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Improvisation as an Alternative to Initiate Hands-on Activities in Mathematics and Science Lessons among 14 Districts of Rwanda

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Abstract

Using improvisation materials is an easy, fun, effective way to help students learn and grow, and unlock their full creative potential. The study aimed at examining the status of using improvisation materials in the process of teaching and learning by mathematics and science teachers. It employed a longitudinal survey design with the population of 4755 (1571 females and 3184 males) trained Mathematics and science teachers. A sample of 351 teachers selected purposively answered a survey questionnaire showing the status of using improvised materials while conducting experiments. An analysis by frequencies, percentages and the independent sample t-test indicate that 87.46% of teachers conduct experiments using improvised materials while 12.53% of the trained Mathematics and science teachers do not use improvised materials. The study also revealed a statistically significant difference between the status of Mathematics and science teachers' use of improvisation materials before and after trainings ($p>0.000$) by the African Institute for Mathematical Sciences, Teacher Training Program (AIMS-TTP). The study recommends that improvisation using locally available materials should be well selected, utilized and appropriately integrated into teaching and learning to initiate instruction though hands-on activities.

Key words: engagement and application; improvisation; improvised instructional materials; alternative instructional materials

Introduction

A large number of students learn more easily by doing activities. Practical activities should be emphasized to structured lessons and improve engagement and knowledge retention to help students strengthen the conceptual understanding of Mathematics and science concepts (Wakhata et al., 2023).

Improvised instructional material is a method or way of minimizing loss of equipment and materials and an inexpensive method of widening the scope of inquiry. Improvised instructional material is a meaningful attempt to find a suitable substitutes or alternatives to conventional science materials (Ndihokubwayo et al., 2018). Improvised instructional materials generate interest and motivation for indigenous technology with practical and physical links between science and theory, they help to eradicate the menace of lack or inadequate instructional materials for Mathematics and science (Okori & Jerry, 2017).

Improvised instructional materials make teaching Mathematics and science concepts more interesting to both students and teachers in the classroom; improvised materials are

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usually simple and may not have perfect finishing, because they are made from local raw resources that are acceptable to students (Okori & Jerry, 2017). Improvised instructional materials help Mathematics and science students to realize that science has to do with ordinary things and will possibly motivate them to carry out experiments and learning activities themselves using such improvised materials (Mbwile & Ntivuguruzwa, 2023).

Conducting experiments using improvisation materials tends to remove abstraction(s) in learning theories because the products of improvisation are tangible, handy and concrete. Improvised instructional materials must be very safe to use during demonstrations and experiments. Improvisation materials in Mathematics and science instruction must be hazard-free or danger free (Holdhus et al., 2016).

Integrating conventional and improvised labs can create a dynamic and flexible learning environment that maximizes resources and fosters innovative approaches to scientific inquiry (Patrix, 2017). By perfectly connecting well-equipped traditional laboratories with adaptable and cost-effective improvised setups, students and researchers gain access to a wide spectrum of experimental opportunities. This collaborative synergy enables them to explore diverse scientific concepts, experiment with creative solutions, and adapt to various constraints, ultimately enhancing their problem-solving skills and enhancing their scientific education

Mathematics and science teachers have been trained by the Teacher Training Program (TTP) of the African Institute for Mathematical Science (AIMS) for over a period of five years on different concepts, including the trainings on the use of science kit items and conducting experiments using improvised materials in order to strengthen their capacity to deliver Mathematics and science lessons and effectively implement the Competence Based Curriculum.

Effective learning hinges on concrete experience and then proceeds towards theoretical experience. When lessons are presented with instructional materials, students are made to learn through associative mechanisms using multisensory modalities (Umuhoza & Uworwabayeho, 2021). According to Graue et al., (2015) no matter how rich and generous educational authorities might be, they are not always in a position to provide their schools with all the materials they may need. Therefore, the schools, students and teachers might be obliged to make the most of what they can get or construct from locally available raw materials. For instance, certain things like herbarium press, aquarium tank, and wooden splint can easily be improvised by competent science teachers instead of waiting for supplies by the educational authorities. Hence, the need for improvisation and effective utilization of instructional materials by teachers to give students the bread of living experience rather than the stone of abstract theory.

The abundance and easy availability of local natural resources in Rwanda, along with the familiarity of students and teachers with these locally sourced materials, and the proven capacity of these resources to deliver learning outcomes comparable to traditional lab materials, all enhance the relevance of the content (Haliwanda, 2018). This connection to the materials in their daily surroundings helps students assimilate the content more effectively. Given Rwanda's natural resource-rich environment, which offers excellent opportunities for teaching and learning Mathematics and science in an engaging and efficient manner, improvisation stands out as

the optimal choice for making these subjects more exciting for both students and teachers.

To equip Mathematics and science teachers with the necessary skills to conduct hands-on activities using improvised materials, AIMS-TTP intervened by training more than 7000 teachers on the practice, thus a study aiming at examining the status of using improvised materials to conduct experiments among 14 Districts of Rwanda with the following research question:

To what extent do Mathematics and science teachers use improvised materials to conduct experiments?

Literature Review

Concepts of Improvisation and Instructional Materials

An improvised is the act of using alternative materials or resources to facilitate instruction whenever there is lack or shortage of some specific first-hand material to enhance classroom instruction. Improvisation is not just mere substitution of the lacking instructional material with what is available but must serve the purpose of the original material (Gilbertson, 2013). According to Okori and Jerry, (2017), improvisation is the act of using alternative materials or equipment obtained from the local environment or designed by the teacher or with the help of local personnel to facilitate instruction.

Instructional materials are educational resources or materials used to improve students' knowledge, abilities, and skills to enhance their assimilation of the lesson, and to contribute to their overall development and upbringing. The universal task of improvisation and instructional material is to make teaching and learning real and genuine to the students for increased performance and practical application of the lesson in and outside the classroom environment (Ndihokubwayo et al., 2018).

Importance of improvisation in teaching and learning Mathematics and science

Improvisation in teaching and learning Mathematics and science is of paramount importance as it fosters a dynamic and engaging educational environment as it allows educators to adapt their teaching methods to the specific needs and learning styles of their students (Holdhus et al., 2016). Mathematics and science can be challenging subjects, and a one-size-fits-all approach may not effectively reach every student (Sibomana et al., 2020). By improvisation, teachers can tailor their lessons to address individual learning gaps and stimulate interest in these subjects. This personalized approach can lead to increased comprehension, better retention of knowledge, and a deeper appreciation for the topics (Ndihokubwayo et al., 2018). Furthermore, improvisation can help students develop problem-solving skills, critical thinking, and creativity, which are essential in the fields of Mathematics and science. When educators encourage students to explore concepts beyond the textbook and engage in open-ended and exploratory activities, it sparks curiosity and a desire to explore deeper into these subjects. This can lead to a more profound understanding of the underlying principles and concepts, as students are encouraged to ask questions, experiment, and think critically to solve real-world problems (Kihwele & Mkomwa, 2023).

Moreover, improvisation in teaching Mathematics and science can make the subjects more relatable and enjoyable. By incorporating real-life examples, practical applications, and hands-on experiments, teachers can create a connection between the abstract theories and the world around us (Wakhata et al., 2023). This not only makes learning more engaging but also helps students see the relevance of these subjects in their daily lives, potentially inspiring them to pursue further studies and careers in Mathematics and science in a vital tool for

enhancing comprehension, nurturing critical thinking, and instilling a lasting passion for these subjects (Ekwueme et al., 2015; Wakhata et al., 2023).

When to conduct an experiment using improvised material(s)

The timing of when to conduct improvisation in Mathematics and science lesson is crucial for maximizing its effectiveness and different key aspects can be considered when using improvisation, include a motivational introduction that pique students' curiosity where teachers can start with a surprising or thought-provoking question or scenario related to the topic; this unexpected element can capture students' attention and stimulate their interest to learn. Also, in the middle of a lesson when students encounter difficulties or misconceptions, improvisation can come to the rescue for the clarification and concept reinforcement (Ndihokubwayo et al., 2018).

Teachers can be flexible in their approach, adjusting explanations and activities to cater to the specific needs of the class. If students are struggling to grasp a particular Mathematical concept or scientific principle, teachers can improvise additional examples, analogies, or hands-on experiments to make the content more accessible. This adaptability helps ensure that students don't become bored by challenging material and can foster a deeper understanding (Sibomana et al., 2021).

Towards the end of a Mathematical or science lesson, improvisation can be also employed for application and extension to encourage practical application and extend the learning. Teachers can challenge students with open-ended problems, discussions or real-world scenarios that require them to use the knowledge they've gained (Ahmed et al., 2021).

Why improvisation materials in the 21st learning century?

The effectiveness of instructional materials depends on the degree to which they meet the needs of the teacher and students. Training Mathematics on using improvised materials to conduct experiments is of paramount importance for their professional development in the 21st century learning environment because it aligns with the dynamic and rapidly evolving nature of our world (Hota, 2023).

In this era, traditional approaches to education that rely solely on rote memorization and standardized teaching methods often fall short of preparing students for the complexities they encounter in the real world. Improvisation allows educators to adapt their teaching strategies to changing circumstances and cater to the diverse needs and interests of students. It encourages creativity, critical thinking, problem-solving, and adaptability, all essential skills for success in the 21st learning century (Okori & Jerry, 2017).

Moreover, improvisation promotes a more engaging and student-centered learning experience. In an age where information is readily accessible through technology, education should shift its focus from imparting facts to teaching students how to think, learn, and apply knowledge (Srinivasacharlu, 2019). By incorporating improvisation, educators can design interactive, experiential lessons that capture students' attention, foster their curiosity, and encourage active participation. This approach not only enhances students' academic achievement but also equips them with the skills and mindset necessary to thrive in a world characterized by rapid technological advancements and complex global challenges (Nkundabakura et al., 2023).

Furthermore, using improvisation materials is valuable in many educational settings, though there are some notable disadvantages in case of ineffective use or preparation including the lack of consistency and standardization in the learning experience when the quality, accuracy, and relevance of the content can vary widely leading to inconsistencies in the educational content and outcomes (Ndihokubwayo et al., 2018; Ukobizaba et al., 2021). Developing high-quality improvised teaching aids or resources often requires considerable effort, creativity, and access to materials. This can be a strain on both teachers and educational institutions, particularly when allocating insufficient time (Graue et al., 2015).

The time spent on improvisation could be used more effectively for other essential teaching tasks such as lesson planning, assessment, and professional development. Teachers need to carefully weigh the benefits and drawbacks of improvisation to determine when it is most appropriate in the educational context. (Ahmed et al., 2021).

Methodology

The study employed frequencies, percentages and the independent sample t-test to analyze data through a longitudinal survey design. Participants were all Mathematics and science secondary teachers from 14 districts under AIMS-TTP interventions. Getting insight from the table of Krejcie and Morgan about the determination of the sample size, Abdul, (2021), from the population of 4755 (1571 females and 3184 males) trained Mathematics and science teachers, 351 were sampled purposively to answer a survey questionnaire showing the status of using improvised materials while conducting experiments.

Initially we targeted the sample of 357 but six of them could not fill the form after the training, thus, we remained with 351 that filled it before and after.

The questionnaire was tested for validity and yielded a Pearson correlation coefficient of 0.71. The questionnaire with an item "*I use improvisation in my teaching practice*" was scaled rating from strongly disagree =1, Disagree=2, Neutral=3, Agree=4 and Strongly Agree =5, and was administered before and after the trainings.

Training procedures

Initially, a one-week training session was conducted for peer facilitators in collaboration with the Practical Education Network (PEN), an organization from Ghana that provides tools for West African STEM teachers to provide hands-on learning experiences. Subsequently, the trained peer facilitators implemented the program nationwide in a face-to-face format.

Particularly, Mathematics and science teachers involved in the peer facilitation phase had actively contributed to the development of the improvisation manual during its formative stages, thereby facilitating a seamless integration of the training process. In addition, a sizeable of the work was created first hand by the team and most of the illustrations and images.

Findings

Table 1 shows the descriptive statistics of the status of using improvised materials in teaching and learning Mathematics.

Table 1: Descriptive statistics of the status of status of using improvisation materials before and after AIMS-TTP trainings

Groups	*Participants V(n)*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Before AIMS-TTP Trainings	351	2.2	0.862	0.046
After AIMS-TTP Trainings	351	4.21	1.014	0.054

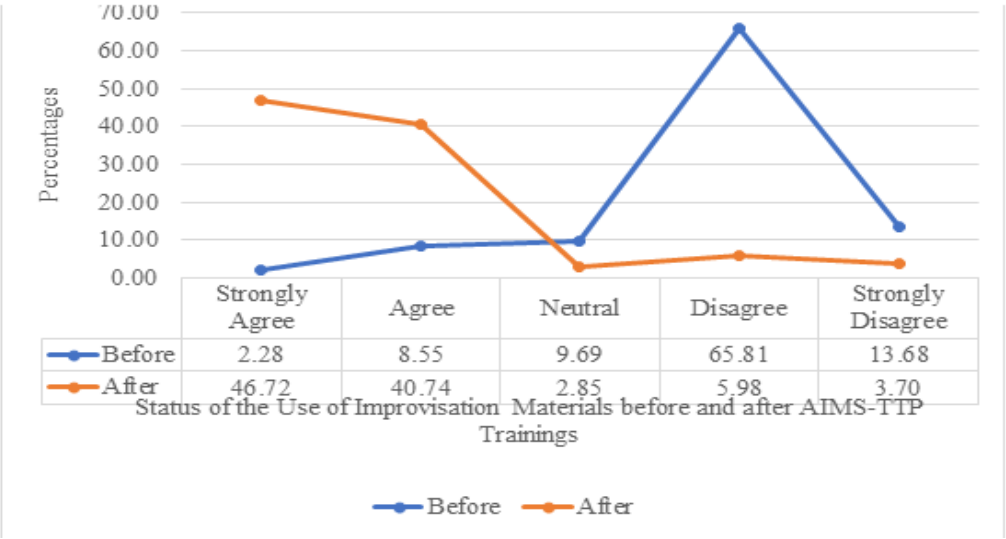
In Table 1, it will be noticed that the status of using improvised materials in teaching and learning Mathematics before {(N=351; Mean=2.2; Std. deviation=.862 and Std. error mean=.046) and after {(N=351; Mean=4.21; Std, deviation=1.014 with the Std. error mean of .054)} the participants rated the mean status of using improvised higher after AIMS-TTP trainings. The difference in the standard deviation of before and after the training sessions is 0.152, which indicates that data points are very close to the mean as it is close to zero. Table 2 shows the results of the independent samples t-test of the mean status of using improvisation before and after AIMS-TTP trainings. The table indicates a statistically significant difference (p>0.000) in the mathematics and science teachers' mean status of using improvisation materials before and after the AIMS-TTP trainings.

Moreover, Figure 1 below, clearly indicate the status of the use of improvisation materials in Mathematics and science lesson among 14 Districts in Rwanda as indicated by teachers' level of agreement from strongly agree, agree, neutral, disagree and strongly disagree before and after AIMS-TTP trainings; 46.72% strongly agreed to use improvisation materials in teaching after being trained while the baseline was 2.28%, 40.74% agreed on the statement from 8.55% before training. 9.69% (before) and 2.85% (after) of Mathematics and science teachers did not either agree or disagree with the statement. In comparison, 65.81% did not use the improvised materials before being trained by AIMS-TTP. This percentage was reduced to 5.95% of Mathematics and science teachers who do not use improvised materials despite the training attended.

Table 2 Independent samples test of the mean status of using improvisation **before and after AIMS-TTP trainings**

	Levene's Test		t-test for Equality of Means				
	F	Sig.	t	Df	Sig. (2-tailed)	Mean Dif.	Std. Error Dif.
Equal variances assumed	9.006	0.003	-28.276	700	0.000	-2.009	0.071
Equal variances not assumed.			-28.276	682.320	0.000	-2.009	0.071

Figure 1: Agreement Categories on the use of Improvisation Materials in Mathematics and Science Lessons Before and After AIMS-TTP Trainings



In addition to the above, 13.68% strongly disagreed to use improvised materials before trainings, and after the percentage was reduced to 3.7% who also strongly disagreed with using improvisation materials in teaching Mathematics and/or science subjects.

Discussions

The study aimed to examine the extent to which mathematics and science teachers use improvised materials to conduct experiments indicate that teachers adopted the use of the improvised materials in the teaching practice to help learners understand the concepts. This finding corroborates the results of Okori and Jerry (2017) that the utilization of improvised materials would help to enhance the teaching and learning of Mathematics and science if teachers who are the implementers of the curriculum engage themselves in proper utilization and improvisation material resources used in the teaching and learning.

Moreover, the trained teachers who do not use improvisation in their teaching practices after being trained (12.53%) might have enough experiment materials at their schools or do not fit comfortable to improvise materials despite the training attended. In addition, the computed $p>0.000$ is deemed to be statistically significant between the status of Mathematics and science teachers' use of improvisation materials before and after trainings. This evidences the effectiveness of the trainings and it corroborates the results of Dange and Siddaraju, (2020) that teachers' professional training and professional development is a necessary ingredient to support innovative and beneficial teaching.

Conclusion

The study aiming at examining the status of using improvised materials to conduct experiments by Mathematics and science teachers in 14 districts of Rwanda reveal that after a series of trainings by the African Institute for Mathematical science, 87.46% of teachers conduct experiments using improvised materials while 12.53% of the trained Mathematics and science teachers do not use improvised materials. Moreover, there is a statistically significance difference of Mathematics and science teachers' use of improvisation materials before and after the trainings by AIMS-TTP.

Recommendations

Improvised materials should be well selected, utilized and appropriately integrated into teaching and learning to equip students with significant learning performance, thereby increasing learning achievement and retention.

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Conflicts of interest

The authors confirm that they have no potential conflicts of interest to disclose.

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