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IMPACT OF TEACHER TRAINING PROGRAM INTERVENTIONS ON MATHEMATICS AND SCIENCE TEACHERS' TECHNO-PEDAGOGICAL SKILLS: CASE IN 14 DISTRICTS OF RWANDA

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Abstract:
Students of this generation are digital natives, so a classroom without technology is not engaging. 21st-century demand requires technology integration in teaching; however, in-service teachers' skills in technology integration into pedagogy are still low, and they are with the needs of teacher training programs. To support teachers, the African Institute for Mathematical Science (AIMS), through its teacher training program (TTP) conducted ICIT in education training for mathematics and science teachers in 14 districts of Rwanda. The study used a web survey design for gathering facts that inform the impact of TTP interventions on trained teachers' ICT skills and their integration in the teaching of mathematics and science. 351 teachers participated in the study and techno-pedagogical and pedagogical surveys with Cronbach alfa reliability of .75 and .702, respectively, were used. Teachers were purposively selected from public schools, and a positive probability of participation was ensured by random sampling. Microsoft Excel and SPSS version 23 served for analysis. The findings revealed that Math and science teachers' techno-pedagogical skills were low before TTP interventions. For instance, 81% did not know how to use classroom technologies, while 82% did not know how to use tools like simulations and animations for teaching; this implies that technology integration in teaching was very low. There is a statistically significant difference ($\chi 2 = 25.342$, df = 12 (1), $p<.001$ between teachers' techno-pedagogical skills before and after attending training. The implication is that training improves teachers' techno-pedagogical skills, and they become techno-pedagogues. There is no statistically significant difference between male and female techno-pedagogical skills after training ($\chi 2 = 40.625$, df = 12 (1), $P > 0.05$). This shows that interventions improved their skills equally. Therefore, we

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recommend the continuance of teacher training programs as digital technology is dynamic.

Keywords: Teacher Training Program, techno pedagogical skills, pedagogy, interventions, ICDL, ICT

1. Introduction

The African Institute for Mathematical Science-Rwanda (AIMS- Rwanda) implemented five-year (2018 to 2022) Teacher Training Program (TTP) in Rwanda with various drives that, among others, include equipping secondary school teachers with the tools and skills to implement the competency-based curriculum (CBC) in Rwanda utilizing technology, to enhance teachers' math and science content knowledge, confidence and technological pedagogical skills, while increasing students' motivation, uptake of mathematics and sciences and improve girls and boys performance in math and science subjects at secondary school level (Alison Connor et al., 2021).

The Teacher Training Program (TTP) Rwanda adopted a blended (face-to-face and online) training mode and was implemented under the sponsorship of the MasterCard Foundation Leaders in Teaching (LIT) initiative and Partnership with Rwanda Basic Education Board (REB), and National Assessment & School Inspection Authority (NESA)

TTP worked under four main pillars:

1) Training teachers on mathematics and science subjects' content, information and communication technology (ICT) and its integration in the teaching process, innovative gender-responsive pedagogic approaches, and most other necessary skills required for improved performance of girls and boys in math and sciences. With this prop, TTP trained over 4,500 in-service teachers from 760 secondary schools and over 500 school leaders, including head teachers and schools' deans of studies from 14 selected leaders in teaching districts of Rwanda.
2) Infrastructure, resources, and ICT support to equip Smart Classrooms are essential to the use of ICT in delivering this program. The pillar was characterized by the provision of different teaching and learning resources like science kits for enhanced math and science hands-on activities in schools, laptops, tablets, internet connectivity, and communication fees to all math and science teachers in 14 districts. Besides, the construction of 14 Smart classrooms in 14 Secondary schools and two at the University of Rwanda College of Education was a success story for this pillar.
3) Outreach and public engagement to provoke change in attitudes, encourage communication, and increase general understanding and support for pursuing an education in math and sciences in Rwanda for boys and girls.
4) Operational research for evidence generation that informs the project and policy dialogue for greater engagement by government, civil society, the private sector, and academia.

Before TTP interventional activities, a situational analysis (Stoelinga, 2018a) was conducted in schools over 30 districts of Rwanda to identify the gap in the competency-based curriculum (CBC) Implementation, the gap in schools' ICT tools and teaching resources, and teacher's gap in using ICT for teaching math and science at secondary schools. A section of its descriptive analysis proved a very large ICT gap between male and female teachers in Rwanda's STEM education context. Many teachers expressed feeling that they still need to upgrade their ICT skills. Besides, females were more likely to have scarcer skills. They highly expressed an ICT training needs to improve different skills like word processing, spreadsheet, presentation, internet navigation, and downloading skills than male counterparts.

Moreover, Munyengabe et al. (2017) noted that instructors must be assisted in developing their technological pedagogical content knowledge skills to successfully integrate ICT in Rwandan education. This showed the lack of necessary skills teachers needed to use technology for pedagogical motives and the competence to integrate technology into math and science teaching. This line with the literature states that teachers still face challenges in integrating technology in science classrooms. Among others, these challenges are lack of training, lack of knowledge about ICT, lack of Positive attitude towards technology, lack of infrastructure facilities, and lack of knowledge about existing technological skills (Bhadana et al., 2023; Kumari & Rani, 2022; Rao et al., 2021).

To mitigate these challenges and gaps, AIMS-TTP adopted a blended training mode where teachers were exposed to a variety of training, including ICT training, along with the provisions of various ICT resources for teaching math and science and training on pedagogy. These mitigation measures align with the literature suggestion advocated by Rao et al. (2021) that in-service training and the provision of proper facilities should be adopted to hone teachers' technological pedagogical skills. Therefore, this study focused on TTP pillars one and two to explore the impact of AIMS-TTP interventions on mathematics and science teachers' technological pedagogical skills.

The study was grounded on the following research objectives:

1) To explore the impact of AIMS teacher training program interventions on mathematics and science teachers' techno-pedagogical skills in 14 districts of Rwanda.
2) To assess math and science teachers' pedagogical skills after AIMS-TTP interventions to identify Teacher training programs' most effective interventions for teachers.

2. Literature Review

2.1. Theory of Change

Understanding the project program's theoretical framework is crucial it clarifies how it works (Walker & Matarese, 2011). A Theory of Change (ToC) provides a comprehensive description and illustration of how and why a given set of services, products, and operations are expected to achieve a desired change or impact. It assists project activity

planning and implementation by stipulating how activities will prime to longer-term outcomes (Connell & Kubisch, 1998).

AIMS-Teacher training programs aimed to yield visible changes in students' learning outcomes conceptualized as improved performance and increased male and female interest in enrolling in math and science subjects. This might be achieved as a result of enhanced teachers' knowledge, skills, attitudes, pedagogy, and ICT use in teaching through training. Hence, to achieve its goals, AIMS-TTP envisioned a framework grounded on a theory of change that was developed focusing on its four pillars and specifying ways to achieve the desired impact.

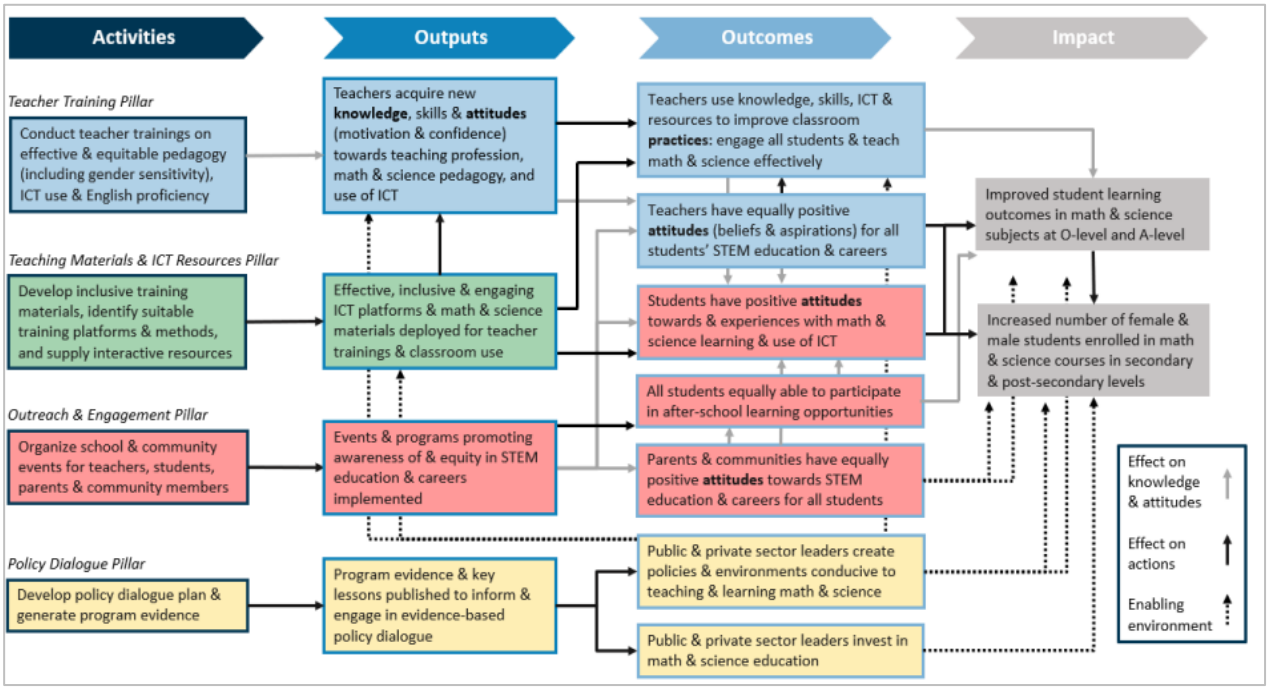


Figure 1: Theory of Change for the AIMS Rwanda Teacher Training Program (Alison et al., 2021)

The theory is the heart of this study that explores the impact that AIMS-TTP unveiled on teachers' technological pedagogical skills required for teaching math and science to yield improved students' learning outcomes and interest in math and science subjects. This study fits explicitly in the teacher training pillar and teaching materials and ICT resources pillar standing as independent variables that intend to produce changes in students through outputs and outcomes in teachers.

AIMS-TTP trained teachers from 14 districts on ICT, pedagogy, math, and science to empower their content knowledge, attitudes, pedagogical skills, and technological skills for teaching. The teachers' implementation of knowledge and skills gained from training engage both male and female students, thus leading to their improved performance and interest in math and science subjects. Additionally, providing interactive resources and training on their use improves teachers' skills in practical activities through ICT-enhanced lessons and hands-on activities. Implementing teachers'

improved skills increases students' attitude toward math and science subjects, resulting in improved academic performance (Nkundabakura, Nsengimana, Nyirahabimana, et al., 2023).

2.2 21st-century Techno-pedagogical Skills for Mathematics and Science Teachers

Technology implementation in the teaching and learning process can produce changes in both teachers and students in terms of skills and outcomes. Using proper techno-pedagogical skills for teaching math and science engages students and leads to improved earning and performance (Palanisamy et al., 2020). The application of innovation in teaching and learning by educators today is crucial for digitalizing education. With the use of technology, education has become more engaging and participatory. Therefore, expanding teachers' techno-pedagogical skills is imperative to enhance learner competencies (Asad et al., 2021).

Techno-pedagogical skills are skills required to use technology for pedagogical goals and the capability to integrate technology into teaching. They are electronically mediated skills that assimilate pedagogical concepts with the use of technology, and they are the foundation of effective teaching (Nayar, 2020). Techno-pedagogy does not mean only the use of the internet and digital resources; however, technology is a method to achieve learning objectives. Kumari & Rani (2022) described technology and pedagogy in terms of academics based on their meaning of origin, "pedagogy" is teaching science and art; in other words, the study of teaching and learning techniques, while techno is a qualification that crosses pedagogy's meaning with its own hence techno pedagogy is an approach of teaching that incorporates technology to raise students' aca demic performance. Teachers need 21st-century techno-pedagogical skills to integrate information and communication technology (ICT) in the teaching and learning process to generate learners' competencies lined with 21st-century demands (Asad et al., 2021). ICT integration in teaching requires teachers to be equipped with skills in the use of the internet, and ICT devices such as printers, computers, laptops, and tablets, etc. 21st-century demand in addition line with modern technology, which is used in teaching math and science add on students' interest and performance (Bhadana et al., 2023).

Today's secondary school teachers are in demand to have skills in the use of ICT tools like simulations, animations, videos, and models, among others related to math and science content. Software programs like Google Meet, Google Spreadsheets, and Microsoft Teams allow interactive learning and support the teaching process in hazardous times; therefore, their use meets1st techno pedagogical skills (Rao et al., 2021). Kumari & Rani (2022) added that techno-pedagogical skills include the ability to assess the merits and shortcomings of various learning systems, the competency to conduct a need analysis so that technology can be introduced in a pedagogical order, the ability to apply new and interactive technologies that are suitable with the nature of the subject and the aptitude to utilize and troubleshoot basic tools and software and deal with minor technical issues.

2.3. Needs for Integrating Techno-pedagogy in Mathematics and Sciences Education

Students of this generation are Digital Natives, so a classroom without technology is not engaging. Technology enhances learning and adds excitement to the teaching-learning process. A teacher becomes a techno pedagogue when they combine technology with pedagogy. Math and science concepts are used to be abstract to learners; however, when technology is integrated into the teaching and learning process, it creates an interactive learning environment, raising concept understanding and student performance (Palanisamy et al., 2020).

Bansa (2022) noted that technology can significantly extend learning when it is properly incorporated into science classrooms. In class, technological resources boost collaboration among students and their teachers, and convey understanding through multimedia, thus attracting learners' learning attention leads to concepts understanding and improved performance.

Teachers are changing the way they teach to incorporate technology into the classroom. Instruction. Technology in the classroom improves educational standards and produces the desired in learners. ICT is a beneficial tool that has the potential to change instructional techniques like teacher-centered to learner-centered as it adapts to the specific learner's needs, hence enabling learners to acquire high-level thinking abilities like analyzing, synthesizing, applying, and inventing, which are critical in today's 21st century needed competencies (Bhadana et al., 2023).

Over the world, educational systems are being challenged by the cumulative of digitalized youth whose potential hobbies are technology applications. To attract their ability to learn math and science, there is a need for technology integration into the teaching process to enhance and revolutionize educational practice (Laxmi & Singh Gure, 2016). In mathematics education, it was recommended that teachers should be trained to get the knowledge and experience necessary to integrate technology when teaching and learning Mathematics. This is because today's learners are not interested in chalkboards but rather in technological resources such as interactive whiteboards, graphics calculators, software mathematics dynamic, program graphics, the system of computer algebra, etc. (Muhtadi et al., 2018). Therefore, there is still a need for teachers to be knowledgeable about technology and its resources and how the technological resources should be incorporated into the teaching process to boost learners' understanding.

3. Methodology

3.1 Research Design

The study used a quantitative research approach and adopted a survey design in its type of web survey design (Creswell, 2015). Survey research is a typical design in education because of its many uses. It helps to describe the population's attitudes, beliefs, behaviors, or features. Researchers may administer a survey to a sample of participants or the entire population to gather quantitative, numerical data using interviews or questionnaires (Fraenkel et al., 2012). In today's advancement of technological dynamics, technology has

made administering surveys on the internet by allowing researchers to use Web-based software and services to collect survey data from their target population. Web-based survey design provides greater advantages that, among others, more user-friendly, less expensive, quicker turnaround, multimedia interface, mobile administration like using portable devices, and less data entry are all benefits (Fraenkel et al., 2012). Web-survey design fits this study that aims to explore the impact of teacher training programs (TTP) on a large population of math and science teachers where a sample was drawn from 14 districts of Rwanda.

3.2 Population and Sampling Techniques

This study targeted all mathematics and science teachers of ordinally level (o-level) and advanced level (A-level) secondary schools in 14 districts of Rwanda where AIMS-TTP has its implementations. Purposive sampling was used to select math and science teachers from all public schools, both nine years of basic education, twelve years of basic education, and excellent schools in 14 districts of Rwanda that received training and facilities of AIMS-TTP. Random sampling gave all of those teachers an equal chance to participate in the study.

3.3 Data Collection Tools

Survey questionnaires were used to collect the data. They were developed by post-doctoral researchers at AIMS-Rwanda teacher's training programs based on their interventional indicators. A techno-pedagogical survey questionnaire was developed, considering ICT training activities, while a pedagogical survey questionnaire focused on training activities on pedagogy. Techno pedagogical survey consists of the pre-interventional items to capture teachers' technological skills for teaching math and science before interventions.

The questionnaire on teachers' pedagogical skills is made of 15 pedagogical items. Before questionnaire development, researchers took time to sit with AIMS-TTP experts to document all covered activities. Additionally, desk documentation was done by reading all TTP-related activities to extract all possible training indicators. After this session, a pool of items was drafted for ICT and pedagogy training subjected to TTP Pedagogic and subject training experts to check if they were in line with all activities done by TTP on ICT and pedagogy. At this stage, the pedagogical questionnaire of pre-intervention was made of twenty-two items, of which five were accused of being out of training activities and were removed; the teachers' pedagogical questionnaire was made on 20 items, of which two were removed. After this session, both questionnaires were subjected to expert researchers at the University of Rwanda College of Education and the AIMS expert team for content validity. From their ratings, four items were removed from the techno-pedagogical questionnaire and one from the teachers' pedagogical questionnaire. The remaining items were corrected following the provided comments.

Both the techno-pedagogical skills questionnaire and teachers' pedagogical questionnaire were scaled rating from Strongly disagree = 1, Disagree = 2, Undecided or

no opinion = 3, Agree = 4, and Strongly Agree = 5. Their Cronbach alpha reliability by SPSS version 23.0 yielded .75 and .702, respectively, proving the two questionnaires' positive reliability.

3.5 Data Collection Procedures

To collect the data the survey questionnaires were put into the Microsoft form, and an online link was generated. The links were administered online to math and science teachers. These teachers in all 14 districts interact on organized different created WhatsApp groups. Before administration, an online meeting was conducted to explain these questionnaires and the confidentiality of their responses; they were voluntarily requested to answer the survey. Internet connectivity was provided to all to access the survey. After explanations, the link for techno pedagogical skills was sent to their groups in three days, and they were timely and regularly reminded about it. After three days, the link was closed, and the responses were downloaded in Excel sheet for analysis. The same process was done to collect the data on teachers' pedagogical skills, and the link was administered after the closure of the first link. Responses of 351 teachers were counted on the techno-pedagogical questionnaire, while 362 were counted for the teacher's pedagogical questionnaire. According to Krejcie and Morgan's table for sample size, the participants' numbers from 14 districts are not very far from the determined sample size of 351 teachers who were considered with a margin of error of 5% (Krejcie & Morgan, 1970).

3.6 Description of Training Intervention

Teacher Training Program (TTP) adopted face-to-face and online training modes. Math and science teachers were trained in both ICT, content, and pedagogy; however, this study focused on ICT and pedagogy training.

3.6.1 ICT Training

Training on ICT and its integration into teaching and learning of math and science was conducted by the AIMS- Rwanda teacher training program (AIMS-TTP) in partnership with the International Computer Driving License (ICDL) a registered Trade Marks of The European Computer Driving License Foundation Limited ("ICDL Foundation"). ICDL-trained AIMS-TTP experts, math and science teachers who were selected as Master trainers. ICDL provided full support like training manuals, access to the ICDL platform, and all necessary training content to master trainers. They were trained face to face on eight modules that they used to train others and one particular module to make them proficient ICT master trainers; in total, nine ICIT -ICDL modules were covered in an intensive period of two months.

AIMS-TTP provides internet connectivity to facilitate master trainers' training. The AIMS-TTP aim was to train 2,500 math and science teachers and school directors of studies in 14 LIT districts of Rwanda. This target was attained, and trained people raised to above 3,500 in 5 years under different cohorts. To afford this number, AIMS-TTP used

trained master trainers as champion teachers to facilitate the training of others. Three master trainers from each district were trained by ICDL staff, and they facilitated the training of others per district with the assistance of TTP members. To start a cohort, AIMS-TTP lanced a call through WhatsApp groups and emails to all math and science teachers to register and select which cohort to attend. Cohorts were organized per year, and in each, 500 teachers were trained, except in the first year of implementation, where one cohort was trained.

Teachers' training was organized at the district level at the same periods in all 14 districts. A single training center per district where face-to-face was conducted during weekends and holidays while online training was organized in the daytime based on teachers' free time per district. AIMS staff assisted physically and online with all activities happening in all districts and provided all facilities, including internet connectivity to all teachers, Laptops to those in need, and all other required materials. Each cohort covered eight modules in 6 months.

Before starting training in districts, ICDL provided a pre-assessment, and after training a post-assessment was given. Only teachers who scored 75% and above post-assessment after training were allowed to sit for the certification exam. Those who scored less than 75% were allowed to sit for a certificate exam after a remedial session. This repetition was to strengthen teachers' technological skills and implementations in the teaching and learning process. With this kind of remedial, all trained teachers received an ICDL certificate through a teacher award celebration organized by AIMS-TTP each year.

3.6.2 Training on Pedagogy

Similarly, before training on pedagogy, AIMS TTP purposively selected teachers from 14 districts, based on their capacity and confidence, as nominated by their colleague teachers of the same schools. These were taken as peer facilitators and were used to be trained two weeks before each training activity. They were trained on different pedagogical aspects in relation to the required skills for competence-based curriculum implementation. AIMS-TTP pedagogic leads and math and science subject leaders were trainers of peer facilitators; however, when a need be, external expert trainers were invited from different organizations like the University of Rwanda College of Education (UR-CE), Rwandan Association of Women in Science and Engineering (RAWISE Rwanda Educational board (REB). Training on pedagogy covered content on innovative teaching methods like inquiry-based, 5Es instructional model, gender-responsive pedagogy, improvisation, and assessment. There was no call to register for this training; all math and science teachers in 14 districts and public schools could attend. AIMS-TTP planned training periods based on the progress of other learning activities as TTP activities were reaching different stakeholders like students, head teachers, and director of studies.

3.7 Data Analysis

The web-survey data were opened in MS Excel 2016, and 351 math and science teachers appeared as respondents; we filtered out those who registered by name but did not answer any statements. After the filtering process, we remained with 344 responses. The "COUNT- IF" functions were used to compute several responses on each statement, counting how many strongly disagreed, disagreed, undecided, agreed, and strongly disagreed on each statement. These rating scales were replaced by associating numbers, and the function counted "1" as strongly disagree, "2" disagree, "3" undecided, "4" agree, and "5" as strongly agree. After that, we computed the total number of disagreements by summing strongly disagree and disagree answers and total agreements by summation of strongly agree and agree answers. For teachers' techno-pedagogical skills, this was done to both statements of before and after AIMS-TTP interventions. We plotted a line chart graph on statements before and after interventions to compare their agreement, neutrality, and disagreements on each statement. A clustered column chart was used to compare male and female agreement levels across thirteen techno-pedagogical statements after interventions. Inferentially, we considered agreement rates of before and after interventions to test where there was a statistical significance difference; in this case, the Chi-square test by SPSS vs. 23 was used as it is the appropriate one when an actual count of the individual's responses is present instead of their scores. The same analysis procedure was also applied to teachers' pedagogical skills, and the Chi-square test by SPSS vs 23 was used to check whether there was a statistically significant difference in agreement between male and female pedagogical skills after AIMS-TTP interventions.

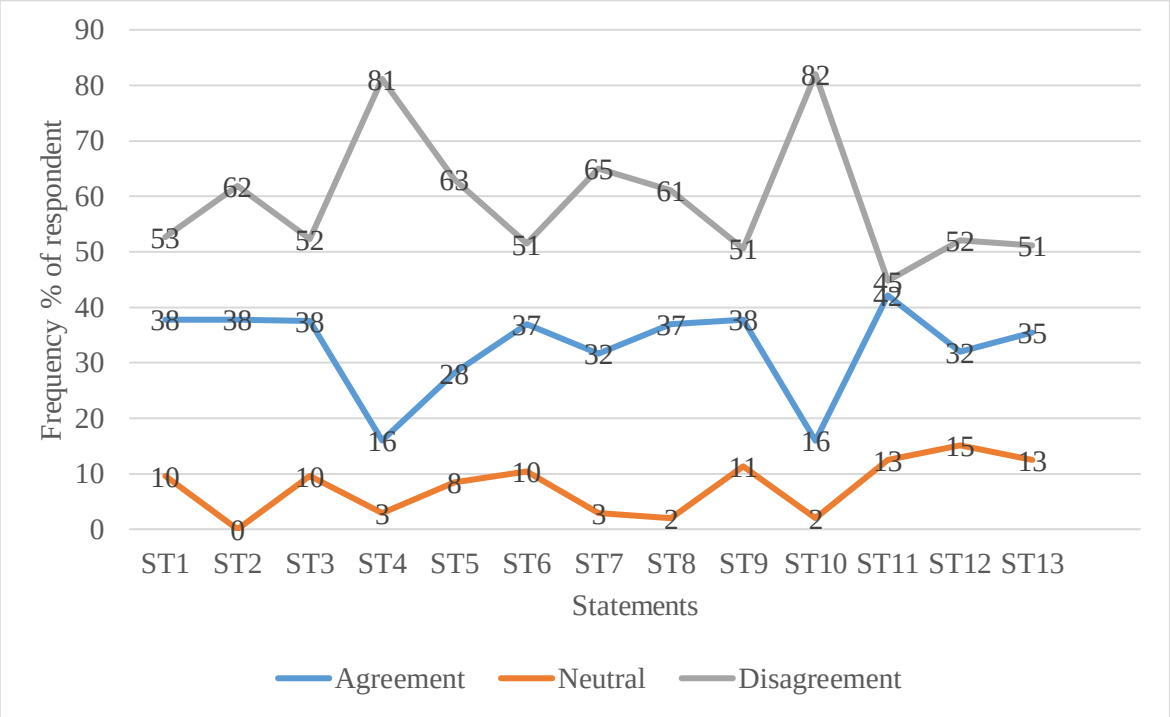
4. Results

4.1 Mathematics and Science Teachers' Techno-pedagogical Skills

Figure 2. Shows math and science teachers' approval of their Techno-pedagogical skills before attending the training provided by the African Institute for Mathematical Science through its Teacher Training Program (AIMS-TTP). It is evidenced that, before TTP interventions, Math and science teachers were equipped with basic skills of ICT; however, based on their agreement and disagreement level, their techno-pedagogical skills were at a lower level. For instance, % of the agreement shows the techno-pedagogical area with difficulties. My ICT skills for teaching math and science at secondary school are very low, 53%, while 62% were not able to use ICT resources available at school in teaching math and science subjects. 52% were not able to identify types of ICT resources necessary for teaching and learning math and science, 81% did not know how to use classroom technologies like interactive whiteboard, mobile learning, digital projector, and concept of screen sharing tools, 65% were not able to create a lesson plan for an ICT-enhanced lesson, 61% did not know ICT tools that they can potentially use in math and science class, and addition to that 82% confirmed that they do not know using tools like simulations, animations for teaching math and science and using online quizzes to assess learning progress. 51% had difficulties accessing e-resources from the

Rwanda education board website, while 52% Did not master the use of computer windows and how to print a document, see statement 12.

Figure 2: Pre-intervention Agreement and Disagreement Level of Mathematics and Science Teachers on Their Techno-pedagogical Skills for Competence-based Curriculum Implementation in Rwanda

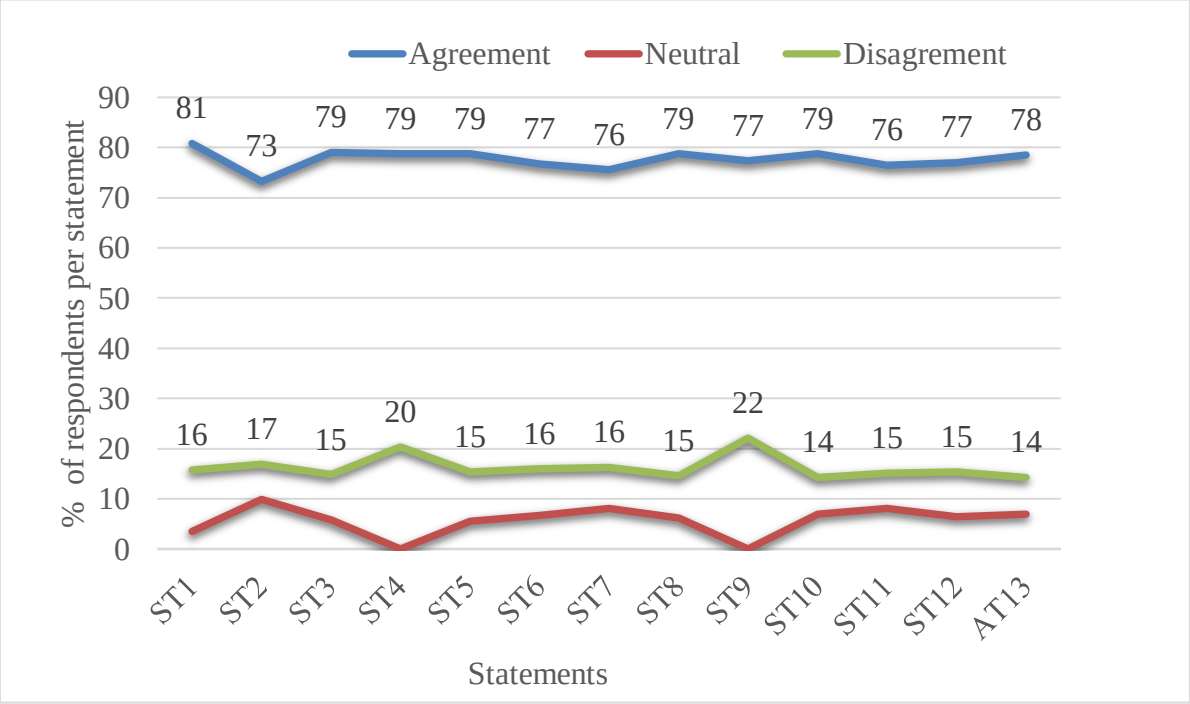


Note: A line chart is used to compare the percentages that each value contributes to a total. It has grouped respondents in agreement, neutral, and disagreement scales that show how math and science teachers confirm the level of their techno-pedagogical skills before attending teacher training program interventions.

Figure 3 expresses mathematics and science teachers' conformational results on their techno-pedagogical skills after attending a series of ICDL ICT and pedagogical trainings by AIMS- TTP. It shows how math and science teachers' technological (ICT) pedagogical skills increased based on their agreement and disagreement levels on techno-pedagogical statements. Overall agreement level is above 70% while disagreements on the statements are less than 30%, which proves the improvement of techno pedagogical skills as an impact of attended ICT training. For instance, 81% agreed that ICDL ICT training improved their skills in the use of the Internet in teaching math and science subjects, and 73% attested that training increased their confidence in using ICT in teaching and learning. Besides, they improved their skills in accessing easily electronic teaching resources from the Rwanda Education Board (REB) e-learning platform. 79% confirmed that, after training, they can use all ICT resources available at school in teaching math and science subjects, and 77% agreed that after attending the ICDL ICT in Education module, they can successfully use different search engines to access all documents necessary to support them in teaching math and science. Training

on ICT in Education improved teachers' skills in using classroom technologies like interactive whiteboards, mobile learning, and digital projectors in teaching math and science, as confirmed by 76%. Likewise, due to training, 77% of math and science teachers can create a lesson plan for an ICT-enhanced lesson. See statement 9. The results show that after attending training on the module of ICDL ICT in education, 76% of math and science teachers can use ICT tools like simulations and animations to implement a competence-based curriculum of math and science see Statement 11. While 78% agreed that due to skills gained from AIMS-TTP training, I mastered the use of computer windows and how to print a document, see statement 13.

Figure 3: Post-intervention Agreement and Disagreement Level of Mathematics and Science Teachers on Their Techno-pedagogical Skills after Attending Training by the Teacher Training Program Project (TTP-project)



Note: This line chart grouped respondents into three scales: agreement, neutral, and disagreement. It clarifies the difference in agreement and disagreements of respondents to each statement.

Figure 4 compares teachers' agreements and disagreements on their technological skills and integration of technology into the teaching process. Based on teachers' confirmation, it is clear that their techno-pedagogical skills were at a low level before attending AIMS-TTP interventions and that their skills improved at a high level after interventions. The percentage of agreement showing their ICT skills and its integration in teaching is less, while disagreement is high before TTP interventions in comparison to post-interventional agreement. Descriptively, this shows that AIMS-TTP interventions improved math and science teachers' techno-pedagogical skills.

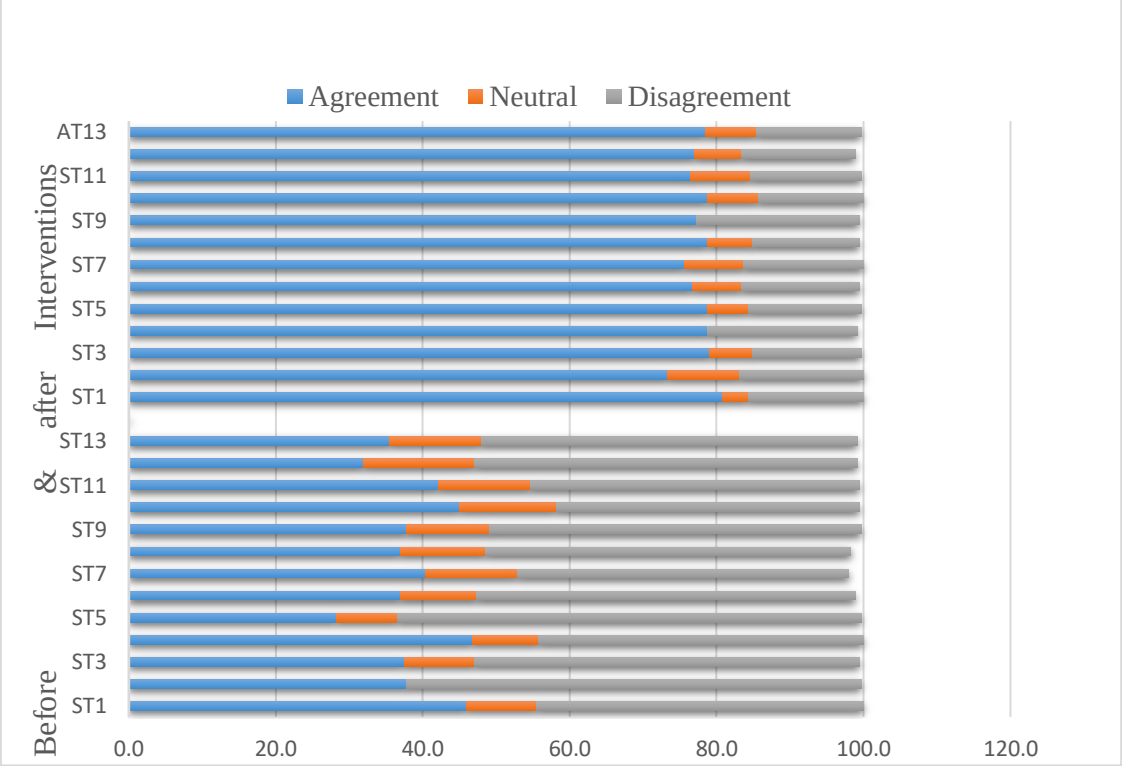


Figure 4: Teachers' pre and post-interventional agreements on their techno pedagogical skills

Besides, the findings show the difference in mean of math and science teachers' pre-intervention agreements and post-intervention agreements on their technological pedagogical skills before and after attending ICDL ICT training by AIMS-TTP (M = 38.6923) and post-training (M = 77.77) see Table 1.

Table 1: Descriptive statistics of pre and post-interventions of math and science teacher's agreement

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-intervention - Post-intervention	38.6923	13	5.43729	1.50803
		77.77	13	2.048	.568

Pearson Chi-Square test of mean comparisons proved a statistically significant difference in pre- and post-intervention agreement ($\chi 2 = 25.342$, df = 12 (1), $p<.001$) and linear by linear association between pre and post-intervention agreements on statements prove a statistically significant difference ($p<0.05$) see Table 2.

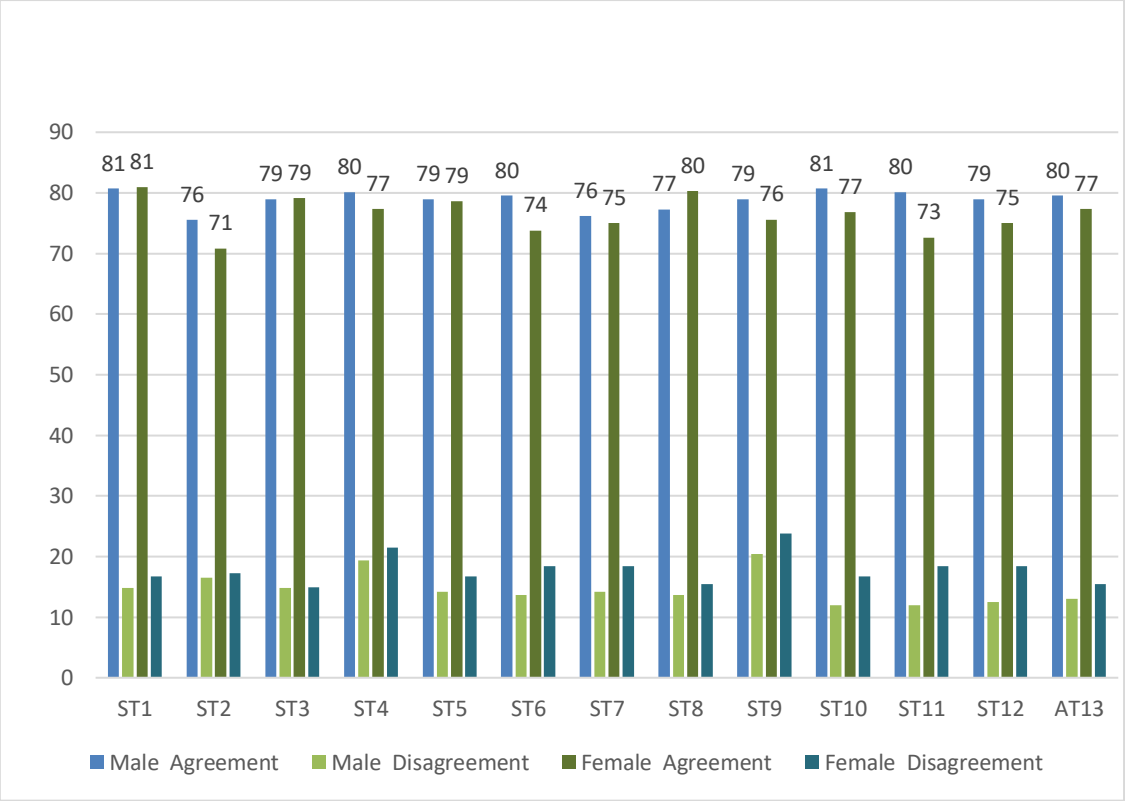
Table 2: Statistically significant difference between pre- and post-intervention agreements

Chi-Square Tests									
Pearson Chi-Square		**Paired Differences**					**χ2**	**df**	**Asymptotic Significance (2-sided)**
		Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
					Lower	**Upper**			
Pair 1	Pre-intervention - Post-intervention	39.07692	5.55970	1.54198	-42.43662	-35.71723	-25.342	12	.000
	Linear-by-Linear association								.012

Figure 5 compares male and female agreements on the techno-pedagogical statements after attending the ICDL ICT in education module. The findings show that male and female agreement levels are purely equal in some statements, while there is little difference in agreement in others. Illustrations show that similar agreement is on Statement 1 (81%) [TTP Interventions improved my skills on the use of internet in teaching], Statement 3 (79%) [AIMS TTP training improved my ICT skills for teaching math and science at secondary school] and statement 5 (79%) [Due to skills gained from AIMS TTP intervention I can easily identify types of ICT resources I need for teaching math and science]. Among the eight remaining statements, there is a threshold difference see Figure 3, except for statement 6 [After attending TTP ICT training, I can successfully use different search engines to access all documents necessary to support me in teaching math and science] where male agreed at 80% level and female 74%. The same as statement 11, where male agreement is 80% while female agreement is 73%. On the other hand, the statement disagreement level is very low and most similar to both males and females for all statements see Figure 5.

Though descriptive statistics of mean comparison proved a difference between male (M = 79) and female (M = 76.4) mean of agreement after interventions, this difference was not statistically significant as proved by Pearson Chi-Square test of mean comparisons ($\chi 2 = 40.625$, df = 12 (1), $P > 0.05$). This confirms that AIMS-TTP ICT training interventions improved equally male and female techno-pedagogical skills.

Figure 5: Male and female agreement level on techno pedagogical skills after attending AIMS-TTP ICT training

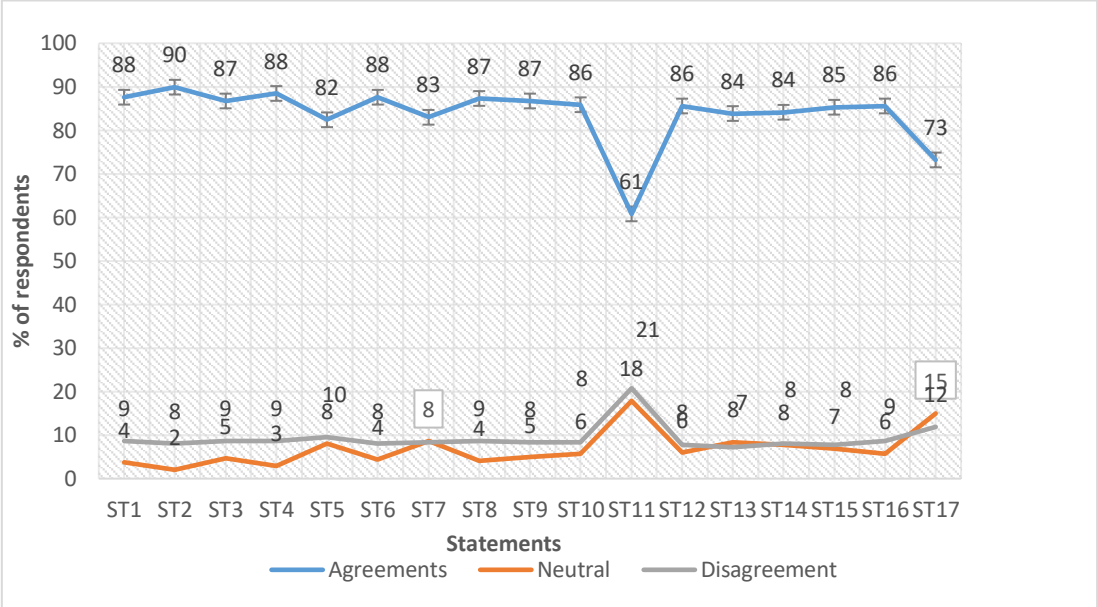


Note: A clustered column chart is used to compare values across a few categories. It compared male and female agreement levels across thirteen techno-pedagogical statements after ICDL ICT interventions.

4.2 Math and Science Teachers' Pedagogical Skills

Figure 6 shows that training increased teachers' pedagogical skills by a high % based on their agreement level on statements. All pedagogical statements were accepted beyond 80% except statement 11[I always show my students that I care about them] and statement 17 [I am able to use various science/math resources that are available in school], accepted at 61% and 73%. To those statements, the agreement and neutrality were increased, as the line pics show. 21% disagreed, while 18 did not respond see Figure 6.

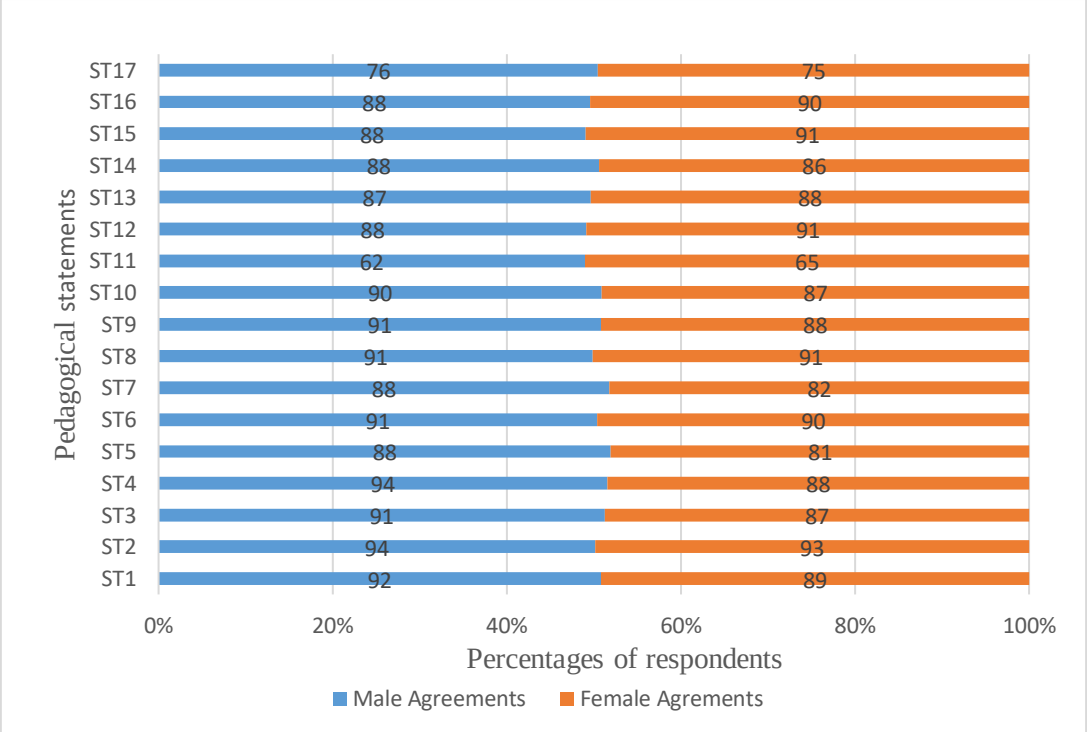
Figure 6: Math and Science teachers' pedagogical skills after attending AIMS-TTP interventions



Note: This line chart grouped respondents into three scales: agreement, neutral, and disagreement. It clarifies the high percentages of increased teachers' pedagogical skills after interventions.

The post-agreement difference between males and females did not make a statistically significant difference, ($\chi 2 = 12.400$, df = 8 (1), $P > 0.05$) which proves a similar impact of TTP Interventions. Both male and female equally increased their pedagogical skills for teaching math and science after TTP interventions.

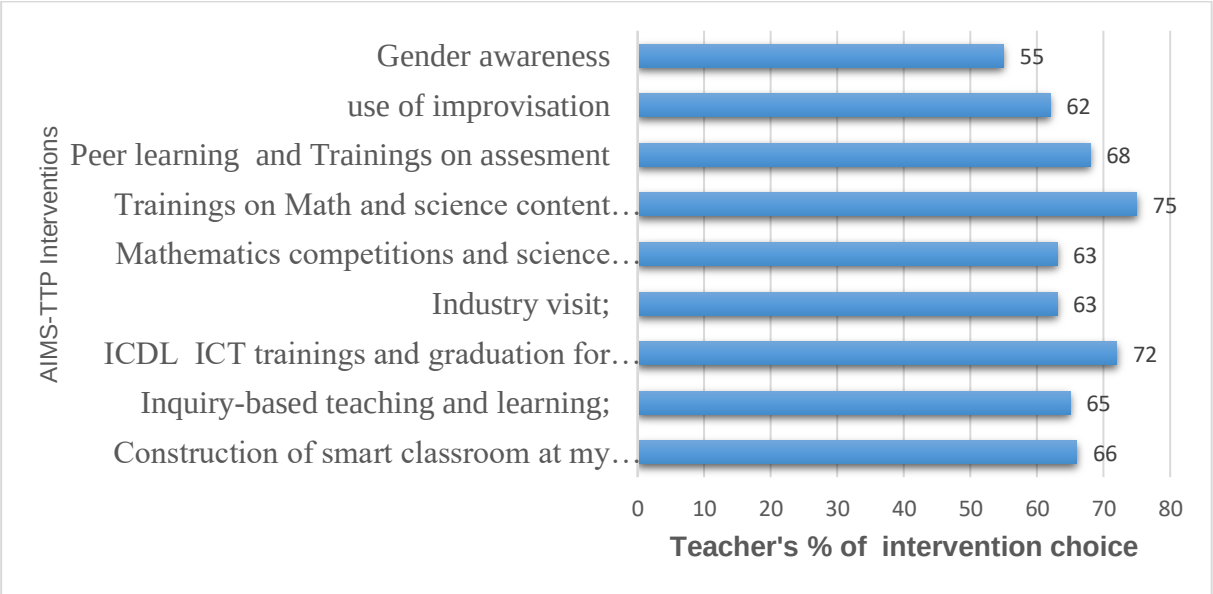
Figure 7: Male and female Pedagogical Skills Comparison after TTP Intervention



4.3 Teacher training programs' interventions that were most effective for teachers

Teacher training programs (TTP) implemented different interventional activities. Figure 8 shows the most effective math and science teachers based on their % of appreciation. Training on math and science content and related hands-on activities were most effective 75% of selections, followed by ICDL ICT training, and teacher's graduation were also effective activities activity 72% of agreement see Figure 8.

Figure 8: Math and Science Teachers' Appreciation of Most Effective TTP Interventional Activities



5. Discussion

Mathematics and science teachers' techno-pedagogical skills in 14 districts of Rwanda where AIMS-TT implemented its activities were very low before its interventions. This was proved by 81% of math and science teachers who did not know how to use classroom technologies like interactive whiteboards, mobile learning, digital projector, and the concept of screen-sharing tools. The reason for this big percentage of teachers who lack skills in the aforementioned use of technologies in the classroom may be attributed to the lack of technological resources in their schools and the lack of the ability to integrate technology resources into the teaching process. The inability to use tools like simulations and animations for teaching math and science and online quizzes to assess learning progress in 82% of teachers denote the absence of in-service training on these technological tools, proving their no use in classroom activities before AIMS -TTP interventions. This implies the low level of ICT integration into the teaching and learning process and the need for training, as likewise was recommended in the situational analysis report by Stoeling (2018b). Besides, this lines with the findings by Murithi & Yoo (2021), who noted that teachers faced a scarcity of ICT facilities in schools and challenges in the integration of technology during the implementation of the competence-based

curriculum in Kenya due to the lack of techno-pedagogical training as an addition to their basic computer literacy training. The training needs relate to the existing literature, where it is noted that training is the most effective way of strengthening in-service teachers' technological pedagogical content knowledge, thus boosting learner's engagement when learned skills are properly integrated into the classroom environment (Sánchez-García et al., 2013).

Teachers' confirmations prove that AIMS-TTP training improved their ICT skills and integration in math and science teaching. The agreement to what they were able to do before interventions is less than to the agreement of what they can do after AIMS-TTP ICT training, which attests to an improvement in their ICT skills and the capability of its integration into teaching. Teachers highly agree that training on ICT improved their skills on the internet, as their confidence in using ICT in teaching may result from the ICT content used in training, which included a module of online essentials that comprised the concept of understanding the internet and connecting to internet. The results also equalize with the findings of Mugiranez (2021), stating that teachers who have access to internet instructional resources and ICT training have higher levels of confidence in using it in teaching who do not use the internet for instructional purposes.

Besides, the high confirmation of gained confidence in ICT use in teaching may be rooted in the way the training was conducted, where both online and face-to-face mode was adopted and teachers as trainee's centeredness were the most approach through a peer learning strategy.

This allowed all teachers to force themselves to know how to join online sessions using digital devices and the internet and freely interact with their colleagues' teachers who were peer facilitators. This states that the training content and approach contribute to the effectiveness of project implementation, thus generating improved teachers' skills. AIMS-TTP training allowed teachers to navigate with internet and digital resources, and through this, they developed their skills in ICT, such as the use of online collaboration tools, mobile collaboration, web page interaction, and email and its uses, among others. These findings line with what was proved by the study of (Sánchez-García et al., 2013), who noticed that teachers expressed high levels of gratification with the ICT training since it helped them improve their teaching abilities. Similarly, the findings agree with Arosha (2022), who noticed that ICT training improves teachers' technological skills to use for science teaching. The implication is that AIMS-TTP interventions on ICT were successful and provided at the right time. When continuously provided, teaching math and science in Rwanda may always be a digitalized teaching, increasing learner engagement, conceptual understanding, and improved learning performance.

The fact that after attending AIMS-TTP interventions teachers can create an ICT-enhanced lesson, use classroom technologies like interactive whiteboard, mobile learning, and digital projector, and use ICT tools like simulations and animations is explained by the well-prepared training activities and the well-prepared master trainers. Master trainers and AIMS-TTP staff were first trained intensively by the world's leading computer skills certification company, ICDL; they were tested and awarded the

certificate of an ICT master trainer. Additionally, teachers successfully learned the module of ICDL ICT in education, which provided them with all necessary skills on ICT and its integration into teaching practice. With this module, teachers covered a number of techno-pedagogical lessons such as ICT and learning styles, ICT and teaching and learning strategies, ICT and learning environment, creating an ICT-enhanced lesson plan, and classroom technologies. This tells that competitive master trainers delivered training and that the resource facilities provided by AIMS-TTP sufficiently supported training, thus leading to great improvements in teachers' techno-pedagogical skills. These findings agree with Kumari & Naik (2016) who noted that well-organized training, delivered by knowledgeable and skilled persons, leads to a successful transfer of new knowledge and improves existing skills. Besides, the findings related to what was found by Wachiuri, (2015) that there is a relationship between ICT training and its integration in the teaching process. The implication is that trained math and science teachers become techno pedagogues as they develop the ability to integrate technology into pedagogy in everyday teaching activities. The same implication applies to the findings in the study of (Rao et al., 2021).

A statistically significant difference tested between pre- and post-interventional agreements proves an enhanced teacher's techno-pedagogical skills after attending AIMS-TTP ICT training. This implies a valued contribution of these trainings to math and science teachers' skills of competence-based curriculum implementation through technology integration. Both male and female equally improved their techno-pedagogical skills. This may result from the equality and equity aspect of gender that characterized TTP interventions, and this implies that both males and females are now ICT-skilled teachers able to integrate technology into the teaching of math and science in 14 districts of Rwanda where TTP activities reached.

AIMS-TTP training not only improved teachers' ICT skills and their implementation in teaching but also their pedagogical skills. This may be because pedagogical training and ICT training alternated; hence, teachers were chanced to upgrade their skills on innovative teaching methods such as inquiry-based learning that are modernized teaching requiring technology integrations. The implication is that when in-service teachers are trained both in technology and pedagogy, they become true techno-pedagogues, and their competencies contribute to students' learning performance. The findings are consistent with the literature stating that technology and its integration into pedagogy are the core of quality education in this highly evolving digital era (Kumari & Rani, 2022). This tells us that if Rwandan in-service math and science teachers are continuously equipped with updated technologies and innovative pedagogy through training, the education quality would successfully meet 21st-century demand and the country's economic development. This was also emphasized by Nkundabakura, et al., (2023), who noted that teachers need continuous training to improve their knowledge and teaching profession.

The improved math and science teachers' techno-pedagogical skills and pedagogy are buoyed by their appreciation of TTP interventions, where the construction of smart

classrooms, ICT training, and improvisation. And inquiry-based learning, among other indicators, is the most pointed activity of their benefits.

6. Conclusion and Recommendations

The study aimed to explore the impact that the Teacher Training Program (TTP) implemented in Rwanda by the African Institute for Mathematical Sciences unveiled on math and science teachers' techno-pedagogical skills. To achieve study objectives, a survey was conducted on math and science teachers' techno-pedagogical and pedagogical skills, identifying the AIMS-TTP Interventional activities that excited and benefitted teachers. Math and science teachers' responses on their techno-pedagogical skills before attending the AIMS-TTP intervention proved that most of them in 14 districts of Rwanda where TTP implementation was done were not skilled in ICT and could not integrate it into classroom pedagogy.

Both male and female equally improved their techno-pedagogical skills, and the Chi-square test confirmed a statistically significant difference in teachers' techno-pedagogical skills before and after attending AIMS-TTP ICT interventions. Therefore, we recommend continuing ICT training to sustain its regular integrations in teaching and learning math and science as digital technology is dynamic. This would always keep teachers with the necessary competencies to use modernized tools in teaching that will result in improved quality education.

Training on pedagogy equally improved male and female teachers' pedagogical skills, and teacher agreement levels attest that they improved skills in inquiry-based teaching and technology integration in this innovative teaching method. This justifies why training teachers on both technologies, their integration into education, and pedagogy itself was important. It shows that teachers were trained on what they needed; therefore, we recommend that in-service training should be based on their needs and the 21st-century demands to be achieved. Teachers should shift from their traditional way of teaching by adopting technology integration and innovative ways of teaching.

7. Limitations and the Way Forward

This study is a part of research on the impact of AIMS- Rwanda teacher training program after its five years of implementation in 14 districts of Rwanda. It has only focused on TTP's impact on techno pedagogical and pedagogical skills of trained teachers, while they are not the only TTP training indicators. Further research will concentrate on AIMS-TTP's impact on teachers' math and science content knowledge and attitude toward teaching math and science and on gendered responsive pedagogy. We used a survey to assess the impact on techno-pedagogical and pedagogical skills; however, we did not check the correlation between their agreements and classroom practical skills; hence, further recommended research on TTP impact should focus on classroom observations.

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Conflict of Interest Statement
The authors declare no conflicts of interest.

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