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RESEARCH ARTICLE

EFFECTS OF INSTRUCTIONAL MEDIA ON LEARNERS' COMPETENCES IN MATHEMATICS IN PUBLIC SECONDARY SCHOOLS IN RWANDA A CASE OF RULINDO DISTRICT

Haragirimana Jean Marie Vianney and Dr. Mugiraneza Faustin (PhD)
School of Education, Mount Kigali University, Rwanda.

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Abstract

This study explored the impact of instructional media on mathematics competencies in public secondary schools in Rulindo, Rwanda. Employing a descriptive and correlational design with a mixed approach, the study aimed to identify influential instructional media, assess mathematics competence levels, and determine their relationship. The target population included 616 teachers and 100 head teachers, totaling 716 individuals, with a sample size of 257 determined using the Yamane formula through purposive and random sampling. Data were collected via questionnaires, documentation research, and a pilot study, then analyzed using SPSS version 21.Key findings indicated strong agreement (85.5%-98.6%) on the effectiveness of computer-based tools, graphing calculators, mathematics textbooks, and dynamic geometry environments in teaching mathematics. Significant associations were found ($p < 0.05$) between competencies in numeracy, use of instructional media, and students' comprehension of mathematical subjects. Recommendations included government scholarships to enhance teachers' mathematics skills, optimized use of teaching resources, training by MINEDUC, and increased educational support for students. The study highlighted the need for further research to explore instructional materials' broader impacts on secondary school students' mathematics performance.

Introduction:-

The rapid advancement of technology in the twenty-first century is relentless. Technology has transcended novelty to become indispensable in human life, impacting education significantly. Instructional Media (IM), defined as the science and practice of developing, utilizing, managing, and evaluating learning resources (Uno & Nina, 2010), plays a crucial role in educational settings, particularly in subjects like mathematics. Mathematics is essential across daily human activities, serving as a tool to simplify life (Goktepe & Ozdemir, 2013). Therefore, it is imperative to teach mathematics in ways that foster positive attitudes from an early age, integrating it seamlessly into daily life.

Research conducted in industrialized nations such as the United States, Europe, and Uruguay has consistently shown widespread acceptance of IM in mathematics education. For instance, Leone, Wilson, and Mulcahy (2010) emphasized that an inclusive classroom environment, equipped with diverse teaching materials, enhances learner engagement and educational outcomes. Addressing concerns from earlier decades about low performance in

Corresponding Author:- Haragirimana Jean Marie Vianney
Address:- School of Education, Mount Kigali University, Rwanda.

mathematics and science, recent initiatives like the Science, Mathematics, and Technology Education initiative (CEMASTEA, 2010) in Japan have focused on enhancing educational materials and methodologies.

Understanding the unique characteristics of young learners is essential for effective education delivery (Musthafa, 2010), particularly considering their limited attention spans. Technology, highlighted as crucial by the National Council of Teachers of Mathematics (2000) and Scotland's Curriculum for Excellence (Education Scotland n.d.), enhances mathematical learning experiences significantly. Cheung and Slavin (2013) found technology to positively influence student achievement compared to traditional methods, though outcomes vary with different IM approaches.

In East Africa, challenges persist regarding the implementation of instructional media in primary schools, impacting students' mastery of fundamental skills like reading and writing (Shirima, 2013; Mtitu, 2014). The Mathematical Association of Tanzania (MAT) reported alarmingly high failure rates in basic mathematics among secondary school students (United Republic of Tanzania [URT], 2018), underscoring the need for effective IM integration.

Kenyan schools, like those in other African nations, have recognized the potential of IM to enhance academic achievement (Otieno, 2010). Projects using projectors in mathematics teaching have shown promise in improving student engagement and retention (Ashiona et al., 2018). Conversely, inadequate IM can hinder mathematical comprehension and contribute to passive learning environments (Okongo et al., 2015).

In Rwanda, efforts to integrate ICT into education, aligned with initiatives such as Sustainable Development Goal Four (SDG4) and Vision 2030, continue to face challenges in providing sufficient instructional resources and facilities (Nizeyimana & Nkiliye, 2021; Ottevanger, 2011). The Rwandan Education Board (REB, 2015) underscores the significance of instructional materials within the competency-based curriculum (CBC) to bolster students' skills and competencies. Primary education in Rwanda commences at age seven and spans six years (REB, 2015). However, there remains a notable research gap in assessing the impact of instructional media on mathematics competencies in day secondary schools. Globally, the integration of instructional media in mathematics education remains a pivotal area for enhancement, with diverse challenges and initiatives evident across various educational settings.

Research Purpose

The study aimed to examine the effects of the use of instructional media on competences in mathematics in public secondary schools in Rulindo, Rwanda.

Materials and Methods:-

Research Design

According to Kirumbi (2018), research design encompasses the methodologies and processes employed to collect and evaluate measurements of variables addressed in the study's investigative problem. It specifies the study type (such as descriptive, correlation, semi-experimental, experimental, review, meta-analytic), sub-type (like descriptive-longitudinal case study), research problem, hypotheses, independent and dependent variables, experimental design, and, if applicable, data collection methods and statistical analysis plan. Therefore, this study employed a descriptive survey research approach integrating both quantitative and qualitative techniques. Specifically, quantitative methods included a survey conducted via questionnaires distributed to instructors and a sample of students throughout the study period.

Target Population

A research population is a sizable group of subjects or objects that are the subject of a scientific investigation. The goal of research is to benefit society as a whole (Hassan, 2019). The population was 616 teachers, and all 100 head teachers of the schools constitute the study's target population. Since they are in charge of managing administrative duties and allocating instructional resources in their schools, head teachers were targeted. Instructional media that is used by math’s teachers as well as implemented by them. In addition, teachers carry out administrative tasks that have been assigned to them by head teachers.

Data Collection Techniques and Data Sources

Sampling for this study involved employing Taro Yamane's (1967) mathematical approach to determine a sample size of 257 respondents from the research population. The sampling technique utilized purposeful and random selection criteria based on the specific characteristics of the subject under investigation. Purposeful sampling was employed to select secondary schools based on location and type, and teachers were chosen based on their teaching level and subject expertise. Additionally, stratified random sampling was used to select head teachers as key informants. Data collection methods included questionnaires, which gathered demographic information and closed-ended responses, supplemented by guided interviews to explore qualitative insights on instructional media's impact on mathematical competencies in Rwandan public secondary schools. These methods ensured comprehensive data collection, combining structured quantitative data with nuanced qualitative perspectives to enrich the study's findings.

Ethical Considerations

In social research, obtaining informed consent is crucial, allowing participants to weigh the benefits and risks before deciding to participate (Howe & Moses, 1999). The researcher clearly explained the study's purpose, participants' roles, and ensured their voluntary participation without coercion. Privacy protections were also emphasized to maintain confidentiality. Maintaining anonymity is essential to uphold ethical standards (Gay, Mills, & Airasian, 2009); participants were instructed not to disclose their names on questionnaires to safeguard their information. Proper citation and referencing practices were employed to acknowledge existing work and minimize plagiarism, adhering to MKUR guidelines. The findings were faithfully reported based on respondents' responses to ensure accuracy and integrity.

Results and Discussions:-

The study analyzed data through frequency and percentage tables, focusing on the impact of instructional media on mathematics competencies in public secondary schools, competency levels in mathematics, and the correlation between instructional media usage and mathematics competencies in Rulindo District, Rwanda.

The instructional media that affect competences in mathematics in public secondary schools in Rulindo district, Rwanda

The following table indicate the perception of teachers on the instructional media that affect competences in mathematics in public secondary schools in Rulindo district, Rwanda

Table 1:- Answers from teachers on the instructional media that affect competences in mathematics in public secondary schools in Rulindo district, Rwanda.

	Strongly Disagree		**Disagree**		**Neutral**		**Agree**		**Strongly Agree**		**Total**	**Mean**	**Sdv**
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**			
Computer-based technological tools in mathematics indicate instructional media in mathematics	1	0.5	13	5.9	18	8.1	37	16.7	152	68.8	221	1.61	.992
Using graphing calculators in mathematic subject mean that am using technology	0	0.0	1	0.5	2	0.9	14	6.3	204	92.3	221	1.15	.531
Using Mathematics Test books teaching and learning indicate instructional media in teaching mathematics subject	1	0.5	1	0.5	13	5.9	16	7.2	190	86.0	221	1.22	.611
Using dynamic geometry environments indicate instructional media in teaching mathematics subject	0	0.0	2	0.9	31	14.0	72	32.6	116	52.5	221	1.64	.788

Source: Primary data (2024)

Based on Table 1, the use of computer-based technological tools in mathematics, such as instructional media, was strongly supported by 68.8% of respondents, with an additional 16.7% in agreement. Similarly, 92.3% strongly agreed and 6.3% agreed that graphing calculators are integral to teaching mathematics. Mathematics textbooks were viewed as instructional media by 86.0% who strongly agreed and 7.2% who agreed. Dynamic geometry environments were also recognized as instructional media, with 52.5% strongly agreeing and 32.6% agreeing. These findings underscore that a majority (68.8%) strongly acknowledge the role of various technological tools and resources in mathematics education. According to Umuhoza (2022), Rwanda's Vision 2030 program emphasizes lifelong learning, inclusivity, and high-quality education, reflected in its competency-based curriculum (CBC) designed to enhance student skills and competencies through effective engagement with course materials.

Table 2:- Heads of teacher's perception on the instructional media that affect competences in mathematics in public secondary schools in Rulindo district, Rwanda.

Statement on instructional media	Strongly Disagree		Disagree		Not Sure		Agree		Strongly Agree		Total	Mean	Sdv
	N	%	N	%	N	%	N	%	N	%			
The use of mathematics test books for teaching and learning, which denote instructional material in the teaching of mathematics.	1	2.8	3	8.3	5	13.9	5	13.9	22	61.1	36	178	1.14
The use of graphing calculators in math class, which indicates that I am utilizing technology.	0	0.0	1	2.8	3	8.3	2	5.6	30	83.3	36	1.31	.749
use of dynamic geometry environments as an instructional medium in mathematics teaching.	1	2.8	1	2.8	3	8.3	6	16.7	25	69.4	36	1.53	.971
use of computer-based technical tools in mathematics to denote the educational medium of mathematics.	0	0.0	2	5.6	8	22.2	9	25.0	17	47.2	36	1.94	1.12

Source: Primary Data (2024)

Table 2 presents responses from head teachers regarding instructional materials in mathematics teaching. It shows that 61.1% strongly agreed and 13.9% agreed that mathematics textbooks are essential instructional materials, while 83.3% strongly agreed and 5.3% agreed that graphing calculators signify the use of technology in math classes. Additionally, 69.4% strongly agreed and 16.7% agreed on dynamic geometry environments as instructional media in mathematics teaching, and 47.2% strongly agreed with 25.0% agreeing on computer-based technological tools as educational mediums in mathematics. According to Twizeyimana (2024), this study examines the correlation between students' attitudes toward learning science courses in Rwandan secondary schools and teachers' utilization of instructional resources. The sample included 63 teachers from Muhanga district, surveyed through questionnaires and an online survey. The study found significant associations between the integration of audio-visual aids, laboratory equipment, models, drawings, illustrations, photos, and visual aids. It suggests that leveraging diverse instructional resources enhances student engagement and attitudes in the learning process.

The level of competences in mathematics in public secondary schools in Rulindo district, Rwanda

This study aimed to assess the level of mathematical competencies in public secondary schools in Rulindo district, Rwanda. To achieve this, respondents expressed their views through an online survey. In addition, the researcher analyzed various records related to mathematics levels in secondary schools across Rulindo District. Respondents' opinions were rated on a scale ranging from strongly disagree (SD), disagree (D), not sure (NS), agree (A), to strongly agree (SA), with assigned numerical values of 1, 2, 3, 4, and 5, respectively.

Table 3:- Mathematical teachers s' perspectives on the level of competences in mathematics in public secondary schools in Rulindo district, Rwanda.

	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree				
	N	%	N	%	N	%	N	%	N	%	Tot	Mean	Sdv
Skilled students in numeracy show me the competencies in mathematics	9	4.1	12	5.4	26	11.8	36	16.3	138	62.4	221	1.9	1.273

basic arithmetic skills indicate me the level of students the competencies in mathematics	0	0.0	1	0.5	2	0.9	11	.7	101	84.9	221	1.12	.485
Improved scores the level of student's performance me the level of competencies in mathematics	1	0.6	1	0.5	18	8.1	29	13.1	172	77.8	221	1.33	.683
understanding and computing geometrical shapes indicate me the level of competencies in mathematics	0	0.0	2	0.9	33	14.9	69	31.2	117	52.9	221	.683	.799

Source: Primary Data (2024)

Results from Table 3 indicate that in public secondary schools, 62.4% strongly agreed and 16.3% agreed that proficiency in numeracy reflects competencies in mathematics, while 84.9% strongly agreed and 11.7% agreed that basic arithmetic skills demonstrate students' competencies. Moreover, 77.8% strongly agreed and 13.1% agreed that improved scores correlate with mathematics competencies, and 52.9% strongly agreed with 31.2% agreeing that understanding and computing geometrical shapes signify competencies in mathematics. According to Edouard's (2021) research on mathematics performance in Rwandan public secondary boarding schools, which included 1761 students from E.S. Nyamugali, E.SES Rukozo, Inyange Girls' School of Sciences, and LNDV Girls' School, maintaining a positive learning environment, good behavior, and punctual attendance were found crucial for academic success. The study also highlighted mixed findings regarding the impact of a competitive culture on performance, emphasizing the importance of discipline and a supportive learning environment.

Table 4:- Heads Teacher's perception on the level of competences in mathematics in public secondary schools in Rulindo district, Rwanda.

Statement	**Strongly Disagree**		**Disagree**		**Not Sure**		**Agree**		**Strongly Agree**		**Total**	**Mean**	**Sdv**
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**			
Basic arithmetic skills show a student's level. the mathematical abilities	2	5.6	4	11.1	4	11.1	5	13.9	21	58.3	36	1.94	1.30
Numeracy-skilled children demonstrate mathematical abilities.	0	0.0	1	0.5	2	8.3	3	8.3	30	83.3	36	1.31	.749
Students' performance understanding and computing scores have improved.	1	2.8	1	2.8	3	8.3	7	19.4	24	66.7	36	1.56	.969
Geometrical forms represent the amount of mathematical competency.	0	0.0	2	5.6	8	22.2	10	27.8	16	44.4	36	2.00	1.12

Source: Primary Data (2024)

Results from Table 4 illustrate head teachers' perspectives on students' academic performance in mathematics. The table indicates that 58.3% strongly agreed and 13.9% agreed that basic arithmetic skills are indicative of students' performance levels. Furthermore, 83.3% strongly agreed and 8.3% agreed that proficiency in numeracy demonstrates mathematical abilities, while 66.7% strongly agreed and 19.3% agreed that students' performance has improved. Additionally, 44.4% strongly agreed that understanding and computing geometrical shapes reflect mathematical competency, with 27.8% agreeing with this statement. Nzabalirwa's (2022) study on the quality of biology instruction in secondary schools in the Rulindo region, using a descriptive survey for data collection, highlighted challenges such as insufficient infrastructure and training for ICT. The study concludes that increased funding for teacher development and ICT infrastructure is essential to effectively integrate ICT into biology teaching.

The relationship between the use of instructional media and competences in mathematics

The third object was used the relationship between the use of instructional media and competences in mathematics in public secondary schools in Rulindo District, Rwanda, which means that the tables below show the correlation between the independent and dependent variables as well as regression analysis.

Table 5:- Correlation Analysis between the use of instructional media and learners' competences in mathematics in public secondary schools in Rulindo District, Rwanda.

		Computer-based technological tools	Mathematics Test book	Using projectors in teaching mathematic	Using dynamic geometry environments	Skilled students in numeracy	Use of representations of mathematical objects	Understanding and computing geometrical shapes
Computer-based technological tools	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	256						
Mathematics Test book	Pearson Correlation	.317**	1					
	Sig. (2-tailed)	.000						
	N	256	256					
Using projectors in teaching mathematic	Pearson Correlation	.163*	.596**	1				
	Sig. (2-tailed)	.029	.000					
	N	256	256	256				
Using dynamic geometry environments	Pearson Correlation	.115	.591**	.495**	1			
	Sig. (2-tailed)	.125	.000	.000				
	N	256	256	256	256			
Skilled students in numeracy	Pearson Correlation	.197**	.263**	.156*	.217**	1		
	Sig. (2-tailed)	.008	.000	.037	.003			
	N	256	256	256	256	256		
Use of representations of mathematical objects	Pearson Correlation	.796**	.272**	.211**	.367**	.205**	1	
	Sig. (2-tailed)	.000	.000	.005	.000	.006		
	N	256	256	256	256	256	256	
Understanding and computing geometrical shapes	Pearson Correlation	.736**	.197**	.182*	.254**	.357**	.766**	1
	Sig. (2-tailed)	.000	.008	.015	.001	.000	.000	
	N	256	256	256	256	256	256	256

**. Correlation is significant at the	0.01 level (2-tailed).
*. Correlation is significant at the	0.05 level (2-tailed).

Source: Primary Data (2024)

The data presented in Table 5 indicates significant associations between various research variables. Skilled students in numeracy show statistically significant relationships with computer-based technological tools (r = 0.197**, p = 0.008), Mathematics Test book (r = 0.263**, p = 0.000), using projectors in teaching mathematics (r = 0.156*, p = 0.037), and using dynamic geometry environments (r = 0.217**, p = 0.003). Similarly, the use of representations of mathematical objects correlates significantly with comprehension of mathematical subjects (r = 0.796**, p = 0.000), Mathematics Test book (r = 0.272**, p = 0.000), using projectors in teaching mathematics (r = 0.211**, p = 0.005), and using dynamic geometry environments (r = 0.367**, p = 0.000). Conversely, the association between understanding and computing geometrical shapes and various instructional media—computer-based technological tools (r = 0.736**, p = 0.000), Mathematics Test book (r = 0.197**, p = 0.008), using projectors in teaching mathematics (r = 0.182*, p = 0.015), and using dynamic geometry environments (r = 0.254**, p = 0.001)—was found to be less significant due to a p-value above 0.05. This study is informed by Tatnall's (2017) investigation into ICT integration in mathematics education across secondary schools, highlighting the influence of school-level variables on technology use and student arithmetic proficiency. Ngirabakunzi's (2017) qualitative study on instructional materials in Rwandan private secondary schools underscores the importance of creative teaching practices and ongoing teacher training to enhance learning outcomes.

Conclusions:-

The investigation yielded significant findings based on the study's outcomes and comparisons with prior research. Firstly, it identified shortcomings in the instructional media affecting mathematics competencies in public secondary schools in Rulindo district, highlighting computer-based technological tools, mathematics test books, projectors in mathematics teaching, and dynamic geometry environments. Secondly, regarding mathematics competencies in Rulindo district's public secondary schools, the study underscored that numeracy skills, use of mathematical object representations, understanding and computing geometrical shapes, and enhanced class participation are key indicators. Lastly, the study aimed to establish correlations between instructional media use and mathematics competencies in Rulindo District's public secondary schools. The correlation matrix between independent variables (computer-based technological tools, mathematics test books, projectors in teaching mathematics, and dynamic geometry environments) and dependent variables (numeracy skills, use of mathematical object representations, and understanding and computing geometrical shapes) revealed statistically significant positive relationships, supported by p-values below 0.05.

Conflict of interest statement

The author declares no conflicts of interest.

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