problem-based Learning Theory

Arrows, H. S. (1986) contributed to designing PBL curricula that incorporate complex, ill-structured problems that require students to integrate and apply their knowledge from various disciplines. Problem-based learning (PBL) is an educational learning theory where learners are required to identify a problem as a context for learning. In addition, it involves the development of thinking skills, deductive reasoning, knowledge, and behaviors in students. This theory is explained as a pedagogical approach that emphasizes real-life problems or situations and involves learners in active decision-making (Duch et al., 2001). This theory is significant in terms of using smart classrooms in teaching Mathematics as it facilitates learners and teachers to learn anywhere at any time provided that they have adequate devices. Additionally, learners may enjoy this learning theory in using ICT devices such as smart phones to guide their search for a solution to problems they have formulated (Mishra et al., 2006).

2.2. Empirical Review

2.2.1. Pedagogy and ICT use

According to Tondeur, J., Hermans, R., van Braak, J., & Valcke, M. (2017), teachers' educational beliefs influence their integration of ICT in teaching, highlighting the importance of aligning beliefs with technology use. The teachers' attitudes and beliefs affect their use of mobile technology in K-12 education (Hsu & Ching (2021)). According to Liu & Zheng (2021) on "The effects of digital game-based learning on students' motivation and academic achievement: A meta-analysis." This meta-analysis evaluates the impact of digital game-based learning, an ICT-integrated approach, on student motivation and academic performance. These studies provide a comprehensive view of recent advancements and research on ICT integration in education, emphasizing its benefits, challenges, and impact on teaching and learning processes.

2.2.2. Technology in education

Technology in classrooms has the potential to increase student motivation, social interactions, positive outcomes, student learning, and student engagement. Technology is capable of unlocking keys of learning with all students.

(Das, 2019b) asserted that ICT has a tremendous impact on education in terms of acquisition and absorption of knowledge to both teachers and students. The government of Rwanda has built infrastructure, such as optic fiber, telecommunications towers, routers, etc. to speed up the use of technology in school and society in general. However, internet access is still a challenge for some Rwandan schools.

2.2.3. Essential smart classroom tools

Interactive Whiteboard: The traditional whiteboards with markers are replaced with these interactive whiteboards also known as smart boards. It has a touch-sensitive display. It comes with a range of features and a built-in smart class app. Digital tools and apps designed for educational purposes, including interactive simulations, educational games, and learning management systems. The description of "Digital tools and apps designed for educational purposes, including interactive simulations, educational games, and learning management systems" can be referenced in general educational technology literature, but here are some key sources that discuss educational software and applications in the context of smart classrooms Zhao & Zhang (2022)

Interactive Display Panels (IDPs): IDPs are LEDs with big interactive screens. These panels are used to represent the 2D and 3D animations, pictures, videos, etc. Visual learning is more effective than traditional learning.

Speakers: Systems that include microphones and speakers to enhance audio quality in the classroom ensures that all students can hear the teacher and multimedia content clearly, which is particularly useful in larger classrooms (Chen & Huang (2019)). Portable devices that students use for accessing digital content, conducting research, and completing assignments, facilitates individualized learning, digital collaboration, and access to a wide range of educational resources (Harris & Hofer (2021)).

These tools collectively contribute to creating an interactive and dynamic learning environment, helping to engage students and support effective teaching practices. Technologies that create immersive learning experiences by overlaying digital information onto the physical world or creating virtual environments, enhances engagement and understanding by providing interactive simulations and visualizations (Yang & Chen (2021).

3. Methodology

3.1 Research Design and methodology

Research methods comprise a systematic process of inquiry applied in such a manner as to learn something about our social world (Wani, 2017). According to the research proposal, this research is based on experimental approach and deductive approach which was focused one independent variable "Smart Classroom Tools" and three dependent variables "Teachers' Perceptions, Students' Perceptions and Mathematics Learning Outcomes" are used in the study. The following hypothesis were identified "Teachers and students in Nyarugenge District who use smart classroom technologies perceive them as significantly enhancing their ability to teach mathematics compared to traditional teaching methods, The use of smart classroom tools in teaching mathematics is associated with improved student performance in mathematics assessments compared to traditional classroom settings in Nyarugenge District, Despite the positive perceptions, teachers and students in Nyarugenge District face significant challenges related to the use of smart classroom technologies, such as technical issues and lack of training"

3.2. Location and context of the study

Nyarugenge District is one of the administrative districts located in the capital city of Kigali, Rwanda. It is known for its urban and semi-urban characteristics, which include a mix of educational institutions and community services. The district plays a significant role in the educational landscape of Rwanda due to its central location and diverse population. Four schools were used for data collection and selected by systematic approach to ensure that the sample is representative, relevant, and feasible for the study's objectives. The schools were represented by codes: School A, School B, School C and School D.

3.3. Research population

The term population is defined as the set of units possessing the characteristics of the variable under study and that can be generalized from the findings of the research (Shukla, 2020) and Wani (2017) added that population can also be defined as a group of human beings or a group of non-human entities, such as an education institution, time units, geographic areas, wheat prices, or salaries drawn by individuals.

Therefore, the target population of this study was 12 Teachers of Mathematics and 286 Secondary school students enrolled in Mathematics courses from the selected schools of Nyarugenge district.

3.4.1. Sample size

According to Wani (2017), the sample is a selected group of some items from the whole population. Thus, the sample of this study involved 286 students and 12 Teachers taken from 4 schools that are randomly selected from Nyarugenge.

Table 1.Target Population

Department	Target population
School A	68
School B	60
School C	45
School D	125
Total	**298**

3.4.2. Sampling methods

Schools: A stratified random sampling method has been used to ensure representation of different types of schools (public, private, and faith-based).

Participants: Within each selected school, simple random sampling was used to select participants. A sample size of 4 schools, with 12 teachers and 286 students has been targeted to ensure sufficient data for analysis. Both the students and Teachers were purposely selected from the selected schools

3.5. Data collection methods

Questionnaires for teachers and learners were used in all four chosen schools. To investigate the accessibility

and adaptability and observation and open-ended question was used. In-depth insight of teachers' perceptions, viewpoints, feelings, and opinions on the use of smart classroom interviews will be used only for teachers. Interviews served as a tool for researchers to learn what informants thought, felt, and remembered about circumstances that needed to be understood clearly and deeply. In order to gather information about the teaching management of teachers through an interview methodology, structured interviews will be conducted.

3.6. Data processing and analysis methods

3.6.1. Data Processing

For entering marks on their respective score sheets for accurate outcome analysis, each participating school was given a code for each category of students.

3.6.2. Data Analysis Techniques

In terms of quantitative data, the efficiency using smart classroom, accessibility, adaptability and academic success were studied using means and standard deviations and interpreted in tables based on the Likert scale: 1=Strongly agree 2=Agree 3= Disagree 4= Strongly disagree. Pearson's Correlation coefficients were used to investigate the links between smart classroom, accessibility, adaptability and academic success. The acceptable level of statistical significance was chosen at alpha ($\alpha = 0.05$). Current teachers for each school were involved in data analysis. To examine the test findings, a T-test was used. Data summaries was categorized in accordance with the goals of the research, and the summary of findings will be displayed using tables and graphs.

4. Results and Discussion

4.1. Assessing the perceived usefulness on the use of smart classrooms in teaching and learning Mathematics by Teachers and students

Table 2: Perceived Usefulness on the use of smart classrooms

STATEMENT	SA	F (%)	A	F (%)	D	F (%)	SD	F (%)
It has been found that ICT tools and online resources stimulate the learners' interest and engagement in the lesson	286	100	0	0	0	0	0	0
Teachers encourage learners to use smart class room after class	0	0	150	52.4	136	47.2	0	0
Smart classroom helps learners to learn more various skills deemed necessary and proper for them to achieve success in the global society	119	41.6	167	58.3	0	0	0	0
Visual learning using smart technology elements like images, graphs, flow charts, videos, etc., are considered highly effective and help students grasp the concepts quickly	286	100	0	0	0	0	0	0

Smart classrooms reduce distractions, and therefore, students can concentrate more and retain more information.	286	100	0	0	0	0	0	0
Smart classroom facilitates learners to get easily the content of the lesson and academic resources	286	100	0	0	0	0	0	0
Learners use computer to do group exercises /assignments	0	0	0	0	82	28.6	204	71.3
Learners use various educational software	0	0	0	0	192	67.1	94	32.8
Learners search for supplementary reading/ learning materials	0	0	0	0	211	73.7	75	26.2
Learners watch videos or audio clips to better understand the learnt topics or subjects	0	0	0	0	120	41.9	166	58.04
Learners use virtual laboratory to manipulate laboratory experiments	0	0	0	0	0	0	286	100

Learners use digital games for learning related purposes	0	0	0	0	0	0	286	100
Smart classes can transform the teaching and learning process into an interactive experience	126	44.05	160	55.9	0	0	0	0
Smart teaching, learning and evaluation promotes students' academic performance	155	54.1	131	45.8	0	0	0	0

According to the table above about students' perceptions about the use of the smart classroom in teaching Mathematics, the students agree that ICT tools and online resources stimulate the learners' interest and engagement 286 (100%), helps learners to learn more various skills SA,119 (41.6%), A, 167 (58.3%), all students agree that smart technology elements like images, graphs, flow charts, videos, are considered highly effective and help students grasp the concepts quickly 286 (100%), concentration 286 (100%), facilitates teachers and learners to get easily the content of the lesson and academic resources 286 (100%), learners disagree that they use computers to do group exercises /assignments 82 (28.6%) and 204 (71.3%). Students do not use various educational software D, 192(67.1%), SD 94 (32.8%), they do not search for supplementary reading/

learning materials D, 211 (73.7%), SD 75 (26.2%), they do not watch videos or audio clips to better understand the learnt topics or subjects D, 120 (41.9%), SD: 166 (58.04%), students never use virtual laboratory to manipulate laboratory experiments and the use digital games for learning related purposes 286 (100%). Some students strongly agree that smart classes can transform the teaching and learning process into an interactive experience 126 (44.05%), while others agree with it 160 (55.9%). All students agree that smart teaching, learning and evaluation promotes students' academic performance 286 (100%).

4.2 Challenges affecting the use of the smart classroom in teaching and learning mathematics

Table 3: Challenges_affecting_the_use_of_the_smart_classroom

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	A high number of the students	1	8.3	8.3	8.3
	A lack of sufficient computers and other materials	3	25.0	25.0	33.3
	A lack of connectivity	1	8.3	8.3	41.7
	A lack of training in ICT	4	33.3	33.3	75.0
	A lack of classroom agenda in curriculum	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

According to the figure above, the challenges affecting the use of smart classroom are a high number of the students (8.3%), a lack of sufficient computers and other materials (25 %), a lack of connectivity (8.3%), a lack of training in ICT (33.3%) and a lack of the classroom agenda on the curriculum (25.5%).

According to the figure below, the challenges affecting the use of smart classroom are a high number of the students (8.3%), a lack of sufficient computers and other materials (25 %), a lack of connectivity (8.3%), a lack of training in ICT (33.3%) and a lack of the classroom agenda on the curriculum (25.5%).

4.3. Exploring essential Smart Classroom Tools towards the use of smart classrooms in teaching and learning Mathematics

Table 4: Essential_classroom_tools

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Educational software	2	16.7	16.7	16.7
	Interactive display panels	2	16.7	16.7	33.3
	Interactive white board	3	25.0	25.0	58.3
	Optical mark reader	2	16.7	16.7	75.0
	Speakers	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

According to the figure above, the following classroom tools have been identified in different schools, Educational software (16.7%), Interactive Display Panels 5 (16.7%), Interactive white board (25%), Optical Mark Reader (16.7%), Speakers (25%).

This study found that smart classrooms significantly improve student engagement and learning outcomes by providing interactive and dynamic learning environments supports the hypothesis that smart classrooms enhance the teaching and learning of mathematics by increasing student motivation and participation (Zhao, Y., & Zhang, T. (2022)). This meta-analysis found that interactive whiteboards positively impact student learning outcomes across various subjects, including mathematics provides empirical support for the benefits of specific smart classroom tools such as interactive whiteboards (Chen, C. H., & Huang, Y. M. (2019)). This review identified several challenges associated with smart classrooms, including technical difficulties, lack of teacher training, and resistance to change provides a balanced view by acknowledging the potential obstacles in implementing smart classroom technologies effectively (Klimova, B., & Kuca, K. (2020)).

5. Conclusion and Recommendations

5.1. Conclusion

This study assessed the perception of teachers and students on the use of smart classroom in teaching and learning Mathematics in Nyarugenge district, Rwanda. Teachers and students stated that ICT tools and online resources stimulate the learners' interest and engagement and help learners to learn more various skills. Some students disagree that smart technology elements like images, graphs, flow charts, videos, are considered highly effective and help the grasp the concepts quickly. Smart classrooms increase concentration in learning, facilitate teachers and learners to get easily the content of the lesson and academic resources. Students disagree that they use computers to do group exercises and assignments, they do not use various educational software and search for supplementary reading and learning materials. They watch videos or audio clips to better understand the learnt topics or subjects, they never use virtual laboratory to manipulate laboratory experiments and the use digital games for learning related purposes. Teachers and students agree that smart classes can transform the teaching and learning process into an interactive experience, while others disagree. Some Teachers and students agree that smart teaching, learning and evaluation promotes students' academic performance while others disagree with it.The most challenges affecting the use of smart classroom are a high number of the students, a lack of sufficient computers and other materials, a lack of connectivity, a lack of training in ICT and a lack of the classroom agenda on the curriculum.The smart classroom tools encountered are Interactive Whiteboard, Interactive Display Panels, Speakers, Student Response System, Educational Software, OMR (Optical Mark Reader) Scanner, Digital Podium, Wireless Microphone, Graphic Tablets .

5.2. Recommendations

The study came up with the following recommendations:

1. The ministry of education to introduce use of classroom agenda in the curriculum.
2. The Rwanda Education Board Should increase audio, video resources and ICT training in Teachers, Provision of computers and other ICT materials, Provision of enough connectivity, Provision of essential smart classroom tools.
3. The schools should prepare and implement a plan of the use of smart classrooms in teaching and learning, enhance the use of technology in teaching and learning

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