



Strengthening Mathematics and Science Education in Africa

[SMASE-AFRICA]

Journal for Science, Technology, Engineering and Mathematics Education in Africa (JSTEMEA)



Volume 1

Number 2

Journal for Science, Technology, Engineering and Mathematics Education in Africa (JSTEMEA)

[Published] April, 2024, Nairobi, Kenya

[Copyrights] ISSN 2617-6300

Copyrights of the papers in this journal belong to SMASE-Africa.

[Secretariat]

National Science Centre (NSC)

Ministry of Education

Private Bag 5, Woodlands, Lusaka, Zambia

Tel +260-211-262391 or +260-211-266772

Email: jstemea@gmail.com

Contact Information

[Regional Secretariat]

Strengthening Mathematics and Science Education in Africa (SMASE-Africa) P. O. Box 22949-00505

Located inside the University of Nairobi - Kenya Science Campus, Ngong Road Nairobi, Kenya.

Tel: +254 720 073 533

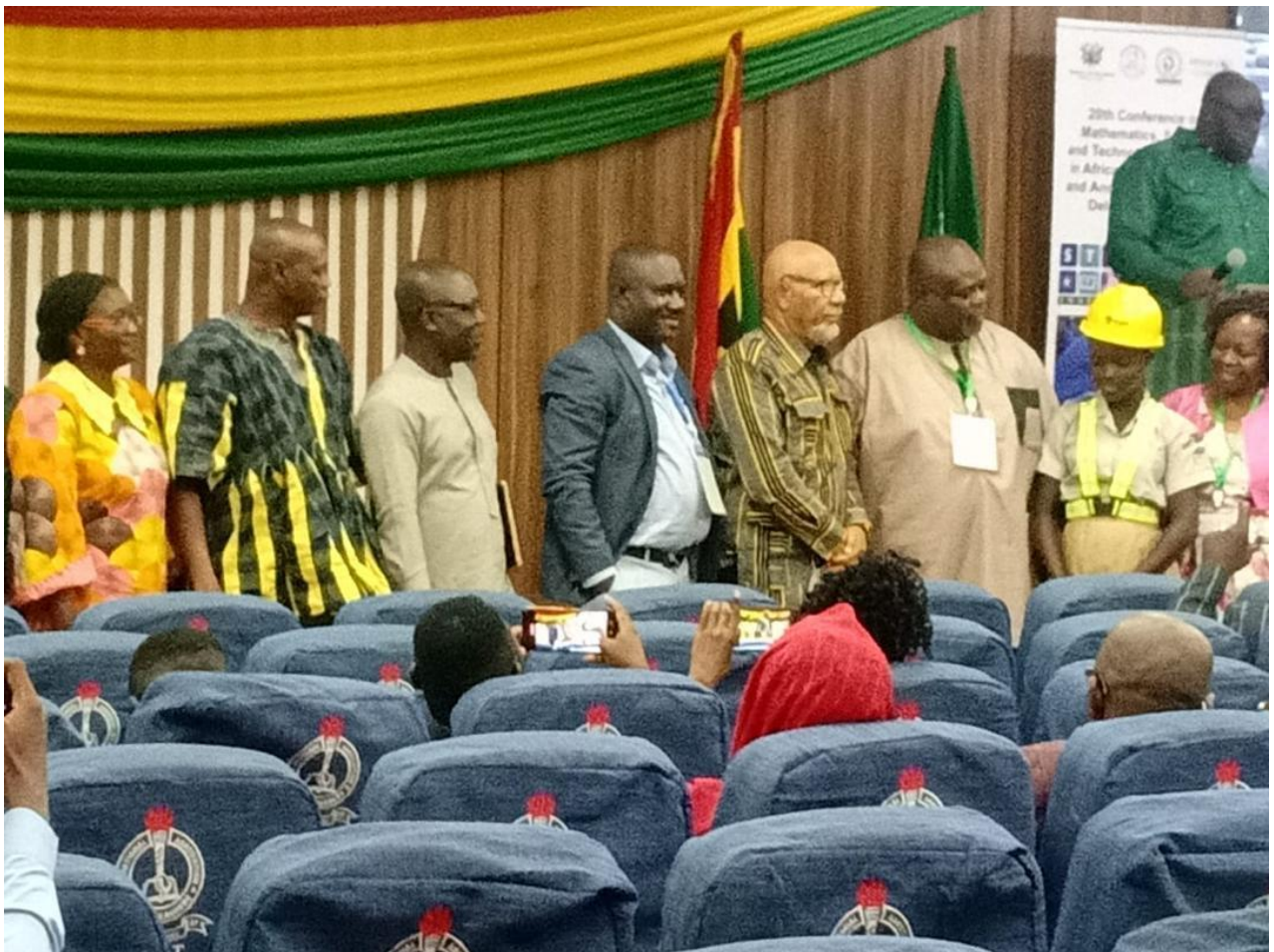
E-mail: info@smase-africa.org

Website: www.smase-africa.org



Strengthening Mathematics and Science Education in Africa

SMASE-AFRICA



COMSTEDA 20 GHANA CONFERENCE HELD IN 2024

Table of Contents

Journal Articles

EDITORIAL BOARD	vi
PREFACE	vii
ABOUT SMASE-AFRICA AND COMSTEDA FORUMS	viii
EDITORIAL	ix

Article 20

Analysis of girls' enrollment in science majors at ISP/GOMBE during the 2021-2022 and 2022-academic years by Christine Mvondo Pashi.....	1
--	---

Article 21

Implementing STEM Pathway in Competence Based Curriculum: Lessons from STEM Model Schools Initiative was presented by Mungai Njoroge,.....	5
--	---

Article 22

Investigating the Impact of Continuous Professional Development Training on Mathematics and Science Teachers' content knowledge in Rwandan Lower Secondary Schools by Nkundabakura Pheneas ¹ , Nsengimana Theophile, Uwamariya Eugenie, Byukusenge Celine, Nzaramyimana Etienne	11
--	----

Article 23

Solving By Experimentation Some Problems Of Statistics, Analytic Geometry And Descriptive Geometry by Bibomba Tshiananga Nancy, Ngoyi Ngoyi Faustin.....	29
--	----

Article 24

Evaluation of the use of Information and Communication Technology and modernized tools in selected Rwandan secondary Schools by Nkundabakura Pheneas, Nsengimana Theophile Nsabayeze Ezechiel	37
---	----

Article 25

Professional Development of Teachers in Stem Education In Mozambique by Damasco Rocha
Mateus Chalenga, Emília Maria José Guiraguira ,Sarifa Abdul Magide Fagilde52

Article 26

What constitutes Science, Technology and Mathematics in Botswana Pre-Schools, and how does it
look like in the classroom by Chako G. Chako.....65

Article 27

Teachers’ Feedback Practices During Teaching and Learning of Mathematics by Caroline, C.M, Makato
and Fredrick, J.F Mtenzi71

Article 28

Teacher Perceptions of the Competence-Based Curriculum. A case study of
Sam Iga Memorial College, Uganda by Betty Rose, B.R.N, Nabifo.....79

Article 29

The Impact of Using GeoGebra Software in Teaching and Learning Reflection and Congruence on
high School Student’s Achievement by Mercy C. Misoi, Prof. Peter Kajoro90

Article 30

The Impact of Paper Activity in Teaching Circle Geometry (Circle Theorem) on SS1 Students’ Academic
Achievement among students of Government Senior Secondary School Rigachikun, Kaduna-Nigeria
by Yahaya Sani Rigachikun.....98

Article 31

Advancing Sustainable Solutions in Zambia: Assessment of Solar Energy Exhibitions at a National
Science Fair by Chipso Namakau Sakala, Benson Banda.....112

Article 32

Facilitating Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria by Joel Isaiah JUTUM and Jinadu Garvey YAWE.....134

Article 33

The Role of Teacher Professional Development in Advancing Gender-Inclusive Teaching Practices in STEM among Senior Secondary School Teachers' in Igabi Local Government Area, Kaduna state, Nigeria by Dr. Zainab Muhammad Shuaibu, Mrs. Fatima Abbas Jega.....155

Article 34

Hindsight, Insight, and Foresight from Third-Country Trainings: Contextualized Teacher Continuous Professional Development Strategies for Competency-Based Lesson Delivery in Uganda by Caroline Taliba, Dennis Zami Atibuni.....161

Article 35

An Investigation on The Extent of Utilization of Social Networking Sites in Crises Management of Public Secondary Schools in Nairobi County, Westlands Subcounty by Martin Mungai Ndung'u, Dr John Kitur, Prof Rosemary Mbogo.....180

EDITORIAL BOARD

Editor-in-Chief

Prof. Benson BANDA (Phd)

President, SMASE-Africa /

Director, National Science Centre (NSC), Lusaka, Zambia

Deputy Editor-In-Chief

Mrs. Jacinta L. AKATSA

Executive Secretary, SMASE-Africa /

Chief Executive Officer, CEMASTEAM, Nairobi-Kenya

Editors

1. Dr. Mary W. SICHANGI
2. Mr. Francis KAMAU
3. Mrs. Sera Njeri MBURU
4. Mr. Gregory NJOGU
5. Mr. Richard JAKOMANYO
6. Mr. Ben MWANGI
7. Ms. Charity KILONZI
8. Ms. Faith MUCHIRI
9. Ms. Jivian CHERONO
10. Mr. Elvis MENGECH

Paper Reviewers

- | | |
|---------------------------|---------------------------------|
| 1. Anecetus Moonga | National Science Centre, Zambia |
| 2. Alvin Masendeke | National Science Centre, Zambia |
| 3. Foster Mwanza | National Science Centre, Zambia |
| 4. Hussein Mwale | National Science Centre, Zambia |
| 5. Lameck Nyirongo | National Science Centre, Zambia |
| 6. Katuka Darius | National Science Centre, Zambia |
| 7. Mwango Mulenga Deborah | National Science Centre, Zambia |
| 8. Chipso Namakau Sakala | National Science Centre, Zambia |
| 9. Christine Kafulo | National Science Centre, Zambia |
| 10. Purity Sibote | National Science Centre, Zambia |

11. Martin Chanda	National Science Centre, Zambia
12. Kasakula Shitina	National Science Centre, Zambia
13. Patricia Malukutla	National Science Centre, Zambia
14. Yvonne Malama	National Science Centre, Zambia

SMASE-Africa Executive Committee Members

Prof. Benson BANDA (PhD)	President, SMASE-Africa / Director, National Science Centre (NSC), Lusaka, Zambia
Prof. Sarifa FAGILDE	Vice President, SMASE-Africa / Vice Chancellor, Universidade Rovuma, Nampula, Mozambique
Mrs. Jacinta L. AKATSA	Executive Secretary, SMASE-Africa / CEO, CEMASTEА, Nairobi, Kenya
Dr. Mary W. SICHANGI	Treasurer, SMASE-Africa / Head of Department, Partnerships and Linkages, CEMASTEА, Nairobi, Kenya

PREFACE

Welcome to the Fifth Edition of the Journal for Science, Technology, Engineering and Mathematics Education in Africa (JSTEMEA)

The first blended (physical & virtual) Conference for Mathematics, Science and Technology Education in Africa [COMSTEDA20] was held on 22nd -25th, November 2024 in Accra, Ghana. The theme of the conference was, *“Teacher Professional Development in Africa: Knowledge, Skills, Values & Attitudes in STEM Learning Environments”*. Teacher professional development in Science, Technology, Engineering and Mathematics (STEM) education is a critical area of discussion owing to its importance in equipping learners with 21st century skills. Research in this area widens the scope of understanding context of STEM education and deepens knowledge and skills that respond to the needs of African continent.

The international forum focused on four topical strands: (1) Teacher Professional Development in Africa towards developing knowledge, skills, and values in STEM learning and teaching engagements; (2) school culture and learning in STEM towards creating supportive learning environments; (3) STEM curriculum development, implementation and assessment; and (4) ICT integration in STEM education.

A total of forty-four papers were presented during the conference. The 5th edition of the journal will continue to further trigger research in STEM education from early learning to tertiary levels of education. The edition contains fourteen (14) research papers that were presented during the forum.

We thank the leadership of Uganda Institute of Information and Technology for hosting the conference in partnership with SMASE-Africa. Gratitude to the conference organizing committees with membership drawn from various stakeholders including country focal point persons for teamwork during planning and implementation of the conference.

Gratitude to all the SMASE-Africa partners for support in terms of material and human resources that immensely contributed to a rich event. To SMASE Africa delegates, participants, and paper

presenters, we are grateful that you chose to be part of this great milestone and for valuable inputs during the virtual conference.

We hope that COMSTEDA 20 was a wonderful learning experience and look forward to seeing more research papers in COMSTEDA 20 in Ghana.

COMSTEDA 20 Organizing Committee

ABOUT SMASE-AFRICA AND COMSTEDA FORUMS

SMASE-Africa Association: was established in the year 2001 during a regional conference with an aim of strengthening mathematics and science education in African countries. The Association grew in membership to include representatives from ministries of education, STEM-based organizations or stakeholders with interest in STEM education in African countries. The members share innovative ideas and practices that are relevant to respective countries through conferences, technical workshops and exchange visits. The regional secretariat located in Kenya is hosted in one of the premises of CEMASTEPA. SMASE-Africa is also an affiliate member of two clusters of the African Union's Continental Strategy for Africa namely; teacher development and STEM education.

Vision: "A leading organization in promoting quality STEM education in Africa"

Mission: "To promote quality STEM education through research, capacity development, advancing policies, good governance, collaboration and linkages in Africa."

COMSTEDA International Forums: SMASE-Africa designed an international forum known as the Conference on Mathematics, Science and Technology Education in Africa (COMSTEDA). It is a continental platform for sharing innovative ideas, best practice and interrogating issues relating to Science, Technology, Engineering & Mathematics (STEM) education. The annual conference hosted by member countries or STEM-based organizations aim at building synergy in strengthening capability of youth in STEM subjects for 21st century living. COMSTEDA forums bring together; policy makers, researchers, teachers, educators, NGOs working in education, public and private sector. In 2001 to 2013, the regional conference was known as SMASEWECSA which was later changed to COMSTEDA in 2014. COMSTEDA 14 was held in Nairobi, Kenya (2016); COMSTEDA 15 Livingstone-Zambia (2017); COMSTEDA 16 Maun-Botswana (2018) and COMSTEDA 17 Nairobi, Kenya (2019), virtual COMSTEDA 18 hosted by Mozambique (2021), blended COMSTEDA 19 hosted by Uganda (2022), and blended COMSTEDA 20 hosted by Ghana (2023).

The objectives of COMSTEDA 20 were:

1. To bring together educators, governments, academic and private sector institutions to interrogate issues, share ideas on best and promising practices and challenges relating to the teaching and learning Mathematics, Science and Technology Education in Africa

2. To improve quality of education in Africa through sharing impact and research findings on classroom practices to inform policy and practice
3. To present case studies and research findings in Mathematics, Science and Technology Education in Africa
4. To promote and highlight the role of STEM education in the development of Education in Africa

EDITORIAL

Article 20

Presented by *Christine Mvondo Pashi*. The paper titled: 'Analysis of girls' enrollment in science majors at ISP/GOMBE during the 2021-2022 and 2022- academic years' investigated that DRC has valuable women in science and they perform actions that are appreciated and admired by the community. In this study we want to ensure that the presence of these valuable women inspires young girls and pushes them to enroll in STEM options and that therefore in the near future the DRC will have a plethora of women in science who will distinguish in the different fields of mathematics, science, technology in the country. This study aims to prove that girls take the great women scientists of the DRC as role models by embracing STEM fields in their study registrations.

Article 21

Implementing STEM Pathway in Competence Based Curriculum: Lessons from STEM Model Schools Initiative was presented by *J. Mungai*. This study focused on Competence Based Curriculum reform in Kenya was initiated in 2017, with an emphasis on STEM education. CEMASTEAs mandate involves professional development of Science and Mathematics teachers, with the ultimate goal being strengthening of STEM Education. As the country gears to launch STEM pathway in 2016, a pertinent question is: How can Senior Schools support learners in STEM pathway? How can Senior Schools support learners in STEM pathway? This is a pertinent question to think and act on – given that the first cohort of students to enroll in STEM pathway are expected soon (in 2026?). This article makes an attempt at this; first by giving an overview of the STEM Pathway, as envisioned in the Basic Education Curriculum Framework. Secondly, outlining the STEM Model School initiative by the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA). Thirdly, by illuminating commendable practices implemented in STEM Model School and suggested areas of improvement based on the research titled Impact of CEMASTEAs Initiatives in Promoting STEM Education in Kenya conducted by CEMASTEAs during the Financial Year 2022/2023 Performance Contracting cycle. Suggestions shared can provide useful support to other countries in Africa focused on strengthening STEM Education.

Article 22

The paper titled 'Investigating the Impact of Continuous Professional Development Training on Mathematics and Science Teachers' content knowledge in Rwandan Lower Secondary Schools' was presented by *Nkundabakura Pheneas, Nsengimana Theophile, Uwamariya Eugenie, Byukusenge Celine, Nzaramyimana Etiennea*. The study revealed that a Teachers' competency and aptitude in the field of education are vital for influencing students' academic achievement and providing a helpful learning environment. Particularly, Teachers' level of content understanding has a substantial impact on students' learning of Mathematics and Science. In this vein, the Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) sub-component 1.2 provided various types of training to Rwandan teachers in lower secondary schools through a Continuous Professional Development for innovative teaching methods in Mathematics and Science (CPD-ITMS) program. The training focused on selected topics that were identified to be challenging to teachers during the pilot phase of the project. Therefore, the aim of this study was to investigate the impact of these CPD training on the teachers' content and pedagogical knowledge in mathematics and science. The study involved 569 teachers namely 178 females and 391 males from seven districts of Rwanda. The pre-and post-tests were used to collect quantitative data on teachers' performance and conceptual understanding in mathematics and science subjects. The results showed that the CPD training impacted the teachers' conceptual knowledge with learning gain of 32% in mathematics, 38% in Physics, 33% in Biology and 38% in chemistry. The overall results highlighted that teachers' performance improved significantly following the intervention, indicating that the training effectively corrected teachers' misconceptions and difficulties in the subject matters. More CPD training are therefore recommended in order to continuously improve teachers' effectiveness and possibly to expand the training to all secondary school teachers nationwide.

Article 23

Presented by *Bibomba Tshiananga Nancy, Ngoyi Ngoyi Faustin* the paper titled: "Innovative Pedagogical Strategies in STEM Education: Effect of code-switching instructional strategy on the academic achievement and retention of students in basic science in Bauchi Metropolis, Bauchi State Nigeria". The study investigated the effect of the averages of statistics series are determined by calculation. The coordinates of the gravity centers and those of the inscribed circles of triangles in the plane, in the space and in descriptive Geometry are found either by calculation

or by construction. We are going to show in this paper how to determine by experimentation, as in a laboratory of Physics, the averages of statistics series, the coordinates of the gravity centers and those of the centers of the inscribed circles of triangles in the plane, in the space and in Descriptive Geometry.

Article 24

The paper titled, Evaluation of the Use of Information and Communication Technology and Modernized Tools in Selected Rwandan Secondary Schools was presented by *Nkundabakura Pheneas, Nsengimana Theophile, Nsabayezu Ezechiel*. The focus was on the The Rwanda Quality Basic education for Human Capital Development (RQBEHCD) Project, sub-component 1.2, funded by the World Bank Group, aims to strengthen science and mathematics instruction in upper primary through secondary schools. The purpose of this study is to evaluate the use of ICT tools and modernized resources by mathematics and science teachers upper primary through lower secondary schools in Rwandan. The study comprised 959 teachers selected purposively from 10 districts in Rwanda, with 300 from upper primary and 659 from lower secondary as participants of the study. Quantitative data was obtained using a classroom observation tool, and data was analyzed using MS Excel and SPSS. The analysis of the results from the study showed that secondary school teachers use the provided ICT tools at a rate of 65.5%, while it is 63% for primary school teachers. It was also found that secondary school teachers use resources provided by Rwanda Quality Education for Human Capital Development (RQBEHCD) at a rate of 65.5%, while primary school teachers use them at a rate of 63.00%. Furthermore, it was revealed that both upper primary and lower secondary mathematics and science teachers use ICT and modernized tools at 77.89% and 80.51%, respectively. However, there is no significant difference between upper primary and lower secondary schools in terms of using ICT and modernized tools ($F=1.067$, $df=957$, $p>.50$). Authors recommend policymakers to support the use of ICT tools and modernized tools to improve the teaching and learning of Mathematics and sciences in Rwanda.

Article 25

The paper on ‘Professional Development of Teachers in Stem Education in Mozambique’ by *Damasco Rocha Mateus Chalenga, Emília Maria José Guiraguira, Sarifa Abdul Magide Fagilde* observed in the past decades, reform initiatives have been taking place in education, aiming to integrate STEM (Science, Technology, Engineering and Mathematics) approaches in the classrooms, which obviously have implications for teaching practices. The integration of the STEM approach in Mozambique appears implicitly in curriculum plans, but is not accompanied by teacher professional development training programs. This paper presents how teachers, considered as key elements for implementing any pedagogical proposal, are implementing this approach in Basic Education, in grades 7-9, in the cities of Lichinga and Nampula, in Mozambique. The study used a qualitative approach of an interpretative nature. Based on data collected from interviews and questionnaires with teachers, it was possible to realize, that teachers are not prepared to implement the integrated STEM approach and they teach the content of each subject as an independent one. In the face of the current situation, it is suggested that teacher training be promoted in STEM areas, so that they acquire specialized knowledge, with a view to transforming their practices and visions in the classroom context. This training should be designed including better teaching practices and real-life scenarios as a way of motivating students to seek solutions to society's problems.

Article 26

The paper titled, ‘What constitutes Science, Technology and Mathematics in Botswana Pre-Schools, and how does it look like in the classroom’ was presented by *Chako G. Chako*. This study explored Pre-School Science, Technology, Engineering and Mathematics (STEM) in Botswana. Recently, Botswana’s education system recognized and incorporated Pre-School education into her basic education system. Since 1996, Pre-School education was offered by private schools to those who could afford costs. The Botswana government did not consider Pre-School education a necessary requirement for entrance into public primary education. A major hindrance was lack of resources such as trained personnel and availability of resources. However, evidence from research has since influenced education policy makers in Botswana to consider Pre-School essential and foundational to further learning at primary school level. In Botswana’s basic education system in (which year?). It is believed that provision of free Pre-School education to all Botswana children in public schools will provide access to quality and equitable education. The

incorporation was also seen as a strategy to transform Botswana's economy from mineral based to knowledge-based. While we do know a lot from international research focused on Pre-School education, in Botswana, our research in this phenomenon is emergent. Hence, the need to conduct this study. In particular, the study will focus on what and how STEM subjects. Pre-school curriculum in Botswana has been designed to introduce learners to STEM early in their schooling. The rationale lies in the view that STEM subjects are critical in a knowledge based economy. The aim of the on going study is to explore what constitutes STEM by studying how it is Intended (planned by the teacher) Enacted (taught in the classroom), and Lived (learnt by learners in the class) (Runneson, 2005) and seeks to gain insight into what constitutes Science, Technology, Engineering and Mathematics (STEM) in tasks that learners are given, and how concepts are made accessible to Pre-school learners. The research question of interest for this study is stated as: What is the nature Pre-school teachers' explanations of Science, Technology, Engineering and Mathematics (STEM) concepts embedded in tasks given to learners. Casting some light into what and how pre-school Science, Technology, Engineering and Mathematics (STEM) tasks are enacted is critical for policy and Pre-school teacher professional development. The sociocultural perspective framed the research. Adler and Rhonda's (2014) notion of exemplification and explanatory communication are used to analyze tasks given to learners and teachers' explanations respectively. Participants in the study includes one pre-school teachers and their pre-school learners from one school in Gaborone. The school was purposefully selected based on its performance in Botswana's 2019 national examinations. Specifically, the study is interested on teachers' explanations of Science, Technology, Engineering and Mathematics (STEM) concepts embedded in Pre-school Science, Technology, Engineering and Mathematics (STEM) tasks. The interest on explanations was informed by the view that suggests that, the Science, Technology, Engineering and Mathematics (STEM) learners get to learn, resides in teachers' explanations.

Article 27

Teachers' Feedback Practices during Teaching and Learning of Mathematics was presented by *Caroline, C.M, Makato and IFredrick, J.F Mtenzi*. The study reported that although effective feedback can foster class interactions and stimulate mathematical thinking, it may be underutilized. Studies on the same are also rare in the Kenyan context. This gap informed the study. This qualitative case study explored teachers' feedback during the teaching and learning of mathematics in a secondary school in Kenya. The

paper establishes the characteristic features of mathematics teachers' feedback. Three form two mathematics teachers and 150 form two students were purposely chosen for the study. Informed consent through the principal and further assent from the learners was sought before conducting the study. 18 students from the participated in focus group discussions (FGDs). Other methods included; Teacher interviews, class observations, and document analysis. Findings revealed that the documents analysed were silent on teachers' feedback. Teachers' interviews, FGDs, and observations portrayed feedback as mainly oral and evaluative. In addition, interviews revealed all learner engagement in questioning, in contrast to FGDs and observations. Girls' FGDs showed a liking for telling feedback and a dislike for peer discussions. FGDs further revealed feedback at times was: generalized, embarrassing, delayed, and denied. The teachers' feedback practices demonstrate an overlook of planning, alarm to inclusion and equity and the acquisition of critical thinking skills. The study recommended exposure of teachers to effective feedback strategies during in-service and pre-service training.

Article 28

The paper entitled, 'Teacher Perceptions of the Competence-Based Curriculum. A case study of Sam Iga Memorial College, Uganda' was presented by *Betty Rose, B.R.N, Nabifo*. The paper seeks to discuss the impacts of the 1989 Education Policy Review Commission chaired by Professor Senteza Kajubi highlighted the concerns of a number stake holders in reference to the irrelevance of the country's (Uganda) education system and its failure to meet the needs of the society as quoted below; "Education is failing, among other things, to promote a sense of national unity, self-reliance, social justice and equity, and to impart scientific and technological knowledge, cultural values, literacy and a sense of social responsibility to a degree that society would like to. There has been too much academic learning, passing examinations and paper work per se to the neglect of knowledge, skills and values to solve real life problems. The result has been that the system has fallen far too short of turning out the right number and type of manpower needed for optimum development"

Article 29

The Impact of Using GeoGebra Software in Teaching and Learning Reflection and Congruence on high School Student's Achievement was presented by *Mercy C. Misoj, Prof. Peter Kajoro*. The paper explored Information and Communication Technology (ICT) era has fuelled the desire for educational reform based on its use in schools. This study explored the use of GeoGebra software

in teaching and learning Reflection and Congruence topics, in one public secondary school in Mwatate Sub-County in Kenya. The main study objective was to assess the effects of GeoGebra on learners' achievements. This was a classroom action research study that utilized a mixed-method approach for data collection through interviews with learners, document analysis through test items, and classroom observation. Purposive sampling was used to obtain 55 participants in a form two class. The research process involved reconnaissance, the intervention, and the post-intervention phases. In the reconnaissance phase, entry interviews were conducted, and a pre-test was given to assess the learners' entry behaviour on the topic of reflection and congruence, whereas, the intervention phase involved the use of the GeoGebra instructional software as a pedagogical tool and eventually evaluate the intervention strategies using a similar post-test. The results from the descriptive and inferential statistics revealed that the post-test had higher scores than the pre-test, most probably attributed to the technology intervention. In addition, the post-intervention interview to capture the learner's experiences in the use of the GeoGebra software demonstrated that its application captured learners' attention, promoted experimentation, discovery, and visualization in geometry learning, as well as brought excitement and increased engagement. Based on these findings, therefore, the researchers recommend that teachers should embrace GeoGebra or other related ICT tools to enhance students' achievement.

Article 30

The Paper entitled 'The Impact of Paper Activity in Teaching Circle Geometry (Circle Theorem) on SS1 Students' Academic Achievement among students of Government Senior Secondary School Rigachikun, Kaduna-Nigeria' was presented by *Yahaya Sani Rigachikun*. The paper examined the role of innovation in teaching and learning mathematics cannot be over-emphasized. Continuous efforts should then be made by teachers to explore more innovative strategies and investigate their effectiveness and efficiency to enhance the teaching and learning of mathematics. This study investigated the impact of paper activity on students' academic achievement in circle geometry. Quasi-experimental research design was used. Two research questions were raised and two null hypotheses were formulated and tested at 0.05 level of significance. The academic achievements of students taught using paper activity (experimental group) was compared with students taught using conventional method (control group). Mathematics Achievement Test (MAT) was developed by the researcher and validated by two experts in measurement and evaluation. The population of the study was SS1 science students (90 students) of Government Senior Secondary School

Rigachikun, Kaduna-Nigeria. SS1 A1 (45 students) was selected as experimental group while SS1 A2 (45 students) as control group using simple random sampling techniques. The instruments used for data collection was pre and post-test on circle theorems. Mean and standard deviation were used to answer the research questions while the null hypotheses were tested at 0.05 level of significance using independent t-test. The result of the study showed a significant differences in academic achievement in favor of the experimental group. The researcher recommends the use of paper activities in teaching and learning circle geometry and generally geometry for effective teaching and learning outcomes.

Article 31

Chipo Namakau Sakala, Benson Banda (PhD) presented a paper based on 'Advancing Sustainable Solutions in Zambia: Assessment of Solar Energy Exhibitions at a National Science Fair'. This research focused on understanding the types of solar energy exhibitions within the context of a National Science Fair. It analysed the diversity and scope of the exhibitions. The study adopted a descriptive cross-sectional design with qualitative and quantitative aspects. It investigated exhibitions at an annually held National Junior Engineers Technicians and Scientists (JETS) Fair made by participants from all the 10 provinces of Zambia. These included 10 Early Childhood Education (ECE) and primary learners, 11 junior secondary learners, 11 senior secondary learners, 8 out-of-school individuals, and 5 teachers. The research findings revealed a diverse focus on different aspects of solar energy. Furthermore, the research identified that the exhibitions were predominantly at the concept development stage. Furthermore, the research revealed that the exhibitors demonstrated gaps in STEM (Science, Technology, Engineering, and Mathematics) abilities. The implications of this research extend to enhancing the understanding of the multifaceted nature of solar energy and its potential to contribute to sustainable learning in physics education. These findings are valuable for educators, policymakers, and researchers aiming to promote STEM education and sustainable solutions. The innovative products showcased at these exhibitions hold promise as potential nuclei for addressing Zambia's pressing energy needs. In conclusion, this research analysed solar energy exhibitions at an annual National Science Fair, providing insights into the diversity of their focus and their potential in promoting sustainability and STEM education. Continued development and support for these exhibitions is recommended to maximise their educational impact and contribute to the advancement of solar energy solutions in Zambia.

Article 32

The paper on 'Facilitating Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria' was presented by *Joel Isaiah Jutum and Jinadu Garvey Yawe*. This study examined the Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria. Three specific objectives with corresponding research questions and two hypotheses guided the study. The study adopted a quasi-experimental research design of non-equivalent research design of non-equivalent group. Intact classes were assigned to both the experimental group (Integrated Inquiry-Based Teachers Practice Instructional Strategy) and control group (guided Inquiry Instructional Strategy) using multi stage sampling technique. The population for the study was 1,141 basic education students. The sample for this study is 292 Basic Education students comprising of 139 boys and 153 girls from six public secondary schools. Data for this study was generated using the instrument named Basic science Performance Test (BSPT), Kuder-Richardson (K-R20) formula was used to estimate the reliability index of 0.85 for the BSPT. Mean and standard deviation were used to answer all research questions. While, Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. Based on the data collected and analyzed, there was significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based Science Teaching Strategy and those taught using guided inquiry instructional strategy, The study therefore, recommended among others that basic science teachers should be encourage to use Integrated Inquiry-based Science Teaching Strategy. In conclusion, it is evident from the finding of this study that the use of integrated inquiry-based science teachers practice could provide a good way for Basic Education students to learn Basic Science; since the strategy enhanced students' academic performance in Basic science.

Article 33

The paper on 'The Role of Teacher Professional Development in Advancing Gender-Inclusive Teaching Practices in STEM among Senior Secondary School Teachers' in Igabi Local Government Area, Kaduna state, Nigeria' presented by *Dr. Zainab Muhammad Shuaibu, Fatima Abbas Jega*. The paper reported that in recent years, addressing the gender disparity in Science, Technology, Engineering, and Mathematics (STEM) fields has gained global prominence. This quasi-experimental study, conducted in Kaduna State's Igabi Local Government

Area, Nigeria, explores the transformative potential of teacher professional development in promoting gender-inclusive teaching practices within STEM education. The investigation sought to determine whether a structured professional development programme for STEM educators could effectively reshape their teaching approaches, ultimately nurturing enhanced gender equity and inclusivity in the classroom. The study adopted a pre-test and post-test control group design, enlisting a sample of 120 STEM teachers drawn from select secondary schools in Igabi. These educators were divided into two cohorts: the experimental group, benefitting from a gender-inclusive professional development programme, and the control group, receiving no specific intervention. Data collection encompassed surveys, classroom observations, and student performance evaluations. Data analysis employed descriptive statistics, independent sample t-tests, and qualitative content analysis. The findings unveiled a noteworthy transformation in the pedagogical practices of STEM teachers who participated in the professional development programme. Teachers in the experimental group exhibited a heightened commitment to employing inclusive strategies, adapting curriculum materials, and nurturing a supportive learning atmosphere for all students, regardless of gender. Furthermore, students taught by educators in the experimental group demonstrated increased engagement and achieved better academic performance in STEM subjects. The study's implications are far-reaching, suggesting that targeted professional development programmes can serve as catalysts for narrowing the gender gap in STEM fields and fostering a more equitable and inclusive learning environment for all students.

Article 34

The presentation by *Caroline Taliba and Dennis Zami Atibuni (PhD)* titled 'Hindsight, Insight, and Foresight from Third-Country Trainings: Contextualized Teacher Continuous Professional Development Strategies for Competency-Based Lesson Delivery in Uganda'. This study examined that in Uganda, one of the in-service pedagogical initiatives undertaken to provide contextualized strategies for enhancing pedagogical paradigm shift from teacher-centred to learner-centred approaches of teaching and learning STEM is the third country training programme (TCTP). The initiative fits seamlessly into the change from the knowledge- to

competency-based lower secondary curriculum advocated by the Government of Uganda. During the trainings a select group of science and mathematics teachers and 'other' stakeholders are offered training trips to other countries deemed to be well grounded and advanced in STEM education. A number of participants benefited from these trainings. In this paper, we argue that if these trainings were efficacious, then the beneficiaries should be able to recount teacher continuous professional development (CPD) lesson strategies encountered during the trainings that can be used to generate contextualised strategies to enhance the delivery of competency-based education as currently required at the lower secondary education in Uganda. Employing a concurrent mixed methods study design, we used a semi-structured questionnaire to gather quantitative and qualitative data from a

Article 35

Martin Mungai Ndung'u, Dr John Kitur, Prof Rosemary Mbogo conducted a study on An Investigation on The Extent of Utilization of Social Networking Sites in Crises Management of Public Secondary Schools in Nairobi County, Westlands Subcounty. This study investigated the role of Social Networking Sites (SNS) in communication during crises in public secondary educational institutions within Westlands Sub County – Nairobi County. There has been increased usage of communication tools such as the Social Networking Sites (SNS), that is, virtual communities where users create profiles to interact with people on shared interests. Every organization encounter crises at some point or another, and public schools are no exception. In those situations, SNS have been used to either propagate or diminish?? crisis. The objectives of the study were to: investigate the extent of utilization of SNS by public schools, determine the kind of information shared through SNS by public schools and to find out how management the use of SNS during a crisis. The research was done using a mixed method approach, incorporating qualitative and quantitative data. Data was collected from principals, teachers, parents, union and MOE officials within the Nairobi County, Westlands Sub-County, using questionnaires and interviews. Data was presented descriptively analyzed and reported through percentages, figures and tables. The results showed that 78% of the respondents identified SNS as communication platforms used in crisis management in public secondary schools in Westlands. The results depicted high usage of platforms such as WhatsApp and Facebook. In addition, 71% of parents preferred venting their grievances on SNS before addressing them with the school; however, they were reluctant to communicate directly with the administration on the same platforms. About (15%) administrators used the SNS

platforms for communication during a crisis. The study findings will be useful to managers of public schools and other stakeholder of education in Kenya on how SNS can be managed and used for effective communication during crises.

Article 20

Analysis of girls' enrollment in science majors at ISP/GOMBE during the 2021-2022 and 2022- academic years

Christine Mvondo Pashi

ISP-Gombe, Research center

christine.mvondo39@gmail.com

Abstract

The DRC has valuable women in science and they perform actions that are appreciated and admired by the community. In this study we want to ensure that the presence of these valuable women inspires young girls and pushes them to enroll in STEM options and that therefore in the near future the DRC will have a plethora of women in science who will distinguish in the different fields of mathematics, science, technology in the country. This study aims to prove that girls take the great women scientists of the DRC as role models by embracing STEM fields in their study registrations.

Introduction

Let us remember that for a long time, the field of science was considered as belonging to men. But with the progress of society and the presence of several remarkable women in this sector, things have evolved a lot. We are meeting more and more girls in STEM sections (Science , Technology, Engineering , Mathematics.) It is therefore proven that women are capable of working in fields formerly reserved for men. We find women in all fields formerly reserved for men.

STEM (Science, Technology, Engineering and Mathematics) options ; 40% of researchers are not African, and therefore their governments entrust STEM service to expatriates. Africa contributes less than 1% to global search results.

In the DRC, the research budget is less than 1% of GDP. It essentially covers the payroll. Based on this unfortunate observation, Sultani Makutano⁵ and the non-profit organization Investing in People initiated scholarships for women in STEM. These relate

to the financing of studies (bachelor's and master's) in STEM; participation in international STEM conferences and symposia and funding of a STEM-related research topic.

Actualités.cd of October 5, 2021, interviewed young Congolese girls, wanting to understand why they do not enroll in mathematics. The synthesis of their survey gave three sets of responses. Firstly, the girls say that you have to be strong in mathematics and scientific drawing and have the ability to think a lot. When you know that you don't have these skills, why complicate your life. others responded that STEM options have too many hands-on hours. Finally, they said that STEM options do not lead to a specific profession. Progress has certainly been made, we want to prove it through the registrations of girls over the last two years at the ISP de la Gombe, our higher institution.

Objectives of the study

The objective of this study is twofold, firstly, to ensure that girls are indeed enrolled in science options. Options which are considered a key element of development in Africa and particularly in the DRC; secondly, to show how society, that is to say the authorities, contribute to giving young girls the desire to embrace STEM fields in their choice of studies.

Methodology of work

To carry out our study we used the documentary technique: reading articles, magazines and other documents allowed us to discover information about these women; We have compiled the list of student registrations to find out the number of girls who have registered, particularly for the science options.

Delimitation of work

We have taken, given the time, only one higher institute, namely the Institute Supérieur de la Gombe in Kinshasa, acronym ISP/Gombe. And we limited ourselves to registrations from the last two years 20201-2022 and 2022-2023.

ISP/Gombe is an institution of higher and university education. It is a mixed institution which aims to train future secondary school teachers.

It includes several options; Hospitality and tourism, Hospitality, commercial and administrative sciences, Geography and environmental management, French, History, English and African culture, Educational and professional guidance, Biology, Math-info, Computer science etc. Classes are held day and evening.

We chose to analyze the registrations of girls for the exact sciences options (chemistry, biology, mathematics, computer science.)

The last two academic years enrolled a total of 3765 girls.

Of this total, we have 906 girls registered in science courses, or 24% of registrations. We have distinguished between sciences (chemistry, biology, mathematics) and computer science.

Of the 906 girls enrolled in science, there are 425 girls in exact sciences and 481 in computer science.

The most popular science section is computer science. For some time now, when applying for a job, one of the requirements is mastery of computer tools, which is why computer science dominates over the exact sciences. Let's remember the girls' responses to the Actu.cd (nouvelles.cd) interview asking why girls don't want to do science: " STEM options don't lead to a specific profession, if you study, it's to contribute to the development of the country, but it is also to be well through a decent job. »

The unemployment rate which dominates among academics is pushing more and more young people to opt for practical sections, that is to say those which quickly lead to gainful employment.

From my point of view, the exact sciences encourage research and teaching, which are areas that do not pay in our country. Furthermore, I find that awareness is not raised enough among girls to encourage them to choose and enroll in STEM options. Leaders of the women in STEM association must establish an awareness program accompanied by their concrete achievements to motivate girls. Likewise, when it organizes Science and Technology Week, it must ensure that the information reaches as many girls' schools as possible. the initiative of the president of women in STEM, Professor Raïssa MALU launched with the aim of bringing together women in Science, Technology, Engineering and Mathematics (STEM or STIM in French) from the DRC into a network in order to deconstruct stereotypes on women and science, to facilitate the sharing of information and opportunities, and to promote mentoring and positive representation is highly commendable and deserves to be supported and maintained by other structures. The support of school leaders is a major asset that must be relied on to hope to attract more people. If prejudices are in decline regarding the choices of

girls' fields of study and activities, there is still a lot to be done, notably the complex of the girl herself when she says: " you have to be strong in mathematics and scientific drawing and having the ability to think a lot. When you know that you don't have these skills, why complicate your life. Others responded that STEM options have too many hands-on hours. »

Conclusion

Women have an important role to play in the development of the country. They therefore need to study, train and get hired in the STEM field. Institutes must push STEM girls into creative experiences, give them models of women who have succeeded with these concrete achievements, sources of inspiration, they will feel revalued and will no longer consider the STEM field as unprofitable (Karen Verstappen .)

Reference

- SIKULISIMWA Céline, (2019), "Feminine Genius", in *Magazine Quarterly for Women*, n°4 January, Filles de Saint Paul RDC-CI
- SIKULISIMWA Céline, (2022), "Female Genius", in *Magazine Quarterly for Women*, Special Issue Women in STEM, Filles de Saint Paul RDC-CI
- KABEMBA ASSANI, François, (2021), *The African woman, a plural perspective: from identity to equality*, Kinshasa, CRESEDIP,
- KESTELOOT, Lilyan, (1992), *Negro-African anthology, History and texts, from 918 to the present day*, New revised and expanded edition, EDICEF.
- LOGOS-RDC, February 2014, n°4 MAGAZINE Culture and Education Tribute to the women of the DRC
- TSHIBILONDA NGOYI, A, (2016), *Issues in women's education in Africa, case of Congolese women in Kasai, Kinshasa*, L'Harmattan, www.globalpartnership.org, www.nouvelles.cd, www.unesdoc.unesco.org, www.lesechos.fr, www.amicalepontins.blog4ever.com

Article 21

Implementing STEM Pathway in Competence Based Curriculum: Lessons from STEM Model Schools Initiative

Mungai Njoroge

jmungai@cemastea.ac.ke

Abstract

The Competence Based Curriculum reform in Kenya was initiated in 2017, with an emphasis on STEM education. CEMASTEAs mandate involves professional development of Science and Mathematics teachers, with the ultimate goal being strengthening of STEM Education. As the country gears to launch STEM pathway in 2016, a pertinent question is: How can Senior Schools support learners in STEM pathway? How can Senior Schools support learners in STEM pathway? This is a pertinent question to think and act on – given that the first cohort of students to enroll in STEM pathway are expected soon (in 2026?). This article makes an attempt at this; first by giving an overview of the STEM Pathway, as envisioned in the Basic Education Curriculum Framework. Secondly, outlining the STEM Model School initiative by the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEAs). Thirdly, by illuminating commendable practices implemented in STEM Model School and suggested areas of improvement based on the research titled *Impact of CEMASTEAs Initiatives in Promoting STEM Education in Kenya* conducted by CEMASTEAs during the Financial Year 2022/2023 Performance Contracting cycle. Suggestions shared can provide useful support to other countries in Africa focused on strengthening STEM Education.

Keywords: Competence Based Curriculum, Education for Sustainable Development, learner-centred, pedagogical leadership, STEM pathway, STEM model school

Implementing STEM Pathway in Competence Based Curriculum: Lessons from STEM Model Schools Initiative

The Competence Based Curriculum (CBC) reform in Kenya was initiated in 2017 (KICD, 2017). The implementation involved a transition of the Basic Education from an 8-4-4 system of education (8 years primary, 4 years secondary, and 4 years tertiary) to a 2-6-6-3 system of education consisting of age based levels (2 years pre-primary, 6 years primary, 6 years secondary, and 3 years tertiary) and staged based levels for special needs education (foundation, intermediate, pre-vocational, and vocational) (KICD, 2017). Emphasis on STEM education is characterized by having a STEM pathway in Senior School.

Unpacking the STEM Pathway

The Kenya Institute of Curriculum Development (KICD, 2017) details in the Basic Education Curriculum Framework (BECF) two levels of secondary education in the Competence Based Curriculum (CBC), namely, lower secondary (Grades 7, 8 and 9) and senior school (Grades 10, 11 and 12). The BECF outlines that while the Lower Secondary (Junior School) is expected to “expose the learner to a broad-based curriculum to enable them to explore their own abilities”, the purpose of the Senior School is to “lay foundation for further education and training at the tertiary level and the world of work”.

The specialization in Senior School will involve the learner making a choice to pursue studies in one of the three pathways: the Arts and Sports Science; Social Sciences; or Science Technical Engineering and Mathematics (STEM) pathway. The STEM pathway is intended to boost the science, technology and innovation (ST&I), which is a key enabler to the attainment of Vision 2030. How then can Secondary Schools support learners in STEM pathway?

Establishment of STEM Model Schools

Implementation of CEMASTEAs core mandate (Research and Training) includes deliberate interventions aimed at advancing STEM Education in Kenya. Towards this end, CEMASTEAs through the support of the Ministry of Education has initiated support to 103 schools (referred to as STEM Model Schools) that are spread across all the 47 counties. The intervention to STEM Model schools includes provision of STEM infrastructure, professional development of subject teachers and pedagogical leaders, and providing learner with innovation opportunities.

The infrastructural support involves providing sample of basic ICT facilities (lap tops and projectors), models for learning mathematics, laboratory equipment and

chemicals for sciences. Professional development of teachers focuses on learner-centred pedagogical approaches, such as Inquiry-Based Learning (IBL) through the 5E model (*engage, explore, explain, extension and evaluate*), ICT integration to support learning, career guidance and learner safety, and Education for Sustainable Development (ESD). Support for school administrators (Principals and Heads of Departments) focuses on pedagogical leadership to enhance their mentoring, effective resource mobilization and efficient utilization, and supervision of effective curriculum implementation.

Learner support in advancing STEM education has included expanding opportunities to engage in innovative activities through makerspace (i.e., mirror incubation centres models in schools), boot camps, Science and Mathematics contests, and Kenya Science and Engineering Fair (KSEF) – particularly, robotic competition category.

Lessons from STEM Model Schools

CEMASTEА conducted research in 28 sampled STEM Model schools. The research purpose was to monitor implementation of effective classroom practices by teachers, establish learner's uptake of STEM subjects, and assess provision of innovative opportunities provided to learners. This was intended to help CEMASTEА and relevant stakeholders determine best practices for up scaling and the necessary interventions required to advance further the STEM education agenda in Kenya. The following is a snippet of the commendable practices identified in the sampled schools and suggested areas of improvements, which is a pertinent contribution in preparation for STEM pathway.

Commendable practices

Development of learners' entrepreneurial and industrial skills through Education for Sustainable Development activities and projects. Sample of the completed projects with evidence of learner involvement included solar energy installations, bio digester, sinking of boreholes, purifying and bottling water, bakery and soap making. Students were involved in agricultural activities, such crop and animal, those were used to substitute diet as well as selling to staff and the community. Schools supported learners in environmental management and conservation programs. This was evident in the well-maintained flower gardens and trees within the school compound which, as reported, were maintained by the learners. Other projects in which learners were involved include prevention of soil erosion, and recycling and reusing non-

biodegradable materials. The bio-degradable waste products were used to make compost manure for farming. Learners generated income for their schools and clubs through sales. These enhanced learners' environmental conservation skills.

Career guidance programs and non-discriminative subject choice policy. Some schools made deliberate efforts to encourage learners to study the three sciences (Physics, Chemistry & Biology). Analysis of self-reports by teachers in-charge of career guidance in selected STEM model schools indicate an increase in learners' enrolment in STEM subjects in the period 2017 to 2021. The findings show that the number of male learners who enrolled in the three sciences increased steadily from 49.68% to 54.64%, while that of female learners increased from 34.31% to 36.89%. further, 71.4% of learners who participated in the focus group discussion had dreams and aspirations to pursue STEM related careers. Of these, 97.8% of the learners were well informed of the requirements of their dream career choices in STEM.

Promoting innovations and improvisation in learning of concepts in the respective STEM subjects. In some of the schools, the learners participated in sourcing and development of learning resources. For instance, in one of the STEM model schools, learners heated waste plastic materials, and used the molten plastic to form carbon and hydrogen models used in teaching and learning of hydrocarbons in Chemistry. In addition, learners made models for teaching and learning mathematics. Principals in some of the sampled schools reported that the teachers were using the ESD projects to support learning of concepts in Biology, Chemistry and Agriculture. Further, the Principals observed that engagement of students in the ESD projects and their application in lessons enhanced students' motivation to learn and discipline.

Areas of improvement and support

Actualizing learner – centred pedagogical approaches. In general, the research findings indicated nuances of learner – centred pedagogical approaches in the lessons observed. However, this was not to a satisfactory level given the expected role that active engagement of learner plays in facilitating learning of concepts in STEM. Table 1 is an excerpt from findings indicating the percentage rating on key aspects of learner involvement in the lessons observed across forms (1, 2, 3,4) and subjects (Mathematics, Biology, Physics, Chemistry). The higher percentage ratings on the "Not evident" column suggest that most teachers require further support to actualize active engagement of learners during lessons in STEM.

Table 1

Percentage rating on evidence of learner involvement during lesson

Key aspects of learner involvement	Evident	Not evident
There is evidence of application of concepts to real world problems (Learner was able to connect concepts to real life situations)	34.8%	65.2%
There is evidence of learners applying the engineering design process to solve a problem (Learner: Imagines/ Plans/ Create-makes Tests- experiments/ Improves Shares/presents)	27.3%	72.7%
Evidence of interdisciplinary approach (Learner is able to use concepts from other disciplines to solve problems /Teacher is able to use concepts from other disciplines to support the learning)	39.1%	60.9%
There was evidence of tasks that allowed learners in coming up with multiple solution (The teacher presented open ended questions and tasks/ Quality of KIQ /Variety of learner response)	36.4%	63.6%

The ratings on the first and second aspects in table 1 suggest that teachers need support on how to help learners connect concepts to real life situations and applying engineering design process to solve a problem. One way to achieve this is emphasis on teachers providing experiential learning opportunities to learners through ESD projects. Some schools had a challenge waste management, which mirrors pollution problem in the society. For example, on the case of organic waste management generated from food left-overs in the kitchen, learners can engage in ESD projects, such as rearing of pig and poultry and vegetable farming. This would promote a cleaner environment as well as food security. Learners should be supported to design, construct, and regular repairs of the pigsty and chicken coops.

The third aspect in the table suggests that teachers need support on implementation of interdisciplinary approach in STEM Education. Concepts were taught in isolation, even where possible connections were possible. For example, in a mathematics lesson that involved the construction of the regular polygon in Geometry, the teacher was advised to help learners relate the concept to survey in Geography. The fourth aspect on the table

is on the aspect providing learner's opportunity to assume an inquiry position. Teachers need to recognize the learner as a co-inquirer and to adapt inclusive instructional practices that provide all learners with opportunities for active participation in the learning process. Teachers can become better in this by engaging in professional development activities, such as Action Research and Lesson Study, through communities of practice at the school level.

Take away! As a stakeholder in the implementation of STEM Education in Africa, what additional suggestions can you think of towards supporting the implementation of the STEM Pathway in Senior School? Please share your thoughts with the author, of this article, Dr. Mungai Njoroge, via jmungai@cemastea.ac.ke

References

Kenya Institute of Curriculum Development [KICD]. (2017). *Basic Education Curriculum Framework* [Unpublished manuscript].
<https://kicd.ac.ke/wp-content/uploads/2017/10/Curriculumframework.pdf>

Article 22

Investigating the Impact of Continuous Professional Development Training
on Mathematics and Science Teachers' content knowledge in Rwandan
Lower Secondary Schools

Nkundabakura Pheneas, Nsengimana Theophile, Jwamariya Eugenie

Byukusenge Celine, Nzaramyimana Etienne

nkundapheneas@yahoo.fr, nsengimanafr@gmail.com, euwamariya@reb.rw,
celinebyukusenge@gmail.com, etiennebunny10@gmail.com

Abstract

Teachers' competency and aptitude in the field of education are vital for influencing students' academic achievement and providing a helpful learning environment. Particularly, Teachers' level of content understanding has a substantial impact on students' learning of Mathematics and Science. In this vein, the Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) sub-component 1.2 provided various types of training to Rwandan teachers in lower secondary schools through a Continuous Professional Development for innovative teaching methods in Mathematics and Science (CPD-ITMS) program. The training focused on selected topics that were identified to be challenging to teachers during the pilot phase of the project. Therefore, the aim of this study was to investigate the impact of these CPD training on the teachers' content and pedagogical knowledge in mathematics and science. The study involved 569 teachers namely 178 females and 391 males from seven districts of Rwanda. The pre-and post-tests were used to collect quantitative data on teachers' performance and conceptual understanding in mathematics and science subjects. The results showed that the CPD training impacted the teachers' conceptual knowledge with learning gain of 32% in mathematics, 38% in Physics, 33% in Biology and 38% in chemistry. The overall results highlighted that teachers' performance improved significantly following the intervention,

indicating that the training effectively corrected teachers' misconceptions and difficulties in the subject matters. More CPD training are therefore recommended in order to continuously improve teachers' effectiveness and possibly to expand the training to all secondary school teachers nationwide.

Keywords: Continuous Professional Development, Teachers' performance, Content Knowledge, Pedagogy, Mathematics and Science

1. Introduction

Teaching is a multifaceted work, and relying solely on pre-service teacher education often falls short in equipping teachers with the comprehensive knowledge and skills necessary for an effective teaching in our dynamic world (Ulferts et al., 2021). Knowing that the journey to becoming an effective teacher is an ongoing process spanning from undergraduate years to the culmination of one's professional career, a substantial portion of teacher education occurs on the job. It is widely acknowledged that teachers should continually update their knowledge and competencies in their subject matter to enhance educational quality (Tallvid, 2016). Specifically, Mathematics and Science teachers require additional training encompassing content, pedagogy, laboratory techniques, and Information and Communication Technology (ICT) through Continuous Professional Development (CPD) (Nkundabakura et al., 2023). CPD training is crucial for the professional development and performance of teachers (Tyagi & Misra, 2021). These sessions serve to keep educators informed about the latest educational methodologies, subject expertise, and technological advancements, enabling them to deliver high-quality and innovative instruction in the classroom (Nkundabakura et al., 2023).

Teachers can positively impact student learning outcomes and create engaging learning environments by continuously developing their skills and knowledge through CPD (Nunguye et al., 2023). Well-trained and knowledgeable teachers in these subjects may inspire and nurture the next generation of scientists, engineers, and problem solvers, propelling the country forward (Williams, 2020). Content Knowledge (CK) is the core understanding of a subject that teachers must have in order to effectively teach it (Shing et al., 2015). However, for effective teaching, teachers must not only have a thorough understanding of the subjects they teach but also an understanding of how to incorporate certain innovative teaching methodologies which may enrich students' learning

experiences and help them to develop necessary competencies related to the subject (Schmidt et al., 2014).

In the pursuit of fostering students' holistic competency development, Rwanda underwent a significant curriculum shift in 2016, transitioning from a knowledge-based curriculum to a Competence-Based Curriculum (CBC). This transformation aimed to equip learners with the essential competencies required in the dynamic world of the twenty-first century (REB, 2015a). The implementation of the CBC necessitated teachers to undergo various forms of Continuous Professional Development (CPD), focusing on enhancing their Pedagogical Content Knowledge (PCK), Content Knowledge (CK), and Technological Content Knowledge (TCK). Despite these efforts, research findings indicate that many teachers still adhere to traditional teaching methods, have difficulties in some topics which have been linked to suboptimal academic achievements among students (Nkundabakura, et al., 2023). This discrepancy underscores the need to critically assess the effectiveness of CPD initiatives and address the persistent gap between curriculum reforms and instructional practices in order to optimize student learning outcomes.

In this context, the Government of Rwanda through the Ministry of Education (MINEDUC) is implement the "Rwanda Quality Basic Education for Human Capital Development" (RQBEHCD) Project. A specific focus of this world bank funded project in its sub-component 1.2, is to enhance the efficiency of Mathematics and Science teachers. This sub-component emphasizes on expanding teachers' content understanding, refining classroom teaching practices, and providing essential teaching materials and ICT tools. Within this framework, the University of Rwanda-College of Education (UR-CE), in conjunction with Rwanda Basic Education REB, has launched the Continuous Professional Development Certificate in Innovative Teaching Mathematics and Science (CPD-ITMS) program for teachers in 16 out of the 30 districts. This program is designed to encourage teachers' active participation and facilitate their transition to more effective instructional methods. The overarching objective is to elevate teachers' competence, ultimately benefiting both students and educators in Rwandan lower secondary schools.

In that regard, through the Ministry of Education (MINEDUC) and the Rwanda Basic Education Board (REB), the Government of Rwandan (GoR), in partnership with the World Bank Group, is implementing the "Rwanda Quality Basic Education for Human Capital Development" (RQBEHCD) Project sub-component 1.2 which deals with the improvement of Mathematics and Science teachers' efficiency. This Sub-component focuses on

expanding teachers' content understanding, improving classroom teaching practices, and providing necessary teaching materials, ICT tools. In this realm, the Continuous Professional Development Certificate in Innovative Teaching Mathematics and Science (CPD-ITMS) program for teachers was initiated in 16 districts out of 30 by the University of Rwanda-College of Education (UR-CE), in collaboration with REB to train Mathematics and Science teachers. This program intends to promote teachers' participation and transition to more effective methods of instruction, ultimately improving teachers' competency and benefiting both students and teachers in Rwandan lower secondary schools. Therefore, the purpose of this study was to determine the influence of CPD training of the cohort 2022-2023 on the content understanding of Rwandan teachers of mathematics and science in lower secondary school. The study was guided by the following objectives:

1. Investigating the influence of CPD training on Rwandan secondary school mathematics and science teachers' conceptual understanding.
2. Examining the influence of CPD training on performance of female teachers compared to their counterpart males in Mathematics and Science.
2. Research hypotheses

Null hypothesis (Ho1): There is no statistically significant difference in teachers' conceptual understanding before and after training.

Null hypothesis (Ho2): There is no statistically significant difference in male and female teachers' conceptual understanding.

3. Theoretical framework

The Theory of Change framework establishes a systematic approach when it is applied to CPD training for math and science teachers. Its long-term goal is to improve educational quality and is divided into intermediate outcomes namely improved pedagogical skills and increased student engagement. Those outcomes are further subdivided into short-term outcomes such as effective adoption of teaching methods and technology integration. Considering that factors such as teacher motivation and resource availability align, specific activities like workshops and online resources can produce these results, the theory of change was used in this study to understand changes in teachers' pedagogical practices and subject knowledge (Laing, 2022). To improve learning results, the project focused on improving teaching, engaging learners, and offering improved

teacher mentoring. Teachers were trained in Content Knowledge, Pedagogical Knowledge, and ICT technologies to improve classroom practices and learners' engagement.

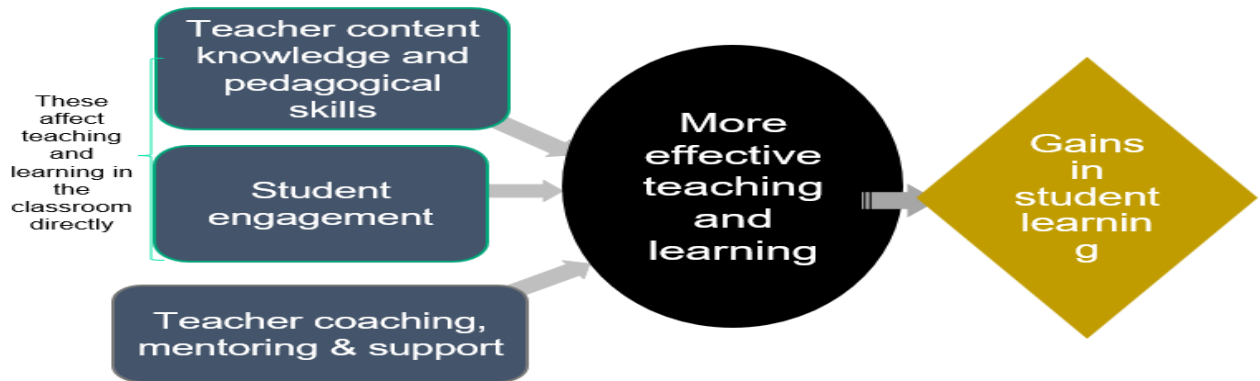


Figure 1: Theory of change (Nkundabakura et al. , 2023)

4. Methodology

4.1 Study Design

This study employed a quantitative research design (one group pre-post-test), with one group performing a pre-test prior to intervention and a post-test following intervention.

4.2 Target population, the sample size and sampling techniques

The targeted population was lower secondary teachers of Mathematics and Science from seven districts of Rwanda, specifically Nyamagabe, Ruhango, Bugesera, Gasabo, Burera, Ngoma and Kirehe. Public schools with electricity were selected. From each school, four teachers, one per subject, were selected by the school Head teacher. However, final analysis was carried out using only data from 569 teachers who participated in both pre-test and post-test (See Table 1).

Table1: Study participants

Subject	Gender	Frequency (%)	Total per subject
Mathematics	Male	107 (74.83)	143
	Female	36 (25.17)	
Biology	Male	86 (62.77)	137
	Female	51 (37.23)	
Physics	Male	115 (76.16)	151
	Female	36 (23.84)	

Chemistry	Male	83 (60.14)	138
	Female	55 (39.86)	
Total	Male	391 (68.72)	569
	Female	178 (31.28)	

4.3 Instruments design and validation

The RQBEHCD project team used test items from standardized assessments based on Rwandan curriculum. The test items were validated by the PhD students from African Center of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS). These students were selected for validation because they are conducting research in Mathematics and Science education. They checked the relevance of the questions and their appropriate answers. The tool consisted of 50 questions from each subject (Mathematics, Physics, Biology and Chemistry) where one or more possible correct answer was expected to be chosen from various distractors.

4.5 Statistical data analysis

Before analysis, data from Kobo Toolbox were transferred into MS Excel where each chosen letter for each question was recorded. MS Excel was used to analyze basic data while SPSS v.26 was used to analyze inferential statistics. To assess how much teachers gained from the training, the learning gain was calculated using the formula by Hake (1998) taking the difference between the average post and pre-test, divided by the difference between a hundred and the average pre-test ($(\bar{g} = \text{AvPost} - \text{AvPre}) / (100 - \text{AvPre})$). Four assumptions (continuous data, sample size greater than 30, normal distribution, and equality of means) were tested using Wilks' Lambda and Pillai's Trace, and in most cases, three of them were met. The data of pre- and post-test of the participants were above 30, the normality test of Kolmogorov shown significance ($p > .05$), and Levene's test of equality of variances demonstrated non-significant ($p > .05$). Since there were two independent variables (male and female teachers) and one dependent repeated variable (pre- and post-test), we performed repeated measures analysis of variance (MANOVA) under a general linear model.

5. Results

5.1 Influence of CPD training on Mathematics and Science teachers' performance

The findings given in Table 3 show that CPD training provided a significant benefit to teachers across all subjects. Notably, for each subject the results showed the learning gains (<g>) 33%, 39%, 33%, 38% in Mathematics, Physics, Biology, and Chemistry respectively.

Table 2: Learning gains at the completion of the CPD training

Subject	AvPre [Overall]	AvPre [Males]	AvPre [Females]	AvPost [Overall]	AvPost [Males]	AvPost [Females]	<g> Overall	<g> Males	<g> Females
Mathematics	53.24	54.10	50.78	68.67	68.88	68.10	0.33	0.32	0.35
Physics	38.33	39.28	35.41	62.26	63.23	59.30	0.39	0.39	0.37
Biology	63.81	64.80	63.79	75.80	75.90	75.56	0.33	0.32	0.33
Chemistry	62.51	62.65	62.29	76.93	76.36	77.78	0.38	0.38	0.41

Av*: average

5.2. Teachers' performance in Mathematics by topic areas in both pre-test and post-test

Mathematics test covered three topic areas namely, Algebra, geometry, and Statistics and probability. In 13 questions (Q24, Q31 to 34, Q38, Q39, Q40, and Q44 to Q48) asked in Geometry, four questions were performed at 50% and above in pre-test and only three questions were performed below 50% in post-test. In 8 questions (Q6, Q9, Q25, Q26, Q28, Q29, Q43, and Q49) of Statistics and probability, 3 questions were performed at 50% and above in pre-test and 2 questions were performed below 50% in post-test. Generally, trainees scored higher marks in questions of Algebra in pre and post-test than in other topic areas. There are some questions scored below 50% in both pre and post-test including Q6, Q49, Q20, Q21, Q22, Q23, Q31, Q38, and Q48 (see Figure 2).

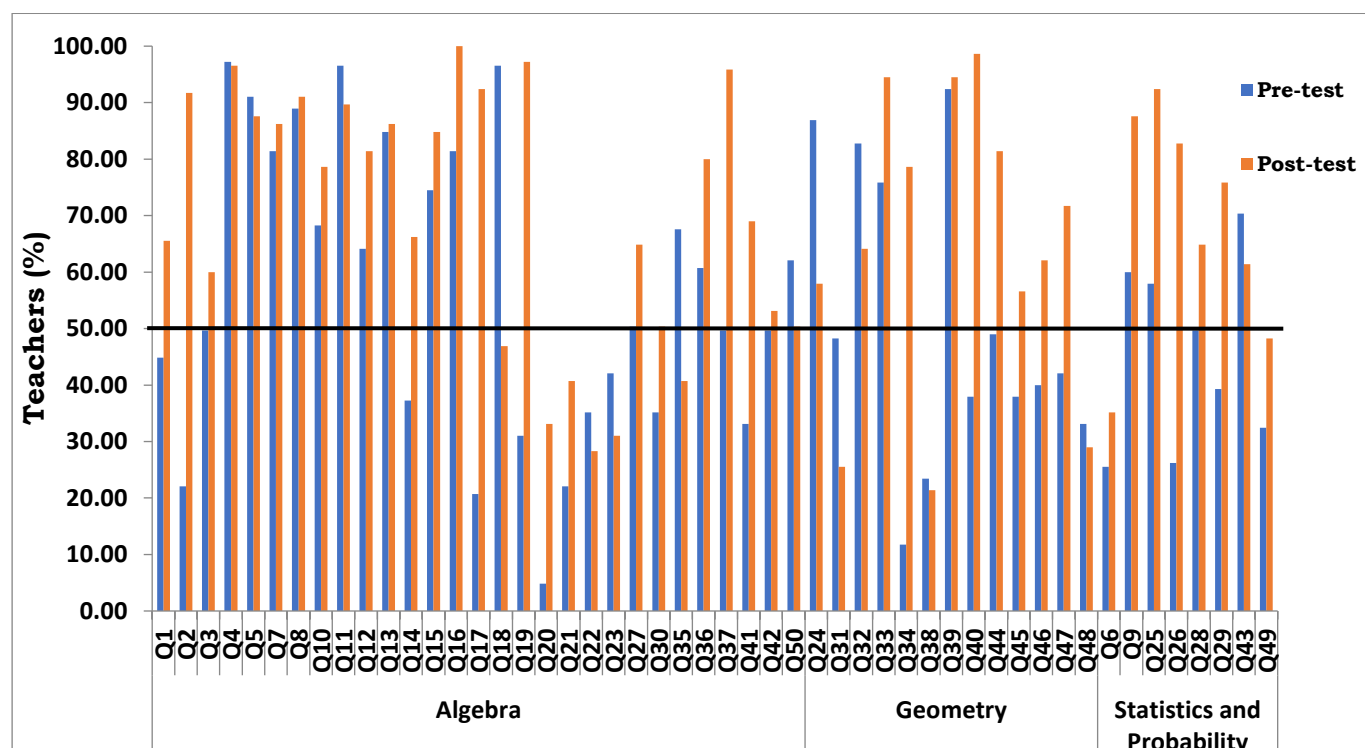


Figure 2: Teachers' performance in Mathematics per topic area in both pre- and post-test [N=143]

5.3 Teachers' performance in Chemistry per topic area in both pre-and post-test

Figure 3 indicate teachers' Chemistry performance by topic area in both pre-and post-tests. Out of the 50 items answered, 46 had scores above 50% on both pre-and post-tests, with only four indicating a modest increase below 50% on both tests. Notably, all questions relating to the Scope of Chemistry and Particulate Nature of Matter, Atomic Structure and Periodic Table, and organic chemistry improved significantly from pre- to post-test. However, certain questions continued to generate persistent misunderstandings. In particular, question 10 on Scope of Chemistry and Particulate Nature of Matter, Question 28 on chemical equations, and question 39 on chemical equations, and organic chemistry scored less than 50% on pre-and post-tests. Question 33 on atomic structure and the periodic table, as well as questions 36 and 20 on chemical processes, scored lower in the pre-test than the pre-test level.

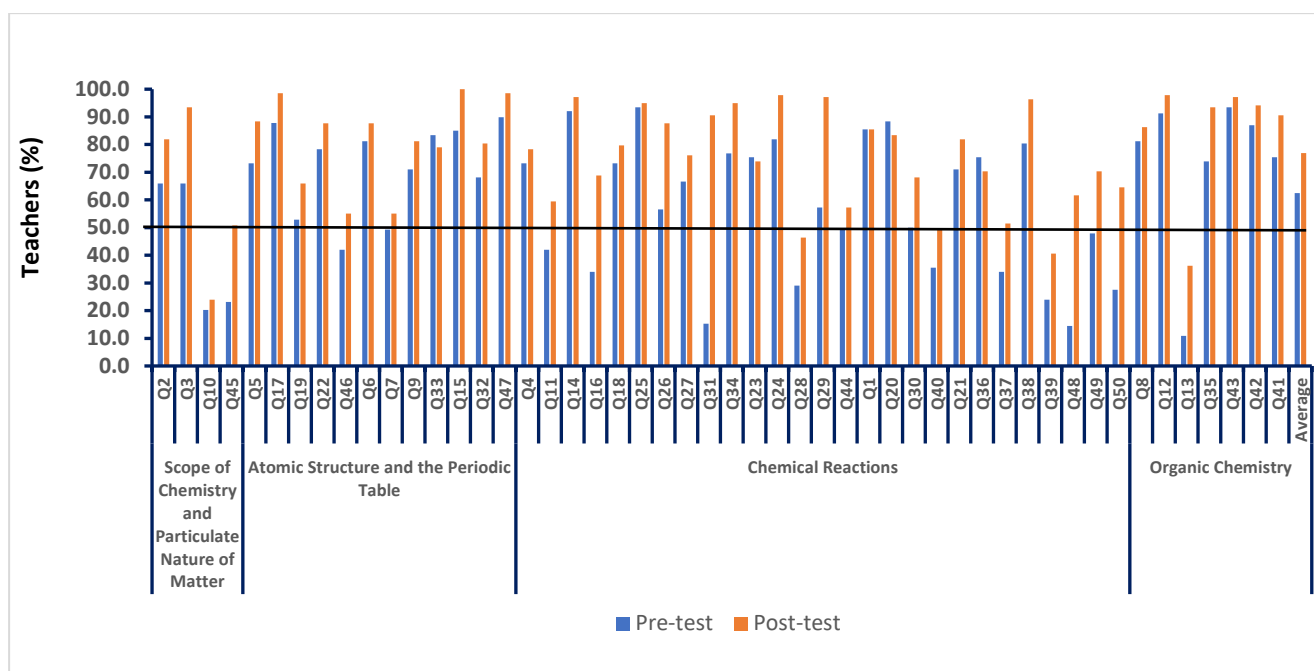


Figure 3: Teachers' performance in Chemistry per topic area in both pre-and post-test [N=138]

5.4 Teachers' performance in Biology per topic area in both pre-and post-test

Considering the results in Figure 4, the most difficult question was question 45, for which a very low performance in both pre and post-test was observed. This means that there was no improvement brought by the training for these questions. Other questions that were difficult in both pre-and post-test were questions Q4, Q2, Q15, Q41, Q17, and Q11 (see figure 4). Generally, all questions that teachers correctly answered at the percentages of less than 50%, especially in post-test, could be annotated as difficult and misunderstood by teachers.

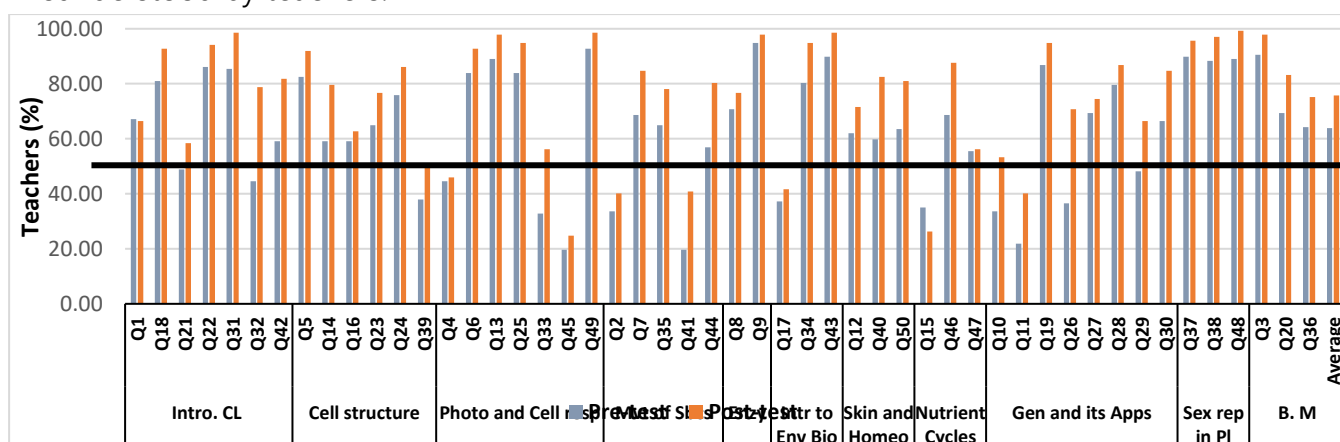


Figure 4: Teachers' performance in Biology questions per topic area in both pre- and post-test [N= 137]

Intr.cl: Intruduction to classification, Photo and cell resp: Photosynthesis and cellular respiration; mvt of sbcs: Movement of substances, Enzy: Enzymes; In.Env.Bio: Introduction to environmental biology, Skin and Homeo: Skin and homeostasis; Gen and its apps: Genetics and its applications; Sex.Rep.Pl: Sexual reproduction for flowering plants; B.M: Biological molecules.

5.5 Teachers' performance in Physics per topic area in both pre-and post-test

Figure 5 shows the performance of teachers in topic areas. The 50 questions asked in pre- and post-test were from seven topics namely Mechanics, Electricity and Magnetism, Light, Fluid Mechanics, Electronics, Thermodynamics and Environmental Physics. 15 out of 50 questions were asked in Mechanics, 11 in Electricity and Magnetism, 9 questions in Light, 5 in Fluid Mechanics, 4 questions in Electronics, 3 in Thermodynamic and 3 questions in Environmental Physics. Among 15 questions asked in Mechanics, only 2 questions (Q9 and Q12) were performed above 50% in pre-test and the number increased to 12 questions in post-test. Among 11 questions asked in Electricity and Magnetism, only Q17 were performed above 50% in pre-test and the number increased to 6 questions (Q13 to Q17, Q21 and Q26) in post-test. Among 9 questions asked in light, 2 questions (Q27 and Q31) were performed above 50% in pre-test and 8 questions (Q27 to Q32, Q33, Q34 and Q35) in post-test. In fluid Mechanics, all questions were performed in both pre- and post-test. Concerning Electronics, only Q41 was performed below in pre-test. For Tthermodynamics, all questions were performed below 50% in both pre-test and post-test except Q47 performed above 50% in post-test. As for Eenvironment Pphysics, Q49 performed below 50% in both pre- and post-test.

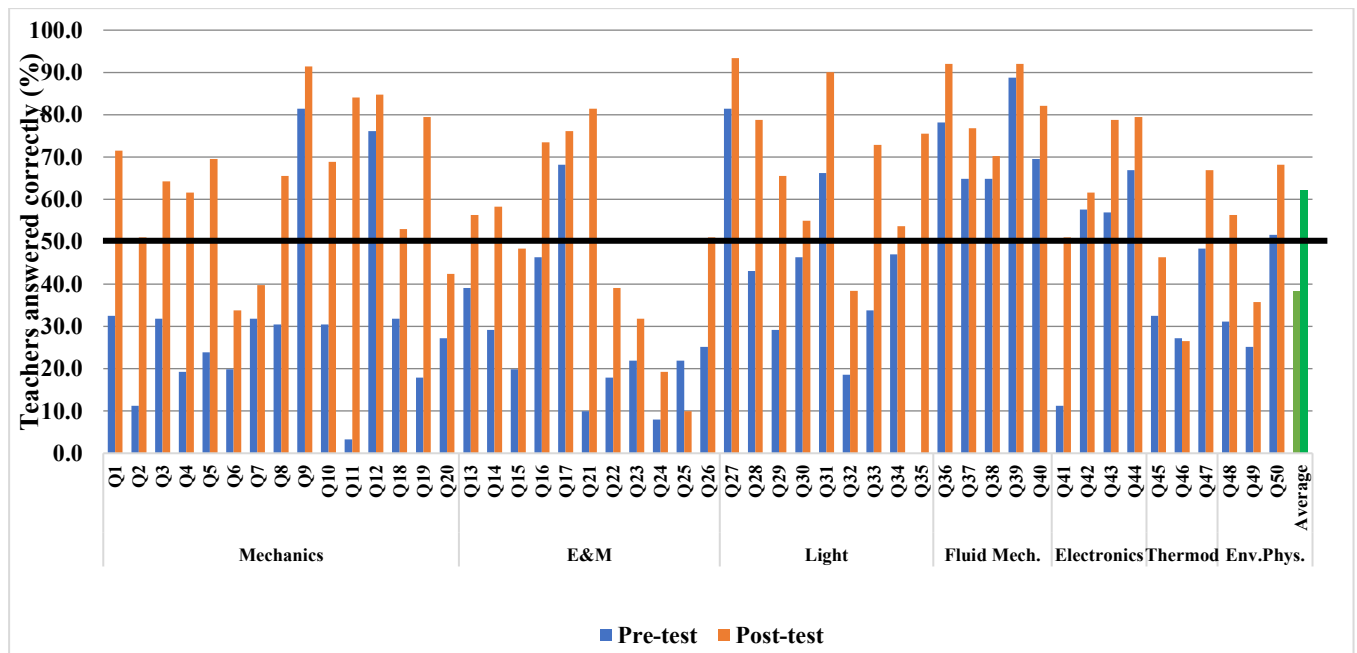


Figure 5: Teachers' performance in Physics questions per topic area in both pre- and post-test [N= 151]

"E&M" stands for Electricity and Magnetism; "Fluid Mech" Fluid Mechanics, "Thermod" stands Thermodynamics, and "Env. Physics" stand for Environmental Physics.

5.6 Influence of CPD training on performance of female teachers compared to the male teachers in Mathematics and Science

The impact of CPD training on gender performance in Mathematics and Science is mentioned, as both male and female teachers improved from pre-test to post-test. The training positive impact on pedagogical skills, content knowledge, and instructional approaches is evident in the advancement of both genders. This demonstrates the usefulness of CPD training efforts to encourage gender professional development, enable good learning outcomes, and contribute to overall gains in teaching quality in the subjects of Mathematics and Science.

Table 2: Descriptive statistical analysis in Mathematics and science subjects

Subject	Gender	N	Mean	Std. Deviation
Mathematics	Male	107	54.1	8.3
	Female	36	50.7	12.2
	Male	107	68.8	9.1
	Female	36	64.5	11.5

Physics	Pre-test Per Gender	Female	36	68.1	10.9
		Male	115	38.1	9.8
	Post-test Per Gender	Female	36	39.1	6.3
		Male	115	62.6	12.6
		Female	36	61.2	13.6
		Male	115	62.6	10.1
Chemistry	Pre-test Per Gender	Male	83	62.6	10.1
		Female	55	62.2	9.6
	Post-test Per Gender	Male	83	76.5	10.1
		Female	55	77.5	8.2
Biology	Pre-test Per Gender	Male	86	63.8	9.9
		Female	51	63.9	13.9
	Post-test Per Gender	Male	86	75.9	7.5
		Female	51	75.5	8.4

In Mathematics, male teachers consistently outperformed their female counterparts in pre-test and post-test, with a substantial improvement from pre-test ($M=54.1$, $SD=8.3$) to post-test ($M=68.8$, $SD=9.1$) while female scores gained from 50.7 ($SD=12.2$) to 68.1 ($SD=10.9$). Male teachers had a modest advantage in Physics, with pre-test mean scores of 38.1 ($SD=9.8$) and post-test mean scores of 62.6 ($SD=12.6$), compared to female scores of 39.1 ($SD=6.3$) and 61.2 ($SD=13.6$) respectively. Interestingly, in Chemistry female teachers showed comparable pre-test performance to male teachers, and outperformed their male counterpart in the post-test (Females, $M=77.5$, $SD=8.2$; Males, $M=76.5$, $SD=10.1$). Finally, in Biology, both male and female teachers showed a significant improvement after intervention (Females, $M=75.5$, $SD=8.4$; Males, $M=75.9$, $SD=7.5$) (see Table 3). This shows the complexities of gender-related aspects in educational achievement and the possible influence of personalized interventions on teachers' subject-specific ability.

Results of inferential statistics (Table 4), which were used to examine the potential statistical significance of performance differences between pre- and post-tests across all individuals, show a dramatic and highly significant difference in favor of the post-test. However, no statistically significant differences were identified among genders in this study.

Table 3: The results of inferential statistics

Subject	Effect		Value	F	df	Error df	Sig.
Mathematics	Test	Wilks' Lambda	.372	237.548 ^b	1.000	141.000	.000
	Test	*					
	Gender	Wilks' Lambda	.990	1.413 ^b	1.000	141.000	.237
Physics	Test	Pillai's Trace	.589	213.250 ^b	1.000	149.000	.000
	Test	*					
	Gender	Pillai's Trace	.004	.527 ^b	1.000	149.000	.469
Chemistry	Test	Wilks' Lambda	.429	180.858 ^b	1.000	136.00	.000
	Test	*					
	Gender	Wilks' Lambda	.997	.428 ^b	1.000	136.000	.514
Biology	Test	Pillai's Trace	.435	104.029 ^b	1.000	135.000	.000
	Test	*					
	Gender	Pillai's Trace	.000	.040 ^b	1.000	135.000	.843

Results in Table 4 revealed a considerable and highly statistically significant difference between the pre-test and post-test in Mathematics, Physics, Chemistry and Biology ($df = 1$, $p\text{-value} = .0001$). Furthermore, there were no significant statistical differences between male and female teachers in the pre-test and post-test in Mathematics, Physics, Chemistry and Biology ($P\text{-value} = .237, .469, .514, .843$) respectively.

6. Discussion

The present study aimed at assessing the influence of CPD training secondary school mathematics and science teachers' content knowledge. The study sought to discover the misconceptions and challenges teachers have when teaching mathematics and science subjects so that these obstacles could be removed through various forms of CPD training. The teachers' test scores before and after training was analyzed to see the influence of CPD training. The overall results revealed a significant improvement in scores from the pre-test to the post-test, suggesting the intervention or teaching period had a positive impact on the participants' performance.

6.1 In Mathematics

The current study was conducted to describe mathematics teachers' misconceptions and challenges they face in mathematics concepts to improve their teaching practices. The study showed that there was statistically significant difference in teachers' mean scores between the pre-test and post-test ($p < .05$). Even though the teachers performed well on the post-tests, there were some question that they failed in both pre- and post-test. According to the findings of the preceding analysis, teachers continue to face difficulties and misconceptions in Algebra and Geometry. Such findings are consistent with Mukuka et al. (2019) who found out that algebra is a challenging topic for both teachers and students due to its abstract nature

Similarly, in Statistics and Probability, the questions Q6 and Q49 were poorly performed in both pre- and post-test at less than 50%. Indeed, the concept of probability requires abstract reasoning. In addition, Probability was used to be taught in advanced level (A-Level) in the old curriculum, but it is currently introduced in O' Level together with statistics based on the roles they are playing in game theory, in the census, and scientific studies (REB, 2015). In this regard, teachers are not sufficiently prepared to teach this content generally taught towards the end of the program at all levels (REB, 2015). Consequently, this content may be left untaught by some teachers, especially those who are behind in completing the program. Thus, the more some teachers do not teach this unit, the more they may forget about the concepts involved in.

6.2 In Chemistry

As indicated by their mean score improving from 62.50% in the pre-test to 76.92% in the post-test, the study found a considerable improvement in trained chemistry teachers' performance. This development shows that the training program was helpful in improving their content knowledge. Pilo *et al.* (2012) discovered comparable results in their study, emphasizing the importance of teacher training in the field of science education. The study found that such training boosts significantly productivity in the educational sector, resulting in beneficial effects on student results and classroom management.

More so, the study findings revealed that both male and female teachers performed well on the pre- and post-test. These findings are consistent with the research which states that professional training is a terrific tool for teaching improvement and learning

achievement when it is designed, provided, and followed on a regular basis to match the needs of teachers and students (Srinivasacharlu, 2019). Overall, the teachers responded to the questions suitably. However, there are some areas where they are facing difficulties. Questions Q10, Q28, Q40, and Q39, for example, continue to be stumbling difficulties for teachers in the scope of chemistry and particulate nature of matter, as well as in chemical reaction, with scores remaining below 50%.

The findings are consistent with previous literature which highlights the necessity of chemistry teachers having the necessary abilities, knowledge, and practical expertise in the topic they are responsible for (Hermanns & Ermler, 2021). The findings show that teachers' subject matter expertise has a direct impact on their ability to successfully present material to students.

6.3 In Biology

The results of the study revealed that there is a significant impact of CPD training on content understanding for both male and female teachers. Analysis of the results shows that the questions related to gene and its applications have been very difficult where the mean scores were below 25% and below 50%. Both gene technology and genetics are found in senior 3 specifically in the topic area called genetics and its applications (Q10, Q11, Q19, Q26, Q27, Q28, Q29, and Q30). Question 2 was also difficult and this was related to the unit of movement of substance across the cell membrane. The latter topic is abstract in nature and teachers present a lot of misconceptions about it. These findings confirm the recent study's findings on teachers' perceptions of difficult biology topics in the reformed biology curriculum (Byukusenge et al., 2022). In the latter study, teachers avowed difficulties in their content knowledge for some topics similar to the ones identified in the present study like genetics and genetic technology, cellular respiration, selection and evolution, nervous coordination, not to mention a few. It is important to remember that most of the topics in the biology curriculum are progressive from the ordinary level to the advanced level.

6.4 In Physics

The current study was conducted to describe physics teachers' misconceptions and challenges they face in physics concepts to improve their teaching practices. The study showed that there was statistically significant difference in teachers' mean scores between the pre-test and post-test ($p < .05$). These results were supported by Kola and Taiwo (2013) who argued that by preparing teacher how to use technological tools boosts teaching

confidence have improved teachers' performance. In addition, Ndiokubwayo et al. (2022) has found that students in Science and physics do not adequately grasp the concepts. Thus, Ndiokubwayo et al. (2022) suggested that physics teachers should be trained to improve their professionalism for an effective teaching and learning of physics. As shown by the post-test results, it is indicated that some questions in physics where teachers have misconceptions, have been addressed during trainings. The misconceptions addressed with the content which is aligned with the physics Rwandan competence curriculum (REB, 2015). The results from the study showed that female teachers performed better than their counter part male. However, our results are contrast from the study conducted by Kola and Taiwo (2013) who showed that the male performs better than female in physics. The female teachers' performance should be transferred in classroom setting to have female students who highly perform in Physics. For instance, Lorenzo et al. (2006) argued that teaching that incorporating interactive strategies, collaboration, and competition may increase both male and female students performance.

7. Conclusions

The goal of this study was to investigate whether the training received by lower secondary teachers improved their conceptual understanding of some of the units where they had difficulties in the mathematics and science subjects. Overall, the findings showed that teachers' performance improved from pre- to post-test, indicating that teachers' subject mastery and classroom practices improved. Both female and male teachers increased their performance from pre-test to post-test. Notwithstanding this situation, there is no statistically significant difference between male and female teachers mean scores that was observed. The results from the descriptive statistics showed that male teachers scored highly compared to their counterpart female teachers. Despite the fact that there was an improvement from pre- to post-tests, several questions in specific units were proven to be hard since teachers failed them. The results further indicated that there is still a misunderstanding among teachers that must be addressed in the subsequent training to improve topic knowledge and classroom practices of Mathematics and science teachers.

8. Key Recommendations

Based on the findings, the study suggests future training should focus on hands-on activities, use of ICT tool for challenging topics identified. The study recommends that

teachers should conduct more CPDs on Content Knowledge in their schools according to departments. Educational administrators should also be encouraged to organize competitions for Mathematics and Science, and monitor attendance of teachers in CPD training.

9. Data availability

The datasets generated and/or analyzed during the current work are available at <https://data.mendeley.com/datasets/86d7tz7wwk/1>

10. References

- Byukusenge, C., Nsanganwimana, F., & Paulo Tarmo, A. (2022). Difficult topics in the revised biology curriculum for advanced level secondary schools in Rwanda: teachers' perceptions of causes and remedies. *Journal of Biological Education*, 57(5), 1112–1128. <https://doi.org/10.1080/00219266.2021.2012225>
- Etobro, A. B., & Fabinu, O. E. (2017). Students' perceptions of difficult concepts in biology in senior secondary schools in Lagos state. *Global Journal of Educational Research*, 16(2), 139. <https://doi.org/10.4314/gjedr.v16i2.8>
- Eya, N. M., & Attah, F. O. (2020). Competencies Possessed and Utilized by Chemistry Teachers for Effective Teaching of Chemistry in Secondary Schools in Nsukka Education Zone of Enugu State. *IV(II)*, 237–241.
- Hermanns, J., & Ermler, N. (2021). Why school-related content knowledge for pre-service chemistry teachers should include basic concepts in organic chemistry. *Chemistry Teacher International*, 3(3), 303–311. <https://doi.org/10.1515/cti-2020-0033>
- Innocent, Nunguye; Ezechiel, Nsabayezi; James, Mbonyuburyo; Leon, Rugema, Mugab; Froncois, N. N. (2023). Perception of the Continuous Professional Development Programs among Secondary School Heads and Teachers of Biology in Gicumbi , Rwanda. *East African Journal of Education and Social Sciences*, 4(2), 163–168.
- Kola, J., & Taiwo, Z. (2013). Analysis of Gender Performance in Physics in Colleges of. 4(6), 1–6.
- Laing, K. (2022). The contribution of a 'synergic theory of change' approach to democratising evaluation. *Research for All*, 6(1), 1–17. <https://doi.org/10.14324/rfa.06.1.08>
- Lorenzo, M., Crouch, C. H., & Mazur, E. (2006). Reducing the gender gap in the physics classroom. *American Journal of Physics*, 74(2), 118–122.

<https://doi.org/10.1119/1.2162549>

- Mukuka, A., Mutarutinya, V., & Balimuttajjo, S. (2019). Exploring the barriers to effective cooperative learning implementation in school mathematics classrooms. *Problems of Education in the 21st Century*, 77(6), 745–757. <https://doi.org/10.33225/pec/19.77.745>
- Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2022). Assessment of Rwandan physics students' active learning environments: classroom observations. *Physics Education*, 57(045027), 1–12. <https://doi.org/10.1088/1361-6552/ac69a2>
- NkundabakPheneas Nkundabakura, Theophile Nsengimana, Pascasie Nyirahabimana, Jean Baptiste Nkurunziza, Concilie Mukamwambali, Jean Claude Dushimimana, Eugenie Uwamariya, Jane Batamuliza^{1, 2, 3} · Celine Byukusenge, Ezechiel Nsabayeze, Jean Nepomuscene Twah, K. N. (2023). Usage of modernized tools and innovative methods in teaching and learning mathematics and sciences : A case of 10 districts in Rwanda. *Education and Information Technologies*, 28(1), 3–6.
- Pilo, M., Gavio, B., Grosso, D., & Mantero, A. (2012). Science Education and Teachers' Training: Research in Partnership. *US-China Education Review*, 1(2), 106–111.
- REB. (2015). *Mathematics Syllabus for Ordinary Level S1-S3*. Kigali: Ministry of Education.
- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2014). Technological Pedagogical Content Knowledge (TPACK): The Development and Validation of an Assessment Instrument for Preservice Teachers. *Journal of Research on Technology in Education*, 42(2), 2531p.
- Shing, C. L., Saat, R. M., & Loke, S. H. (2015). The knowledge of Teaching- Pedagogical Content Knowledge (PCK). *The Malaysian Online Journal of Educational Sciences*, 3(3), 40–55.
- Srinivasacharlu, A. (2019). Continuing Professional Development (CPD) of Teacher Educators in 21st Century. *Shanlax International Journal of Education*, 7(4), 29–33. <https://doi.org/10.34293/education.v7i4.624>
- Williams, R. T. (2020). A Systematic Review of the Continuous Professional Development for Technology Enhanced Learning Literature. *Engineering International*, 8(2), 61–72. <https://doi.org/10.18034/ei.v8i2.506>

Article 23

Solving By Experimentation Some Problems Of Statistics, Analytic Geometry And Descriptive Geometry

Bibomba Tshiananga Nancy, Ngoyi Ngoyi Faustin

Assistant in Mathematics and didactics of disciplines in the science department of ISP/GOMBE,DRC,
Senior Lecturer at the Department of Mathematics and Computer Sciences; ISP TSHOFA, Province of
LOMAMI, Democratic Republic of CONGO

Abstract

The averages of statistics series are determined by calculation. The coordinates of the gravity centers and those of the inscribed circles of triangles in the plane, in the space and in descriptive Geometry are found either by calculation or by construction.

We are going to show in this paper how to determine by experimentation, as in a laboratory of Physics, the averages of statistics series, the coordinates of the gravity centers and those of the centers of the inscribed circles of triangles in the plane, in the space and in Descriptive Geometry.

Key words : Average: Arithmetic mean of a statistics series, Center of gravity: Point where is concentrated the weight of a body. Center of the inscribed circle of a triangle: Center of the circle tangent to the three sides of a triangle, Equilibrium: Balance, Statistics series: Sequence of quantitative data

1. Literature Review

Many textbooks on the averages of statistics series, the gravity centers and the centers of the inscribed circles of triangles exist. As far as we know, finding textbooks where the averages of statistics series, the gravity centers and the centers of the inscribed circles of triangles are determined by experimentation is far from easy.

2. Methodology

Documentary method, deduction and experimentation are the three major methods we have resorted to in this paper.

3. Documentary Method

We have consulted existing literature on the following subjects: the averages of statistics series, the barycenters of massive points and their applications, the centers of gravity and the centers of the inscribed circles of triangles, the resultant of forces and its position and the equilibrium of levers.

3.1. Deduction

We have noticed that formulae used for determining by calculation the averages of statistics series, the barycenters of massive points, the centers of gravity and the centers of the inscribed circles of triangles are similar.

As the barycenters of massive points are determined both by calculation and by experimentation, the averages of statistics series, the centers of gravity and the centers of the inscribed circles of triangles are liable of being determined by experimentation.

3.2. Experimentation

Rigid weightless bars with appropriate masses hung at appropriate positions have been used for determining by experimentation the averages of statistics series and the coordinates of two particular points of any triangle.

4. Introduction

Experience tells us that the average of Statistics series, the Gravity center and the center of the inscribed circle of a triangle are all particular barycenters of massive points. Most teachers of Mathematics and or of Descriptive Geometry do not know that:

- 1) The true size of a triangle Can be drawn After determining by calculation the true lengths of its sides,
- 2) It is possible to find by experimentation the coordinates of the Gravity center and those of the inscribed circle of a triangle,

It is possible to find the average of a Statistics series by experimentation and by means of constructions. We intend to help learners dive into the practical realm and to introduce to teachers some New and easy approaches different from those they are used to.

5. Results

The averages of statistics series have been made tangible.

Coordinates of the gravity centers, and those of the centers of the inscribed circles of triangles are determined by experimentation without resorting to calculation.

Below are solved problems that confirm our statements.

- 5.1. Problem 1: Determine the average of the below statistics series. (MINOR C., 1962)

x_i	n_i
4	7
6	5
8	4
10	4

Fig.1

- Solution by calculation

x_i	n_i	$n_i x_i$
4	7	28
6	5	30
8	4	32
10	4	40
	$\sum n_i = 20$	$\sum n_i x_i = 130$

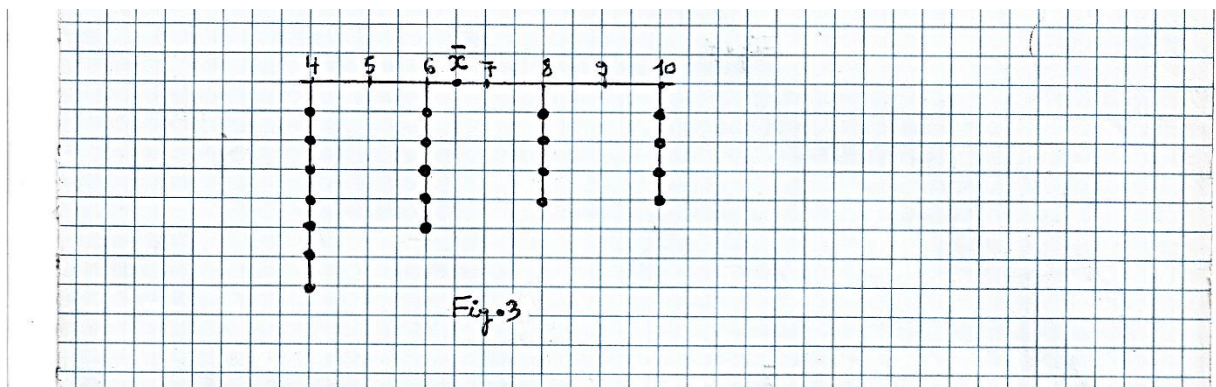
Fig.2

$$\bar{x} = \frac{\sum n_i x_i}{\sum n_i} = \frac{130}{20} = 6.5$$

- Solution by experimentation

Needed material: 6.5 dm-long rigid weightless bar, 20 identical objects, a ruler, a marker and 4 light shoe laces.

1. From the left end of the bar, step off 1 cm and mark point 4 as shown in Fig. 3 below.
2. From point 4, step off 6 equal segments of 1 dm each.
3. From point 10, step off 1 cm and cut off the remaining part of the bar.
4. Hang 7 objects at point 4, 5 at point 6, 4 at point 8 and 4 at point 10.
5. Find on the bar the point $\bar{x}$ where the set made of the bar and the 20 hung objects are kept or maintained in equilibrium: $\bar{x} = 6.5$.



Let $\bar{x}$ be the x-coordinate and $\bar{y}$ be the y-coordinate of the gravity center G of the triangle ABC:

$$\bar{x} = \frac{1 + 7 + 10}{3} = 6$$

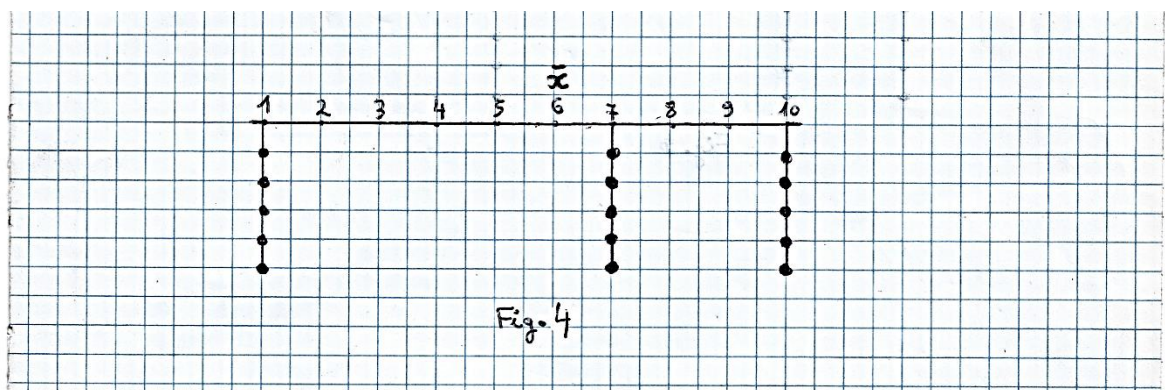
$$\bar{y} = \frac{3 + 2 + 10}{3} = 5$$

The gravity center of the triangle ABC is the point G (6, 5).

- Solution by experimentation (F. NGOYI, 2019)
 - Determination of the x-coordinate $\bar{x}$ of the gravity center G of the triangle ABC

Needed material: A 11-dm long rigid and weightless bar, 15 identical objects, a ruler, a marker, and 3 light shoe laces.

1. From the left end of the bar, step off 1 cm and mark point 1.
2. From point 1, step off 9 equal segments of 1 dm each.
3. From point 10, step off 1 cm and cut off the extra portion of the bar.
4. Hang 5 objects at point 1, 5 at point 7 and 5 at point 10.
5. Find on the bar the point $\bar{x}$ where the set made of the bar and the hung objects are kept or maintained in equilibrium: $\bar{x} = 6$.

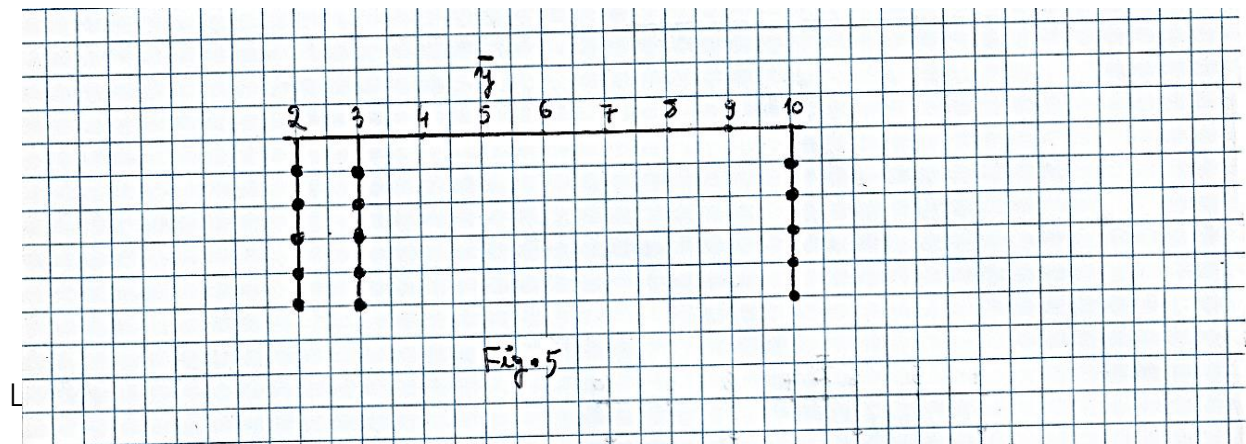


- Determination of the y-coordinate $\bar{y}$ of the gravity center G of the triangle ABC

Needed material: A 11-dm long rigid and weightless bar, 15 identical objects, a ruler, a marker, and 3 light shoe laces.

1. From the left end of the bar, step off 1 cm and mark point 2.
2. From point 2, step off 8 equal segments of 1 dm each.
3. From point 10, step off 1 cm and cut off the extra portion of the bar.
4. Hang 5 objects at point 2, 5 at point 3 and 5 at point 10.
5. Find on the bar the point $\bar{y}$ where the set made of the bar and the hung objects are kept or maintained in equilibrium: $\bar{y} = 5$.

The center of gravity of the triangle ABC is the point G (6, 5).



center G of the triangle ABC:

$$\bar{x} = \frac{1 + 7 + 10}{3} = 6$$

$$\bar{y} = \frac{3 + 2 + 10}{3} = 5$$

$$\bar{z} = \frac{0 + 2 + 7}{3} = 3$$

The center of gravity of the triangle ABC is the point G (6, 5, 3).

- Solution by experimentation (F. NGOYI, 2019)

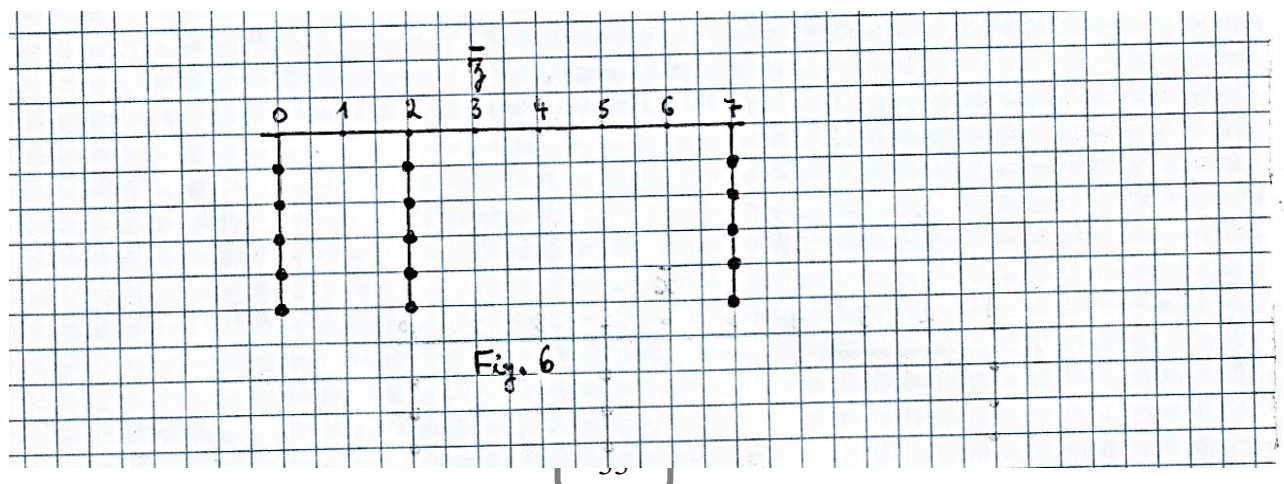
See problem 2 for $\bar{x}$ and $\bar{y}$.

- Determination of the z-coordinate $\bar{z}$ of the gravity center G of the triangle ABC

Needed material: 8 dm-long rigid weightless bar, 15 identical objects, a ruler, a marker and 3 light shoe laces.

1. From the left end of the bar, step off 1 cm and mark point 0.
2. From point 0, step off 7 equal segments of 1 dm each.
3. From point 7, step off 1 cm and cut off the extra portion of the bar.
4. Hang 5 objects at point 0, 5 at point 2 and 5 at point 7.
5. Find on the bar the point $\bar{z}$ where the set made of the bar and the hung objects is kept or maintained in equilibrium: $\bar{z} = 3$.

The gravity center of the triangle ABC is the point G(6,5,3).



5.4. Problem 4: Determine the gravity center G of the triangle ABC located as follows.

$$A \begin{cases} A^h(1,3) \\ A^f(1,0) \end{cases} \quad B \begin{cases} B^h(7,2) \\ B^f(7,2) \end{cases} \quad C \begin{cases} C^h(10,10) \\ C^f(10,7) \end{cases}$$

- Solution by calculation (A. GUION, 1967)

See problem 3 for $\bar{x}$, $\bar{y}$ and $\bar{z}$.

The gravity center of the triangle ABC is the point G such that $G \begin{cases} G^h(\bar{x}, \bar{y}) \\ G^f(\bar{x}, \bar{z}) \end{cases} \Rightarrow G \begin{cases} G^h(6,5) \\ G^f(6,3) \end{cases}$.

- Solution by experimentation (F. NGOYI, 2019)

Same as problem 3.

5.5. Problem 5 : Determine the center O of the inscribed circle of the triangle A(1,3,0)B(7,2,2)C(10,10,7).

- Solution by calculation (MINOR C., 1962)

Let $\bar{x}$ be the x-coordinate, $\bar{y}$ be the y-coordinate and $\bar{z}$ be the z-coordinate of the center O of the inscribed circle of the triangle ABC.

The length of side AB is $l_1 = \sqrt{(7-1)^2 + (2-3)^2 + (2-0)^2} = \sqrt{41} = 6.40312$.

The length of side AC is $l_2 = \sqrt{(10-1)^2 + (10-3)^2 + (7-0)^2} = \sqrt{179} = 13.37909$.

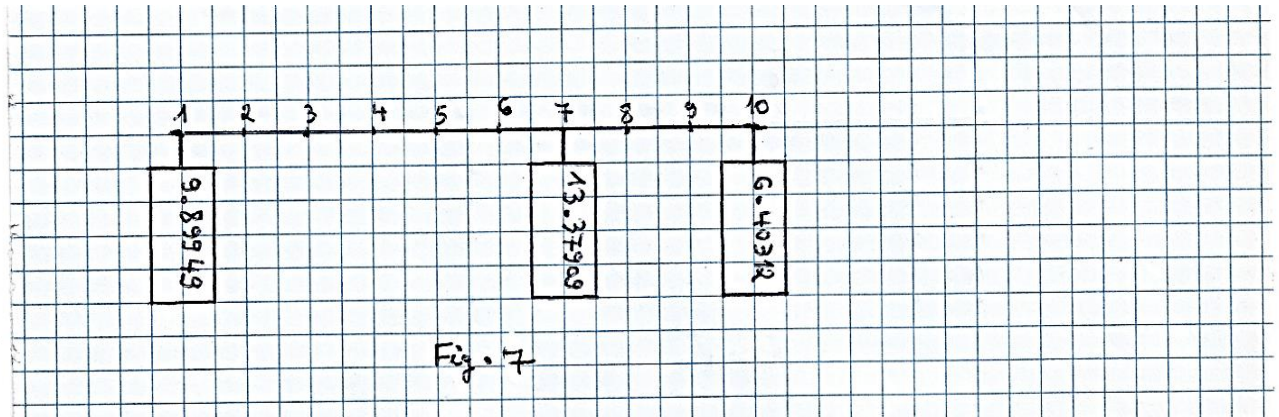
The length of side BC is $l_3 = \sqrt{(10-7)^2 + (10-2)^2 + (7-2)^2} = \sqrt{98} = 9.89949$.

$$\begin{aligned} \bar{x} &= \frac{1(\sqrt{98}) + 7(\sqrt{179}) + 10(\sqrt{41})}{\sqrt{41} + \sqrt{179} + \sqrt{98}} \simeq 5.64605 \\ \bar{y} &= \frac{3(\sqrt{98}) + 2(\sqrt{179}) + 10(\sqrt{41})}{\sqrt{41} + \sqrt{179} + \sqrt{98}} \simeq 4.05933 \\ \bar{z} &= \frac{0(\sqrt{98}) + 2(\sqrt{179}) + 7(\sqrt{41})}{\sqrt{41} + \sqrt{179} + \sqrt{98}} \simeq 2.41159 \end{aligned}$$

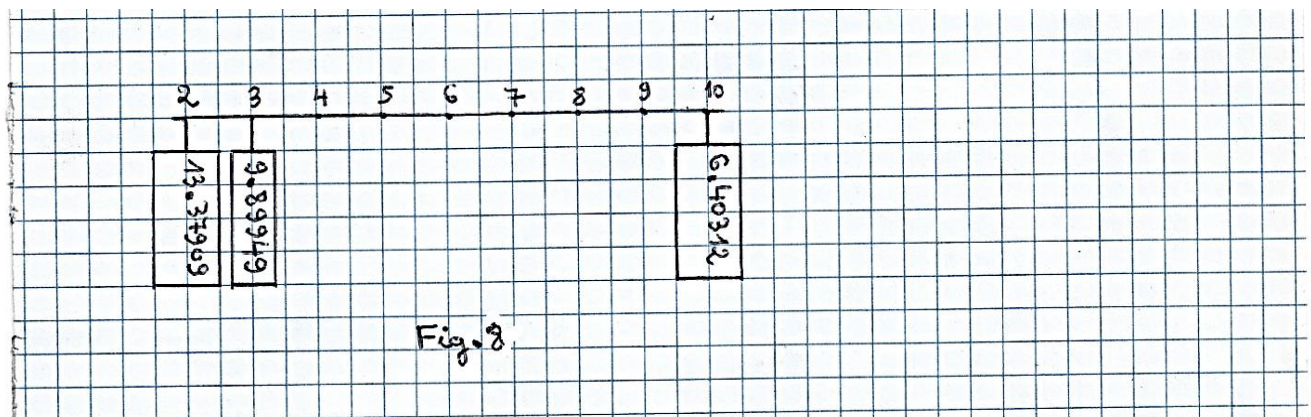
- Solution by experimentation

Needed material: A 11-dm long rigid weightless bar, marked masses and a marker.

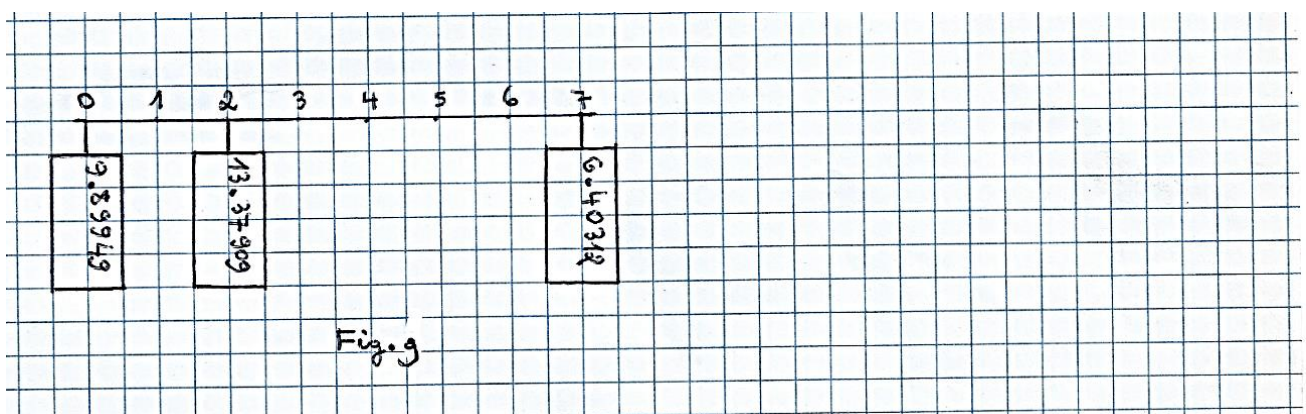
- Determination of the x-coordinate $\bar{x}$ of the inscribed circle
 1. From the left end of the bar, step off 1 cm and mark point 1.
 2. From point 1, step off 9 equal segments of 1 dm each.
 3. From point 10, step off 1 cm and cut off the extra portion of the bar.
 4. Hang 9.89949 units of mass at point 1 and 13.37909 units of mass at point 7 and 6.40312 units of mass at point 10.
 5. Find on the bar the point $\bar{x}$ where the set made of the bar and the hung masses is kept or maintained in equilibrium.



1. From the left end of the bar, step off 1 cm and mark point 2.
2. From point 2, step off 8 equal segments of 1 dm each.
3. From point 10, step off 1 cm and cut off the extra portion of the bar.
4. Hang 13.37909 units of mass at point 2 and 9.89949 units of mass at point 3 and 6.40312 units of mass at point 10.
5. Find on the bar the point $\bar{y}$ where the set mad of the bar and the hung masses is kept or maintained in equilibrium.



2. From point 0, step off 7 equal segments of 1 dm each.
3. From point 7, step off 1 cm and cut off the extra portion of the bar.
4. Hang 9.89949 units of mass at point 0 and 13.37909 units of mass at point 2 and 6.40312 units of mass at point 7.
5. Find on the bar the point $\bar{z}$ where the set made of the bar and the hung masses is kept or maintained in equilibrium



5.6.Problem 6 : Determine the center O of the inscribed circle of the triangle ABC

located as follows. $A \begin{cases} A^h(1,3) \\ A^f(1,0) \end{cases}$ $B \begin{cases} B^h(7,2) \\ B^f(7,2) \end{cases}$ $C \begin{cases} C^h(10,10) \\ C^f(10,7) \end{cases}$

- Solution by calculation

Same as problem 5

- Solution by experimentation

Same as problem 5.

The center of the inscribed circle of the triangle ABC is the point O such that

$$O \begin{cases} O^h(\bar{x}, \bar{y}) \\ O^f(\bar{x}, \bar{z}) \end{cases} \Rightarrow O \begin{cases} O^h(5.64605, 4.05933) \\ O^f(5.64605, 2.41159) \end{cases}.$$

6. Conclusion

Our paper is entitled Solving by experimentation some problems of Statistics, Analytic geometry and Descriptive Geometry. We have determined by experimentation, as in a laboratory of Physics, the coordinates of the gravity center, and those of the center of the inscribed circle of a triangle in the plane, in the space and in Descriptive Geometry and the average of a statistics series.

This paper has made tangible the averages of a statistics series. We invite other researchers to explore possibilities of determining by experimentation other concepts of Statistics, Analytic Geometry and Descriptive Geometry.

References

- GUION, Cours de Géométrie Descriptive (méthode de Monge), tome I, A. De Boeck Bruxelles, 1967.*
- Dino MPAKASA KIBULU, Maitriser les Maths 6, Editions LOYOLA, Kinshasa, 2020.*
- Faustin NGOYI NGOYI, La géométrie descriptive par la méthode analytique, Editions Universitaires Européennes, Lettonie, 2019.*
- MINOR C. HAWK, Theory and Problems of Descriptive Geometry, Schaum's Outline Series, McGraw HILL BOOK COMPANY. 1962*
- MUSELU MUSWIYI, Dessin scientifique 3^{ème} scientifique, Centre de Recherche Pédagogique, Kinshasa, 1980.*

Article 24

Evaluation of the Use of Information and Communication Technology and Modernized Tools in Selected Rwandan Secondary Schools

Nkundabakura Pheneas, Nsengimana Theophile, Nsabayezu Ezechiel

University of Rwanda College of Education (URCE), Kayonza, P.O Box 55, Rwamagana, Rwanda

Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) Project, Kigali,

Rwanda3African Center of Excellence for Innovative Teaching and Learning Mathematics and Science

(ACEITLMS), Kayonza, Rwanda

ezechielsabayezu109@gmail.com

Abstract

The Rwanda Quality Basic education for Human Capital Development (RQBEHCD) Project, sub-component 1.2, funded by the World Bank Group, aims to strengthen science and mathematics instruction in upper primary through secondary schools. The purpose of this study is to evaluate the use of ICT tools and modernized resources by mathematics and science teachers upper primary through lower secondary schools in Rwandan. The study comprised 959 teachers selected purposively from 10 districts in Rwanda, with 300 from upper primary and 659 from lower secondary as participants of the study. Quantitative data was obtained using a classroom observation tool, and data was analyzed using MS Excel and SPSS. The analysis of the results from the study showed that secondary school teachers use the provided ICT tools at a rate of 65.5%, while it is 63% for primary school teachers. It was also found that secondary school teachers use resources provided by Rwanda Quality Education for Human Capital Development (RQBEHCD) at a rate of 65.5%, while primary school teachers use them at a rate of 63.00%. Furthermore, it was revealed that both upper primary and lower secondary mathematics and science teachers use ICT and modernized tools at 77.89% and 80.51%, respectively. However, there is no significant difference between upper primary and lower secondary schools in terms of using ICT and modernized tools ($F=1.067$, $df=957$, $p>.50$). Authors recommend

policymakers to support the use of ICT tools and modernized tools to improve the teaching and learning of Mathematics and sciences in Rwanda.

Keywords: Classroom observation; ICT-based tools; innovative teaching methods; modernized tools; RQBEHCD project.

Introduction

The government of Rwanda, through the Ministry of Education (MINEDUC) and the Rwanda Basic Education Board (REB) is implementing the “Rwanda Quality Basic Education for Human Capital Development” Project. One of the Project’s objectives is to enhance teacher effectiveness for improved student learning through Continuous Professional Development of Mathematics and Science teachers (Sub-component 1.2 in which the University of Rwanda College of Education (URCE) is partner in the implementation). In 2019, the Rwanda Quality Basic Education for Human Capital Development (RQBEHCD) project, facilitated through the World Bank Group, was implemented across primary and secondary schools in Rwanda. The project's overarching goals encompass improving teachers' competencies in science and mathematics, enhancing student retention, and elevating learning standards in basic education. This study focuses specifically on subcomponent 1.2 of the project, dedicated to supporting the professional development of Mathematics and Science teachers (World Bank, 2019). Geared towards educators in upper primary through lower secondary levels (P4-S3), this subcomponent targets the enhancement of teachers' content knowledge and pedagogical skills (MINEDUC, 2019).

Collaborative efforts involving RQBE and key government education organizations, including the Ministry of Education, Rwanda Basic Education Board (REB), University of Rwanda (UR), National Examination and School Inspection Authority (NESA), and Rwanda Development Board (RDB), underscore the comprehensive nature of the initiative. With a focus on modernized instructional tools, the project seeks to expand the use of scripted lessons, providing additional resources like laptops, projectors, formative assessment tools, and science kits to support practical teaching and learning in mathematics and science. Notably, the project actively champions gender equity by prioritizing women's involvement as trainers or trainees in the program, integrating gender-responsive pedagogy to eliminate biases in scripted lessons and exercises (World Bank, 2019). This

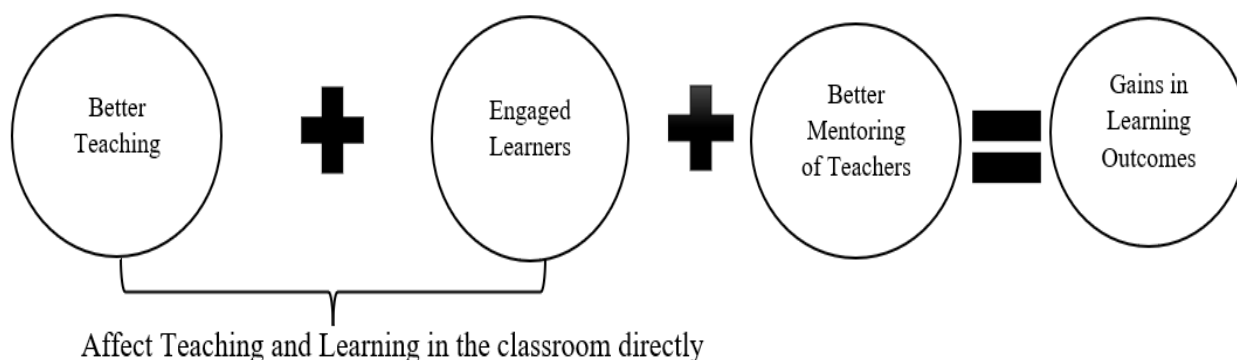
holistic approach addresses sociocultural barriers and promotes gender-inclusive teaching strategies, contributing to a more equitable and effective educational landscape. Toward more effective teaching, the project initiative emphasize on four channels: (a) increase teacher content knowledge; (b) improve classroom teaching practices; (c) ensure availability of critical teaching materials and ICT tools in the classroom; and (d) provide continuous support to teachers in their work. From September 2021, One Thousand One Hundred Seven (1107) S1-S3 STEM teachers and Five Hundred Twenty (520) Math and SET teachers have been trained on Innovative Teaching Methods for Mathematics and Science. After the training, teachers are expected to implement various skills they got from the training. By using different innovative teaching methods and different ICT tools, teachers are expected to show an improvement in their effectiveness in facilitating students' learning (Ratheeswari, 2018; Chitnis, 2016).

In this regard, the project has conducted a supportive field visit of the trained teachers in their respective schools. During the visits, lessons were observed and data on the effectiveness of the teachers were collected. The collected data have informed the project on the outcomes of the training and on what can be improved in the future trainings in other remaining districts of the intervention. The supportive field visit was done in different districts of Rwanda as the STEM trainees who pursue the programme of the project intervention were coming from. The visited schools and trainees are from Nyagatare, Gatsibo, Kirehe, Bugesera, Nyarugenge, Rulindo, Gakenke, Rutsiro, Muhanga, and Huye. Further, trainees from Model Schools of Rusizi, Nyamasheke and Rubavu were visited. This exercise was done from 20th to 24th June 2022; and from 27th to 29th June 2022. During the field visit, the team will meet with educational officials at the school, sector and district levels for discussions about the implementation of the project and on expected impact on the quality of education.

Theory of change

This project is anchored in the theory of change, as outlined by the World Bank in 2019. This framework proves instrumental in comprehending teachers' classroom practices and beliefs, offering a structured approach to aiding teachers in realizing their goals. The transformation of educational practices is envisaged through improved teaching, engaged learners, and enhanced teacher mentoring, all of which are anticipated to contribute positively to learning outcomes. Teachers participating in the project undergo training encompassing Content Knowledge, Pedagogical Knowledge, and the utilization

of ICT tools to elevate their teaching methods and foster increased engagement among learners (Bera, 2015). A teacher's adept understanding of Content Knowledge plays a pivotal role in mediating ideas, creating meaning, and subsequently influencing classroom practices (Krull et al., 2013). The interconnectedness of teaching methods, student engagement, and effective pedagogy is posited to result in improved learning outcomes. This study, aligned with the theory of change, seeks to establish conditions conducive to student success, emphasizing the importance of competent and continuously trained teachers who enter the profession with assured quality. The provision of ample instructional materials, equipment, and facilities for both teachers and students is identified as a crucial indicator for the successful transformation of educational practices, ultimately fostering positive outcomes through the implementation of a robust performance management system.



Research objective

This research seeks to investigate the utilization of contemporary tools and innovative teaching methods by teachers in the fields of mathematics and science at the upper primary and lower secondary school levels in Rwanda. The specific research objectives include:

1. To assess the application of modernized tools by mathematics and science teachers in upper primary and lower secondary schools.
2. To examine and compare the use of modernized tools in the teaching and learning of mathematics and science, considering variables such as gender, level, district, school ownership, type, and location.

Significance of the study

This study holds paramount importance for all individuals involved in the education sector. The findings will serve as crucial insights for curriculum designers and various

stakeholders responsible for developing modernized tools and structuring Continuous Professional Development (CPD) programs. The study is anticipated to serve as a dependable resource, equipping upper primary and lower secondary teachers with enhanced skills and knowledge about contemporary tools and innovative methods. The research outcomes are expected to contribute to the increased competence, and effectiveness of teachers in imparting mathematics and science education. As the primary implementers of educational programs, teachers stand to benefit significantly, gaining valuable insights to provide students with a quality education experience characterized by enhanced classroom interaction and engagement. Ultimately, students are poised to acquire a deeper understanding of mathematics and science through the adoption of modernized tools and pedagogical approaches facilitated by the study's recommendations.

Methodology

Research design

This study adopted a mixed observational survey design, a methodology involving the observation of subjects and phenomena in their natural settings. In the context of this observational study, researchers observed participants without providing guidance on the best approaches or behaviors to adopt (Fraenkel et al., 2012). The observational tool employed in this study seamlessly integrated both quantitative and qualitative research elements. This tool comprised 20 multiple-choice questions and an open-ended observational comment section, aiming to evaluate the implementation of modernized or electronic tools and innovative teaching methods by teachers in upper primary and lower secondary schools in Rwanda. Importantly, it's worth noting that these observations occurred post a comprehensive nine-month training program on the utilization of these tools and methods.

Sample and sampling technique

The focus of this study encompassed all mathematics and science teachers employed in both upper primary and lower secondary schools across Rwanda. Thus, this research involved a sample of 959 teachers, consisting of 300 from upper primary and 659 from lower secondary schools, selected from ten of Rwanda's 30 districts covered by the initial phase of the RQBEHCD project. The selection criteria were purposeful, focusing on teachers who had actively participated in the training under the RQBEHCD project and were affiliated with public or government-aided schools equipped with electricity. The

project's directive was for each school to nominate two teachers responsible for teaching science and elementary technology (SET) in upper primary and mathematics in the lower primary levels.

Data collection and intervention

The RQBEHCD initiative aimed at elevating the Content Knowledge and Pedagogy (CKP) of mathematics and science teachers in upper primary and lower secondary schools. In a collaborative effort between the Rwanda Basic Education Board (REB) and the University of Rwanda College Of Education (UR-CE), teachers underwent thorough training in two key modules. The first module focused on e-learning and ICT integration, with UR-CE lecturers developing scripted lessons accessible on the REB website. Teachers were introduced to online tools like GeoGebra and PhET simulations for enhancing SET and mathematics courses. The second module delved into subject-specific content, innovative pedagogy, and practical activities, including training on the 5Es instructional model and contemporary assessment tools such as pickers, voting cards, show-me boards, and exit tickets.

Data analysis

In the quantitative analysis, a dataset of 20 dichotomous data points, denoted as "yes" or "no," was utilized, with numerical values of 1 and 0 assigned to corresponding responses. Measures such as summation, mean, percentages, and standard deviation were applied to scrutinize each item's findings. After transferring data from KoboToolBox to MS Excel 2016, researchers assessed responses for each inquiry using inferential statistics with SPSS v.25. The primary goal was to organize and filter data collected during school visits by observers, ensuring alignment with the number of instructors observed. The COUNTIF function was employed to determine teacher counts, school types, locations, ownerships, and observer responses. For data analysis, the "COUNTIF" function calculated scores of "1" for accurate and "0" for erroneous answers, generating seven graphs covering topics such as resource use, district-wise comparisons, lesson planning, misconception identification, classroom interaction, assessment methods, and pedagogy use. SPSS was used to explore statistical significance in tool use and innovative methods based on gender and grade level. Thematic analysis of qualitative data focused on assessing teachers' facilitation of independent e-resource manipulation by students, anticipation of consequences before manipulation, and the availability of time for clarifications during classroom observations.

Ethical consideration

Ethical considerations were diligently addressed in the initial stages of this study. Prior to data collection, the Project Principal Investigator (PI) formally communicated with the Rwanda Basic Education Board (REB), seeking permission to conduct the study. The REB head office responded by issuing an approval letter, granting authorization for classroom observations. It is noteworthy that the participation of teachers in the study was entirely voluntary, with their informed consent obtained before proceeding with data collection.

Findings

As illustrated in Figure 1, a substantial 84% of teachers incorporate the use of a computer with a projector in their classroom instruction. Additionally, the study revealed that 56% of teachers make use of scripted lessons provided to them in their teaching practices. In terms of assessing lessons, approximately 57% of teachers employ various assessing tools, including plickers, voting cards, traffic lights, show-me-cards, and exit tickets. However, the findings indicate that a comparatively lower percentage, specifically 41% of teachers, manage to effectively engage their students in activities where they independently interact with electronic resources, predict outcomes before manipulation, and have the opportunity to pause resources or videos for content clarification. These statistics underscore both the prevalent integration of technology, especially computer and projector usage, in teaching practices and the existing variations in the utilization of interactive tools among teachers. The identified gap in engaging students directly with e-resources emphasizes an area for potential improvement and signifies a valuable focus for enhancing pedagogical approaches and fostering more interactive learning experiences.

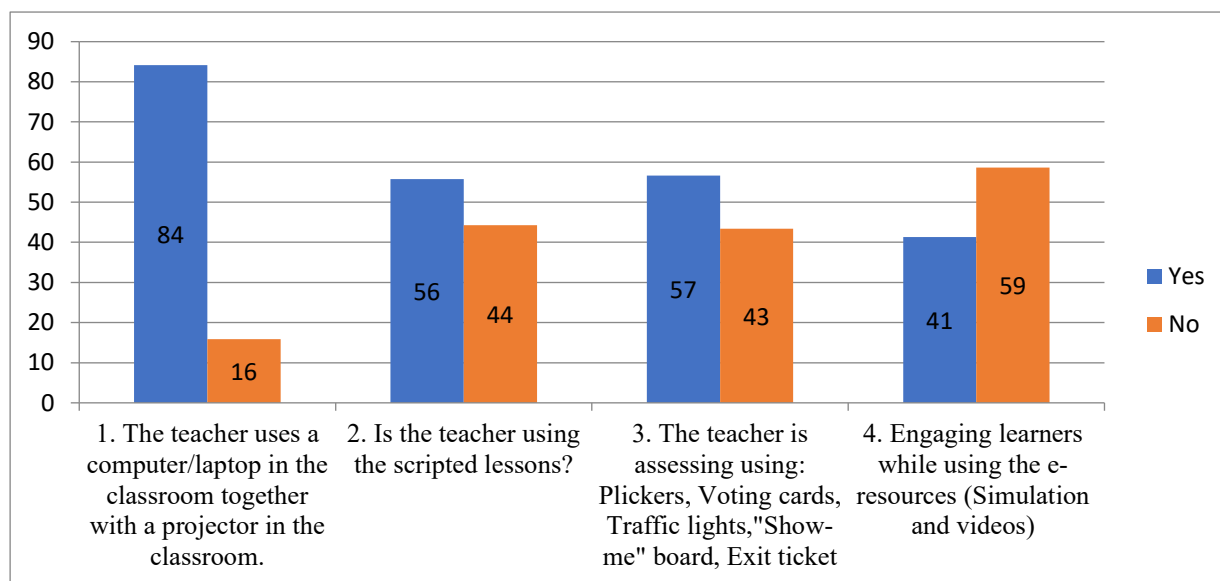


Figure 2 presents a comparative analysis of teachers' resource utilization across ten districts, each depicted distinctly. Among the surveyed districts, six demonstrated resource utilization rates above the established average of 50%. Notably, teachers in Gakenke and Muhanga districts stand out with resource utilization rates of 85% and 82%, respectively, reflecting a notably high engagement with provided instructional materials. In contrast, the remaining four districts (Rulindo, Kirehe, Huye, and Gatsibo) fell below the average, with Rulindo and Kirehe districts reporting resource utilization rates of 40% and 43%, respectively. This district-wise breakdown underscores substantial variations in the integration of provided resources into teaching practices. The stark differences between districts with high and low resource utilization rates suggest potential areas for targeted interventions or resource support in districts that lag behind. These findings emphasize the importance of considering regional disparities when devising strategies to enhance teachers' access to and utilization of instructional resources.

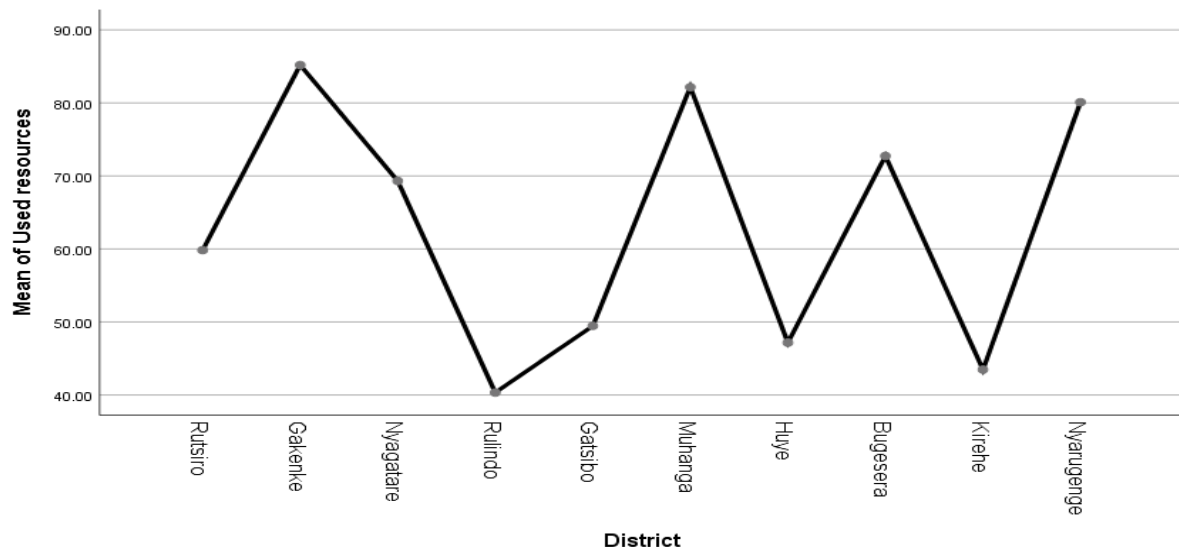


Figure 2: Comparison of teachers in the use of resources per district

Table 2 presents the descriptive statistics, specifically the mean and standard deviation, pertaining to the utilization of modernized tools and innovative methods in both primary and secondary schools. The study encompassed a total of 959 teachers, with 300 from the primary level and 659 from the lower secondary level. Notably, there exists a discernible difference in the mean scores between primary (73.8) and secondary teachers (76.3). Further scrutiny into the specific categories of resources used revealed that secondary teachers employed provided resources with a mean score of 65.5, whereas primary teachers employed them with a slightly lower mean score of 63.00. These statistics provide valuable insights into the prevalence and variance in the adoption of modernized tools and innovative methods between primary and secondary school teachers. The nuanced differences in mean scores shed light on potential areas for targeted intervention or improvement, suggesting avenues for refining educational strategies at both levels.

	Teaching and learning	Grade Level	N	Mean	Std. Deviation	Std. Error Mean
Modernized tools	Using pedagogical resources	Primary	300	63.1111	32.97391	1.90375
		Secondary	659	65.4527	33.00563	1.28572
	Using of ICT resources	Primary	300	40.6667	49.20324	2.84075
		Secondary	659	41.1229	49.24304	1.91824

In analyzing the data based on the districts where teachers conduct their classes, a one-way analysis of variances revealed a highly significant difference ($F=9.253$, $df=952$, $p<.001$) across districts, primarily attributed to variations in school location. Subsequent independent t-tests demonstrated a statistically significant difference ($t=1.983$, $df=954$, $p<.05$) in overall scores (20 items of classroom observation tool used) in favor of teachers in urban schools ($M=78.55\%$, $N=128$). This significance extended to the pedagogical domain overall ($t=1.956$, $df=954$, $p<.05$), specifically in lesson planning ($t=3.503$, $df=954$, $p<.001$), and in classroom interaction ($t=2.547$, $df=954$, $p<.05$). The findings indicate that urban schools tend to exhibit a higher prevalence of effective lesson planning and classroom interactions compared to their rural counterparts. Examining the impact of grade levels on pedagogy, a statistically significant difference ($t=-2.028$, $df=957$, $p<.05$) was observed, with secondary school teachers scoring higher at 80.51% ($N=659$) compared to primary school teachers at 77.89% ($N=300$). Secondary school teachers also demonstrated a notable advantage in identifying and addressing students' misunderstandings ($t=-2.260$, $df=957$, $p<.05$), with a mean of 74.50% compared to 69.33% for primary school teachers. Furthermore, a significant difference ($F=2.679$, $df=957$, $p<.05$) was identified in student engagement, favoring secondary school teachers (mean score of 75.82%) over primary school teachers (mean score of 70.11%). However, no significant differences were found in the variables of school ownership, school type, and gender concerning the use of provided resources, pedagogy, and the utilization of ICT in teaching and learning mathematics and science.

Discussion

This study evaluates the implementation of modernized tools and innovative teaching methods in the context of mathematics and science education in upper primary and lower secondary schools across Rwanda. The examination incorporates diverse teacher demographics, such as geographical location, gender, educational levels, school type, and ownership. The findings indicate widespread use of modernized tools, including computers, projectors, scripted lessons, and assessment tools, among teachers in various districts. Notably, the study underscores that while teachers from six districts exhibit commendable usage rates above 50%, there is room for improvement in engaging students with e-resources, possibly influenced by concerns about potential damage or misuse by students, as well as student apprehension in interacting with ICT tools. The study identifies a relatively low utilization rate of ICT resources, such as projectors,

simulations, animations, and plickers, in both primary and secondary schools, with infrastructure limitations and insufficient tools being contributing factors. The research reveals no statistically significant differences in the use of modernized tools based on gender, educational levels, or geographical location of the schools. However, it uncovers statistically significant distinctions based on school location and grade levels, with urban schools and secondary school teachers demonstrating higher levels of preparedness and interaction in the classroom, possibly influenced by better infrastructures and higher qualifications. Notably, the input from the RQBEHCD project is acknowledged for its transformative impact on teachers, evident in consistent classroom practices across various variables.

Our research aligns with the conclusions drawn by Rubagiza et al. (2011), as it similarly underscores the substantial role of Information and Communication Technology (ICT) in advancing education quality in Rwanda. Our findings echo the recommendation to further elevate the level of ICT utilization in the educational context (Saravanakumar, 2018). This consistency in results emphasizes the importance of integrating ICT into educational practices in Rwanda, highlighting its potential to enhance the overall quality of education (Jazeel & Lanka, 2020). Our findings align also with Tosun and Bariş (2011) research, demonstrating that the integration of Information and Communication Technology (ICT) not only fosters enthusiasm among students and educators but also serves as a positive motivator for students. The utilization of ICT, particularly when actively integrated with the World Wide Web (www), proves to be a substantial catalyst in the restoration and advancement of education (Ratheeswari, 2018). To achieve effective integration, it is imperative to establish a robust hardware platform and prioritize comprehensive training for educators. Afshari *et al.* (2009) found that computer technology effectively widens educational opportunities; however, a substantial number of teachers neither employ it as a primary instructional tool nor seamlessly integrate it into their curriculum. Studies reveal diverse factors influencing teachers' decisions on information and communication technology (ICT) use, encompassing non-manipulative and manipulative school and teacher-related factors (Jo Shan Fu & Fu, 2013). Ongoing professional development is essential to empower teachers in modeling new pedagogies and leveraging technological tools for an enhanced teaching-learning process (Malik, 2022). It is crucial for teacher trainers and policymakers to comprehend the factors

affecting the effectiveness and cost-effectiveness of different ICT integration approaches in teacher training, ensuring the viability of widespread changes (Saxena, 2017).

Conclusion

This study focuses on assessing the utilization of modernized tools and innovative teaching methods in mathematics and science subjects at the upper primary and lower secondary school levels in Rwanda. It delves into the proficiency of teachers in employing these tools, aiming to enhance their productivity, competence, and effectiveness in teaching. Both primary and secondary school teachers were observed to incorporate modernized tools and innovative teaching methods, with inferential statistics revealing no statistically significant differences based on grade level, gender, or the geographical location of the school. The majority of teachers in both upper primary and lower secondary schools were found to utilize these tools, emphasizing the widespread acceptance and application of such methods. Despite the positive findings, the study notes areas for improvement, particularly in the integration of Information and Communication Technology (ICT) resources. While ICT was integrated into the teaching of mathematics and science, there is a recognized need for enhanced efforts to elevate teachers' competence in exploring and utilizing these resources. Notably, the study identifies gaps in teaching practices, including the limited allowance for student manipulation of instructional materials, the infrequent use of assessments involving higher-order thinking skills, the delayed provision of immediate feedback, and insufficient time allocated for discussions and questions to deepen understanding. These findings underscore the importance of ongoing efforts to implement modernized tools and innovative methods in education, urging policymakers to prioritize these aspects for an enhanced instructional process.

Acknowledgement

Gratitude is extended for the invaluable support rendered by the lecturers at URCE and the students from the African Center of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) who actively participated in the data collection process. The funding for this project was made possible through a collaborative agreement between the Government of Rwanda and the World Bank Group.

References

Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2009). Factors Affecting

- Teachers' Use of Information and Communication Technology. Online Submission, 2(1), 77–104.*
- Bera, S. (2015). *Enhancing Quality of Teaching Learning By Using Information and Communication Technology (Ict). In srjis/bimonthly/ saradindu bera & ramakanta mohaliK (Issue September 2020). www.srjis.com*
- Chitnis, R. (2016). *Impact of Ict on Education. Elk Asia Pacific Journal of Electronics and Communication Technology, 2(2), 337–347. www.elkjournals.com*
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to Design and Evaluate Research in Education (8th ed.). McGraw Hill.*
- Jazeel, A. M., & Lanka, S. (2020). *Educational technological vision on distance mode (dm) in teacher education programme (TEP). Global Web Conference on Multidisciplinary Research and Development GWCMRD - 2020 PROCEEDINGS, October.*
- Jo Shan Fu, ., & Fu, J. S. (2013). *ICT in Education: A Critical Literature Review and Its Implications. International Journal of Education and Development Using Information and Communication Technology, 9(1), 112–125.*
- Krull, E., Koni, I., & Oras, K. (2013). *Impact on student teachers' conception of learning and teaching from studying a course in educational psychology. Asia-Pacific Journal of Teacher Education, 41(2), 218–231. https://doi.org/10.1080/1359866X.2013.777026*
- Malik, S. (2022). *Role of ict in improving the quality of education role of ict in improving the quality of education view project. International Journal of Novel Research and Development, 7(6). www.ijnrd.org*
- Ratheeswari, K. (2018). *Recent Trend of Teaching Methods in Education" Organised by Sri Sai Bharath College of Education Dindigul-624710. India Journal of Applied and Advanced Research, 2018(3), 45–47. https://doi.org/10.21839/jaar.2018.v3S1.169*
- Rubagiza, J., Were, E., & Sutherland, R. (2011). *Introducing ICT into schools in Rwanda: Educational challenges and opportunities. International Journal of Educational Development, 31(1), 37–43. https://doi.org/10.1016/j.ijedudev.2010.06.004*
- Saravanakumar, A. (2018). *Role of ICT on improving quality of education. International Journal of Innovative Science and Research Technology, 3(12), 717–719. www/lifelearners.net.com*
- Saxena, N. (2017). *the Role and Impact of Ict in Improving the Quality of. International Journal of Engineering Sciences & Research Technology The, 6(3), 501–503.*

- Tosun, N., & Bariş, M. F. (2011). *Using information and communication technologies in school improvement. Turkish Online Journal of Educational Technology*, 10(1), 223–231.
- Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2009). *Factors Affecting Teachers' Use of Information and Communication Technology. Online Submission*, 2(1), 77–104.
- Bera, S. (2015). *Enhancing Quality of Teaching Learning By Using Information and Communication Technology (Ict). In SRJIS/BIMONTHLY/ SARADINDU BERA & RAMAKANTA MOHALIK (Issue September 2020). www.srjis.com*
- Chitnis, R. (2016). *Impact of Ict on Education. Elk Asia Pacific Journal of Electronics and Communication Technology*, 2(2), 337–347. www.elkjournals.com
- Jazeel, A. M., & Lanka, S. (2020). *Educational technological vision on distance mode (dm) in teacher education programme (TEP). Global Web Conference on Multidisciplinary Research and Development GWCMRD - 2020 PROCEEDINGS, October.*
- Jo Shan Fu, ., & Fu, J. S. (2013). *ICT in Education : A Critical Literature Review and Its Implications. International Journal of Education and Development Using Information and Communication Technology*, 9(1), 112–125.
- Malik, S. (2022). *Role of ict in improving the quality of education role of ict in improving the quality of education view project. International Journal of Novel Research and Development*, 7(6). www.ijnrd.org
- Ratheeswari, K. (2018). *Recent Trend of Teaching Methods in Education" Organised by Sri Sai Bharath College of Education Dindigul-624710. India Journal of Applied and Advanced Research*, 2018(3), 45–47. <https://doi.org/10.21839/jaar.2018.v3S1.169>
- Rubagiza, J., Were, E., & Sutherland, R. (2011). *Introducing ICT into schools in Rwanda: Educational challenges and opportunities. International Journal of Educational Development*, 31(1), 37–43. <https://doi.org/10.1016/j.ijedudev.2010.06.004>
- Saravanakumar, A. (2018). *Role of ICT on improving quality of education. International Journal of Innovative Science and Research Technology*, 3(12), 717–719. www/lifelearners.net.com
- Saxena, N. (2017). *the Role and Impact of Ict in Improving the Quality of. International Journal of Engineering Sciences & Research Technology The*, 6(3), 501–503.
- Tosun, N., & Bariş, M. F. (2011). *Using information and communication technologies in*

school improvement. Turkish Online Journal of Educational Technology, 10(1), 223–231.

World Bank. (2019). Rwanda Quality Basic Education for Human Capital Development Project (Patent No. PAD3212). In The World Bank (No. PAD3212).

Article 25

Professional Development of Teachers in STEM Education in Mozambique

Damasco Rocha Mateus Chalenga, Emília Maria José Guiraguira, Sarifa Abdul Magide Fagilde

Doctoral Student of the Program of Mathematics and Science Education at Universidade Pedagógica de Maputo and
lecturer at Academia Militar Samora Moisés Machel

Vice President of SMASE- Africa, Vice Rector and lecturer at Universidade Rovuma and lecturer of the Program of
Mathematics and Science Education at Universidade Pedagogical Maputo

Abstract

In the past decades, reform initiatives have been taking place in education, aiming to integrate STEM (Science, Technology, Engineering and Mathematics) approaches in the classrooms, which obviously have implications for teaching practices. The integration of the STEM approach in Mozambique appears implicitly in curriculum plans, but is not accompanied by teacher professional development training programs. This paper presents how teachers, considered as key elements for implementing any pedagogical proposal, are implementing this approach in Basic Education, in grades 7-9, in the cities of Lichinga and Nampula, in Mozambique. The study used a qualitative approach of an interpretative nature. Based on data collected from interviews and questionnaires with teachers, it was possible to realize, that teachers are not prepared to implement the integrated STEM approach and they teach the content of each subject as an independent one. In the face of the current situation, it is suggested that teacher training be promoted in STEM areas, so that they acquire specialized knowledge, with a view to transforming their practices and visions in the classroom context. This training should be designed including better teaching practices and real-life scenarios as a way of motivating students to seek solutions to society's problems.

Keywords: Professional development; Teachers; STEM Education; Basic Education.

Introduction

The nature of teaching activity requires teachers to engage in a process of professional development that, according to Day (2001), must be continuous throughout their career, given the demands of the profession itself and the need for change and innovation in

school environments. This engagement should provide teachers with the opportunity to achieve teaching objectives by carrying out innovative and qualified practices in the classroom, taking into account the evolution of knowledge about what is taught and how it is taught.

Today's society is in a process of accelerated transformation and constant change, which in a way causes changes in the educational systems of different countries, making it necessary to develop new skills and abilities to cope with teaching activities.

In this context, the professional development of teachers transcends the individual level to the collective when considered as a continuous and dynamic phenomenon, Richit (2021), constituting a central component of proposals to improve education (Guskey, 2002), as it can be seen as a long-term process, experienced by the teacher in interaction with the school environment, through formal and informal experiences, with a view to improving their practices and promoting educational changes to benefit the school community (Marcelo, 2009).

Among several motivations for carrying out this study is the concern with the path that science and mathematics teaching has taken, taking into account the integration of the STEM approach in the Mozambican educational context and the professional development of the teacher in this area of activity.

It is from this perspective that we establish a bridge between the Teacher's professional development and the implementation of the STEM approach in Mozambican schools that teach basic education from grades 7 to 9, with the purpose of understanding the level of application of the STEM approach in Basic Education in Mozambique, in a context of professional development for Natural Sciences and Mathematic teachers.

To achieve this main objective, the following specific objectives were defined: Assess the level of teacher participation in continuing training courses and possible contributions to their teaching activity; Identify the mastery that Science and Mathematics teachers have over the STEM approach in Basic Education in Mozambique; Describe teachers' perceptions about the implementation of professional development programs in STEM areas.

Methodology

The present research is a case study, characterized by a predominantly qualitative approach, of an exploratory nature, in which the participants were basic education teachers from grades 7 to 9, in the cities of Lichinga and Nampula in Mozambique. In each of the cities, three primary schools were chosen and six teachers were randomly selected to participate in the interview, from a total of 54 Science and Mathematics teachers who responded to a survey with semi-closed questions. Of the 54 participants in this research, 78% were male and 22% were female. The majority of participants have a bachelor's degree, 83% of which are 9.3% Masters and 7.4% High School, with 10 to 15 years of teaching experience. The data produced from the survey and interview were systematized using a Microsoft Excel spreadsheet and analyzed in a qualitative and quantitative way.

Literature review

Assumptions of continuous teacher training and its contribution to education

Before talking about ongoing teacher training, we believe it is relevant to understand what teacher education and training is. Generally speaking, training in countries such as France and Italy is understood as education, teaching, preparation, etc.; In English-speaking countries, the term education (*Teacher Education*) or training (*Teacher training*) is preferred. Whatever the point of view, it is a development process in which the individual searches for their identity in accordance with some sociocultural principles or realities (Garcia, 1999) In other words, it is a process of individual development, aimed at acquiring or improving capabilities.

Another point of view is that of Garcia (1999, p. 20) who defines training as “the ability to transform events that generally occur in everyday life into meaningful experience, with a personal and collective project as its horizon”. From this perspective, trainees can find learning contexts that promote personal and professional progress.

Therefore, teacher training represents a dimension of teaching, seen as an intentional activity, which is developed with the aim of contributing to the professionalization of those responsible for educating new generations (Garcia, 1999). In Mozambique, teacher training for the different Education subsystems is provided by Teacher Training Institutes for Primary Education and by Public and Private Universities for Secondary Education.

Training, also means continuing initial training, as it is an uninterrupted and permanent process of development, taking into account that education is a process in which at any moment there is something new, since knowledge is not something ready and finished (Benedita & Costa, 2016) .

Taking into account the existence of differentiated teacher training models, the Education Strategic Plan (2020-2029) recommends the need for practicing teachers to benefit from continuous training, supervision and pedagogical support, and to this end professional development programs should be carried out for teachers from all subsystems (MINEDH: 2020).

In this context, continuous teacher training was desirable not to be treated as an occasional process or to solve a certain initial training problem, but rather as an integral part of the teacher's professional practice, for the consolidation of theoretical-practical knowledge.

Given the importance of pedagogical training programs for teachers' professional development, they must be focused on the reality of the school and the real needs of teachers, as one of the biggest challenges experienced in all subsystems is the need to improve the skills of these professionals. As mentioned (Marcelo, 2009), the most effective experiences for teacher professional development are those that are based in the school and that are related to the daily activities carried out by teachers.

From the same perspective, Fuhr (2015, p.25) states that when the school becomes a training space, it enables the creation of knowledge networks among teachers, with the opportunity to exchange lived experiences and consequently, favors the development of professional skills.

In Mozambique, more investment has been made in initial teacher training to the detriment of ongoing training for in-service teachers. Considering that professional development presupposes an approach to teacher training that values its contextual, organizational and change-oriented nature, it is essential to ensure the continuous training of teachers in order to promote their professional development so that they can respond to the demands of the Basic Education curriculum (I cycle of Secondary Education in light of Law 18/2018, of December 28), MINEDH (2020). Therefore, training teachers in the performance of their duties is one of the fundamental aspects of professional development.

Professional development of Teachers in STEM in the Mozambican context

Currently, Mozambican schools are challenged to promote teaching based on the STEM approach, an integrative and student-centered approach, in which the teacher assumes the role of organizer and mediator of the teaching-learning process. In STEM education, an integrated approach must include real-world scenarios with the aim of engaging students and providing them with meaningful learning, (Kelley & Knowles, 2016), which can become a challenge for teachers when they are not subjected to training for this purpose.

To face this challenge, it is pertinent to monitor the teacher's professional development, which, according to Day (2001), includes continuous training, attendance at courses, situated in a broader learning context. Therefore, both in initial training and in, in-service training, it is essential to change teaching paradigms and methodologies, in order to ensure that content is approached in an interdisciplinary way, leading students to acquire skills to solve daily problems.

The change referred to the above is only possible if teacher development is ensured, as teachers will only be able to achieve educational objectives if they have adequate training and if they are able to guarantee and improve their professional contribution through commitment to lifelong learning. throughout his career (Day, 2001). This author also states that professional development also involves spontaneous learning experiences and consciously planned activities, which contribute to the quality of teaching.

Following the previous reasoning, the professional development of teachers in STEM areas in Mozambique becomes crucial for the success of the STEM approach in the Teaching and Learning process, as according to MCTES (2021), teachers are fundamental elements in any process of pedagogical innovation insofar as innovations must be appropriated by those who implement them in order to impose changes in teaching practices.

According to MINEDH (2020), the creation of a pedagogical culture and autonomy of the teaching class is a concern for the professional development of teachers, which presupposes the capacity for individual and collective self-improvement.

Nivagarra (2013) points out training of teachers in various models and the lack of unification of these training models, as factors that can contribute to the lack of autonomy

in the exercise of professional activity and opportunities for continuous self-training throughout the professional career.

Thus, with professional development, the teacher builds and rebuilds his knowledge, over time, providing him with skills to face the various challenges experienced in the educational area and beyond. It is in this context that Fullan (1995) also sees professional development as an element that includes any activity or process that seeks to improve the teacher's skills, attitudes, understanding or performance in current or future roles.

For Ponte (1997), professional development concerns “aspects linked to teaching, but also to more general educational action, personal and relational aspects and interaction with other teachers and the extra-school community” (p. 44). In this perspective, the teacher not only assumes the role of mediator of the teaching-learning process, but also contributes to a more dynamic school, actively participating in reflection on strategies for implementing school projects, such as new teaching methodologies, changes to curricular materials, among others.

To boost the professional development of teachers in STEM areas in Mozambique, the Ministry of Science, Technology and Higher Education, in coordination with the Ministry of Education and Human Development, designed a training program for trainers (PCFP) in STEM, which trained in their pilot phase, 60 trainers at national level, and the implementation of the second phase of the program is being prepared, which will cover Secondary Education teachers, starting in 2023 and ending in 2025 (MCTES, 2022), with the purpose of providing teachers in the areas of STEM, skills necessary to face the challenges of the 21st century.

Thus, the second phase of training will be the responsibility of public and private Higher Education institutions that train teachers in STEM areas (MCTES, 2022). However, implementing the PCFP in STEM is not an easy task as it requires commitment and participation from everyone involved in the process, considering the involvement of several public and private sector institutions from the different education subsystems and the various activities on STEM education to be developed.

Results and discussion

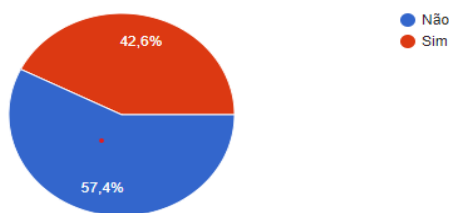
Level of participation of teachers in continuous training and contribution to their activity

To understand the level of participation of teachers in continuous training courses and possible contributions to their teaching activity, some questions were asked from the

survey with teachers, seeking to know whether in the last two years they had participated in any course or pedagogical training and in a few words to describe their contribution to the performance of their duties.

The answers to the questions revealed that 57.4% of participants had never benefited from any course or pedagogical training (see figure 1). However, 42.6% participated in some training with emphasis on teaching and assessment methodologies, lesson planning, use of digital technologies in PEA, early marriages, psychosocial support in times of humanitarian crisis, managers for distance learning, implementation of the new general secondary education curriculum and the teacher's professional ethics.

Figure 1: Level of participation in courses or pedagogical training.



The existence of a higher percentage of teachers who did not benefit from any course or training over the last two years is worrying. Nivagarra (2013) highlights the importance of these trainings, as he understands that continuous training courses or training of in-service teachers, are highly valued by teachers as they consider the topics relevant and contribute to the exchange of information and support between participants.

Regarding the usefulness of the training that teachers have benefited from throughout their careers, 55% of research participants consider them relevant for teaching classes, as can be seen in the statements below:

- ✓ *Yes, it has been useful in that the training provided tools that help to improve teaching activities;*
- ✓ *I was equipped with various information and tools that are helping me during my work activities;*
- ✓ *Use of the participatory method. Think, share and present;*
- ✓ *Helps in preparing classes and approaching content, in assessment and how to look at the student as someone who needs us to learn;*
- ✓ *Through knowledge it has been possible to support students and overcome certain difficulties;*

- ✓ *During the training there was a review of teaching methodologies and techniques, which at some point has escaped our minds and, not only in that, there was also sharing of teaching means and materials;*
- ✓ *They help to streamline the teaching process with the implementation of new methodologies.*

The statements above show the relevance of carrying out courses or pedagogical training for in-service teachers with a view of improving their teaching skills, which in a certain way would contribute to their professional development. In this line of thought, Deixa, Chicote & Calisto (2020), legitimize the above by stating that professional development can be enhanced through training actions where teachers can discuss issues that concern them and is reflected in a set of activities, teaching practices and actions that determine the professionalization of the teacher.

However, 45% of participants consider that the courses and training in which they were involved are not useful in their teaching activity due to the fact that some courses are not directly linked to the teaching and learning process, as well as the lack of means for implementation.

Mastering the STEM approach in Basic Education

One of the concerns of this study has to do with the dominance, that Science and Mathematics teachers have over the STEM approach in Basic Education in Mozambique, as it has been implemented in several countries. Our intention was to understand whether teachers are aware of this approach and apply it to teaching their classes.

The participants' responses revealed that, of the 54 teachers surveyed, 20 corresponding to 37% had heard of the STEM approach. Regarding participation in some training on the STEM approach in teaching Science and Mathematics, of the 54 respondents, only 6, corresponding to 11%, reported having participated and that they use this approach in their teaching (as illustrated in figures 2 and 3), but According to the results of the analysis in this group of questions, it allowed us to understand that they have difficulty explaining what this teaching approach consists of.

Fig 2: Have you already had training in a STEM approach?

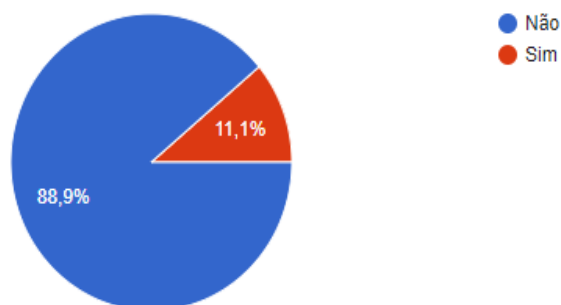
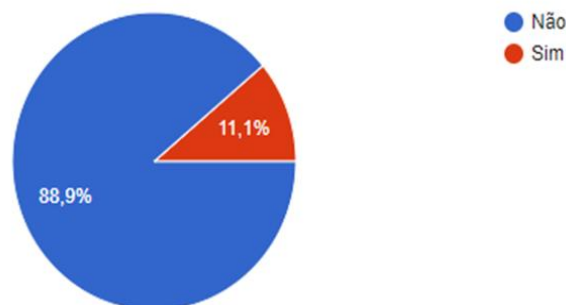


Fig 3: Do you use a STEM approach in your teaching?



Although some Basic Education teachers have received training in the STEM approach, the rates of training and application in the classroom are very low, which means that there is a need for massing pedagogical training in this area.

Teachers' perception of professional development in STEM areas

The questions asked at this point of approach focused on gathering teachers' sensitivities about the implementation of professional development programs in STEM areas. When asked about some experiences with the integrated approach, 47 teachers of those surveyed, corresponding to 83%, reported that they did not have experiences related to integrated teaching throughout their careers, although it is recommended in the Secondary Education Curriculum Plan.

These results become worrying as it was expected that teachers would have had training related to this type of content approach, to comply with the General Secondary Education Curriculum. Of the 7 participants corresponding to 17% who reported having had experiences with integrated teaching, only 2 were able to present examples that fit the STEM approach.

Taking into account that one of the characteristics of the STEM approach is interdisciplinarity, a question was asked in order to find out whether science and mathematics teachers have carried out practical activities that allow for an interdisciplinary approach, and it was found that 24 corresponding to 44.4% have done it and 30 corresponding to 56.6% do not do it.

Some examples presented by teachers who stated that they use the interdisciplinary approach in the classroom led us to realize that it is urgent to carry out pedagogical

training to provide teachers with specific skills on interdisciplinary approaches in teaching science and mathematics, as can be seen in the testimonials below:

- ✓ *When we talk in physics about bodies in free fall, we take students outside the class and use a rock to serve as an example in our class;*
- ✓ *In classes I have guided work on producing posters that are used in biology, chemistry, physics classes and more...*
- ✓ *I show my students that mathematics consists of all areas;*
- ✓ *I have been doing some experiments related to different contents in the process of teaching and learning;*
- ✓ *When talking about homogeneous and heterogeneous mixtures with their separation methods;*
- ✓ *I use Geogebra in my classes;*
- ✓ *I carry out experiments on some chemical components;*

When bridging the question about teacher training, it is clear that the fact that these teachers have not had training in the last two years may be behind the difficulties in using interdisciplinary practices in the classroom, which may negatively influence the professional development of them.

When questioning about integrated teaching and interdisciplinarity, the aim was to assess the extent to which teachers carry out actions that lead them to meet the assumptions of STEM approach, where it was realized that from the results that the implementation of this approach in schools is still a Utopia. However, there is an understanding of the need to boost professional development through courses and training for teachers in subjects related to STEM, as, according to Moreira (2018), the lack of investment in the professional development of teachers in STEM is a barrier to the success of this area.

In this line of approach, Richit (2021) states that professional development involves initial training, the teacher's daily professional activities, their personal experiences, their beliefs and dispositions, as well as various training experiences throughout their career (courses attended, participation in events, socialization of classroom experiences and reflection on teaching), promoting the teacher's personal and professional growth and fostering changes in practice.

Regarding contextualization in the teaching of science and mathematics, 47 respondents, corresponding to 83%, reported that they have related the content to the day-to-day lives of their students, which is positive looking at some examples presented:

- ✓ *When selecting methods for separating mixtures, in heterogeneous mixtures, for example after pillaring the corn, there are grades of corn and bran that are separated using a sieve;*
- ✓ *When teaching negative integers, we use debts as an example;*
- ✓ *When we talk about magnetism, students use magnetism day after day, which is why the student himself ends up being the center of learning for what he experiences at home and what he learns;*
- ✓ *When I talk about the topic "solutions" I relate it to the tea that the student drinks daily;*
- ✓ *In geometry classes, I relate triangles, squares and rectangles and the roofs of houses;*

However, this practice should be encouraged more as it is fundamental to the success of learning.

Asked what should be done to boost teachers' professional development, the research participants put forward some proposals to address this process in their schools. Here are some testimonials:

- ✓ *Carrying out frequent training covering various contents in the teaching area;*
- ✓ *Regular refreshers in pedagogical didactic aspects to overcome professionals' didactic insufficiencies;*
- ✓ *At my school there must be a laboratory and a library to boost my professional development;*
- ✓ *There must be training to implement STEM;*
- ✓ *Provide training on new ways of teaching across subject groups;*
- ✓ *Regular refreshers (continuous teacher training);*
- ✓ *Creation and equipping of computer laboratories, applied mathematics, physics, chemistry, etc.;*
- ✓ *Greater support in the development of training initiatives in natural science disciplines.*

The proposals presented by the research participants are in line with Moreira's (2018) reflection, when he states that the teacher training policy must clearly define the relationship between continuous training and professional development of teachers.

With the results of the research, it was clear that pedagogical training and qualifications are fundamental actions to boost professional development, followed by equipping schools with libraries, laboratories and the allocation of various teaching materials. From this perspective, with training actions the teacher is given space to reflect, share, deepen and (re)signify knowledge, expand beliefs and dispositions as well as experiment with new practices (Hargreaves, 1995 cited in Richit, 2021).

Final considerations

The analysis and discussion of the results presented throughout this research and according to the objectives whose content is based on understanding the level of implementation of the STEM approach in Basic Education in Mozambique, in a context of professional development of Natural Sciences and Mathematics teachers, allowed us conclude that:

- Teachers have few opportunities to participate in pedagogical courses or training and that, the few who participate, have not made a significant contribution in the classroom, since some courses are not directly linked to the teaching and learning process.
- There is poor knowledge of STEM approach, due to the low rate of training of in-service teachers in this area, which compromises its implementation in the classroom.
- There is a crisis in continuous teacher training, that allows professional development in STEM areas, which means that there is a need for mass pedagogical training in this area;

For the implementation of the STEM approach to be successful in Mozambican schools, it is important that continuous training strategies are designed to address the professional development of teachers through innovations in pedagogical practices, recognizing teaching as an indispensable part of the process and the teacher as the key element to success. From this perspective, it is pertinent that teachers distance themselves from classical teaching and start implementing integrated teaching, relating content to the real world.

References

- Benedita, A., & Costa, P. (2016). *Continuing training for teachers. Union contributions towards quality education*. <https://comum.rcaap.pt/bitstream>
- Leave it, VG; Chicote, RS & Calisto, SF (2020). *The first steps in the teaching career: a study with Mozambican teachers*. RPD, Uberaba-MG, v.20, n.45, p.01-13, Sept./Dec.
- Day, C. (2001). *Teachers' professional development: Learning challenges*.
- Deixa, V.G.; Chicote, R.S & Calisto, S.F. (2020). *The first steps in the teaching career: a study with Mozambican teachers*. RPD, Uberaba-MG, v.20, n.45, p.01-13, Sept./Dec.
- Führ, R. C. (2015). *The collective construction of the school as a training space*. Curitiba, Brazil: Appris.
- Fullan, M. (1995). *The school as a learning organization*. *Theory Into Practice*, 34(4), 230–235.
- Guskey, T. (2002). *Professional Development and Teacher*. *Teachers and Teaching: theory and practice*, 8(3/4), 381-391.
- Garcia, C. M. (1999). *Teacher Training: For educational change*; Harbor; Porto Editora.
- Kelley, T.R.; Knowles, J. G. (2016). *A conceptual framework for integrated STEM education*. *International J.STEM Educ.* 3, 11. Permanent. Porto: Porto publisher.
- Marcelo, C. (2009). *Teacher Professional Development: past and future*. *Sisyphus. Revista de Ciências da Educação*, 08, pp. 7-22.
- MCTES. (2022). *STEM Teacher Trainer Training Program & Implementation Mechanism*. Maputo.
- MINEDH. (2020). *Strategic Education Plan 2020- 2029*. Maputo
- Moreira, MA (2018). *Teaching STEM (Science, Technology, Engineering and Mathematics) in the 21st century*. *Brazilian Journal of Science and Technology Teaching*, v. 11, no. two.
- Nivagara, D. (2013). *Teacher training and professional development: a critical analysis of their practice in the context of Mozambique*. *EDUCAmazônia Magazine – Education, Society and Environment*. ISSN 2318-8766 (digital version). Year 6, Vol XI, No. ².
- Richit, A. (2021). *Professional development of teachers: a theoretical framework*. *Research, Society and Development*, vol. 10, no. 14. DOI: <http://dx.doi.org/10.33448/rsd-v10i14.22247>
- Ponte, J.P. (1997). *The professional knowledge of mathematics teachers (Final Project Report "Teachers' knowledge: Conceptions and practices")*. Lisbon: DEFCUL.

Article 26

What constitutes Science, Technology and Mathematics in Botswana Pre-Schools, and how does it look like in the classroom?

Chako G. Chako

Ministry of Basic Education, Botswana.

Chakocg@gmail.com; cchako@gov.bw

Abstract

The study reports on an ongoing research that explores Pre-School Science, Technology, Engineering and Mathematics (STEM) in Botswana. Recently, Botswana's education system recognized and incorporated Pre-School education into her basic education system. Since 1996, Pre-School education was offered by private schools to those who could afford costs. The Botswana government did not consider Pre-School education a necessary requirement for entrance into public primary education. A major hindrance was lack of resources such as trained personnel and availability of resources. However, evidence from research has since influenced education policy makers in Botswana to consider Pre-School essential and foundational to further learning at primary school level. In Botswana's basic education system in (which year?).. It is believed that provision of free Pre-School education to all Botswana children in public schools will provide access to quality and equitable education. The incorporation was also seen as a strategy to transform Botswana's economy from mineral based to knowledge-based. While we do know a lot from international research focused on Pre-School education, in Botswana, our research in this phenomenon is emergent. Hence, the need to conduct this study. In particular, the study will focus on what and how STEM subjects. Pre-school curriculum in Botswana has been designed to introduce learners to STEM early in their schooling. The rationale lies in the view that STEM subjects are critical in a knowledge based economy. The aim of the on going study is to explore what constitutes STEM by studying how it is Intended (planned by the teacher) Enacted (taught in the classroom), and Lived (learnt by learners in the class) (Runneson, 2005) and seeks to gain insight into

what constitutes Science, Technology, Engineering and Mathematics (STEM) in tasks that learners are given, and how concepts are made accessible to Pre-school learners. The research question of interest for this study is stated as: *What is the nature Pre-school teachers' explanations of Science, Technology, Engineering and Mathematics (STEM) concepts embedded in tasks given to learners.* Casting some light into what and how pre-school Science, Technology, Engineering and Mathematics (STEM) tasks are enacted is critical for policy and Pre-school teacher professional development. The sociocultural perspective framed the research. Adler and Rhonda's (2014) notion of *exemplification* and *explanatory communication* are used to analyze tasks given to learners and teachers' explanations respectively. Participants in the study includes one pre-school teachers and their pre-school learners from one school in Gaborone. The school was purposefully selected based on its performance in Botswana's 2019 national examinations. Specifically, the study is interested on teachers' explanations of Science, Technology, Engineering and Mathematics (STEM) concepts embedded in Pre-school Science, Technology, Engineering and Mathematics (STEM) tasks. The interest on explanations was informed by the view that suggests that, the Science, Technology, Engineering and Mathematics (STEM) learners get to learn, resides in teachers' explanations.

Keywords: Classroom; Explanation; Science, Technology, Engineering and Mathematics (STEM); Preschool; Tasks

Introduction

Botswana arguably boasts among the countries that invest heavily towards educational endeavors in Africa. Over the years, Botswana has chosen to invest a lot of resources on the education system. The educational system is heavily pegged to the developmental and sociocultural needs of the country as a whole. The country is shifting from Agro based economy to Industrialisation. After establishing early childhood education in government schools, now the attention is now on the importance of teaching in pre-school (Moomaw, 2013). Science Technology Engineering and Mathematics (STEM) subjects are important in the 21st century. This subjects enhances the soft skills (collaboration, creativity, communication etc.) of preschool learners which are very critical in the 21st century. The early childhood is regarded as the most critical stage of brain development (National Scientific Council in the Developing Child, 2017). It is at this stage of biologically development that we should introduce the early childhood to scientific enquiries, that is, introducing STEM to them. Naturally, children are born scientists, they explore the world

around them (Piaget, 1952; El kind, 1976). Children who engage in scientific activities at an early stage develop positive attitudes towards science which will correlate with science achievement and chances are high that they will pursue STEM careers in future. It is imperative for any country to raise pre-school learners that they will be useful in the near future. The common saying that 'earlier is better' or 'train a tree when is still young' futures here.

Significance of the Study

The study is an external evaluation and therefore will give non-biased findings and will help to see external factors attributed to the lack of good STEM teaching and learning. This study will be of help to the following;

- a) Policy development and Implementers
- b) Curriculum Developers
- c) Teachers and other practitioners
- d) Parents, Government and other stakeholders
- e) Pre-school Students/Learners

Research Questions

Research questions should not be questions that require yes or no answer (Selamat 2008) in Nenty (2009). The main research question of the study is: a) what is the nature Pre-school teachers' explanations of Science, Technology, Engineering and Mathematics (STEM) concepts embedded in tasks given to learners?

Limitations

According to (Isaac and Michae,1990) argues that what limitations exist in the researcher's method, design or approach, sampling restrictions, uncontrollable variables, faulty measurements, and other compromises to internal validity. The school were chosen randomly in Southern East Districts in Botswana hence the results cannot be generalized.

Delimitations

The schools and classes were chosen at random in South East District Council randomly hence the results cannot be generalized. The other reason is that some teachers were not comfortable with video filming.

Ethical Considerations

According to Opie (2004) in Moalosi (2014) any research that involves people has the potential to cause unintentional damage and has the need for a careful elaboration on

how the moral aspect of the envisaged research will be addressed to minimize the damage.

Ethics are norms or standards of conduct that distinguish between right and wrong. They help to determine the difference between acceptable and unacceptable behaviors. According to Shamoo and Resnik (2015) argues that there are several reasons why it is important to adhere to ethical norms: a) Norms promote the aims of research such as knowledge, truth and avoidance of error.eg, prohibitions against fabricating, falsifying, or misrepresenting research data the truth and minimize error.

b) Since research often involves a great deal of cooperation and coordination among many different people in different disciplines and institutions, ethical standards promote the values that are essential to collaborative work such as trust, accountability, mutual respect and fairness.

c) Many of the ethical norms help to ensure that researchers can be held accountable to the public, for instance federal policies on research misconduct etc.

d) Ethical norms in research also help to build public support for research. Ethical codes address issues of honesty, objectivity, respect for intellectual property, social responsibility, confidentiality, non-discrimination and etc. (<http://ethics.elsevier.com/index.asp>) Some Organizations have Institutional Review Boards (IRB); This is a panelist who makes sure that there is safety in human subjects and that human rights are protected. The following ethical consideration was done

Methodology a) Beginning the study

The researcher informed the participants (pre-school learners and teacher) about the purpose of the study and presented a consent form to the participants. The participants (pre-school and teachers) were told that their participation will be treated as confidential. Participants were further informed that failure to participate in the study will not have any effect on their daily work.

Data collection

I studied the records (lesson plan), observations, interviewing both the students and teachers. I lastly recorded a video of one primary teachers teaching and engaging the pre-school learners with tasks.

Data analyzed

Instead of participants to use their real/original names, fictions or sydonomius was used instead. All the data for were analyzed together with the records (lesson plans) and interviewing both the students and teachers.

Sample

The data was collected from one (1) primary schools, in Gaborone, capital city of Botswana.

Researchers' role

According to Creswell (2014:256) in Kunene (2016) urges that researcher's role necessitates the identification of assumptions, values and biases, as the primary data collection instrument at the outset of the study. The researcher compared watched the video taking points as to whether there are STEM skills.

Results

It was found that the pre-school learners in Botswana school are exposed to STEM and are even exposed to tasks that has STEM activities.

Conclusions and Recommendations

It is important to introduce STEM activities to children at an earlier stage. It was found that teachers include STEM activities in their lesson plans. From the video analysis, it was observed that teachers applied the concept of STEM and during the interviews the teachers said they understood and enjoy STEM activities to be taught to preschool learners. It is recommended that teachers need opportunities to relearn STEM they teach in preschools such as attending short courses during school vacations. According to Moalosi (2014) also found that professional development is important mathematics teaching and learning. There is a need for research that looks into the relationship between teachers' appeals and learners to explore the extent to which learners learn what was taught in class.

References

- Buchter, J. (2017). *Supporting STEM in Early Childhood Education*. Retrived from: https://academic.edu/supporting_STEM_in_Early_Childhood_Education.
- ELKind, P. (1976). *Child Development and Education: A Piagetian perspective*. New York: Oxford.
- Moomaw, S. (2013). *Teaching STEM in the early years: Activities for integrating science, technology, engineering, and mathematics*. St Paul, MN: Redleaf Press.
- Moalosi, S. (2014). *Enhancing teacher knowledge through an object-focused model of professional development*. PhD thesis, University of Witwatersrand, South Africa.

Nenty, H.J. (2009). Writing a Qualitative Research Thesis. Introduction Journal Education Science, 1(1):19-32.

Piaget, J. (1952). The Origin of Intelligence in Children. New York: International University Press, Inc.

Shamoo, A., & Resnik, D. (2015). Responsible conduct of research. 3rd Ed. (New York : Oxford University Press).

Rinehart and Winston Kunene, T.A.N. (2016). Using argumentative writing frames to support dialogue and writing problem-solving in multiplicative word problems. Doctoral Dissemination.

University of North West.

Article 27

Teachers' Feedback Practices during Teaching and Learning of Mathematics

^{1,2} Caroline, C.M, Makato and ¹Fredrick, J.F Mtenzi

Institute of Educational Development, Aga Khan University, Tanzania

Mathematics and Science Department, Mwambonu Secondary School, Kenya

makatocar@gmail.com,

+254725791023

Abstract

Although effective feedback can foster class interactions and stimulate mathematical thinking, it may be underutilized. Studies on the same are also rare in the Kenyan context. This gap informed the study. This qualitative case study explored teachers' feedback during the teaching and learning of mathematics in a secondary school in Kenya. The paper establishes the characteristic features of mathematics teachers' feedback. Three form two mathematics teachers and 150 form two students were purposely chosen for the study. Informed consent through the principal and further assent from the learners was sought before conducting the study. 18 students from the participated in focus group discussions (FGDs). Other methods included; Teacher interviews, class observations, and document analysis. Findings revealed that the documents analysed were silent on teachers' feedback. Teachers' interviews, FGDs, and observations portrayed feedback as mainly oral and evaluative. In addition, interviews revealed all learner engagement in questioning, in contrast to FGDs and observations. Girls' FGDs showed a liking for telling feedback and a dislike for peer discussions. FGDs further revealed feedback at times was: generalized, embarrassing, delayed, and denied. The teachers' feedback practices demonstrate an overlook of planning, alarm to inclusion and equity and the acquisition of critical thinking skills. The study recommended exposure of teachers to effective feedback strategies during in-service and pre-service training.

Keywords: Mathematics, feedback, effective questioning, rote learning, mathematical thinking

Subtheme: Capacity Development in STEM Education Innovative Pedagogy (Gender, inclusion, and equity).

Introduction

Mathematics roles are global as a medium of communication, a predictor, as well as a device, therefore, a science, a tool, and a language (Luitel, 2019). Therefore, quality education in numeracy is fundamental. This implies that study of teacher practices specifically feedback that characterizes the position of the teacher and learner during the teaching and learning of mathematics are paramount if the goals of education are to be realised.

Feedback is an oral, written, or non-verbal response to a learner's question which may emanate from the teacher or peer learners. According to Wiggins (2012), feedback is information about how we are doing in our efforts to reach a goal and effective feedback is actionable, tangible transparent, friendly to the user, time-conscious, on-going, consistent, and goal-referenced.

The need to find out whether teachers' feedback is learner centred by taking care of learner differences, acquisition of critical thinking skills, and learners' ability to socialize and urge to continue learning inspired the study. Furthermore, use of teacher centred teaching approaches is among the factors contributing to low learner achievement (Molenje, 2020).

This paper sought to answer the question; what are the characteristic features of secondary mathematics teachers' feedback? This is because this is the practice that the participating teachers acknowledged to be aware of and practicing therefore, the need to explore the extent to which they promote student thinking and class interactions. This would inform education stakeholders.

Firstly, the paper discusses the role of feedback, based on existing literature, Secondly, description of the method adopted in the study. Thirdly, findings are outlined and discussed, and finally, recommendations and a conclusion are made.

Vygotsky's 1978 theory on the zone of proximal development (Karl & Riley, 2019), was the lens for the study.

Feedback

Fyfe and Rittle-Johnson (2017) study revealed that immediate feedback increases accuracy in immediate performance but practice without feedback leads to a high level of mastery

of content. However, this depended on gender, ethnicity, and grade level pre-test scores. In addition, Fyfe et al. (2012) established that feedback accelerates learning for students with low domain knowledge. These studies reveal that feedback is crucial but not clear how the teacher identifies and strikes a balance between high and low achievers and promotes them to learn coherently.

Van der Kleij et al. (2015) found that more elaborate feedback led to higher attainment, specifically in the acquisition of higher-order thinking skills. Kastberg et al. (2020) study revealed that feedback was constructive through matching feedback with self and the task objective and questionable in that it did not rely on learners' responses. Written feedback was not thorough. Zhang (2019) study established that England teacher's often requested learners to explain how they got their answers through the why question before giving neutral feedback. Also, the Chinese teachers commented and gave feedback to the students on their answers to questions. The studies value learners' line of thought ought. However, the voice of the learner on which type of feedback may be of value to them is missing yet they are the reason for any teaching and learning.

Guo et al. (2019) study disclosed that teachers dealing with high-achieving learners embraced more praise, verification, directive, and scaffolding feedback but less criticism, unlike teachers at low-achieving schools. Githua and Mwangi (2003) study established that regular feedback is one way of promoting learners' mathematics self-concept and their motivation to learn the subject.

The few studies conducted in Kenya on feedback portray the value of effective feedback, however, demonstration of how feedback is actualized in a class setting is silent, therefore, the reason for the study.

Materials and methods

The study involved describing the teachers' practices, and the class interactions while paying attention to questioning practices and understanding teachers' reasons behind their questioning practices. This led to the study adopting a qualitative approach. A qualitative approach enables a researcher to study a phenomenon in their natural settings, and interpret and allow inquiries (Anderson, 2017).

The study purposed to reveal detailed characteristics of teacher questioning practices in mathematics classrooms; therefore, a case study was adopted. A case study provides an opportunity to acquire in-depth particulars of phenomena in their natural context (Crowe et al., 2011).

Participants

The study was carried out in Bidii (pseudonym) secondary school in Kenya which is a mixed-day, girls' boarding, public secondary school. The selection of this study area ensured that teachers' questioning practices for both boys and girls were studied. Took care of the challenges found in boarding and day schools and this would reduce the influence of extraneous variables in the findings. The school was purposively and conveniently selected.

Form two students and the three mathematics teachers teaching the classes were purposively selected; Teachers A, B, and C. Purposeful sampling involves dealing with people who are relevant to the study (Hall, 2020). Form two class was studied because the learners monitored the teachers' questioning practices. In addition, effective questioning practices need to start in the lower classes. Two girl classes and one boy class were studied. Stratified random sampling based on learners' mathematics achievement of six learners in each class who took part in FGDs was done.

Data collection methods and tools

Each teacher took part in face-to-face, semi-structured interviews, and three non-participant class observations. Observational research allows the researcher to record and observe situations in their natural settings (Hall, 2020). Sampled learners took part in FGDs. Document analysis of the mathematics syllabus, Form 2 schemes of work, lesson plans, and lesson notes were intended to be analyzed. Digital audial recorder and research journal were the tools used for recording data. Several data collection methods enabled corroboration leading to triangulation.

Data analysis procedure

This involves understanding how to make sense of text and images to get answers to the research questions (Creswell, 2014). A verbatim transcript of the audio data from interviews and FGDs was done. The data was then, coded, put in categories, and finally put in themes. The themes gave the data more meaning and better understanding. The themes were discussed and interpreted while referring to document analysis and class observation. This strengthened the justification of the study findings. This paper discusses the classroom environment theme created by teachers' feedback based on the paper's objective.

Results

Feedback

Teachers' interviews demonstrated that feedback was very vital in teaching and learning mathematics since it motivated learners, promoted learners' thinking by probing, and encouraged learner participation. FGDs upheld this, however, added that some feedback demotivated learners from participating in the questioning process. This was experienced in girls' FGDs. Instances of delayed and denied feedback were also highlighted and witnessed during class observations.

Interviewer: How often do you ask a question in class?

H: I can't ask any question because when I ask a question, instead of the teacher responding, she tells me to follow her, and I can't.

(FGD B: September 13th, 2021)

Interviewer: What is your feeling after you have done a question wrongly and someone else has been appointed to do it?

M: I feel like, the teacher...

N: I feel embarrassed

R: I feel jealous and as though am not good at mathematics

Interviewer: How does the teacher embarrass you?

Q: For instance upon missing addition, the teacher asks just adding?

Interviewer: How do you feel the teacher can correct you without embarrassment?

P: When have wronged a question, the teacher should correct me without appointing someone else. This would not annoy me.

(FGD C: September 13th, 2021)

In FGD C, learners preferred feedback where the teacher does the entire question not giving clues. During class observations, a lack of feedback on a student's response was very common, rather the teacher shifted to ask another student. This was common with Teacher A and Teacher C. Oral feedback was common and mainly evaluative. Written feedback was rarely witnessed, and when it occurred, the teacher was only interested in the answer. Peer feedback was rare. When witnessed, learners sitting close were supposed to check on each other's work on the correctness of their answers. However, most learners seemed not to do that.

Discussion

It is evident that although the teachers acknowledged feedback as an effective questioning practice, its main intended purpose of promoting class interaction and learner thinking was not cultivated in their practices. Teachers' personalized feedback and attached value to answers only.

In addition, in search of the answer only, teachers brought in other students to answer the teachers' questions while ignoring previous learners' responses. This makes learners feel embarrassed and hurt. This was in contradiction to Clarke (2020) take that teachers' feedback should help learners view errors as an invitation for opportunities, not as embarrassing signs of failure or things to be avoided therefore, the need to embrace them.

Teachers majored in evaluating learners' feedback and appreciating their answers with no probes. Appreciating learners' efforts is good. However, making a stride further to confirm their thinking is marvellous since this strengthens their relational understanding. This study contradicted Kastberg et al. (2020) who found that feedback was matched with self and the task objective.

The learners were ignorant of their role in the construction of knowledge which led them not to appreciate hints and cues from teachers. This ignorance made them emotional. This was experienced in girls' FGDs. According to Shute (2008) as cited in Bates (2019) feedback is like trying to let somebody's mind free by only showing the person the door and only him who must walk through it. It, therefore, implies that learners were not aware of their position in knowledge construction.

This study's finding on gender matched with Githuba (2013) finding that there are gender differences in learning Mathematics though his findings were not specific to feedback. In addition, it was in agreement with Fyfe and Rittle-Johnson (2017) who found that the value of feedback depended on gender.

Throughout the study, teachers seemed to be chasing something. Could time be inadequate to give effective feedback? The teachers seemed to take a shorter time in the actual teaching than is indicated in the syllabus, and schemes of work therefore, a mismatch in time between the actual teaching and the pedagogical documents. According to Wiggins (2012) the notion that no time can be understood, however, lack of time to provide and use feedback, in reality, means no time to cause learning. Furthermore, the finding was in line with Wafubwa and Ochieng (2021) that feedback as

one of the formative assessment strategies was lacking in Kenya context schools. Teachers overlook of some learners' responses contradicted promotion of equity as one of the goals of education and mathematics as a language spoken by all.

Conclusion

This paper aimed at exploring teachers' feedback, in questioning in promoting student thinking and causing class interactions. The study established that teachers' feedback practices were inadequate to cultivate a classroom atmosphere that promotes learners' thinking and class interactions which may impair learners' acquisition of 21st-century skills jeopardizing Kenya's realization of Vision 2030.

Therefore, need to equip teachers with effective questioning strategies during pre-service and in-service training. It is proposed that action research on teachers' questioning practices be conducted. The limitation of the study is that the findings may not be generalized to other schools in the country without modification since a case study was adopted.

Acknowledgment

I would like to acknowledge Aga Khan University for granting me the chance and partial scholarship to pursue this research. My special gratitude also goes to the entire AKU IED faculty and staff for the vital roles you played in bringing this to success.

Reference

- Anderson, V. (2017). *Criteria for evaluating qualitative research. Human Resource Development Quarterly*, 1-9.
- Bates, B. (2019). *Learning theories simplified ...and how to apply them to teaching : 130+ theories and models from great thinkers (2 ed.)*. Sage.
- Clarke, S. (2020). *A Little Guide for Teachers: Formative Assessment*. Sage.
- Creswell, J. W. (2014). *Educational research : planning, conducting, and evaluating quantitative and qualitative research, fourth edition*. Pearson Education.
- Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A., & Sheikh, A. (2011). *The case study approach. BMC Medical Research Methodology*, 11(1), 1-9.
- Fyfe, E. R., & Rittle-Johnson, B. (2017). *Mathematics practice without feedback: A desirable difficulty in a classroom setting. Instructional Science*, 45(2), 177-194.
- Fyfe, E. R., Rittle-Johnson, B., & DeCaro, M. S. (2012). *The effects of feedback during exploratory mathematics problem solving: Prior knowledge matters. Journal of Educational Psychology*, 104(4), 1094.

- Githua, B. N. (2013). *Secondary school students' perceptions of mathematics formative evaluation and the perceptions' relationship to their motivation to learn the subject by gender in Nairobi and Rift Valley Provinces, Kenya. Asian journal of social sciences and humanities, 2(1), 174-183.*
- Githua, B. N., & Mwangi, J. G. (2003). *Students' mathematics self-concept and motivation to learn mathematics: relationship and gender differences among Kenya's secondary-school students in Nairobi and Rift Valley provinces. International Journal of Educational Development, 23(5), 487-499.*
- Guo, W., Lau, K. L., & Wei, J. (2019). *Teacher feedback and students' self-regulated learning in mathematics: A comparison between a high-achieving and a low-achieving secondary schools. Studies in Educational Evaluation, 63, 48-58.*
- Hall, R. (2020). *Mixing Methods in Social Research: Qualitative, Quantitative and Combined Methods. Sage.*
- Karl, A., & Riley, A. (2019). *Understanding and using educational theories. Sage.*
- Kastberg, S. E., Lischka, A. E., & Hillman, S. L. (2020). *Characterizing mathematics teacher educators' written feedback to prospective teachers. Journal of Mathematics Teacher Education, 23(2), 131-152.*
- Luitel, L. (2019). *Nature of mathematics and pedagogical practices. Proceedings of the Tenth International Mathematics Education and Society Conference Hyderabad, India*
- Molenje, H. (2020). *The Impact of teacher quality on performance of Mathematics in Kenya Certificate of Secondary Examinations in Busia sub county public secondary schools, Busia county Kenya [Post graduate diploma, university of Nairobi].*
- Van der Kleij, F. M., Feskens, R. C., & Eggen, T. J. (2015). *Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. Review of educational research, 85(4), 475-511.*
- Wafubwa, R. N., & Ochieng, P. O. (2021). *Students perception of teachers' use of formative assessment strategies in Mathematics classrooms. Elementary education online/ilkoegretim online, 20(2), 123-132.*
- Wiggins, G. (2012). *Seven keys to effective feedback. Feedback, 70(1), 10-16.*
- Zhang, W. (2019). *A comparative study of the beliefs about and practices of secondary school mathematics in England and China concerning teacher questioning [Doctorate, University of arwick]http://wrap.warwick.ac.uk/132000/1/WRAP_Theses_Zhang%2C%20W_2018.pdf*

Article 28

Teacher Perceptions of the Competence-Based Curriculum. A case study of
Sam Iga Memorial College, Uganda

Betty Rose, B.R.N, Nabifo

Wakiso/Kalangala Region, Secondary Science and Mathematics Teachers' (SESEMAT)
Programme, Uganda.

brosenabifo@gmail.com, +256781070902

THEME: Learning in STEM Education

SUB-THEME: Learning attainment

Background

The 1989 Education Policy Review Commission chaired by Professor Senteza Kajubi highlighted the concerns of a number stake holders in reference to the irrelevance of the country's (Uganda) education system and its failure to meet the needs of the society as quoted below;

"Education is failing, among other things, to promote a sense of national unity, self-reliance, social justice and equity, and to impart scientific and technological knowledge, cultural values, literacy and a sense of social responsibility to a degree that society would like to. There has been too much academic learning, passing examinations and paper work per se to the neglect of knowledge, skills and values to solve real life problems. The result has been that the system has fallen far too short of turning out the right number and type of manpower needed for optimum development"

Introduction

It is from this background that the government of the Republic of Uganda, through its National Curriculum Development Centre, overhauled the Lower Secondary Curriculum with an aim of migrating from the Knowledge Based Curriculum (KBC) which mainly focused on academic learning and passing of exams to the Competence Based

Curriculum (CBC) which focuses on acquisition of skills and values to solve real life problems.

According to the New Curriculum Framework (2019), the role of the teacher changed from being the sole authority of knowledge to a facilitator of the learning process. On the other hand, the learner's role changed from being a recipient of knowledge and facts from the teacher to that of a major contributor towards the learning process. John Dewey asserts that, *"Learning is not the product of teaching. Learning is the product of the activity of learners."* He goes on to add that it is not right for anyone to claim that they have taught when no one has learned. Thus, the ultimate goal of teaching is for learning to take place. In *An Introduction to Methods of teaching*, Nacino et al maintain that whereas it is necessary for a teacher to have learners in order to teach, learning can take place without the help of the teacher. The teacher is needed to organize and direct students in their learning experiences but on the whole; learners are more responsible for their learning. This responsibility places learners at the centre of the learning process.

This paper uses data obtained from three different sources from within Sam Iga Memorial College –Uganda. First, twelve (12) lessons were observed in the department of Physics; then there was an interaction with the teachers and finally; learners were tested on their knowledge and skills. The study revealed learning gaps among the learners which were attributed to a number of factors. Teachers' perception of the CBC was low and the situation at Sam Iga Memorial College rhymed with what appeared in the *Journal of New Vision in Educational research* in reference to the implementation of the CBC (2015) in Zimbabwe.

...the significant aspects of motivation, resources and teacher sensitization and preparation on the new demands of implementing the new curriculum were not seriously considered.... The ministry of Primary and Secondary education did not psychologically and professionally prepare the teachers to implement the new curriculum initiative...

Part 1: The Teacher Perceptions about the New Competence Based Curriculum

In this context, teacher perception refers to the cognitive, emotional, and attitudinal perspective held by a teacher about the CBC. It could be a thought or mental image a teacher has about the same.

Despite the fact that the National Curriculum Development Centre (NCDC) organized a number of workshops for the teachers to retool them, teachers continued to cite lack of

involvement, poorly and hastily rolled out training, inadequate resources, and lack of adequate understanding of the curriculum by the curriculum trainers themselves.

'It is true that NCDC trained some teachers and expected them to cascade the information to the rest. However, they could not because each came back with their own version of the story.'

'No one seems to be cock sure of the '*what*' and '*how*' of the CBC. Different teachers have different ideas about the same thing and staffrooms are characterized by arguments most of the time.'

'The curriculum is good but it requires a lot of resources to implement.'

'We need more training to effectively facilitate the learning process.'

'Assessment is a big challenge since we are told that all answers are correct.'

'We teach learners with diverse backgrounds hence each learner is unique in one way or another'.

'The CBC requires a small size class. For the school under study, the class sizes range between 160 and 200 learners.'

'The paper work involved is too much'

'The curriculum requires too much preparation for one to effectively conduct a lesson'.

'The new curriculum text books have shallow content.'

'No one seems to be sure of how to assess the learners'.

'Too much ICT involvement yet some teachers are still computer illiterate.'

'The CBC bestows too much responsibility on the learner'

'I long for that moment when every stake holder in the New Curriculum will understand what and how they are supposed to do'.

The perceptions of the teachers have been summarized in figure 1.

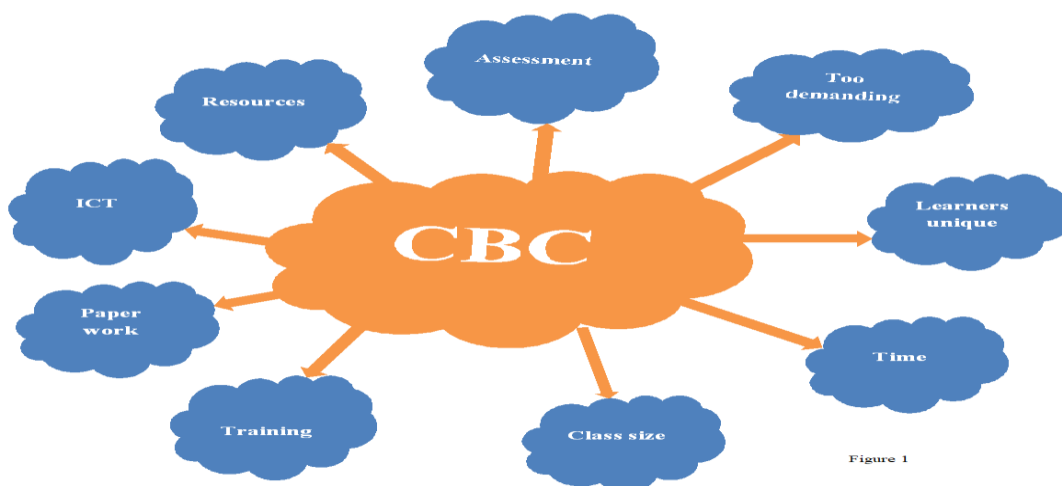


Figure 1

Based on these perceptions, it was concluded that most of the teachers had shifted from the denial stage to the acceptance stage. Since it is not possible to revert to the KBC, measures need to be put in place to enable them (the teachers) to acquaint themselves with the CBC and as thus, improve on their perception of the same. Some mistakes have already been made concerning the implementation of the New Lower Secondary curriculum and there is need for timely action by the concerned stakeholders to streamline content delivery as well as assessment to enhance the smooth implementation of the CBC.

PART 2: Learning Attainment In The CBC

Learning attainment in this context refers to how much a child has achieved in school which compares every child to a standardized expectation for their age level without paying attention to the starting point. To determine the level of attainment of the students in grade 8-10, assessments were given in form of written tests namely activities of integration (AOI) and end of cycle assessments. The assessment items given were scenario based and they were based on the content that the learners had covered. Responses got from learners in line with the questions based on the content they had covered revealed a lot of learning gaps which were attributed to the following.

Large class sizes

Prior to COVID-19, both Private and Public schools were surviving with substantial numbers of learners. In the aftermath of COVID-19, the number of students in public schools increased to abnormal levels. According to *USAID/Uganda learning activity on the impact of COVID-19 on learning (2023)*, the pandemic led to the closure of some privately owned schools, loss of jobs hence lack of tuition among many others. Consequently, parents resorted to sending their children to the Public schools which were assumed to be less demanding in terms of tuition and other school based charges (requirements). This resulted into a very high student-teacher ratio as observed in the school under study. This put a lot of pressure on the teacher as he/she was required to triangulate in the course of the lesson as the learners discover, explore, analyse and apply. Under triangulation, the teacher listens to the learners and converses with them; observes them as they discuss in groups; and also assesses the product of their learning. It was hard for a single teacher to do that within the allocated lesson time and also allow learners to present the findings of the different groups before the class. Moreover, the teacher

was required by the same curriculum to capture and track the generic skills, values and attitudes exhibited by the learners and report about the same.

Limited resources.

Lesson observation revealed that many of the resources that were needed to effectively conduct lessons in the CBC were lacking. Acquisition of these resources had financial implications on the school and teachers needed more time to adequately prepare for the lessons than it was before. According to *The New Curriculum Framework (2019)*, it was clearly stipulated that learners would need to have access to textbooks as well as other learning materials. These included improvised no cost and low cost materials which were available within a local community or environment. They would also include chemicals for Science experiments, calculators for Mathematics, instruments and materials for Creative Arts and tools for Technology and Enterprise. These materials would enable learners to learn for themselves and to ensure a greater depth of understanding was achieved. Given the school setting, almost all materials including those that were referred to as '*locally available*' materials were obtained at a cost. The cost implication for the school was high given that such materials had to be obtained in bulk to match the large number of learners.

Limited creativity on the side of the teachers

The New Lower Secondary Curriculum (2019), emphasized the acquisition of generic skills that were sought by employers and believed to enable learners deepen learning across the curriculum and also unlock the World of Work (WoW). Creativity and innovativeness were examples of such skills. Learners were expected to be creative and innovative so that they could develop into lifelong learners; adapt to change and cope with the challenges of the 21st Century. The challenge here was that the teachers themselves were not as creative as they were expected to be. Each concept under the CBC was to be introduced with a scenario/ short story to help learners relate what was learnt in the classroom to real life situations. The required degree of creativity on the side of the teachers was found to be lacking. It was, therefore, difficult for learners to become creative and innovative before their teachers. In other words, it takes a creative teacher to produce a creative learner. In support of this, Friedrich Fröbel (1852-1982) advocated for a holistic development and creativity in early childhood education. He emphasized the importance of play, nature, and hands-on experiences while fostering a child's intellectual, emotional and physical growth. Fröbelian educators facilitate and guide

rather than instruct. They provide rich real life experiences and observe children carefully, supporting and extending interests through freedom and guidance.

Learning through project work

Nacino Brown. R et al (1989), in his discussion of modern approaches to teaching emphasized a shift from the teacher to the learner. It transformed the learner from a passive receiver of knowledge to an active creator of the process in which he learned. He identified the project method as one of those approaches through which learners got a chance to learn by doing which was in line with Dewey's philosophy. Fröbel said and I quote, '*To have found one fourth of an answer by his own effort is of more value and importance to the child than it is to half- hear and half- understand it in the words of another*'. Failure by the majority of the learners to identify projects based on the learning areas they had covered provided evidence that there were learning gaps that hindered them from developing the skill of critical thinking as well as problem solving. Through project work, learners are able to identify and solve problems in their communities.

DIT versus Project work

Some teachers were not able to distinguish between DIT occupations meant for acquainting learners with the WoW and the subject based projects. It, therefore, became very difficult for the teachers to guide the learners and also assess their work. The guidelines for assessment were provided by the NCDC. However, teachers still found it difficult to judge whether a given piece of work produced by a learner was a project or not. In some cases, teachers questioned the relevance of a given product to subject under which it was carried out.

Limited access to the internet

Learners' proficiency in functional Mathematics as well as the use of Information, Communication and Technology (ICT) rank highest among the generic skills to be acquired by the learners in the CBC. However, during the study, it was observed that these skills were lacking for the majority of the learners at our school and it was attributed to the limited number of computers the school had. Besides, students were not and are still not allowed to possess smart phones. Limited access to the internet limited the learners' research base to text books some of which were outdated. This had a bearing on the quality of discussions held by the learners in the CBC and hence, the amount of content learned.

The cost of study trips and access to relevant study resources

The cost associated with resources, school trips, uniforms as well as access to computer devices and the internet widened the learning gap among the learners. The study trips organized by school were attended by a small section of the learners. Take home assignments were never accomplished in time as most students depended on the school for reference books. In this regard, limited access to information and exposure to the outside world hinders research and impacts negatively on attainment.

The school's level of funding

The *level of funding* of a school has an impact on the schooling experience of learners and hence their learning attainment. Being a universal secondary school, most of the funding comes from the government in form of capitation grant and the amount depends on how many learners the school has. However, consideration per child is too low to enable the schools provide all necessities to the learners. This brought in the idea of cost sharing whereby parents have to meet certain costs such as lunch and provision of scholastic materials to their children among others. Even at that level, not all parents were able to meet the dues. This consequently worsened the level of learning attainment in STEM subjects where calculators, geometry sets, graph books were a must have if effective learning was to take place.

Persistent poverty

Children belonging to low income households are more likely to have low educational outcomes arising from low aspirations. All children have dreams and these dreams are influenced by the environment they live in. A child who has never seen a doctor born and raised in his village may not know that is possible to become one. More so, children need role models to shape their lives and therefore, have a positive impact on their learning attainment.

Limiting beliefs among the learners

As the Zig Zilgar quote goes, *"Your attitude, not your aptitude will determine your altitude"*. Learners' perception of STEM subjects determines their attainment in the same. Learners especially those of the female gender still have a perception that Science and Mathematics are generally for males. Consequently, their attainment in such subjects is low both at school level and in the national examinations as evidenced in the past years.

Teacher expectations

According to John Saphier, students are greatly affected by the messages they receive about their abilities, from important people in their lives. Such messages may be conveyed through the teacher's tone, voice, body language or choice of words. Consequently, these messages impact negatively on the learners' attainment in and outside class.

Family break ups and parenting gaps.

Family plays an important role when it comes to learning attainment. Children who come from supportive families have greater chances of achieving more learning outcomes than those that are not supported by their families. In this era where many fathers have chosen to shy away from responsible fatherhood, the education of children is left in their hands of mothers. In some cases, some children have to fend for themselves in which case, the learners struggle to strike a balance between work and study. To them, spending more hours at school is a like a punishment because they are denied a chance to make some money.

Part 3: What Interventions are Helping Students to Catch Up?

Handling the large class sizes

Our home grown solution to this challenge has been to have more than one teacher in the same class to carry out team teaching. As one teacher conducts the lesson, the other teacher monitors the learners especially at the back of the classroom to ensure proper classroom control and management.

Parental involvement

In an effort to reduce learning gaps caused by the absence of parents in children's lives, the school has engaged parents through a number of platforms coupled with continuous guidance and counseling sessions for the learners. *Parenting for brain* acknowledges that children develop their own skills through observing their parents' behaviors and modeling them. Thus, ensuring a secure attachment with parents promotes a child's cognitive, social and emotional development.

Engagement of teachers in workshops

In addition to the workshops organized by the NCDC, the school has organized a number of workshops to enhance deeper understanding of the CBC. It has gone an extra mile to invite motivational speakers to cause change of attitude and therefore, uplift the teaching

ability of the teachers to realize their full potential. However, whereas the message has been taken well by many, there are some few whose attitude has remained negative.

Lesson observation

The school administration has ensured that lesson observation is carried out not just as a ministry requirement, but also as a way of identifying and supporting those that are still challenged in terms of teaching according to the guidelines of the CBC. It is through lesson observation that most of the challenges cited in this paper were identified.

Way forward

Much as different measures have been put in place to overcome the challenges faced by the teachers in the implementation of the CBC, the following have been suggested for improvement of our own system and to guide the implementation of future curriculum reforms in Uganda

Individual learning needs

Teaching should be planned in a way that students' learning journeys are well directed for easy exploration of the curriculum. Learners with demonstrated ability to perform tasks exclusively should be guided to sail through the curriculum without leaving out the time takers. This will ensure that individual learning needs are taken into consideration.

Pre-service training

The training of teachers should start right from the teacher training institutions so that they can be acquainted with the CBC as early as possible. This will allow them enough time to interact with the curriculum before they start the practice of teaching.

Change of attitude for serving teachers

Serving teachers who are still held hostage by the KBC should understand that we have reached a point of no return. With the New Upper Secondary Curriculum in the pipeline, every teacher needs to get on board. Otherwise, there is risk of some teachers becoming irrelevant and being knocked out of the system technically.

Lesson preparation

The importance of adequate preparation for lessons by teachers cannot be overemphasized. The success of any lesson is highly dependent on the teacher's level of preparation. Without adequate preparation, lesson delivery cannot be successful. Notably, both lesson delivery and adequate preparation are key determinants of a good lesson and without them; scores attained by learners in both formative and summative

assessment do not reflect what is actually done in class. Abraham Lincoln once said, *'Give me six hours to chop down a tree and I will spend the first four sharpening the axe.'*

Continuous Professional Development (CPD) for teachers

There is need to have frequent CPD workshops coupled with routine inspection and monitoring by the ministry of Education and Sports. The district of Wakiso, under the Secondary Science and Mathematics Programme, conducted lesson study to help teachers acquire skills in teaching challenging topics in Science and Mathematics. Resource teachers would then follow up teachers in their respective schools to provide support in case of need.

Learning to learn;

Teachers with challenges should open up in order to learn, unlearn and relearn. As one saying goes, *'A tightly closed jerry can cannot draw water from a well'*. Teachers should make an effort to build capacity order to be successful in the field of education. To be successful in the field of education, the following are key;

- Emotional intelligence
- Classroom management
- Knowledge of subject content
- Knowledge of the demands of the curriculum and standards

Bring parents on board

Let teachers be teachers and parents be parents. Parents should not shy away from their responsibilities. The parents' and teachers roles are complimentary none can substitute the other. In Africa, it takes a whole village to raise a child.

Government should invest more in education

The school under study runs short of both space and infrasture; both hardware and software. It is the reason why there almost 200 learners in a classroom yet the number of teachers is small. During the UCE-2023 National examinations which were conducted between October and November this year, senior one and senior two learners lost at least one week of learning to enable UCE candidates write their examinations in a conducive environment.

Enhancement of salaries for the Arts teachers

I do appreciate the Government of Uganda for enhancing salaries for scientists including science teachers though the impact is yet to be seen. In this regard, I appeal to the

government to narrow the income gap between the teachers of humanities and Science teachers.

Conclusion

The successful implementation of the CBC calls for the involvement of all stakeholders; the government, the school administration, the parents, the learners themselves plus the teachers. However, the successful implementation of a lesson in the classroom depends on the teacher. Other factors may come into play, but the teacher should take a leading role in ensuring that existing gaps are filled and learner attainment is enhanced. Only then will the aspirations of the CBC be achieved.

"If we teach today's students as we taught yesterday's, we rob them of tomorrow." John Dewey

References

Education Policy Review Commission Report (1989); Ministry of Education

The Uganda government White paper (1992); Republic of Uganda.

Journal of New Vision in Educational Research, JoNVER Volume 1, Issue 2, 2020.

Dewey, J. (1938). Experience and education. New York: Macmillan

Nacino-Brown, R., Oke, F. E., Brown, D.P. (1990). Curriculum and instruction. An introduction to methods of teaching. London and. Basingstoke: Macmillan.

MLA. Fröbel, Friedrich, 1782-1852. Friedrich Froebel's Education by Development: the Second Part of the Pedagogics of the Kindergarten

Article 29

The Impact of Using GeoGebra Software in Teaching and Learning Reflection and Congruence on high School Student's Achievement

Mercy C. Misoi, Prof. Peter Kajoro

Murray Girls High School. +254 (0)720 140 496, The Aga Khan University, IED- East

Africa, Tanzania, +255 (0)734 485 966

misoimercy@gmail.com, mercy.misoi@scholar.aku.edu, peter.kajoro@aku.edu

Abstract

The Information and Communication Technology (ICT) era has fuelled the desire for educational reform based on its use in schools. This study explored the use of GeoGebra software in teaching and learning Reflection and Congruence topics, in one public secondary school in Mwatate Sub-County in Kenya. The main study objective was to assess the effects of GeoGebra on learners' achievements. This was a classroom action research study that utilized a mixed-method approach for data collection through interviews with learners, document analysis through test items, and classroom observation. Purposive sampling was used to obtain 55 participants in a form two class. The research process involved reconnaissance, the intervention, and the post-intervention phases. In the reconnaissance phase, entry interviews were conducted, and a pre-test was given to assess the learners' entry behaviour on the topic of reflection and congruence, whereas, the intervention phase involved the use of the GeoGebra instructional software as a pedagogical tool and eventually evaluate the intervention strategies using a similar post-test. The results from the descriptive and inferential statistics revealed that the post-test had higher scores than the pre-test, most probably attributed to the technology intervention. In addition, the post-intervention interview to capture the learner's experiences in the use of the GeoGebra software demonstrated that its application captured learners' attention, promoted experimentation, discovery, and visualization in geometry learning, as well as brought excitement and increased

engagement. Based on these findings, therefore, the researchers recommend that teachers should embrace GeoGebra or other related ICT tools to enhance students' achievement.

Keywords. Reflection and Congruence, GeoGebra, Euclidean Geometry, Teaching, and Learning Geometry.

a. Introduction

Education should evolve at the same rate as technology in our fast-changing world today. Raja (2018) points out that Information, Communication, and Technology (ICT) should have a transformational role in education which necessitates exploring new pedagogies and curricula for a new generation using new technologies. Kenya, through the ministry of Education has embraced the integration of ICT in the school curriculum. Mathematics being a compulsory subject that is taught in both primary and secondary schools in Kenya has not been left behind in this integration. The Kenya Institute of curriculum Development (KICD), has made several curriculum reviews to incorporate emerging issues in teaching and learning Mathematics.

Geometry being a study of shapes and space, is a strand that is taught from primary, secondary and tertiary levels with the basics introduced at the primary level (Brannan, 2011). However, learning geometry may be challenging and many students do not acquire the necessary knowledge, reasoning, or problem-solving abilities in geometry (Jones, 2016). This is because geometry is seen as a visual topic as learners are required to visualise objects in three-dimension from a two-dimensional perspective. Hence, many learners find it challenging to grasp these concepts which may eventually lead to poor performance. The performance in geometry in the Kenya National Examination Council (KNEC), has remained low for many years. According to KNEC (2022), Examiner surveys reveal that a majority of students did not possess a relational comprehension of geometry ideas, which has had an impact on their total arithmetic performance. The table below shows the performance in mathematics in three years:

Year	Paper	Number of Candidates	Highest score	The Mean score	Standard deviation
------	-------	-------------------------	------------------	-------------------	-----------------------

2020	1	742796	100	22.27	19.41
	2	742760	100	14.45	14.97
	Total		200	36.72	33.45
2021	1	822376	100	23.66	19.87
	2	822242	100	16.39	15.27
	Total		200	40.04	33.98
2022	1	877215	100	16.17	16.42
	2	877128	100	14.22	14.84
	Total		200	30.38	29.93

Source: KNEC 2022.

However, geometry instruction has evolved as a result of technological advancements and appropriate software tool use. One example of a tool for teaching geometry is the GeoGebra program, which encourages students to participate in interactive exercises and therefore advance their understanding. Advocates for GeoGebra assert that teachers may use the application to help pupils understand Geometry concepts through an engaging presentation (Hollebrands, 2018). To enable students to "see" the ease of computing made possible by technology, we teachers must stress the usage of GeoGebra in the Geometry classroom. That being the case, this study sought to explore how GeoGebra software could be used to teach and learn Euclidean Geometry's reflection and congruence and its effects on students' achievement.

1.1 GeoGebra Software

Diković (2009) states that GeoGebra is a free open-source dynamic software tool that supports constructions with all conic section's lines and points. Furthermore, Wassie and Zergaw (2019) reveal detail features of GeoGebra which makes it to be a preferred tool for teaching and learning especially geometry such as:

- The software is easily and freely available online by logging on to www.geogebra.org and download or work on it online.

- GeoGebra encourages instructors to utilize and evaluate technology in mathematics and its applications, as well as in the visualization of mathematical concepts and scientific research.

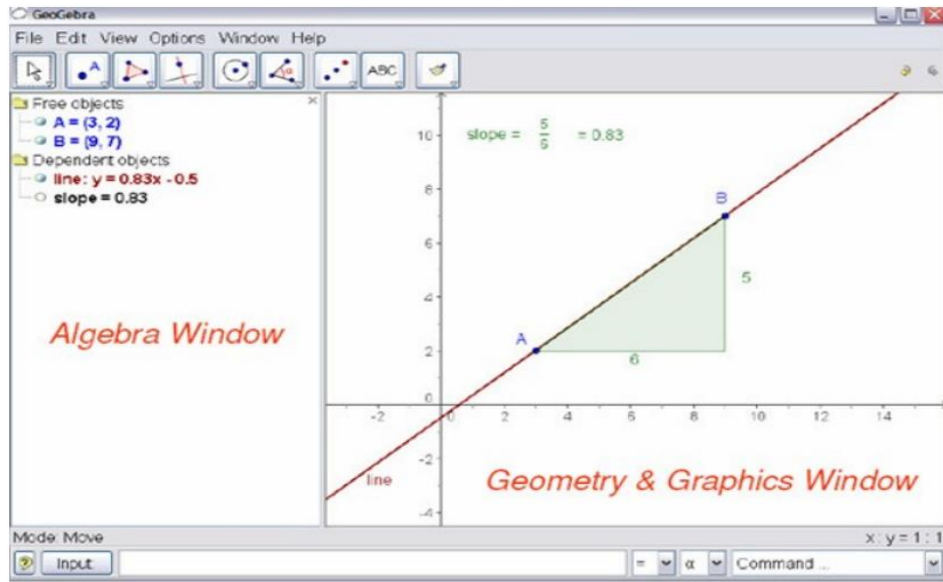


Figure 4: Screenshot from a GeoGebra window, showing both the algebra and the geometric window.

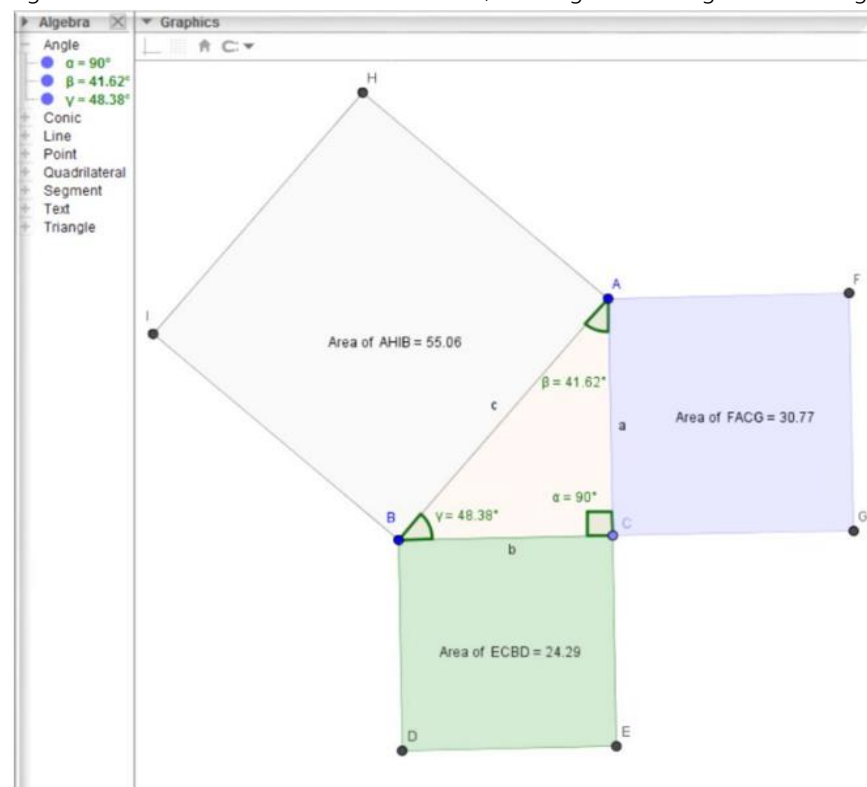


Figure 5: Screenshot from a GeoGebra window: Pythagorean theorem explained using GeoGebra.

2. Research Objectives

The objective of this study were as follows:

1. To establish how students are engaged in using GeoGebra to learn reflection and congruence in Euclidean geometry.
2. To establish how the learner's use of GeoGebra affect their achievements in reflection and congruence topic in Geometry.

3. Methodology

This research study used a mixed method research approach , this is because it involved collecting, analysing and integrating both qualitative and quantitative data (Creswell & Poth, 2016). For the qualitative data, the study adopted the use of interviews, document analysis and classroom observation while the quantitative data the study used the pre-test and post-test scores. Furthermore, the study adopted Bachman's Action Research spiral design whereby the process involved cycles or spirals of planning, action, observation, and reflection. According to Mertler (2009) Lorenz Bachman's action research spiral has this notion of the cyclical nature of action research.

The action research approach was used to ascertain the use of GeoGebra in the teaching and learning reflection and congruence. It involved two cycles, and, in each, data was collected through observation, interviews and document analysis. Additionally, the researcher kept a reflective notebook in which she documented her own practices, events that occurred in the classroom, and her opinions on the efficacy of various activities.

The study is a pre-experimental research design adopting a one-group pre-test post-test research design. Prior to being exposed to the GeoGebra software, all the students in form two who were 55 in number took a pre-test. They were instructed on reflection using the conventional approach, then asked to depict it (pre-test). Following the pre-test, during their ICT lesson, the students were given a brief overview of the GeoGebra software and allowed to interact with it for a period of one month where active learning took place as well as peer teaching during learners' free time. Observation data of learning activities was conducted from completion of students work in view of students' mathematical skills. Thereafter. Learners took a post test.

One Group Pre-test-Post-test Design:

Group	Pre-test	Intervention	Post test
A	O ₁	X	O ₂

4. Findings

The findings were discussed based on the objectives stated. The quantitative data from the pre-test and post-test was done using Ms Excel 2016 MSO to aid in getting the trends and distributions. For descriptive statistics, means, standard deviation and percentages were used while for inferential statistics, paired sample t-test was used to test the hypotheses at alpha, $\alpha = 0.001$ level of significance and appropriate degrees of freedom.

Differences in mean between the pretest and posttest scores before students utilized GeoGebra and after utilizing GeoGebra as an instructional tool.

The analysis of the post-test and the pre-test scores revealed an increase in the student's average scores after the intervention with the GeoGebra software.

Table 4: Descriptive statistics of the pre-test performance (N=50)

Test	Minimum (%)	Maximum (%)	mean	Standard deviation
Pre-test	2	50	22.16	11.37
post test	6	94	55.43	16.69

The least score obtained in the pretest was 2% while the highest score was 50%. However, the minimum and maximum score for the post test was 6% and 94% respectively. In addition, the mean score for the pre-test was 20.73% while that of the post-test was 55.43%. This is an indication that the results of the post tests were higher than that of the pre-test which reveals that the performance of the students had increased.

Based on this finding, it is highly probable that the use of GeoGebra software during the learning process could have led to improvement in the student learning and achievement in the topic of reflection and congruence.

Results of the paired samples t - test on the pre- and post- test performance.

test	Mean difference	Standard deviation	Std error mean	t	df	sig
Pre-test-post-test	30.75	18.07	2.55	11.91	48	.001

To find out how the learner's use of GeoGebra affects their achievement in geometry, a paired samples t-test was carried out to compare the students' results on the pre-test and the post-test in order to determine whether the changes noted earlier with

the descriptive were statistically significant. The results showed that there were ($Md=30.75$, $SD = 18.07$) between the pre- and post-test. The table above demonstrates a significant rise in learners' performance between the pre-test and the post-test. The results also suggest that the grasp and mastery of geometry concepts had improved significantly after the students underwent the intervention.

Classroom observations

The study showed that the learners had gained skills in plotting using the Geogebra software as depicted by the time they used in completing the activity. Through classroom presentations, it was also noted that the learners had gained confidence and awareness for the use of the GeoGebra software as an alternative to plotting on paper. Moreover, there was active learning with minimal supervision as observed during the class activities and group work.

5. Conclusion.

The observation made especially during the intervention phase indicated that learners were actively involved in teaching and learning activities when using GeoGebra throughout the lessons. Moreover, the use of GeoGebra to learn geometry triggers learners interest in learning and this helps in motivating learners to have a positive attitude towards learning geometry. Additionally, GeoGebra makes lessons more enjoyable, practical, engaging and easier to grasp. It also encourages students to visualize concepts rather than memorize them. The study concludes that GeoGebra is a good software instructional tool that may aid learners to improve performance in issues requiring transformation and geometry ideas since it helps in understanding, which is important for successful mathematics learning at the secondary school level.

The study also found that combining computer-assisted learning with traditional classroom training is more successful. This study supports previous research by Ahmad Tarmizi et al. (2010), Mwingirwa (2016) found that using mathematical learning software improves student learning and understanding. GeoGebra outperforms standard building tools for teaching purposes.

References

- Brannan, D. A., Esplen, M. F., & Gray, J. J. (2011). *Geometry*. Cambridge University Press.
- Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

- Diković, L. (2009). *Applications GeoGebra into teaching some topics of mathematics at the college level. Computer Science and Information Systems*, 6(2), 191-203.
- Hollebrands, K., & Okumuş, S. (2018). *Secondary mathematics teachers' instrumental integration in technology-rich geometry classrooms. The Journal of Mathematical Behavior*, 49, 82-94.
- Jones, K., & Tzekaki, M. (2016). *Research on the teaching and learning of geometry. The second handbook of research on the psychology of mathematics education*, 109-149.
- Mertler, C. A. (2009). *Action research: Teachers as researchers in the classroom*. Sage.
- Mwingirwa, I. M., & Miheso-O'Connor, M. K. (2016). *Status of Teachers' Technology Uptake and Use of GeoGebra in Teaching Secondary School Mathematics in Kenya. International Journal of Research in Education and Science*, 2(2), 286-294.
- Och, J. P., & Indoshi, F. C. (2011). *Challenges and benefits of using scientific calculators in the teaching and learning of Mathematics in secondary school education*.
- Raja, R., & Nagasubramani, P. C. (2018). *Impact of modern technology in education. Journal of Applied and Advanced Research*, 3(1), 33-35.
- Wassie, Y. A., & Zergaw, G. A. (2019). *Some of the potential affordances, challenges and limitations of using GeoGebra in mathematics education. Eurasia Journal of Mathematics, Science and Technology Education*, 15(8), em1734.

Article 30

The Impact of Paper Activity in Teaching Circle Geometry (Circle Theorem) on SS1 Students' Academic Achievement among students of Government Senior Secondary School Rigachikun, Kaduna-Nigeria

Yahaya Sani Rigachikun

Strengthening Mathematics and Science Education (SMASE)

National Teachers' Institute Kaduna Nigeria

yahayasanirigachikun@gmail.com

+2348065617676

Abstract

The role of innovation in teaching and learning mathematics cannot be over-emphasized. Continuous efforts should then be made by teachers to explore more innovative strategies and investigate their effectiveness and efficiency to enhance the teaching and learning of mathematics. This study investigated the impact of paper activity on students' academic achievement in circle geometry. Quasi-experimental research design was used. Two research questions were raised and two null hypotheses were formulated and tested at 0.05 level of significance. The academic achievements of students taught using paper activity (experimental group) was compared with students taught using conventional method (control group). Mathematics Achievement Test (MAT) was developed by the researcher and validated by two experts in measurement and evaluation. The population of the study was SS1 science students (90 students) of Government Senior Secondary School Rigachikun, Kaduna-Nigeria. SS1 A₁ (45 students) was selected as experimental group while SS1 A₂ (45 students) as control group using simple random sampling techniques. The instruments used for data collection was pre and post-test on circle theorems. Mean and standard deviation were used to answer the research questions while the null hypotheses were tested at 0.05 level of significance using independent t-

test. The result of the study showed a significant differences in academic achievement in favor of the experimental group. The researcher recommends the use of paper activities in teaching and learning circle geometry and generally geometry for effective teaching and learning outcomes.

Key: Circle Geometry, Circle Theorem, Hands-on Activities, Paper Activity, Academic Achievement.

Introduction

Mathematics is considered to be the bedrock for science and technological advancement of all nations. The importance of mathematics has been pointed out by studies such as (Astriani et al., 2017; Gregoire, 2016). Mathematics as a subject is required for entry into many professions and it is important for existing as well as emerging occupations in a global economy that is recently based on information and technology. It is a key subject in both primary and secondary school curricula because it provides learners an opportunity to develop ability for critical thinking and logical judgment. However, students in our secondary schools experiences difficulties with the learning of some concepts of the mathematics curriculum because the subject is taught in such a way that the mathematical concepts are largely removed from the everyday life of the students and real world applications (CEMASTE, 2013). Understanding of mathematical concepts forms the basic foundation for its application in the day-to-day activities. The strategies used by teachers to teach concepts of mathematics matters a lot, because it is the key for ensuring good understanding and application of the learned concepts. In this regard, continuous efforts should be made by teachers to explore more innovative strategies that are learner-centred and investigate their effectiveness and efficiency to enhance the teaching and learning of mathematical concepts for better understanding and effective learning outcomes of students. Learners, therefore, need to be effectively supported to gain an in-depth understanding of mathematical concepts for the appropriate application. To encourage and enhance students' mathematics mastery, teachers need to be creative by using innovative explorations to create dynamic instructional strategies that are activity-based/learner-centred approaches.

Students face difficulties in learning Circle Geometry (Circle Theorem) because teachers do not use innovative teaching and learning strategies that enhances students' learning abilities. This has created challenges for parents, students, teachers, educationists and

governments. Teachers and teacher educators are now faced with this challenge to explore more innovative teaching and learning strategies that would result to better academic achievement of students learning Circle geometry in general.

By paper activity such as folding cut out paper circles, learners can visualize the positions and relationships between the lines and angles in the circle theorems. These activities illustrate the properties stated in the theorems and the activities lead to visualization that helps learners to gain a deeper understanding of the geometrical properties and helps them to remember these properties and to apply them to solving geometrical problems (Diana Townsend).

The opportunity offered by paper activity to explore and visualize some concepts of geometry is claimed to foster understanding and improve high-order spatial abilities. When students are provided with learning opportunities that engage them in explorations, investigation and visualization of geometric relationships, they develop their geometric conceptual ideas.

In the context of mathematics teaching, one of the reasons why students have difficulties in studying geometry is the lack of conceptual understanding of the concepts involved. This has led to their inability to reason at the highest levels of geometric thinking Dogwi (2014).

The failure to understand mathematical concepts and hence poor achievement might have stemmed from the teaching methods. In teaching mathematics, teachers' instructional approach is a major determinant to students' level of understanding and development of the topic. According to Dogwi (2014), the instructional method and the choice of exercise a teacher adopts play a key role in any meaningful learning process.

For a country that aspires to address the problems of under-development; mathematics education have to be at the fore front of every educational programme.

Mathematics is one of the core subjects listed in the National Policy on Education (FRN, 2013) for Secondary Schools in Nigeria.

Mathematics is a fundamental which cut across subject boundaries that offers learners' experiences that help them to develop an operational understanding of the science and technology that could enrich their lives and make them responsible citizens in the society.

Eze (2012) asserted that for learning to be meaningful and effective in the classrooms, the teacher should be able to select the appropriate teaching strategies that will stimulate the interest of the learners and get them actively engaged in the process of learning. This brought a change in the trend of educational practice. These trends are daily occurrences that reflect positive change which is a move from transmission view of education to that of knowledge construction especially in the face of current world realities such as technological development. The National Policy on Education (2014) emphasizes paradigm shift in educational practices from teacher to learner centeredness, so as to enhance conceptual learning in mathematics. As a result of the shift, conventional practices of teaching are now more in vogue.

Researchers have found that conventional practices such as lecture method and expository approach have scarcely proved the capability of giving the desired learning outcomes among students (Umoren & Aniashi, 2007; Atomatofa, 2013). These seems not to help students acquire necessary skills that will enable them understand mathematical concepts thereby limiting their ability to self-reliant lives in the society after graduation from secondary school. The search for alternative but viable option could have led to the exploration of innovative instructional strategies.

Adedoyin (2010) as well as Danmole, Femi & Adoye (2004) further submitted that instructional approaches that involve the active participation of students could be more effective. Moreover, science is an abstract knowledge which cannot be easily understood using traditional teaching methods. The National Commission for Colleges Education (NCCE, 2002) stated that teachers ought to explore several methods of teaching for effective teaching and learning to be achieved in mathematics. This is because mathematics occupies a special position in secondary school curriculum and represents the foundation stone for subsequent instruction in the science and related courses in life. In mathematics teaching and learning process, the achievement of students depends on the qualities of teachers, availability of resources, the use of appropriate methods of instruction and appropriate choice of techniques of teaching.

Research Questions

1. What are the students' achievement scores in Circle Geometry (Circle Theorem) before exposure to paper activity and conventional method in Government Secondary School Rigachikun Kaduna?
2. What is the impact of paper activity on the mean achievement scores of students taught Circle Geometry (Circle Theorem) and those taught using conventional method in Government Secondary School Rigachikun Kaduna?

Null Hypotheses

The following hypotheses were formulated to guide the study and tested at 0.05 level of significant.

H_{01} : There is no significant difference in the achievement scores of the students of control group and experimental group in the pre-test.

H_{02} : There is no significant difference in the achievement scores of the students taught Circle Geometry (Circle Theorem) using paper activity and those taught using conventional lecture method in the post-test.

Methodology

Quasi-experimental research design was adopted for the study, specifically the pre-test, post-test, control group. The sample for the study consists of Ninety (90) mathematics students randomly selected in two different classes in Government Secondary School Rigachikun Kaduna, which were divided equally into experimental and control groups. The instrument for data collection was Mathematics Achievement Test (MAT) developed by the researchers to test the students' knowledge of the selected mathematical concept. The instrument was validated by the senior colleagues in the department of Academic Services of the National Teachers' Institute, Kaduna Nigeria.

Experimental procedure

Prior to the treatment, a pre-test was administered to all the students in the two groups to determine the ability levels of both experimental and control groups in circle geometry (circle theorems). After that, the experimental group was taught circle theorem using hands-on activities (paper folding, paper-cut and paste: paper activity) for four weeks

while the control group was taught same concept using conventional lecture method. At the end of the treatment, a post-test was administered to both the two groups (Experimental and Control)

Pre-Treatment Activities

The researcher administered a pre-test to confirm the entry level of both experimental and control groups in circle geometry (circle theorem).

Treatment activities

Treatment after using the pre-test to ascertain the impact of paper activity on students' academic achievement on circle geometry, and the following activities were conducted as treatments.

Learning circle theorems through investigation and visualization

Investigate the angle subtended by an arc at the centre of a circle is double the size of the angle subtended by the same arc at the circumference by paper folding, cutting and pasting.

First let us start with centre of a circle

Activity: Using manila sheet/paper, find the centre of a circle. (In group)

a. Cut-out paper circle



Figure (1a): A circle on paper



Figure (1b): A paper circle cut-out

c. Now unfold the circle and fold again along a different diameter and mark the ends C

b. Fold your circle along a diameter and mark the ends A and B

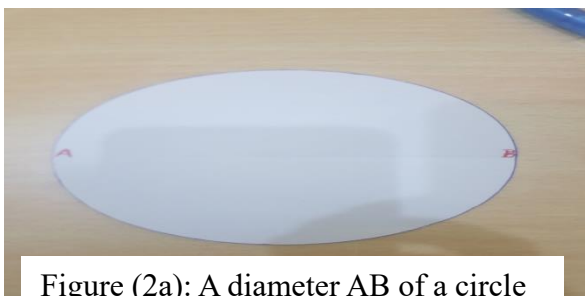


Figure (2a): A diameter AB of a circle

D.

d. Mark the point of intersection of AB and CD as O. Why is point O the centre?



Figure (2b): Centre O of a circle

e. Is there another way of finding the centre?

Observations

- For (b), does it matter which diameters are used? Repeat if necessary so that it's clear that any two diameters will intersect at the centre.
- For (c), folding the circle in half and then half again, so that A lies on B, also gives the centre and a right-angle.

Secondly let us look at perpendicular bisector of a chord

Activity 2: Using manila sheets/ paper, find the perpendicular bisector of a chord. (In group)

Cut-out paper circle with centre O marked.

b. Fold over a segment of the circle to make a chord. Mark the ends A and B.

c. Fold the circle so that A and B come together. Unfold and mark the points where this line cuts the circle as C and D.



Figure (3a): A chord AB

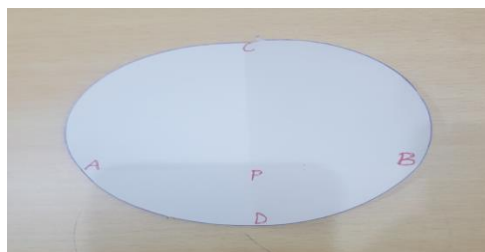


Figure (3b): A perpendicular bisector CD

d. If AB and CD intersect at P, what do you know about AP and PB? What about angle CPA?

- e. How is CD related to AB?
 f. Is CD a diameter of the circle?

Observations

- In (d) we're looking for the recognition that CD is the perpendicular bisector of the chord AB.
- In (f) the fold-line CD should pass through the centre O. This demonstrates the theorem that the "perpendicular bisector of a chord passes through the centre".

Now, let us look at the angles at the centre and circumference subtended by the same arc/chord

Activity 3: Using manila sheet/paper, compare the angles at centre O and the circumference subtended by the same arc/chord. (In group)

- Cut-out paper circles with centre O marked.
- You and your partner should have identical circles and mark identical points. Both mark two points A and B on one side of O and a point P the other side of O.

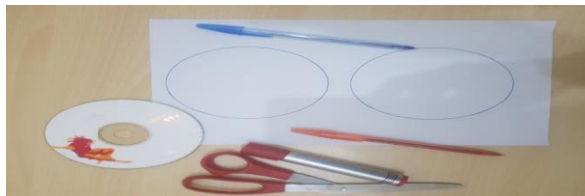


Figure 4: Two identical circles

- One of you folds along the chords AP and BP, the other AO and BO.
- By folding again so that AO and BO are aligned, make the angle $\frac{1}{2}$ AOB.



Figure 5a: A chords AP and BP

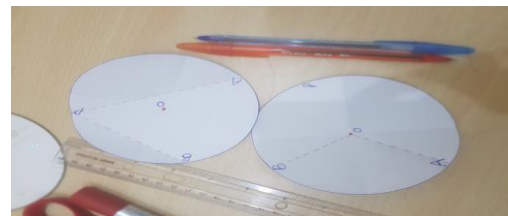


Figure 5b: An arc AOB and $\angle APB$

- Compare this angle $\frac{1}{2} \angle AOB$ with $\angle APB$

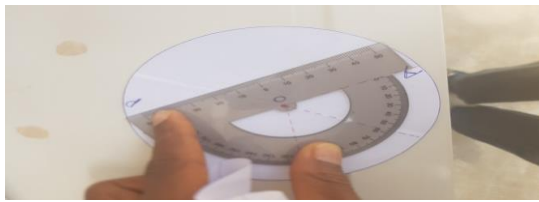


Figure 6a: $\frac{1}{2} \angle AOB$



Figure 6b: $\angle APB$

Observations

- This illustrates the theorem that "angle subtended at the centre of a circle is twice the angle subtended at the circumference".
- In (d) it may be easier to cut out $\angle AOB$.
- In (e) it is easier to cut out $\frac{1}{2} \angle AOB$ and $\angle APB$ or use protractor.

Discussion on the activity

- By folding cut out paper circles learners can visualize the positions and relationships between the lines and angles in the circle theorems.
- These activities illustrate the properties stated in the theorems and the activities lead to visualization that helps learners to gain a deeper understanding of the geometrical properties and helps them to remember these properties and to apply them to solving geometrical problems.
- The sequences of steps in the paper folding activities can be described and written as formal statements with reasons that together build formal proofs of the theorems.
- Similar paper folding activities can easily be devised to illustrate the remaining theorems.

Method of Data Analysis

Data collected were analyzed using mean, standard deviation and t-test statistical tools.

Hypothesis One: There is no significant difference in the achievement scores of the students of control group and experimental group in the pre-test.

Independent t-test statistics on difference in the pre-test's mean achievement scores of experimental and control groups.

Table 1

Group	N	Mean	SD	Df	α	t-cal	t-crit	Decision
Exp.	45	10.5000	2.9187	88	0.05	0.68	1.66	Retained
Cont.	45	10.0500	3.0331					

Result of independent sample t-test statistics in the table above revealed the mean score of 10.50 and the standard deviation of 2.92 for the experimental group, while the control group recorded the mean score of 10.05 with the standard deviation of 3.0331. The table also show the observed t-calculated value of 0.68 and the p-value of 1.66 ($P < 0.005$). The null-hypothesis is thus retained because there was no significant difference in the pre-test mean academic achievement scores of experimental and control groups of mathematics students of Government Secondary School Rigachikun, Kaduna-Nigeria.

Hypothesis Two: There is no significant difference in the achievement scores of the students of control group and experimental group in the post-test.

Independent t-test statistics on difference in the mean achievement scores of students in experimental and control groups.

Table 2

Group	N	Mean	SD	Df	α	t-cal	t-crit	Decision
Exp.	45	16.0750	4.6303	88	0.05	9.11	1.66	Rejected
Cont.	45	14.4000	4.5792					

The independent sample t-test statistics in the table above revealed the mean score of 16.08 and the standard deviation of 4.63 for the experimental group, while the control group recorded the mean score of 14.40, with the standard deviation of 4.57. The table

also show the observed t-calculated value of 9.11 and the p-value of 1.66 ($P < 0.005$). The null-hypothesis is thus rejected because there was significant difference in the post-test mean achievement scores of experimental and control groups of mathematics students of Government Secondary School Rigachikun, Kaduna-Nigeria.

Discussion of result

The result in table 1 give answer to research question one and the analysis of independent t-test of the hypothesis one.

The findings showed that students taught Circle Geometry (Circle Theorem) in the experimental group had (10.50) and the control group (10.05) indicated no significant difference in students' pre-test achievement scores. This result shows that students in both control and experimental groups have same ability in Circle Geometry (Circle Theorem). This may be due to the fact that both schools use the same curriculum, teaching method and they are government owned schools.

The result presented in table 2 revealed answers to research question two and the analysis of independent t-test of hypothesis two. The result indicated that there was significant difference in the achievement scores of students taught Circle Geometry (Circle Theorem) using hands-on activities (paper folding, paper-cut and paste: paper activity) and those taught with conventional teaching method. This implies that the use of hands-on activities (paper folding, paper-cut and paste: paper activity) has significant impact on the achievement scores of students in mathematics. It therefore showed that the paper activity has enhanced the students with the skill and understanding of Circle Geometry (Circle Theorem). This showed that using paper activity in teaching and learning of circle theorems has help to improve students' achievement immensely. This result agrees with the findings of other research where activity based learning and conventional learning were compared in terms of impacts on students' achievement. This result agreed with Magno et al. (2005) who concluded that students who received instruction through

activity method had significantly higher performance in tests than those who receive instruction through the conventional method. The result obtained is inline with the findings of Adedoyin (2010), Damole, Femi & Adoye (2004), whose findings reveals that instructional approaches that involves active participation of students would be effective.

The finding also agreed with the finding of Batdi (2014), who pointed out that the activity based teaching and learning had positive impact on students' academic achievement. Additionally, the finding agreed with the finding of (Celik 2018; Camaci 2012). These studies investigate the impact of activity based teaching and learning of mathematics on students' achievement. The concluded that activity based learning strategy increases academic success. It was also concluded that, if teaching and learning were based on activities that actively engaged learners, the topics or concepts of the learning were grasped better Rubin et al. (2014), teaching enriched with activities affect student perceptions positively (Kosterelioglu and Yapici, 2016).

Conclusion

On the basis of the findings of this study, it can be concluded that the use of hands-on paper activity such as paper folding, paper-cut and paste is an effective strategy in enhancing students' achievement in learning the concept of Circle Geometry (Circle Theorem) than conventional lecture method of teaching, because it boosts the academic achievement of mathematics students in Government Secondary School Rigachikun, Kaduna-Nigeria.

Recommendations

Based on the findings from this study, the researchers recommended that:

1. Teachers should practice paper activity because the approach is effective in the teaching and learning the concept.
2. Further should be carried out to investigate the impact of hands-on activities (paper folding, paper-cut and paste: paper activity) on students' academic achievement to provide database for researchers and educators.

3. Expanding the sample population, time of intervention or investigating and introduction of another dependent variable are potential points for future studies.
4. Conferences and workshops should be organized to mathematics teachers on the use of paper activity in the teaching and learning of Circle Geometry.

References

- Adedoyin, O. (2010). *An investigation of the effects of teachers' classroom question on the achievements of students in mathematics: case study of Bostwana Community Junior secondary schools. European Journal of Educational Studies*. 2(3). 313-328
- Astriani, N., Surya, E., & Syahputra, E. (2017). *The effectiveness of using problem based learning in mathematics problem solving ability for junior high school students. International Journal of Advance Research and Innovative Ideas in Education*, 3(2), 3441-3446.
- Danmole, B. T. & Femi-Adoye, K. O. (2004). *Effect of Concept Mapping Technique on Senior Secondary School student' Achievement and Retention of Ecological Concepts. Journal of the Science Teachers Association of Nigeria*. 39 (1&2) 32-38.
- Eze, G.N. (2012): *Improving Teaching/ Learning of Secondary School Chemistry Through Home Experiment ESUT Journal of Education* 5(3) 371-379.
- Federal Government of Nigeria (FGN), (2014). *National Policy on Education*. Lagos: NERDC Press.
- Federal Republic of Nigeria (FRN) (2013) *National Policy on Education*. Lagos: NERDC Press.
- Gregoire, J. (2016). *Understanding creativity in mathematics for improving mathematical education. Journal of Cognitive Education & psychology*, 15(1), 24-36. <https://doi.org/10.1891/1945-8959.15.1.24>.
- National Commission for Colleges of Education (2002). *Teachers' Education in Nigeria*. Abuja: NCCE Press.
- Batdi, V. (2014). *The effect of activity-based learning approach on academic achievement (A metaanalytic and thematic study). E-International Journal of Educational Research*, 1 (1), 39-55.
- Camaci, F. (2012). *Effects of activity based teaching grounded on active learning on students'academic skills and learning process . Master Dissertation. Adiyaman University*.
- Celik, H. (2018). *The effects of activity based learning on sixth grade students' achievement and attitudes towards mathematics activities. Eurasia Journal of Mathematics, Science and Technology Education*, 14 (5), 1963-1977.

- CEMASTEА (2013). *Effective Implementation of SMASE Primary Activities for sustainable ASEI-PDSI practice; Head teachers' Workshop manual*, CEMASTEА, Kenya.
- Diana Townsend. *Circle Theorems: Learning through investigation and visualization*.
- Dongwi, B. L. (2014). *Using the Van Hiele phases of instruction to design and implement a circle geometry teaching programme in a secondary school in Oshikoto region: A Namibian case study*. Retrieved from <http://hdl.handle.net/11070/2174>.
- Rubin, R. J., Marcelino, J., Mortel, R. & Lapinid, R. C. (2014). *Activity-based teaching of integer concepts and its operations: DLSU Research Congress. De La Salle University, Manila, 6-8 March 2014*.
- Magno, C., Lajom, J. A., & Regodon, J. R. (2005). *Developing a deep approach and attitude to through project-based learning*. *Learning edge*.
- Kosterelioglu, I. & Yapici, M. (2016). *The effects of activity based learning process on prospective teachers' perceptions of constructivist learning environment*. *International Journal of Human Sciences*, 13 (1), 1342-1354.
- Umoren, G. U. & Aniashi, S. O. (2007). *Prior presentation of Behavioral Objectives and Students' Performance in Biology*. *Educational Research and Review*. 2(2), 22-25

Article 31

Advancing Sustainable Solutions in Zambia: Assessment of Solar Energy
Exhibitions at a National Science Fair

Chipo Namakau Sakala

chiponamakau@gmail.com

Benson Banda

Bensonbanda2003@yahoo.co.uk

Ministry of Education

Directorate of National Science Centre

Abstract

This research focuses on understanding the types of solar energy exhibitions within the context of a National Science Fair. It analysed the diversity and scope of the exhibitions. The study adopted a descriptive cross-sectional design with qualitative and quantitative aspects. It investigated exhibitions at an annually held National Junior Engineers Technicians and Scientists (JETS) Fair made by participants from all the 10 provinces of Zambia. These included 10 Early Childhood Education (ECE) and primary learners, 11 junior secondary learners, 11 senior secondary learners, 8 out-of-school individuals, and 5 teachers. The research findings revealed a diverse focus on different aspects of solar energy. Furthermore, the research identified that the exhibitions were predominantly at the concept development stage. Furthermore, the research revealed that the exhibitors demonstrated gaps in STEM (Science, Technology, Engineering, and Mathematics) abilities. The implications of this research extend to enhancing the understanding of the multifaceted nature of solar energy and its potential to contribute to sustainable learning in physics education. These findings are valuable for educators, policymakers, and

researchers aiming to promote STEM education and sustainable solutions. The innovative products showcased at these exhibitions hold promise as potential nuclei for addressing Zambia's pressing energy needs. In conclusion, this research analysed solar energy exhibitions at an annual National Science Fair, providing insights into the diversity of their focus and their potential in promoting sustainability and STEM education. Continued development and support for these exhibitions is recommended to maximise their educational impact and contribute to the advancement of solar energy solutions in Zambia.

Key words: Sustainable Solutions, Solar Energy Exhibitions, STEM abilities

1. Background

In the wake of pressing global challenges and a growing commitment to sustainable development, the exploration of renewable energy sources has taken centre stage as a crucial avenue for meeting energy demands while mitigating environmental impacts. Among these sources, solar energy has emerged as a beacon of hope, offering an abundant and eco-friendly solution. However, Zambia's energy scenario presents a paradox as the nation is endowed with abundant solar resources, yet this wealth of potential energy remains largely untapped. The average solar radiation is approximately 5.5 kWh/m²/day, positioning the country among the top solar energy potentials in Africa (Mwanza, 2017). Despite this, the current exploitation of these resources for electricity generation is minimal. While Zambia has made strides in increasing its renewable energy footprint, solar power, which could significantly mitigate the nation's energy challenges, contributes to a minor fraction of the national energy mix (Energy Regulation Board, 2021).

Research has often focused on the technological and infrastructural aspects of renewable energy applications. However, there is a noticeable gap in the exploration of educational avenues that could bridge the existing disconnect between Zambia's solar energy potential and its practical application. National platforms such as the JETS Fairs, which showcase science and technology projects, provide an opportunity to disseminate

knowledge and foster innovation. JETS is one of the avenues in Zambia's Education system that has consistently embraced its mission to provide a dynamic platform for learners from diverse educational backgrounds to showcase their ingenuity and creative abilities. For over 5 decades, the JETS Fair has firmly established itself as a hallmark event of innovation, scientific inquiry, and technological exploration within the educational landscape. The Physics category for the 2023 National JETS fair was skewed towards renewable energy with specific context of harnessing solar energy for sustainable development. Innovations in Solar energy were a preference that needed to be explored because according to the previous studies and data undertaken by the Meteorological Department of Zambia, the country has a significant potential for solar energy for both power production and thermal from solar energy technologies. The country is situated at a latitude of 8 to 18 degrees south of the equator and longitude 22 to 34 degrees east of prime meridian with an average sunshine of about 6 to 8 hours per day and high monthly average solar radiation incident rate of 5.5kWh/m²/day throughout the year (Mwanza, 2017). Therefore, the need to have learners begin thinking about ways to harness this solar energy cannot be overemphasised.

While these JETS Fairs have been running, their impact on actual skills development and innovation uptake has not been thoroughly investigated. There is a potential to cultivate a generation of innovators who can harness Zambia's solar potential to its fullest by integrating educational initiatives such as JETS with the nation's energy strategy. This study therefore, was aimed at exploring innovative ideas on the educational platforms in view of how they can effectively contribute to the national energy agenda and sustainable development goals.

1.1. Introduction

In Zambia, where sunlight is abundant and the potential for solar energy is among the highest in the world, the paradox of energy poverty persists. While the nation basks in an average of 2,000 to 3,000 hours of sunshine per year, translating this natural bounty into practical energy solutions remains a challenge (Zambia Meteorological Department, 2020). The role of education in addressing this paradox is pivotal, However, the

integration of solar energy education within the national curriculum has been an area of slow progress (Browns.T.J.et al, 2020).

This study emerges from this background, aiming to investigate the contribution of educational platforms, specifically the Physics category in the National JETS Fair, in advancing solar energy knowledge and application. The National JETS Fair, an annual event dedicated to promoting scientific innovation among learners, provides fertile ground for assessing the potential of educational interventions in fostering renewable energy expertise. This research is directed by three principal objectives which include categorising the focus areas of exhibitors' projects within solar energy, examining the developmental stages of these projects, and evaluating the exhibitors' STEM capabilities. These objectives anchor the study's investigation into the educational ecosystem's efficacy in promoting solar energy as a sustainable solution for Zambia's energy needs. With these aims, this study presents a novel contribution to the existing body of research. This study seeks to inform policy decisions and educational strategies, with the goal of energising Zambia's future with the power of its sun.

1.2. Research Problem

In Zambia, a nation endowed with an average 2,000 to 3,000 hours of sunshine per year, the solar potential is substantial yet underutilized. While Zambia's geographical and climatic conditions are favourable for solar energy production, the actual implementation of solar projects has not kept pace with this potential (Mwanza and Ulgen, 2021). For instance, the International Renewable Energy Agency (IRENA) indicates that as of 2021, solar energy constituted less than 2% of Zambia's total energy mix, despite the country facing electricity deficits of up to 750 megawatts during peak periods (IRENA, 2021). This disparity shows a significant research gap in the exploration of solar energy projects in addressing Zambia's energy shortfall. Further, the Republic of Zambia (1996:17) states that "Zambia has lagged behind in technological advancement, which is generally enhanced by improved diffusion, transfer, innovation and commercialisation processes. It is essential to stimulate commercial innovation of technology in Zambia. In addition, a whole range

of incentives and support are required to ensure the transfer, diffusion, commercialisation and innovation of new technologies in the key sectors". Therefore, this study was driven by the urgent need to investigate the practical application of innovations in solar energy showcased at the National Science Fair in the Physics category. Through examining the feasibility and scalability, of the Fair projects, the study aspired to understand how these innovations could act as catalysts for the nation's energy solutions, aiming to transform Zambia's abundant sunlight into a cornerstone of its energy strategy.

1.3. Purpose of the Study

The overarching purpose of this research was to meticulously explore the landscape of solar energy exhibitions at Zambia's National Science Fair, elucidating the full extent and breadth of these projects. This examination was not merely about cataloguing the variety of solar energy solutions on display but also about understanding their pedagogical value and impact. By closely analysing the educational content and interactive experiences offered through these exhibitions, the research intends to determine how effectively they promote sustainable solutions and foster proficiency in STEM disciplines among participants. Zambia is a country where solar irradiance levels are among the highest in the world (World Bank, 2017), therefore, there is a pressing need to tap into this vast renewable resource through education. Hence, this study aimed to fill the critical void identified in the literature by providing empirical evidence of the role that educational platforms can play in driving innovation and skill development within the renewable energy sector. Consequently, the findings of this research could offer pivotal insights for educational policymakers and practitioners, positioning science fairs as a potential catalyst for Zambia's sustainable energy future.

1.4. Research Objectives and Questions

The study was guided by the following specific objectives and research questions.

The objectives were as follows:

- a. To Investigate the focus areas of exhibitions among exhibitors participating in the Physics and Renewable Energy Category

- b. To Identify and developmental stages of exhibitions by participants
- c. To Highlight STEM competences, relevant to sustainable learning. displayed by exhibitors who participated in these exhibitions

The research questions were as follows:

- a. What are the focus areas of exhibitions among participating exhibitors in the Physics category at the National Science Fair in Zambia?
- b. At what development stage are the exhibited projects predominantly?
- c. To what extent do exhibitors possess STEM abilities for sustainable learning?

1.5. Significance of the Research

The significance of this research is multifaceted and extends beyond the confines of the fair itself. It aims to unravel the dynamic relationship between innovation, solar energy, and sustainable development, offering insights into the pivotal role of creative thought and empirical substantiation in driving transformative change. First, it is ready to speed up how better and greener ideas in physics can be offered. Moreover, as a beacon for future exhibitors, the research can chart a course for forthcoming innovators, furnishing them with a navigational compass to craft inventive and sustainable solutions within the dynamic landscape of physics, in turn nurturing a culture of heightened environmental consciousness. This significance extends to the policymaking spheres with the potential to spark collaborative synergy, inciting potential cooperation between academia, industry, and visionary minds to forge innovative solutions. Furthermore, the educational terrain stands to be enriched as the research outcomes take on the mantle of educational resources, embellishing curricula and learning initiatives across physics and its interconnected disciplines. In summary, the significance of this research is a cascade of interconnected impact, fostering transformative change, igniting inspiration, fostering collaboration, amplifying awareness, and underpinning the pursuit of knowledge in the relentless quest for a more sustainable and enlightened future.

2. Literature Review

The review of literature encompassed the global, African and Zambian perspective

2.1. Global Context

Globally, the emphasis on renewable energy has become increasingly pronounced. The International Energy Agency (IEA) reports a steady rise in renewable energy projects, with solar energy at the forefront due to its scalability and rapidly declining costs (IEA, 2022). Studies by REN21 (2022) suggest that innovative educational interventions, such as science fairs and interactive exhibits, are instrumental in increasing public awareness and fostering young scientists' interest in renewables. Besides, educational institutions worldwide increasingly embrace solar energy to reduce carbon emissions, promote sustainability, and enhance educational experiences. From pioneering solar campuses in the United States to innovative programs in India and Australia, solar power integration in education is transforming campuses and curricula (Oluwaseon et al, 2023). However, there is a notable research gap concerning the effectiveness of these interventions in terms of actual skill development and the long-term engagement of participants in the renewable energy sector.

2.2. African Regional Perspective

In Africa, the narrative is slightly different; the continent is rich in solar potential, yet many regions have not fully harnessed this potential. The African Development Bank Group (AfDB, 2023) highlights several initiatives across the continent aimed at improving renewable energy education and integration. However, there remains a lack of substantial evidence on the ground that connects educational initiatives with real-world applications and innovation in solar energy, especially at the grassroots level (Uggla and Soneryd, 2023).

2.3. Zambian National Perspective

In Zambia, the energy sector has traditionally been reliant on hydropower, but the country faces electricity deficits due to variable rainfall patterns and growing demand (PMRC, 2013). The Zambian government, with support from international bodies, has embarked on initiatives to explore solar energy, recognising its importance in the

country's energy mix (World Bank, 2019). While these steps are commendable, there remains a significant gap in the literature regarding the role of educational programs, like the JETS Fairs, in directly contributing to solar energy knowledge and practical skills development among the youth of Zambia.

The Zambia Development Agency, in its 2019 report, highlights Zambia's significant untapped potential in solar energy, noting that despite the favourable climatic conditions for solar power generation, the use of this renewable resource is still in nascent stages. The report emphasizes the country's theoretical solar electricity potential of 300 MW and encourages investment in the energy sector, particularly in photovoltaic (PV) and concentrated solar power (CSP) technologies. The agency has outlined a series of incentives designed to attract both domestic and international investors to the Zambian energy market, aiming to catalyse the growth of the solar energy sector (Zambia Development Agency, 2017).

In a comprehensive review, UNFCC (2020) examined the trends and determinants influencing renewable energy investments and development in Zambia. They analysed the historical context, policy environment, and current status of renewable energy initiatives, identifying critical challenges and opportunities within the sector. Their findings suggest that while policy frameworks have evolved to support renewable energy, implementation remains hindered by a range of factors, including financing, regulatory issues, and capacity constraints. The authors argue for a more robust approach to renewable energy development, that not only focuses on policy formulation but also on building human capital, enhancing technological capabilities, and establishing public-private partnerships to drive innovation and scalability in the renewable energy sector (UNFCC, 2020).

2.4. Research Gap

Within the scholarly discourse on Zambia's renewable energy potential, a pronounced gap exists regarding the intersection of education and practical application, particularly in solar energy. The nation, with one of the highest insolation levels globally, averaging

around 2,000 to 3,000 hours of sunshine per year, has a theoretical solar electricity potential estimated at 300 MW, yet harnessing this potential has been slow (Zambia Development Agency, 2019). While studies have frequently focussed on the macro aspects of renewable energy policy and infrastructure development (UNFCCC, 2020), less attention has been devoted to understanding how educational interventions such as National Science Fairs translate into tangible skills and innovative solutions in the solar energy sector.

The literature thus far has marginally addressed how participation in educational events like science fairs have potential to influence young people's capabilities in STEM and their potential contributions to the renewable energy industry (Ministry of Education, 2021). Specifically, there is a scarcity of empirical research exploring the effectiveness of these platforms in fostering the critical thinking, and problem-solving skills that are vital for propelling solar energy projects from conceptual models to practical, scalable solutions. This study endeavours to bridge this research gap by systematically evaluating the role that National Science Fairs play in developing the solar energy competencies of Zambian students, thereby informing strategies to utilize such educational platforms for bolstering the country's renewable energy development and achieving its sustainable energy goals (Lucas, Pinnington and Cabeza, 2018). Addressing this gap, the research will offer valuable insights into the effectiveness of science fairs as a medium for promoting solar energy innovation and education, potentially informing policy and educational curriculum development in Zambia.

2.5. Theoretical Underpinning

Diffusion of Innovations Theory, developed by Everett Rogers in the 1960s, seeks to explain how, why, and at what rate new ideas and technology spread through cultures. The Diffusion of Innovations Theory has been widely applied across fields, including public health, communications, marketing, and environmental science, to understand how new technologies and ideas become widespread, and to develop strategies to accelerate the adoption of beneficial innovations. In the context of a study on educational science fairs and renewable energy in Zambia, this theory could be utilised to explore

how new ideas about sustainable energy are taken up by participants and potentially diffused into wider society. Diffusion of Innovations Theory, as articulated by Everett Rogers, offers a framework for understanding how the adoption of new technologies and practices, such as those related to renewable energy, unfold within a community or social system (Rogers, 2003). According to the theory, innovations spread through a social system via communication channels over time, and the rate of adoption is influenced by the innovation's perceived attributes, societal norms, and the roles of change agents and opinion leaders. In the context of a science fair, which serves as a microcosm of a larger social system, this theory can illuminate the pathways through which knowledge and attitudes about renewable energy innovations are disseminated among participants, who may range from innovators to members of the early and late majority.

In applying the Diffusion of Innovations Theory to the current research on Zambia's National Science Fair, the theory guides the investigation into how solar energy innovations presented at the fair are communicated among attendees and how these innovations may be adopted and implemented beyond the fair itself. The theory posits that participants, through their interactions at the fair, may serve as change agents who disseminate knowledge and influence their peers' and communities' attitudes towards solar energy (Rogers, 2003). This research seeks to trace such communication channels and determine the extent to which these interactions can affect the uptake of solar energy practises in Zambia, contributing to the broader goal of sustainable energy.

3. Methodology

The research design used in this study is indicated in Table 1.

Table 5: Research Design

Data Collection Observation: To document showcased solar energy exhibitions, by noting project characteristics, developmental stages and exhibitors' demonstrated STEM attributes Interviews: To gain deeper insights into participants' motivations, understanding of solar energy concepts, and educational impact of the exhibitions.	Target	Qualitative descriptive cross-sectional
	10 ECE & Primary	
	11 junior secondary	
	11 senior secondary	
	8 out-of-	

This study adopted a descriptive cross-sectional design to capture a snapshot of the current state of solar energy exhibitions at the National Science Fair. While the primary focus was qualitative, quantitative methods were employed for descriptive purposes to augment the data, enabling the analysis of numerical trends and correlations that support the qualitative findings.

3.1. Data Collection

In the data collection phase of the research, a multifaceted qualitative approach was employed. Observational methods were pivotal, entailing systematic documentation of the solar energy projects exhibited at the National Science Fair. This included detailed notes on the projects' attributes, the stages of development they represented, and the specific STEM skills demonstrated by the exhibitors in real time. To support these observations and investigate the qualitative aspect of the study, semi-structured interviews were conducted. These interviews served as a conduit to understand the participants' conceptual grasp of solar energy principles and, the purpose of the innovations in mitigating the challenges faced by Zambian society. Additionally, adjudication sheets were instrumental in this phase, providing a structured mechanism to capture and quantify the STEM competencies displayed by the exhibitors, thereby facilitating a more objective assessment. This triangulated approach ensured a comprehensive collection of data, which was essential for capturing the essence of the participants' reasons for developing their innovations.

3.2. Specific Population

The study's data collection efforts were designed to capture a broad representation across the educational spectrum, targeting participants at various stages of their academic journey. The inclusion criteria for the sample encompassed 10 learners from Early Childhood Education (ECE) and Primary School, thus ensuring insights from the foundational levels of education. Additionally, 11 learners from Junior Secondary and another 11 from Senior Secondary schools were part of the sample to provide a perspective on the evolving understanding of solar energy concepts as learners

progressed through their education. Recognising the importance of including diverse educational backgrounds, the study also engaged 8 out-of-school youths, offering valuable viewpoints from individuals in non-formal educational settings. To round off the participant pool, 5 teachers were also part of the sample population in the study for their potential to provide professional insights into the educational strategies employed. This stratified approach allowed for a deeper analysis of the data reflecting the varied educational experiences and learning stages represented at the National Science Fair.

3.3. Data Analysis

Data analysis for this research is structured to interpret both qualitative and quantitative inputs. For the qualitative component, thematic analysis was used as the cornerstone method, and rigorously applied to the body of interview transcripts and observational notes. Braun and Clarke's (2006) thematic analysis framework guided the analysis of data into meaningful patterns and themes, specifically focussing on how the science fair exhibitions were according to the innovations focus and stage. In parallel, quantitative data collected primarily from adjudication sheets were subjected to statistical scrutiny through basic yet robust Excel functionalities. This approach facilitated the identification of numerical trends and the exploration of correlations, thereby offering a quantitative dimension to the analysis of STEM attributes demonstrated by exhibitors. The amalgamation of qualitative richness with quantitative precision allowed for a holistic understanding as the study delineated the characteristics of solar energy exhibitions, categorising them into their thematic diversity, project typologies, focus areas, and developmental stages. Such categorisation is anchored in the framework of educational relevance, shedding light on the pedagogical underpinnings of each exhibit (Creswell & Poth, 2018). Furthermore, analysing the STEM attributes of participants, the research aspired to gauge not just the depth of knowledge imparted but also the practical application of skills, which is a dual focus that echoes Schön's (1984) reflection-in-action and reflection-on-action concepts in learning.

3.4. Ethical Considerations

In this research, ethics were considered as personal information of participants was treated with the utmost confidentiality. Data was also anonymised, with identifiers removed to prevent any association between responses and the individuals

4. Findings

The findings of this study are systematically arranged around three pivotal areas that mirror the research objectives. To investigate the focus areas of exhibitions among exhibitors participating in the Physics and Renewable Energy Category, the findings centre on the various aspects of solar energy as presented in the exhibitions. The findings on the developmental stages of the projects, are an essential aspect of the second objective revealed insights into the maturity and readiness of these solar energy solutions for real-world application. The extent to which exhibitors demonstrated STEM abilities, in relation to the third objective, sheds light on the exhibitors' competencies and potential for contributing to Zambia's renewable energy sector.

4.1. Finding 1: Focussing on Different aspects of Solar Energy

Investigating the thematic breadth of the projects, in order to show the focus areas of the exhibitor's innovations, the findings indicated a diverse focus on different aspects of solar energy at different levels, as indicated in Figure 1.

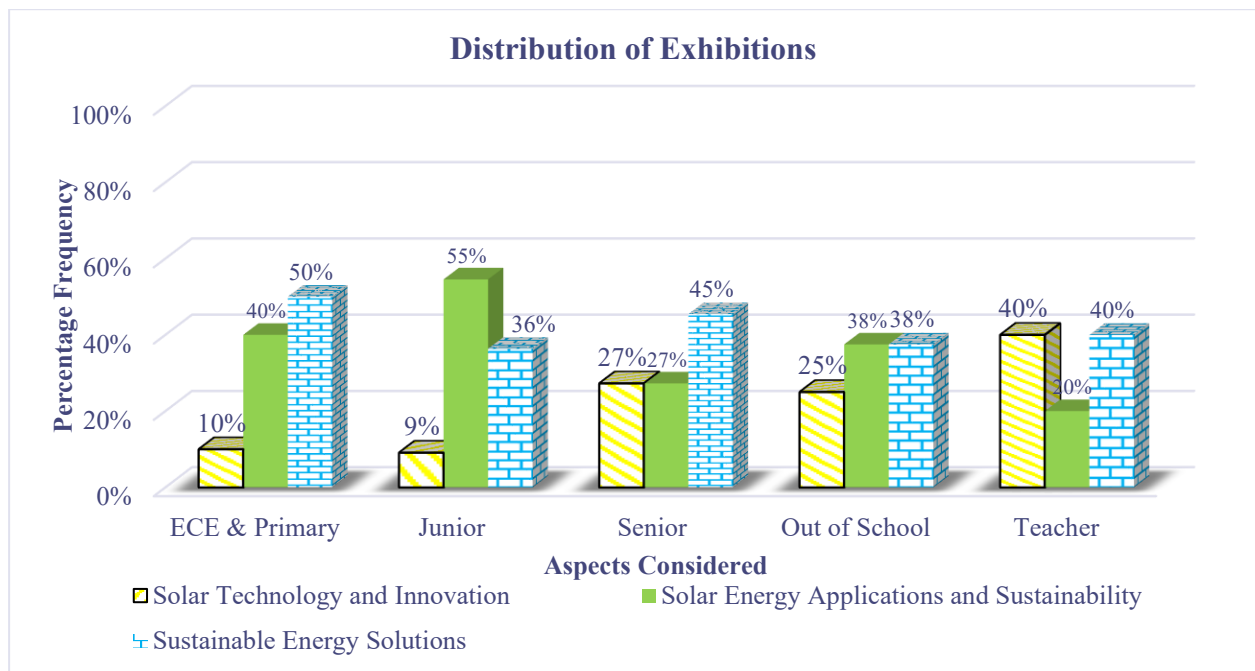


Figure 6: Distribution of Exhibitions

The analysis of the exhibition data illustrated a variation in emphasis on solar energy, segmented into categories such as 'Solar Technology and Innovation,' 'Solar Energy Applications and Sustainability,' and 'Sustainable Energy Solutions.' This diversity is reflected across various educational levels, from ECE and Primary School learners to teachers.

The results revealed that 10% of exhibitions for Early Childhood Education & Primary, 9% for Junior, 27% for Senior, 25% for Out of School, and 40% for Teachers were aligned to Solar Technology and Innovation. This showed a significant emphasis on technological advancements and innovative approaches within the solar energy sector.

Additionally, 55% of Junior, 40% of Early Childhood Education & Primary, 27% at Senior, and 38% Out of School and interestingly, a smaller portion at 20% among Teacher exhibitions were under the Solar Energy Applications and Sustainability theme. This category reflects a diverse range of practical solar energy applications and a commitment to sustainability.

Further, 50% of exhibitions for Early Childhood Education & Primary, 45% for Out of School, 36% for Junior, 38% for Senior, and 40% for Teacher categories aligned to

Sustainable Energy Solutions. This category highlights the collective dedication to addressing broader energy sustainability challenges, encompassing solutions that extend beyond solar energy alone.

Furthermore, across all the categories, on average 22% of exhibitions were aligned to Solar Technology and Innovation, 36% were under Solar Energy Applications and Sustainability, and 42% associated with Sustainable Energy Solutions as indicated in Figure 2.

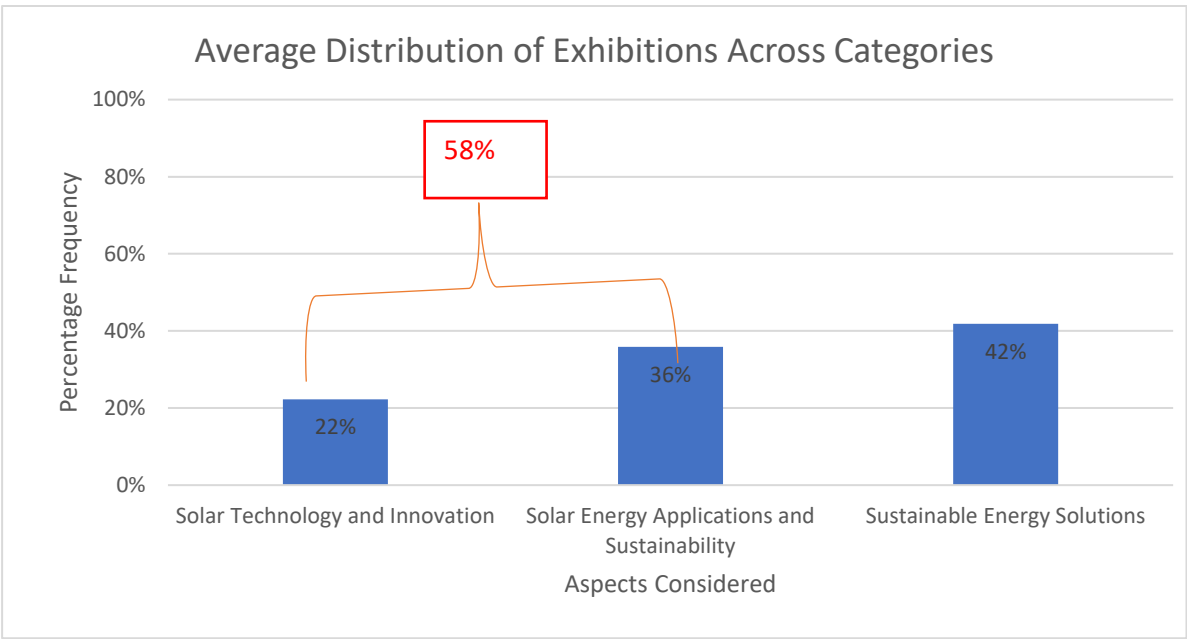


Figure 7:Average Distribution of Exhibitions Across Categories

From the average results, the (22%) exhibitions under Solar Technology and Innovation signifies a substantial, albeit relatively smaller, focus on technological advancements and innovative approaches within the solar energy theme. Solar Energy Applications and Sustainability captured a significant share of innovations at 36% making the total relevance to the theme 58%. Despite the solar theme being provided there was still the prominence of Sustainable Energy Solutions at 42% of exhibitions across all the categories.

4.2. Finding 2: Developmental Stage of Exhibitions

The second finding assesses the developmental stage of the exhibited projects. It catalogues the progression of the projects from conceptual designs to functional prototypes as shown in Figure 3.

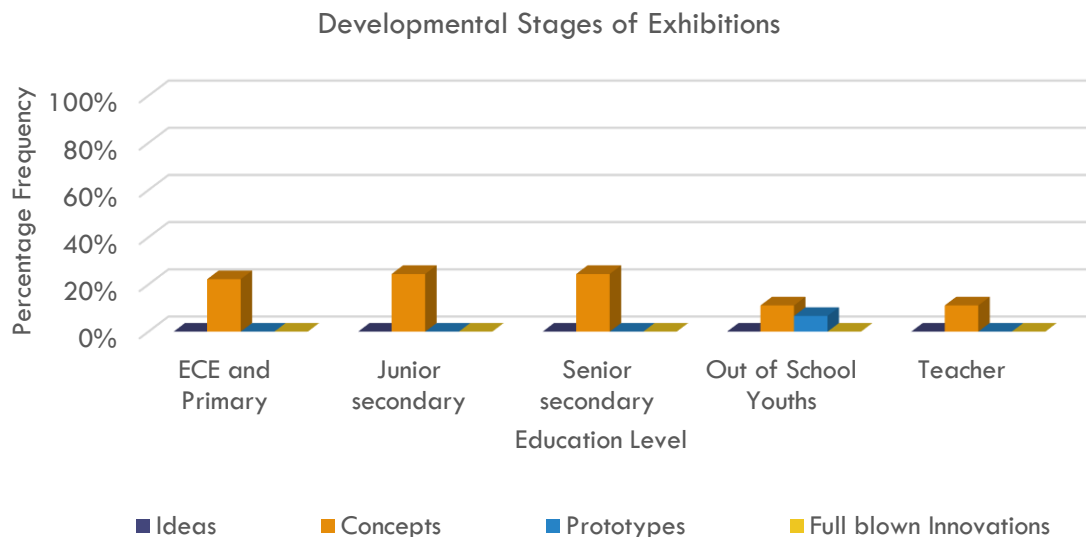


Figure 8: Developmental Stages of Exhibitions

At the ECE and Primary level, a substantial 60% of projects exhibited were in the 'Ideas' stage while 40% are categorised under the 'Concepts' stage. The Junior level exhibitions were marked by 25% of projects in the 'Ideas' phase and another 25% moving into the 'Concepts' stage, with a commendable 10% reaching the 'Prototype' stage. The Senior secondary level showed 15% of exhibitions categorised as 'Prototypes', and 20% at the 'Concepts' stage. The Out-of-School youth's distribution was 10% in the 'Ideas' stage, 20% in 'Concepts', and 5% presenting 'Prototypes'. The 'Teacher' category indicated 10% of projects at the 'Ideas' stage, 10% in 'Concepts', and 15% 'Prototypes'.

4.3. Finding 3: STEM abilities of the Exhibitors

Table 2 shows the third finding of the STEM abilities exhibited by the participants.

Table 6: Variations in Key Areas of Competences across Categories

Category	ECE and Primary	Junior sec	Senior sec	Out of school	Teachers
----------	--------------------	------------	------------	------------------	----------

Research Report	-12	-12	-12	-12	-12
Defence	-7	-7	-7	-8	-8
Product	-11	-10	-10	-12	-12
Scientific Skills	-1	-2	-2	-2	-2

The results indicated a consistent performance gap across all education levels in the key areas evaluated during the science fair. In the 'Research Report' category, every level showed a variation of 12, showing that all levels alike uniformly fell short of the benchmark set for research reporting. In 'Defence', the variation was slightly less at 7 for ECE and Primary, Junior Secondary, and Senior Secondary groups, with a slightly larger gap of 8 for Out of School Youths and Teachers. This suggested that while there was a deficit in defence or presentation skills across the board, it was more pronounced for out of school and teachers. The 'Product' category showed a considerable variation for all groups, with the most significant gap observed for Out of School Youths and Teachers at 12, and a slightly smaller yet substantial gap for Junior and Senior Secondary levels at 10. Lastly, the 'Scientific Skills' category showed the smallest variation, with 1 for ECE and Primary and 2 for the rest.

5. Discussions

5.1. Focus on Different aspects of Solar Energy

The results of the investigation into the thematic focus of exhibitors' projects at the National Science Fair provide both encouraging insights and areas for further development, particularly in relation to the research problem of leveraging Zambia's solar potential to address its energy needs.

On the positive side, the findings showcased a commendable diversity in the focus areas of solar energy, with a substantial representation of projects dedicated to Solar Technology and Innovation. This focus, particularly strong among teachers (40%), is promising as it reflects an emphasis on equipping learners with the latest knowledge and innovations in solar technology essential for fostering a generation capable of advancing Zambia's solar energy sector. However, the relatively lower emphasis on this category among Junior (9%) and Senior (27%) learners suggests an inadequate foundation of innovative solar technology principles at an early educational stage. Meanwhile, the considerable attention towards Solar Energy Applications and Sustainability, especially among Junior learners (55%), indicates a strong interest in practical applications and a desire to address real-world sustainability issues through education. This aligns well with the need to translate theoretical knowledge into practical solutions that can meet the country's energy demands (Maka and Alabid, 2022).

Conversely, while the prominence of Sustainable Energy Solutions (42% on average) demonstrates a holistic approach to sustainability, it raises the question of whether the specific potential of solar energy is being fully explored and emphasised in educational settings. In essence, while the varied focus across educational levels demonstrated a broad engagement with the themes, the findings suggest a need to reinforce the link between innovative solar technology education and its practical applications. Strengthening this link is crucial for empowering the next generation of Zambians to not only understand the potential of solar energy but to also use it effectively in addressing the nation's energy challenges.

5.2. Developmental Stage of Exhibitions

In examining the developmental stages of the solar energy exhibits at the National Science Fair, the distribution across educational levels paints a revealing picture of how knowledge and application of solar energy concepts progress from early education to professional educators

The research findings indicated that most of the exhibited projects at the National Science Fair were categorised under 'Ideas' and 'Concepts', with fewer falling under 'Prototypes' and 'Full blown Innovations', at all levels. This would suggest that a majority of the projects are indeed in the budding stages of development. It implies a focus on the foundational understanding of solar energy and the conceptualisation of its applications rather than on the practical implementation or development of innovative, market-ready solutions. This tendency towards early-stage development in educational settings is not uncommon, as foundational concepts and early ideation are essential building blocks in the learning process. However, for addressing the research problem which aimed at leveraging Zambia's solar energy potential, the findings could indicate a need for enhanced support systems, such as advanced workshops, mentorship programmes, and collaboration with industry (Lucas, Pinnington and Cabeza, 2018), to help transition these concepts into tangible innovations and practical applications.

5.3. STEM abilities of the Exhibitors

The findings from the 'Scientific Skills' category provided insightful data on the STEM abilities of the exhibitors. The relatively lower negative variations in 'Scientific Skills' across all educational levels were indicated a strength in the foundational teaching of STEM within the educational system. ECE and Primary learners demonstrating only a 1 variation might suggest that early education is successfully establishing basic scientific principles. As learners progress, the consistent variation of 2 from Junior Secondary through to Teachers may suggest that there is a continuation in the development of these skills. The fact that teachers share similar variations with learners may imply that they are in tune with the scientific competencies required at these educational stages, which can be advantageous for learning.

However, the fact that all groups still displayed a negative variation, even in the category with the smallest gap, implies that there is room for improvement. Especially at higher educational levels, where more advanced scientific skills are expected, a -2 variation might indicate that learners and educators are not reaching their full potential in terms of scientific proficiency and the ability to apply these skills in more complex scenarios

relevant to solar energy innovation. The uniformity of the gap across diverse groups also raises questions about the uniformity of resources and teaching methods applied at different educational levels and settings.

In relation to the research problem advancing Zambia's ability to harness solar energy through education, the findings suggest that a foundational base in STEM is present but not sufficiently built upon to foster innovation and practical implementation in solar energy. Ensuring that learners can advance their scientific skills to meet higher standards could be key to translating Zambia's solar potential into actionable projects and innovations (Uggla and Soneryd. 2023). Addressing these gaps could involve revising STEM curricula, incorporating more hands-on project-based learning, and fostering industry-academic collaborations that can provide real-world context and resources to enhance learning outcomes.

6. Conclusion

The conclusion of this study synthesised the findings and reflects on the broader implications for Zambia's solar energy sector and educational system. Throughout the investigation, the study revealed a significant focus on the early stages of solar energy education, with a predominant presence of conceptual and ideational projects across all educational levels. While this indicates a promising foundation, the transition from theoretical understanding to practical application and innovation appears inadequate, signalling a critical area for educational development.

The study's findings, aligned with the objectives, demonstrated that while educational interventions such as the National JETS serve as a valuable platform for seeding interest in solar energy, there is an evident need for systemic improvements to elevate Zambia's educational engagement with solar energy to the level of producing practical solutions. There is still a need for support to cultivate advanced skills and innovation necessary to harness Zambia's solar energy potential fully. The consistent gaps in 'Research Report' and 'Product' development categories, alongside challenges in 'Defence' skills, suggest

that the current educational approaches may need to be recalibrated to bridge the divide between theory and practice.

Addressing these gaps calls for an integrated approach involving curriculum enhancements, increased investment in STEM resources, and strengthened industry-academic partnerships to foster a learning environment conducive to innovation. The successful implementation of such measures could not only invigorate Zambia's solar energy landscape but also empower a new generation of learners equipped with the skills to contribute meaningfully to sustainable development. This study contributes to the ongoing dialogue on educational reform and provides a call to action for stakeholders across the educational and energy sectors to collaborate in nurturing the next wave of solar energy experts in Zambia.

7. References

- AfDB. (2023). *Annual development effectiveness review: Enhancing Africa's resilience*. African Development Bank Group.
- Braun, V., & Clarke, V. (2006). *Using thematic analysis in psychology*. *Qualitative Research in Psychology*, 3(2), 77-101.
- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches*. Sage Publications.
- Downs, T. J. (2020). *Unlocking high sustainable energy potential in Zambia: An integrative collaborative project approach*.
- IEA. (2022). *Renewables 2022*. <https://www.iea.org/reports/renewables-2022>. Accessed on 30 October 2023
- International Renewable Energy Agency. (2021). *Renewable energy statistics 2021*. IRENA.
- Lucas, H., Pinnington, S., & Cabeza, L. (2018). *Education and training gaps in the renewable energy sector*.
- Mabvuto, M., et al. (2017). *Assessment of Solar Energy Source Distribution and Potential in Zambia*. *Journal of Renewable Energy*, 5(2), 103-116.
- Maka, O. M., & Alabid, J. M. (2022). *Solar Energy Technology and Its Roles in Sustainable Development*. *Journal of Sustainable Technology*, 11(6), 11-29.

- Ministry of Education. (2023). *JETS Guidelines*. Directorate of National Science Centre.
- Mwanza, M., & Ulgen, K. (2021). *GIS-Based Assessment of Solar Energy Harvesting Sites and Electricity Generation Potential in Zambia*. Springer International Publishing.
- Oluwaseun, et al. (2023). *Global Review of Solar Power in Education: Initiatives, Challenges, And Benefits*. *Engineering Science & Technology Journal*, 4(4).
- PMRC. (2013). *The state of the energy sector in Zambia: Implications for industrial development, jobs, and poverty reduction*. Policy Monitoring and Research Centre.
- REN21. (2023). *Renewables 2023 global status report*.
- Republic of Zambia. (1996). *National Science and Technology Policy*.
- Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.
- Schön, D. A. (1984). *The Reflective Practitioner: How Professionals Think in Action*. Basic Books.
- Ugla, Y., & Soneryd, L. (2023). *Possibilities and Challenges in Education for Sustainable Development: The Case of Higher Education*. *Journal of Education for Sustainable Development*, 17(1), 63-77.
- UNFCCC. (2020). *Renewable Energy Investments and Development in Zambia: A Review of the Trends and Determinants*. *Renewable and Sustainable Energy Reviews*, 121, 109701.
- World Bank. (2017). *Renewable Energy Resource Mapping: Solar Measurement Campaign—Zambia*. World Bank Group.
- World Bank. (2019). *Solar Resource and PV Potential of Zambia*. *Solar Resource Atlas*. World Bank Group.
- Zambia Development Agency. (2017). *Annual Report*.
- Zambia Meteorological Department. (2020). *Annual Solar Radiation Data*

Article 32

Facilitating Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria

Joel Isaiah Jutum. Jinadu Garvey Yawe

Joeljutum@outlook.om, jinadu.yawe@gmail.com

Abstract

This study examined the Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria. Three specific objectives with corresponding research questions and two hypotheses guided the study. The study adopted a quasi-experimental research design of non-equivalent research design of non-equivalent group. Intact classes were assigned to both the experimental group (Integrated Inquiry-Based Teachers Practice Instructional Strategy) and control group (guided Inquiry Instructional Strategy) using multi stage sampling technique. The population for the study was 1,141 basic education students. The sample for this study is 292 Basic Education students comprising of 139 boys and 153 girls from six public secondary schools. Data for this study was generated using the instrument named Basic science Performance Test (BSPT), Kuder-Richardson (K-R20) formula was used to estimate the reliability index of 0.85 for the BSPT. Mean and standard deviation were used to answer all research questions. While, Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. Based on the data collected and analyzed, there was significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based Science Teaching Strategy and those taught using guided inquiry instructional strategy, The study therefore, recommended among others that basic science teachers should be encourage to use

Integrated Inquiry-based Science Teaching Strategy. In conclusion, it is evident from the finding of this study that the use of integrated inquiry-based science teachers practice could provide a good way for Basic Education students to learn Basic Science; since the strategy enhanced students' academic performance in Basic science.

Keywords: Integrated Inquiry-based Science, Teaching, strategy, Students, and Academic Performance.

Introduction

Science is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence; it is the observation, identification, description, experimental investigation and theoretical explanation of natural phenomenon. Science is a systematic investigation of nature with a view to understanding and harnessing them to serve human needs (Okoro, 2013). The importance of science has led scientist to strategizing on how to develop science and technology to earn national and international recognition. The world is becoming a global market with every nation struggling to control it through scientific investigation with capacity to attract global acceptances. The scientific development of a nation is dependent on the level of scientific knowledge of her citizenry (Abungwa, Okene & Wachanga, 2014). Therefore, science being the foundation for sustainable development is undeniably and unquestionably a key to national economic growth and prosperity. In the current information and technology age, when scientific information increases day by day, technological innovations advance rapidly, it is clearly seen that education in science plays a key role for the future of the society because the effects of science are seen overtly in every aspect of our lives. This could be one of the reasons science concepts is taught at the Primary School in the form of Basic Science.

Basic science is the science subject designed to expose learners to scientific and technological knowledge and skills that will assist them to make informed decisions, develop strategies and learn to contribute meaningfully in the contemporary society (Ellah & Achor, 2017). This implies that acquisition of adequate knowledge in the subject

could equip the learner with what it takes to become useful to the society and also to be prepared for further studies in science thus fulfilling, the National goals of Education in Nigeria (FRN, 2014). On the same note, Ayodele (2016) submitted that Basic Science is the bedrock of future understanding of advanced studies in Science, Technology and Engineering. This shows that the concept if well-captured could prepare the learner for further studies in science at the secondary school level of Education as insinuated by Oludipe (2012). This submission implies that the subject is the foundation of science education in Nigeria.

The subject introduces learners to the basic rudiments of science at primary Education level. The National Policy on Education defines Basic Science as the aspect of education which leads to acquisition of practical and applied basic scientific knowledge. The main reason for teaching Basic Science is to widen the knowledge of students in science which enables them to appreciate the unity among science subjects and apply what they have learnt to real life situation (Nwafor, 2016). This submission by Nwafor indicates the need for learners to excel in basic science.

Despite this importance of basic science to life, students perform poorly in Basic Science as documented in the Education Resource centre of Taraba State Ministry of Basic and Secondary Education report of BECE results for Basic Science and Technology (BST) from 2013-2022. Statistics of results revealed poor performance by students in Basic Science.. From the analysis, it is clear that there is a trend of poor performance as performance was inconsistent and score per year range. There is no appreciable improvement in academic performance of students in Basic Science in BECE between the years 2013 – 2022.

The performance of students is below average and therefore calls for serious attention. The low academic performance could be as a result of the teaching strategy adopted by Basic Science teachers which probably failed in enabling the students to apply what they have been taught to real life situation, hence unable to appreciate the unity among science subjects because it was probably taught without adequate teacher feedback.

Feedback is defined as a process by which teachers and students provide response during instruction to organize the learning and teaching process in order to increase students'

performance. Feedback could be viewed as a valid and vital part of blending teaching and assessment. There are four main components of feedback as a process of formative assessment. These are explaining learning objectives and success criteria, increasing the quality of marking/feedback/record keeping, using self and peer assessment and increasing the quality of inquiry/dialogue (William, 2011). For the components of teacher feedback to be realized,

Inquiry as submitted by Danjuma (2015) is an approach to learning that involves a process of exploring the natural or material world, and that leads to asking questions, making discoveries, and testing those discoveries in the search for new understanding. The term inquiry is used to invoke the idea of teaching science in the way it is actually practiced by scientists, that is, problem-solving through formulating and testing hypothesis Teachers use varieties of assessment activities and strategies in problem-solving to gain comprehensive insight into how much students learn via feedback integrated-inquiry-based as an instructional strategy in science practice. Feedback is a process by which teachers and students provide response during instruction to organize the learning and teaching process in order to increase students' performance. The types of inquiry-based learning as clearly outlined by Yoon, Joung and Kim (2012) are: Confirmation inquiry, structured inquiry, guided inquiry, open/true Inquiry and integrated inquiry based strategy.

Warner and Myers (2014) submitted that Integrated inquiry-based science teaching is a student-centered pedagogical approach that leverages the interconnections across different areas of science and focuses on cultivating critical thinking and problem-solving skills in students through active investigations. Some key components and teacher practices include:

1. Feedback integrated inquiry- based practice: Effective use of feedback integrated inquiry-based practice involves the learners in teaching and learning processes. it is the process which teachers and students provide response during instruction to organize the learning process for attainment of stated objectives.

2. Integration across domains: The curriculum and learning activities incorporate linkages across domains like physical, life, earth sciences rather than teaching them separately. Students learn to apply concepts across disciplines.

3. Student-directed exploration: Learners are able to frame research questions, design experiments, collect observation data, analyze results and draw evidence-based conclusions with appropriate scaffolding. Activities develop lab, analytical and questioning abilities.

4. Hands-on investigations: Students conduct practical and interactive investigations through lab work, field studies, controlled tests, simulations etc. manipulating variables and witnessing concepts first-hand through repeated trials.

5. Critical analysis: Learners are taught to synthesize findings, critique methodologies, assess sources, argue using evidence, identify knowledge gaps and formulate further questions to continue inquiry. Develops analytical skills.

6. Collaborative work: Group discussions, team-based projects, interactive presentations and peer learning tasks enable perspective sharing and allow students to build on each other's ideas under teacher guidance.

The teacher plays a shaping role by planning appropriate sequences of problems, questions and investigations that connect concepts across domains, guide student inquiry using probes, promote evidence-based reasoning skills and collaborative work behaviours. Assessment includes project outcomes, portfolio submissions and concept application tasks. Integrated Inquiry-Based Strategy is a hybrid of two or more types of inquiry-based learning. Integrated-inquiry-based learning involves developing questions, making observations, doing research to find out what information is already recorded, developing methods for experiments, developing instruments for data collection, collecting, analyzing, and interpreting data, outlining possible explanations and creating predictions for future study. The teachers' role is that of modifying students' responses. Integrated inquiry-based instructional strategy addresses the context of basic science from multiple subject area.

Academic performance is defined as a measurable, observable and specific statement that clearly indicates what a student should know and be able to do as a result of learning experience. It consists of individual scores at any particular time obtained from either a teacher-made test or a standardized test. According to Spady (2016) academic performance are statements that describe significant and essential learning that learners have achieved, and can reliably demonstrate at the end of a programme. Spady notes that academic performance identifies what the learner will know and be able to do by the end of a programme. In Nigeria, at least a credit pass in Basic Science is the requirement for getting admission into secondary school to study Secondary School Science. However, this trend of poor students' performance in Basic Science has aborted the ambition of many students' studying science discipline programmes such as medicine, space science engineering, (ICT) among others.

In reference to gender, Nworgu, Ellah and Oparah (2019) opine that gender is a dimension of social organization which shapes how people interact with others and how people behave or act and think about themselves. Gender is the societal meaning assigned to male and female with a particular role that each should play. This is verifiable in relation to belief, interest and academic performance of students in this study because there is a general belief among Nigerians that male are superior to female in terms of physical, cognition, logical reasoning and academic achievement (Ellah, 2014). Furthermore, Garba (2019) found that gender has impact on science education. The author noted that boys appear to have a natural positive interest to technical and science subjects while girls show negative interest. However, there are mix results on the achievement of male and female in science. For instance, Egbo (2015) found that female students achieved better than male students in the science subjects. On the other hand, Liga and Emaikwu (2015) found no significant difference in science achievement between male and female students.

The poor performance of students in Basic Science is taken as a wake-up call to re-examine the methodologies in use, to prevent it from constituting a clog on the wheel of

educational progress of Nigerian learners at the primary school level offering Basic Science. This is because a credit pass in Basic Science is required for admission into secondary school to learn science subjects that may enable them study Medicine, Pharmacy, Nursing and other Science related disciplines at the university level. It therefore follows that there is the need for science educator to check students' poor performance in basic science during basic education level, program at the primary education to avoid low enrolment into sciences at the secondary school education level. Therefore, there is an urgent need for an innovative teaching strategy such as feedback integrated-inquiry-based that could improve students' beliefs, interest and academic performance in Basic Science.

Purpose of the Study

The purpose of this study was to investigate the Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria. Specifically, the study sought to:

3. Find out the effect of integrated-inquiry-based science teaching strategy and guided inquiry instructional strategy on students' Academic Performance in Basic Science.
4. Ascertain the effect of integrated-inquiry-based science teacher and guided inquiry instructional strategy practice on male and female students' Academic Performance in Basic Science.

Research Questions

The study was guided by the following research questions:

- What is the effect of integrated-inquiry-based science teaching strategy and guided inquiry instructional strategy on students' Academic Performance in Basic Science?
- What is the effect of integrated-inquiry-based science teaching strategy and guided inquiry instructional strategy practice on male and female students' Academic Performance in Basic Science

Hypotheses

The following hypotheses were formulated to be tested at 0.05 level of significance

1. There is no significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based Science Teaching Strategy and those taught using guided inquiry instructional strategy.
2. There is no significant difference in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based Science Teaching Strategy and those taught using guided inquiry instructional strategy.

Materials and Methods

Research Design

The research design that was adopted for the study was quasi-experimental design of pretest, posters and non equivalent groups.

Area of Study

The study was conducted in Jalingo Education Zone of Taraba State, Nigeria.

Jalingo education zone is made up of three local governments namely; Ardo-kola local Government, Jalingo Local Government and Lau local Government.

Population of the Study

The population of the study consisted of all the 4,141 upper basic II Students from the 50 Public Secondary Schools in Jalingo education zone of Taraba State 2023/2024 academic session, Taraba State Ministry of Education, Post Primary School Management Board. The population of Upper Basic II Students which will consist of 2,338 males and 1,803 females' students

Sample and Sampling Technique

The sample of the study comprised of 292 Upper Basic Education Two students from Jalingo Education Zone. Which was made up of 139 male students and 153 female students randomly drawn from 6 intact classes which constituted the sample for the study? The multi-stage random sampling techniques were used in constituting the sample for the study.

Instruments for Data Collection

The instrument that was used for the study was adapted and organized by the researcher. The instrument that was use for the study to collect data was Basic Science Performance Test (BSPT).

Reliability of Instruments

In order to determine the internal reliability of the instruments, 40 copies of the instruments were pilot test at Bali Education Zone of Taraba state which will not be part of the schools for the main study. The instrument was administered at GDSS Bali, the data obtained was analyzed to establish the reliability index of BSPT. The reliability index obtained was 0.85 for BSPT using K-R formula 20. The index above reveals that the instrument was highly reliable for the study.

Method of Data Analysis

Means and Standard Deviation was employed to answer the research questions 1-2, while Analysis of Covariance (ANCOVA) was used to test the null hypotheses 1-2 at 0.05 level of significance.

Results

Research Question One.

What is the mean performance score of students taught basic science using integrated inquiry-based science teaching strategy what and those taught using guided inquiry instructional strategies? Data answering this question are contained in Table 1.

Facilitating Students' Learning Outcomes in Basic Science Using Innovative Integrated Inquiry -Based Science Teachers' Practice in Taraba State, Nigeria

Table 1: Mean Performance Score of Students taught Basic Science using Integrated Inquiry-Based Science Practice and Guided Inquiry Instructional Strategies

Strategies		Pre BSPT	Post BSPT	Mean Gain
Integrated Inquiry-Based Science teaching strategy	Mean	8.72	21.84	13.12
	N	138	138	
	Std. Deviation	3.88	5.61	
Guided inquiry instructional strategy	Mean	8.40	17.16	8.76
	N	154	154	
	Std. Deviation	3.90	7.25	
Mean difference				4.36

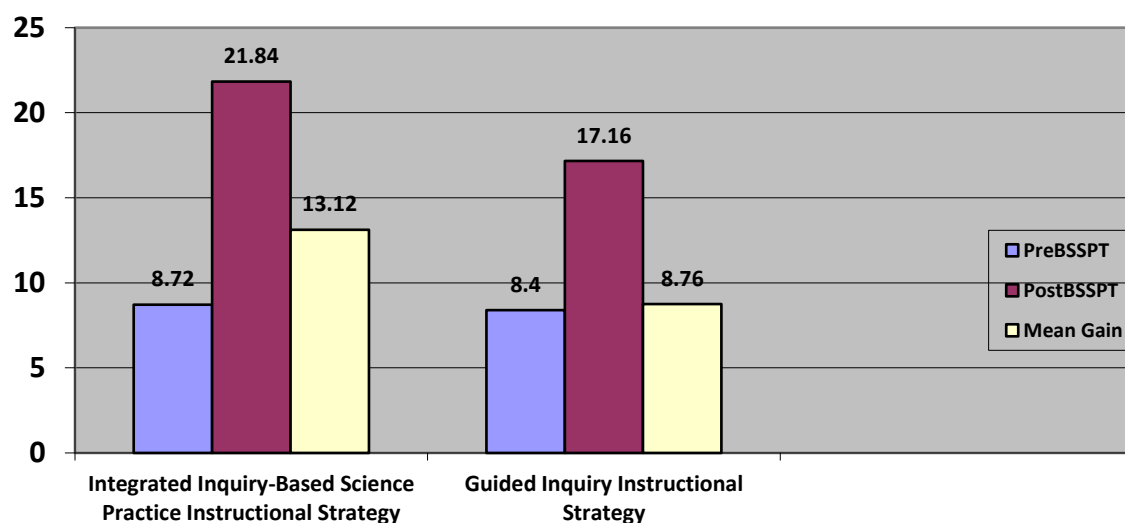


Figure 1: Pretest, Posttest Mean Gain in Performance Score of Students taught Basic Science using Integrated Inquiry-Based Science teaching strategy and Guided Inquiry Instructional Strategies. Table 1 shows the mean performance score of students taught basic science using integrated inquiry-based science teaching strategy and guided inquiry instructional strategies. The table shows that 138 students were taught basic science using integrated inquiry-based science teaching strategy and 154 students were taught basic science using guided inquiry instructional strategy. The table reveals that the mean performance score of students taught basic science using integrated inquiry-based science practice instructional strategy is 8.72 with a standard deviation of 3.88 during pre-test and 21.84 with a standard deviation of 5.61 in posttest while the mean performance score of students taught basic science using guided inquiry instructional strategy is 8.40 with a standard deviation of 3.90 during pre-test and 17.16 with a standard deviation of 7.25 in posttest. The table further shows that the mean gain for integrated inquiry-based science practice instructional strategy is 13.12 and guided inquiry instructional strategy is 8.76. The difference in the mean performance score of students taught basic science using integrated inquiry-based science practice instructional strategy 4.36 in favour of students in integrated inquiry-based science practice class. The summary of the pretest, posttest mean performance score as well as the mean gain in the performance score of students in the strategies is as shown in Figure 1.

Research Question Two.

What is the mean performance score of male and female students taught basic science using integrated inquiry-based science practice? Data answering this question are contained in Table 2.

Table 2: Mean Performance Score of Male and Female Students taught Basic Science using Integrated Inquiry-Based Science teaching strategy

Gender		Pre BSPT	Post BSPT	Mean Gain
Male	Mean	9.01	22.29	13.28
	N	65	65	
	Std. Deviation	3.66	5.73	
Female	Mean	9.04	21.68	12.64
	N	73	73	
	Std. Deviation	3.73	5.49	
Mean difference				0.64

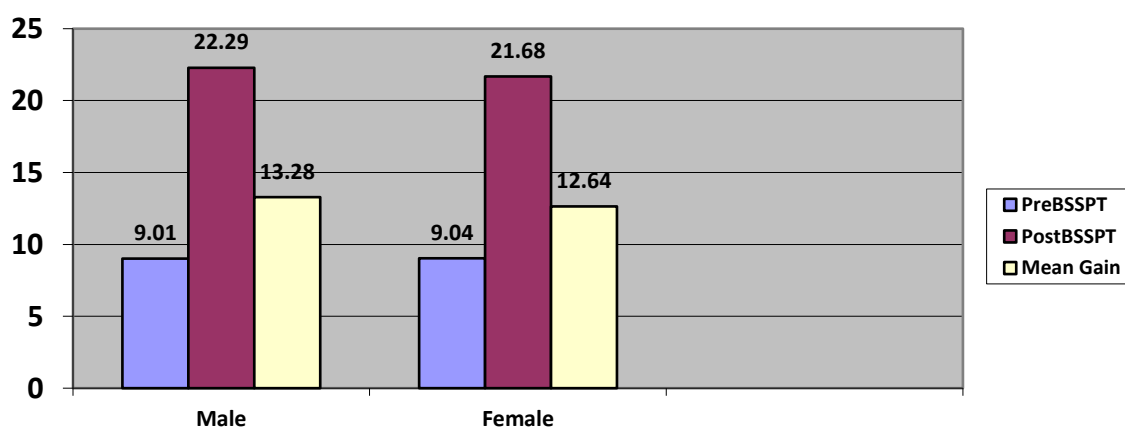


Figure 2: Pretest, Posttest Mean Gain in Performance Score of Male and Female Students taught Basic Science using Integrated Inquiry-Based Science teaching Strategy.

Table 2 shows the mean performance score of male and female students taught basic science using integrated inquiry-based science teaching Strategy. The table shows that 65 male students and 73 female students were taught basic science using integrated inquiry-based science practice instructional strategy. The table reveals that the mean performance score of male students taught basic science using integrated inquiry-based science practice is 9.01 with a standard deviation of 3.66 during pre-test and 22.29 with a standard deviation of 5.73 in post test while the mean performance score of female students taught basic science using integrated inquiry-based science teaching strategy was 9.04 with a standard deviation of 3.73 during pre-test and 21.68

with a standard deviation of 5.49 in post test. The table further shows that the mean gain for male students is 13.28 and females' student is 12.64. The difference in the mean performance score of male and female students taught basic science using integrated inquiry-based science practice 0.64 in favour of male students in integrated inquiry-based science practice class. The summary of the pretest, posttest mean performance score as well as the mean gain in the performance score of male and female students is as shown in Figure 2.

Hypothesis One

There is no significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based science teaching Strategy and those taught using guided inquiry instructional strategy. Data testing this hypothesis are contained in Table 3.

Table 3: ANCOVA of Performance of Students taught Basic Science using Integrated-Inquiry-Based Science teaching strategy and Guided Inquiry Instructional Strategy

Dependent Variable: postBSPT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1776.946 ^a	2	888.473	21.081	.000	.127
Intercept	15691.284	1	15691.284	372.318	.000	.563
Performance	183.556	1	183.556	4.355	.038	.015
Strategies	1546.257	1	1546.257	36.689	.000	.113
Error	12179.859	289	42.145			
Total	123629.000	292				
Corrected Total	13956.805	291				

a. R Squared = .127 (Adjusted R Squared = .121)

Table 3 reveals that $F(1,289) = 36.689$; $p = 0.000 < 0.05$. Thus, the null hypothesis is rejected. This implies that there is significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based science teaching Strategy and those taught using guided inquiry instructional strategy. Thus, there is significant difference in the effect of integrated-inquiry-based science teaching Strategy and guided inquiry instructional strategy on mean academic performance score of students in Basic Science. The partial Eta square of 0.113 obtain for strategies means that only 11.3 percent of students' mean academic performance in Basic Science can be attributed to the strategies employed.

Hypothesis Two

There is no significant difference in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based science teaching Strategy and those taught using guided inquiry instructional strategy. Data testing this hypothesis are contained in Table 4.

Table 4: ANCOVA of Performance of Male and Female Students taught Basic Science using Integrated-Inquiry-Based Science teaching Strategy

Dependent Variable: postBSPT

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	130.327 ^a	2	65.163	2.119	.124	.032
Intercept	7260.363	1	7260.363	236.062	.000	.647
preBSPT	118.308	1	118.308	3.847	.052	.029
Gender	12.294	1	12.294	.400	.528	.003
Error	3967.552	135	30.756			
Total	67810.000	138				
Corrected Total	4097.879	137				

a. R Squared = .032 (Adjusted R Squared = .017)

Table 4 reveals that $F(1,135) = 0.400$; $p = 0.528 > 0.05$. Thus, the null hypothesis is not rejected. This implies that there is no significant difference in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based science teachers practice. Therefore, there is no significant difference in the effect of integrated-inquiry-based Science Teaching Strategy on mean academic performance scores of male and female students in Basic Science. The partial Eta square of 0.003 obtain for gender means that only 0.3 percent of students' academic performance in Basic Science can be attributed to gender.

Discussion

Finding revealed that the mean academic performance scores of students taught basic science using integrated inquiry-based teaching Strategy was higher than those taught using guided inquiry instructional strategy. There was significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based science teaching Strategy and those taught using guided inquiry instructional strategy. This implies that significant difference exists in the effect of integrated-inquiry-based Science Teaching Strategy and guided inquiry instructional strategy on the mean academic performance score of students in Basic Science. The finding agrees with Igoh and Danjuma (2021) that students under rubric self-

assessment tool scored higher than those taught using a conventional method. The finding agrees with Danjuma Michael and Ndong (2021) that student taught basic science using assignment feedback perform and retained knowledge higher than those taught without assignment feedback indicating that assignment feedback improves student, performance and retention in basic science. The finding agrees with Bajon and Danjuma (2021) that there was significance difference in the achievement between teaching strategies and students in the mean gain achievement scores of students taught using laboratory teaching strategy and their counterpart taught using traditional teaching strategy. The finding agrees with Tekin and Mustu (2021) that the use of research-inquiry based strategies in science courses in research was thus found to have a positive impact on students' academic achievements and scientific process skills. The finding agrees with Ojekwu and Oguleye (2020) that there was significant difference in science students' performance scores across the experimental and guided inquiry groups ($P < 0.05$) in both cases, students taught with the Jigsaw strategy achieved greater improvement in their mean scores than those taught with the conventional lecture method. The finding agrees with Fatokon (2020) that students taught using mole concept using PBL strategy perform better than those taught using lecture method. The finding agrees with Ozan and Kincal (2018) that the experimental group in which the formative assessment practices were performed had a significantly higher academic achievement levels than the students did in the guided inquiry group. The finding agrees with Yakubu (2016) that there was a significant difference in performance between students taught climate change using Field-based Teaching Strategy and those taught using lecture method in favour of those taught using Field-based Teaching Strategy. The finding agrees with Ukoh and Saheed (2018) that there was a significant mean effect of treatment on students Achievement in Basic science concepts. The finding agrees with Agboola and Oloyede (2018) that students taught with the lecture-demonstration as well as project method performed better than those taught with inquiry method.

The use of integrated-inquiry-based science teaching Strategy in the present study engages students' curiosity in science, provides opportunities for students to use appropriate laboratory techniques to collect evidence, necessitates students to solve problems using logic and evidence, encourage students to conduct further study to develop more elaborate explanations, emphasize the importance of writing scientific explanations on the basis of evidence. The teacher in the

integrated-inquiry-based science practice classroom environment constructs a community of practice like the scientists' world. This enable student to take action as scientists did, experiencing the process of knowing and the justification of knowledge. This may be responsible for the significant difference in the mean academic performance score of students taught Basic Science using integrated-inquiry-based Science Teaching Strategy and those taught using guided inquiry instructional strategy.

Finding revealed that the mean academic performance of male students taught basic science using integrated inquiry-based science teaching strategy and female student taught basic science using integrated inquiry-based science teaching strategy There was no significant difference in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based science teachers practice. This implies that the use of integrated-inquiry-based Science Teaching Strategy is gender friendly with reference to the mean academic performance scores of male and female students in Basic Science. The finding agrees with Bajon and Danjuma (2021) that there was significance difference in the achievement between gender of students in the mean gain achievement scores of students taught using laboratory teaching strategy and their counterpart taught using traditional teaching strategy. The finding agrees with Fatokon (2020) that PBL improve the achievement of both male and female students equally. The finding agrees with Audu, Ajayi and Angura(2017) that no significant difference in the mean achievement scores between male and female students taught Basic Science and Technology using guided inquiry instructional strategy. The finding agrees with Ajayi (2017) that there was no significant difference between the mean achievement scores of male and female students taught stoichiometry using hands-on activities. The finding agrees with Efe and Khalil (2016) that there is no significant difference in the academic performance of both male and female students exposed to demonstration instruction in teaching chemistry.

The finding agrees with Yakubu (2016) that there was no significant difference in performance between male and female students in the experimental group which implies the teaching strategy is gender-friendly. The finding agrees with Ogbonne (2012) that there was no significant difference in the level of achievement and retention of male and female students in statistics due to the use of the Kumon teaching strategy. The finding agrees with Achor and Shikaan (2015) that gender have no significant effect in the acquisition of science process skills in the experimental group. However, the finding disagrees with Sylvanus and Eke (2017) that male chemistry students

achieved higher than their female counterpart. The finding disagrees with Saka-Alikinla, Owodunni, and Babatunde (2016) that the mean score of boys taught Basic Electricity using guided inquiry instructional technique was higher than the mean score of girls taught using the same guided inquiry instructional technique in the academic achievement test. The finding disagrees with Efe (2015) that there was significant difference in the performance of male and female students in the two groups.

Gender differences do not permeate basic science class when integrated inquiry-based science practice was used. The present study found no significant difference in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based science teaching Strategy. This implies that the use of integrated-inquiry-based Science Teaching Strategy is gender friendly with reference to the mean academic performance scores of male and female students in Basic Science. The teacher in integrated-inquiry-based science teaching strategy class adapts the science practice process to the knowledge and ability level of male and female students. The teacher starting process, promoting students' conversation, transition between small groups and classroom discussions, intervene to clear misconceptions or develop students' understanding of content material and utilized student experiences to create new content knowledge irrespective of gender. This may be responsible for the no significant difference found in the mean academic performance of male and female students taught Basic Science using integrated-inquiry-based science teachers practice.

Finding revealed that the profile plot of the interaction effect of gender and instructional strategies on students' academic performance in Basic Science shows that the plots for male and female do not intersect although not parallel. There was no significant interaction effect of gender and instructional strategies on students' academic performance in basic science. This implies that the use male and female students' academic performance in basic science cancelled the interaction effect of integrated-inquiry-based Science Teaching Strategy and guided inquiry instructional strategy. The finding agrees with Audu, Ajayi and Angura (2017) that no significant interaction effect between strategies and gender on the mean retention scores of students in Basic Science and Technology.

Conclusion

It is evident from the findings of this study that the use of integrated inquiry-based science teaching strategy could provide a good way for Basic Education students to learn Basic Science.

The strategy enhanced students' academic performance in Basic science across gender.

If integrated inquired based instructional strategy proposed in this study is adopted in Basic science and science teaching and learning, it will improve the performance of students in skills, development. This will equip the students intellectually and lead to a remarkable breakthrough in science, Technology, Engineering and Mathematic (STEM) in our country and globally.

Recommendations

The implication of this study and the associated recommendations as it borders on Basic Education are as follows: -

1. Basic Science Teachers should be encouraged to use integrated inquiry-based science teaching Strategy.
2. Basic science teacher's trainees should be trained on the use of this instructional strategy which could improve academic performance of Basic Education student.
3. Curriculum planners and science teachers should be incorporate innovative, problem solving and activity based pedagogical strategies like inquiry based instructional strategy in all teacher education instructions.
4. Professional bodies like Science Teachers Association of Nigeria (STAN) in collaboration with the Nigeria Education Research and Development center (NERDC) and Federal Ministry of Education should organize seminars, workshops and symposia on the use of inquiry based instructional strategy for science teachers at the federal, State and Local Government levels. If this training is done on regular basis, the science teachers will be proficient in use of innovative instructional strategy like integrated inquiry instructional strategy.

References

- Abungwu, E. O. Okene, I. O. & Wachanga, W.S. (2014). Effects of science process skills teaching strategy on boys and girls achievement in chemistry in Nyando district, Kenya. Journal of Education and Practices, 5(15), 42-50.*
- Achor, E. E., Aligba, S., & Iloakasia, A. (2021). Collaborative teaching strategy and academic performance of students of different cognitive styles in Basic Science. Journal of the International Centre for Science, Humanities and Education Research, 5(1), 85-98.*

- Adejo, L. O. (2015). *Effects of inquiry method on academic performance of chemistry students in senior secondary schools in Kaduna State, Nigeria*. Unpublished M. ED Thesis. Department of Educational Foundations and Curriculum, Faculty of Education, Ahmadu Bello University, Zaria.
- Adeyemi, B. A. (2016). *The efficacy of social studies teachers competence in the use of play way method in lower primary schools in Osun State, Nigeria*. *Journal of Education and Human Development* 5(1), 249-255.
- Agboola S. O., & Oloyede O.E. (2018). *Effects of project, inquiry and lecture-demonstration teaching methods on senior secondary students' achievement in separation of mixtures practical test*. *Educational Research and Reviews*, 2(6), 124.
- Ajayi, V. (2017). *Effect of hands-on activities on senior secondary Chemistry students achievement and retention in stoichiometry in Zone C of Benue State*. Retrieved from SSRN, Electronic Journal. 10.2139/ssrn.2992803 on January 15, 2023.
- Amir, K, Mohamed, H. C. & Mnjokava, C. E. (2016). *Learners' interests and performance in science subjects in a-level in secondary schools, in Mbarara, Uganda*. *Journal of Educational Research*, 2(5), 10 - 25
- Aniaku, O. L. (2012). *Effects of guided and unguided inquiry teaching methods on secondary school students' achievement and interest in biology in Enugu State*. M.Ed Thesis University of Nigeria, Nsuka. Retrieved 1st January, 2023 from <http://www.unn.edu.ng/publications/files/images/Mrs.%20Aniaku%20Obiageli%20Loretta.pdf>.
- Arhin, D., & Yanney, E. G. (2020). *Relationship between students' interest and academic performance in mathematics: A study of Agogo State College*. *GSJ*, 8(6), 389-396.
- Audu, C. T, Ajayi, V.O., & Angura, M.T. (2017). *Do guided and structured inquiry in Basic Science and Technology: A field report*. *Journal of Education and Practice*, 8 (33), 70-83.
- Ayodele, M. O. (2016). *Interest, self-concept and achievement of Junior Secondary School students in Basic Science in Ekiti State, Nigeria*. *Journal of Educational and Social Research (MCSER Publishing, Rome-Italy)*, 6(1)167 – 172
- Bajon, R. H. & Danjuma, G. S. (2021). *Effects of laboratory teaching strategy on secondary school biology students' in Takum Education Zone, Taraba state, Nigeria*. *Journal of Science, Technology, Mathematics and Entrepreneurial Education (JSTMEE)*.vol.1

- Bertalanffy, L. V. (1968). *General systems theory*. New York: Braziller.
- Chukwueneke, B. A., & Chikwenze, A. R. (2012). *Reform in Integrated Science curriculum in Nigeria: Challenges and prospects*. *Journal of Research and Development*, 4(1), 82-84.
- Danjuma, G.S, (2015). *Effects of collaborative and competitive learning strategies on upper basic II students' interest and achievement in basic science*. Unpublished Ph.D. thesis, University of Nigeria Nsukka
- Danjuma, G.S, Michael, A. & Ndong P. (2021). *Journal of Science Technology Mathematic and Entrepreneurial Education (JSTMEE)*. Vol.1 NO.4 (special issues)
- Ellah, B. O. & Achor, E. E. (2017). *Achievement in Basic Science and Technology as correlates of student's performance in science in senior secondary schools in Nigeria*. *Journal of the International Centre for Science, Humanity and Education Research*. 3(2), 73-83.
- Eziyi, M, Mumuni, U & Nwanekezi, A. (2016). *Effects of guided inquiry and cooperative instructional strategies on SS1 students' academic achievement in conceptual understanding of Photosynthesis*. *International organization of Scientific Research*, 6(8), 1-11
- Garba, F.N. (2019). *Comparative effects of experiential, inquiry and expository strategies on students' achievement and interest in Social Studies in education Zone B, Benue State*. An unpublished PhD thesis, Benue State University Makurdi, Benue State.
- Hester de Boer, Anneke C. Timmermans & Margaretha P. C. van der Werf. (2018). *The effects of teacher expectation interventions on teachers' expectations and student achievement: narrative review and meta-analysis*, *Educational Research and Evaluation*, 24(3-5), 180-200, DOI:10.1080/13803611.2018.1550834
- Hughes, P.W. (2014). *Teaching scientific inquiry: inquiry-based training for Biology graduate teaching assistants improves undergraduate learning outcomes*. Toronto: Higher Education Quality Council of Ontario. Retrieved on 9th March, 2017. From <http://www.heqco.ca/SiteCollectionDocuments/Carleton%20Scientific%20Inquiry%20ENG.pdf>
- Ibrahim, J. (2015). *Effects of inquiry method on performance of junior secondary school students in Islamic studies in Kaduna State*. An unpublished M.Ed Dissertation ABU Zaria Kaduna state.
- Kapur, R. (2018). *Factors influencing the students' academic performance in secondary schools in India*. Retrieved 16th July, 2019 from www.researchgate.net/publications

- Karaman, A., & Karaman, P. (2013). *Examining the beliefs of prospective elementary and science teachers regarding reformed science. International Journal of Research in Teacher Education*, 4(3), 1-9.
- Kazempour, M. (2014). *The interrelationship of science experiences, beliefs, interests, and self-efficacy: A case study of a pre-service teacher with positive science interest and high science teaching self-efficacy. Journal of Education and Learning (Edu Learn)*, 8(1), 51.
<https://doi.org/10.11591/edulearn.v8i1.205>
- Mansour, N. (2013). *Consistencies and inconsistencies between science teachers' beliefs and practices .International Journal of Science Education*, 35(7), 1230-1275.<https://doi.org/10.1080/09500693.2012.743196>
- Mohammed, S. M. (2022). *Teachers' beliefs: positive or negative indicators of inquiry-based science teaching? World Journal of Education*, 12(1), 17 – 33.
[doi:10.5430/wjev12n1p17](https://doi.org/10.5430/wjev12n1p17)
- Muodumogu, C. A. & Odey, O. G. (2018). *Influence of topic of interest in students' achievement in literacy skills. Journal of Research in Curriculum and Teaching*, 10 (10), 19-27
- Nwafor, C. E. (2016). *Effects of computer assisted instruction on junior secondary school students' achievement in Basic Science. International Journal of Scientific & Engineering Research*, 7(10), 1941-1957.
- Ogbonne, I. A. (2012). *Effect of Kumon teaching strategy on junior secondary school students' achievement, interest and retention in Statistics. Unpublished M. Ed Dissertation, Department of Science Education, University of Nigeria, Nsukka.*
- Ojekwu I. N & Ogunleye, B. O. (2020). *Effects of jigsaw learning strategy on science biology in selected school in rivers state, Nigeria. Sapiential Foundation Journal Of Education Science And Gender Studies* 2 (3) 325-334
- Oludipe, O. I. (2017). *Gender differences in Nigerian junior secondary students' academic achievement in Basic Science. Journal of Educational and Social Research*, 2(1), 93 – 99.
- Oludope, D. I (2012). *Gender difference in Nigeria junior secondary basic science. Journal of Educational and Social Research*, 2 (1), 93-98
- Okoro, A. U. (2013). *Effects of investigative approach and expository methods on acquisition of science process skill in biology students of different levels of science literacy. Journal of Science Teachers' Association of Nigeria*, 41(172), 79-88.

- Okoye, R. O. (2014). *Educational psychological measurement and evaluation*. Lagos: Ed-Solid Foundations.
- Opara, J. O. (2011). *Bajah's model of teaching of Integrated Science*. *African Journal of Basic and Applied Science* 3(1), 1 -5
- Saka-Alikinla, I, Owodunni, A & Babatunde, H. (2016). *Comparative effects of structured and guided inquiry instructional techniques on students' academic achievement in Basic Electricity in Kwara State Technical Colleges* .*British Journal of Applied Science & Technology*. 14. 1-10.
- Sampson, V., Enderle, P., & Grooms, J. (2013). *Development and initial validation of the Beliefs about Reformed Science Teaching and Learning (BARSTL) Questionnaire*.*School Science and Mathematics*, 113(1), 3-15.<https://doi.org/10.1111/j.1949-8594.2013.00175.x>
- Schwab, S, Markus S & Hassani, S. (2022). *Teachers' feedback in the context of students' social acceptance, students' well-being in school and students' emotions*. *Educational Studies*, DOI: 10.1080/03055698.2021.2023475
- Shieh, C. J & Yu, L.A (2016). *Study on Guided Discovery Instrument toward Students Learning, Achievement and of Mathematics*. *Science & Technology*, 12 (14) 833-842
- Tekin, G.& Mustu, E. Ö. (2021). *The effect of research-inquiry based activities on the academic achievement, interests, and scientific process skills of students in the Seventh Year Science course*. *The European Educational Researcher*, 4(1), 109-131. DOI:<https://doi.org/10.31757/euer.416>
- Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2016). *Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence*. *Educational Technology Research and Development* 2016 65:3, 65(3), 555-575.<https://doi.org/10.1007/S11423-016-9481-2>
- Yakubu, K. O. (2016). *Effect of field-based teaching strategy on interest retention and performance in climate change among secondary school students in Anchau Jaduna Nigeria*. Unpublished thesis, Ahmadu bello university, Zaria

Article 33

The Role of Teacher Professional Development in Advancing Gender-Inclusive Teaching Practices in STEM among Senior Secondary School Teachers' in Igabi Local Government Area, Kaduna state, Nigeria.

Zainab Muhammad Shuaibu
Department of Academic Services
National Teachers' Institute, Kaduna, Nigeria.

Email: zeelamee@gmail.com

And

Fatima Abbas Jega
Registry Department
National Teachers' Institute, Kaduna, Nigeria

Email: Fajegs65@gmail.com

Abstract

In recent years, addressing the gender disparity in Science, Technology, Engineering, and Mathematics (STEM) fields has gained global prominence. This quasi-experimental study, conducted in Kaduna State's Igabi Local Government Area, Nigeria, explores the transformative potential of teacher professional development in promoting gender-inclusive teaching practices within STEM education. The investigation sought to determine whether a structured professional development programme for STEM educators could effectively reshape their teaching approaches, ultimately nurturing enhanced gender equity and inclusivity in the classroom. The study adopted a pre-test and post-test control group design, enlisting a sample of 120 STEM teachers drawn from select secondary schools in Igabi. These educators were divided into two cohorts: the experimental group, benefitting from a gender-inclusive professional development programme, and the control group, receiving no specific intervention. Data collection encompassed surveys, classroom observations, and student performance evaluations.

Data analysis employed descriptive statistics, independent sample t-tests, and qualitative content analysis. The findings unveiled a noteworthy transformation in the pedagogical practices of STEM teachers who participated in the professional development programme. Teachers in the experimental group exhibited a heightened commitment to employing inclusive strategies, adapting curriculum materials, and nurturing a supportive learning atmosphere for all students, regardless of gender. Furthermore, students taught by educators in the experimental group demonstrated increased engagement and achieved better academic performance in STEM subjects. The study's implications are far-reaching, suggesting that targeted professional development programmes can serve as catalysts for narrowing the gender gap in STEM fields and fostering a more equitable and inclusive learning environment for all students.

Keywords: Gender-Inclusive Teaching, Teacher Professional Development

1.1 Introduction

In the global push for progress in the fields of Science, Technology, Engineering, and Mathematics (STEM), it has become increasingly evident that a gender gap persists, with fewer women than men pursuing STEM careers. This gender disparity is not unique to Nigeria but is a worldwide phenomenon. According to UNESCO, less than 30% of researchers globally are women, and women remain underrepresented in STEM-related fields. This gender imbalance in STEM has significant implications for the workforce, innovation, and sustainable development.

The gender gap in STEM often originates at the educational level, where biases and stereotypes can discourage young girls from pursuing these fields. To address this disparity, it is crucial to examine the role of educators in promoting gender-inclusive teaching practices. Teachers play a pivotal role in shaping students' perceptions and interests in STEM subjects.

This study, conducted in the Igabi Local Government Area of Kaduna State, Nigeria, explores the potential of teacher professional development to promote gender-inclusive teaching practices in STEM. It investigates whether a structured professional development programme can reshape teachers' pedagogical approaches, fostering a more inclusive learning environment.

2.0 Literature Review

2.1 Gender Disparity in STEM

The underrepresentation of women in STEM fields is a complex issue influenced by societal, cultural, and educational factors. Stereotypes, biases, and a lack of female role models in STEM can deter girls from pursuing these subjects. This underrepresentation has long-term consequences for women's career opportunities and economic empowerment. "Hill, Corbett, and St. Rose (2010) reported in their study, 'Why So Few? Women in Science, Technology, Engineering, and Mathematics,' that gender disparity in STEM fields remains a significant challenge."

2.2 Teacher Professional Development

Teacher professional development is recognized as a key factor in improving the quality of education. It provides educators with the knowledge and skills needed to enhance their teaching practices. Ingersoll and Strong (2011) conducted a critical review of the research and emphasized the impact of induction and mentoring programs for beginning teachers, highlighting the importance of Teacher Professional Development (TPD) in supporting educators at the early stages of their careers." Research shows that well-designed professional development programmes positively impact teacher effectiveness, student learning outcomes, and classroom environments.

2.3 Gender-Inclusive Teaching Practices

Gender-inclusive teaching practices involve strategies and approaches that create an equitable and supportive learning environment for all students. In the context of STEM education, this means addressing and mitigating gender biases and stereotypes while encouraging all students to participate and excel in these subjects. According to Smith and Johnson (2018) they highlighted the importance of promoting gender-inclusive teaching practices in STEM education, emphasizing the need for strategies that create an equitable and supportive learning environment for all students, regardless of their gender."

Previous research has indicated that teacher professional development can have a positive impact on promoting gender-inclusive teaching practices. However, there is a need for more studies that specifically investigate the effectiveness of professional development programmes in the context of gender equity in STEM education, particularly in Nigeria.

3.0 Methodology

3.1 Research Design

This study employed a quasi-experimental design with a pre-test and post-test control group. The participants included 120 STEM teachers from selected senior secondary schools in Igabi Local Government Area.

3.2 Experimental and Control Groups

Participants were divided into two groups: the experimental group and the control group. The experimental group received a gender-inclusive professional development programme, while the control group received no specific intervention.

Structured professional development programme used was a systematic and organized initiatives that focus on reshaping teachers' pedagogical approaches with the ultimate goal of nurturing enhanced gender equity and inclusivity in the classroom. These programmes are designed to bring about significant changes in how teachers teach and create a more equitable and inclusive learning environment as shown below:

Structured Professional Development for Gender Equity and Inclusivity	
Reshaping Pedagogical Approaches	Nurturing Enhanced Gender Equity
Transform Teaching Methods	Promote Fairness and Equality
Adapt Curriculum Materials	Address Gender Biases and Stereotypes
Foster a Gender-Sensitive Learning Environment	
Promoting Inclusivity ➤ Create an Inclusive Classroom ➤ Respect and Value All Students	Ongoing Professional Development ➤ Evolve and Improve Teaching Practices ➤ Encourage Continuous Learning for Educators
Accommodate Diverse Learning Styles and Backgrounds	

Figure:1

3.3 Data Collection

Data were collected through surveys to assess teachers' attitudes and perceptions, classroom observations to evaluate teaching practices, and student performance evaluations in STEM subjects.

3.4 Data Analysis

Data were analyzed using descriptive statistics, independent sample t-tests, and qualitative content analysis to compare the differences between the experimental and control groups.

4.0 Findings

The results of this study indicated a significant transformation in the pedagogical practices of STEM teachers who participated in the professional development programme. Teachers in the experimental group exhibited a heightened commitment to employing inclusive teaching strategies, adapting curriculum materials to be more gender-inclusive, and nurturing a supportive learning atmosphere for all students, regardless of gender. Students taught by educators in the experimental group demonstrated increased engagement and achieved better academic performance in STEM subjects.

5.0 Discussion

The findings of this study suggest that targeted teacher professional development programmes can serve as catalysts for narrowing the gender gap in STEM fields. By promoting gender-inclusive teaching practices, educators can contribute to creating a more equitable and inclusive learning environment for all students. This is especially crucial in Nigeria and other regions where gender disparities in STEM are pronounced.

6.0 Implications

This study has several implications for educational policy and practice:

1. Teacher Professional Development: Policymakers and educational institutions should invest in the development and implementation of gender-inclusive professional development programmes for STEM educators.
2. Curriculum Adaptation: Efforts should be made to adapt STEM curricula to be more gender-inclusive and culturally relevant.
3. Promoting Female Role Models: Highlighting the achievements of female STEM professionals can inspire and encourage girls to pursue STEM fields.

7.0 Conclusion

Addressing the gender disparity in STEM fields is a global imperative, and teacher professional development is a key strategy in advancing gender-inclusive teaching practices. This study conducted in Igabi Local Government Area, Kaduna State, Nigeria,

has shown that structured professional development programmes can effectively reshape teachers' pedagogical approaches, ultimately nurturing enhanced gender equity and inclusivity in the classroom. As a result, students benefit from increased engagement and better academic performance in STEM subjects. This research underscores the importance of investing in professional development and curriculum adaptation to promote gender-inclusive STEM education.

References

- Hill, C., Corbett, C., & St. Rose, A. (2010). *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. American Association of University Women.
- Ingersoll, R. M., & Strong, M. (2011). *The impact of induction and mentoring programs for beginning teachers: A critical review of the research*. *Review of Educational Research*, 81(2), 201-233.
- Smith, J. A., & Johnson, L. B. (2018). *Promoting Gender-Inclusive Teaching Practices in STEM Education*. *Journal of Education and Gender Studies*, 10(2), 45-62.
- UNESCO. (2017). *Cracking the code: Girls' and women's education in science, technology, engineering, and mathematics (STEM)*. UNESCO.

Article 34

Hindsight, Insight, and Foresight from Third-Country Trainings:
Contextualized Teacher Continuous Professional Development Strategies
for Competency-Based Lesson Delivery in Uganda

Caroline Taliba¹ and Dennis Zami Atibuni (PhD)^{2,3*}

¹ National Trainer – Mathematics, SESEMAT Uganda, Ministry of Education and Sports,
P.O Box 7063, Kampala

Email: carot819@gmail.com / talibacarol@yahoo.co.uk; Cell Phone/WhatsApp:
+256773901737/ +256701085551

² Associate Professor, Busitema University, P.O Box 236, Tororo

³ Research Associate, Ali Mazrui Centre for Higher Education Studies, University of
Johannesburg, P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa.

* Corresponding Author E-mail: zamidennis79@gmail.com,
zamidennis@sci.busitema.ac.ug; Cell Phone/WhatsApp: +256782305430

Abstract

In Uganda, one of the in-service pedagogical initiatives undertaken to provide contextualized strategies for enhancing pedagogical paradigm shift from teacher-centred to learner-centred approaches of teaching and learning STEM is the third country training programme (TCTP). The initiative fits seamlessly into the change from the knowledge- to competency-based lower secondary curriculum advocated by the Government of Uganda. During the trainings a select group of science and mathematics teachers and 'other' stakeholders are offered training trips to other countries deemed to be well grounded and advanced in STEM education. A number of participants benefited from these trainings. In this paper, we argue that if these trainings were efficacious, then the beneficiaries should be able to recount teacher continuous professional development

(CPD) lesson strategies encountered during the trainings that can be used to generate contextualised strategies to enhance the delivery of competency-based education as currently required at the lower secondary education in Uganda. Employing a concurrent mixed methods study design, we used a semi-structured questionnaire to gather quantitative and qualitative data from a census of teachers, and conducted key informant interviews with a purposive sample of 'other' stakeholders who attended the third-country trainings. Sampling frames were obtained from the archives of SESEMAT Uganda. Findings indicated that the course structures were well organised, but the course delivery and instructors were rather unfamiliar to interact with. The participants expressed improved CBE competence as a result of the TCTP. We advocate for policy and practice of CPD for competency-based lesson delivery at lower secondary education in Uganda and other contexts.

Keywords: Competency-based curriculum, Continuous professional development, lower secondary, SESEMAT, third-country training

1.0 Introduction

As a continent, Africa has continued to fall behind America, Europe, and Asia in Science, Technology, Engineering, and Mathematics education. Uganda is not a special case. Limitations in teachers, attitudes, physical facilities, curricula, and financial resources are among the numerous issues responsible for Uganda's poor level of STEM growth. Universal primary education has swelled the secondary student population, causing science and mathematics teachers to face the difficulties of larger class sizes. In the disciplines of science and mathematics, however, there are still a paucity of facilities for facilitating effective student learning. According to Clausen-May and Baale (2014), who cite CGDE (2011), Opolot-Okurut et al. (2008), and World Bank (2008), chalk-and-talk, teacher-dependent pedagogy is a well-established practice in Uganda. The instructor stands in front of the class with a textbook in hand, writing notes and examples on the board. The 'silent learners' write everything down (Clegg et al., 2007).

To revolutionize STEM education in particular and basic education in general, the Government of Uganda has undertaken a series of initiatives aimed at providing opportunities for teachers and teacher educators at primary and secondary school level in STEM Education. These initiatives aim to explore alternative, innovative, and promising classroom practices that could not only improve learner performance, but also develop the necessary literacy and life skills for the 21st century. Among these initiatives, the Ugandan Ministry of Education and Sports implemented a number of third country training programmes (TCTP), including the Knowledge Co-Creation Programme, with assistance from JICA. Through TCTP, participants learn about the strengths, limitations, and prospects of other practitioners and reflect on shared practices. Co-inquiry, collaborative, and reflective communication cycles are utilized in these learning processes. Thus, TCTP offers a reconstruction of learning cultures from several isolated cultures (Yanagisawa, 2017). Acquisition of competencies that can be cross-fertilized inside national education systems to support socioeconomic transformation agenda is the driving force for adopting TCTP.

In this study we purposed to investigate the reflections of participants on third country training programmes (TCTP) as an initiative to cross-pollinate knowledge, skills, values, and attitudes cross-nationally in order to promote competency-based education (CBE), with a specific focus on the “new” lower secondary school curriculum in Uganda. The objectives of the study included (a) to assess the extent to which TCTP aspects influenced participants in light of CBE implementation in Uganda, (b) to explore the TCTP course content aspects that could be infused in the Uganda CBE curriculum, (c) to find out how CBE expectations can be met through TCTP, (d) to appraise the challenges affecting the Implementation of TCTP knowledge and skills in CBE, and (e) to document the support systems for implementing TCTP knowledge and skills in CBE in Uganda. The methodology of the study is presented in the section below.

2.0 Methodology

The study employed a parallel concurrent mixed methods design to quantify participants' TCTP experiences and explain challenges and strategies for implementing acquired knowledge, skills, values, and attitudes (Astalin, 2013). Participants included individuals who attended TCTP related to STEM education and competency-based education. Records were retrieved from SESEMAT and Ministry of Education archives, and contact details were compiled for online data collection.

We used a semi-structured questionnaire translated into an online Google form to gather quantitative and qualitative data from TCTP participants dating back to 2005. Snowballing helped obtain additional contacts, resulting in about 100 participants.

The online instrument consisted of three sections. Section A collected demographic information, including gender, age, TCTP years, and position in the Ministry of Education at the time of TCTP. Section B included an adapted TCTP evaluation questionnaire with 48 closed-ended questions covering course content, structure, delivery, instructors, timing, and learning experiences. The closed items were scored on a 5-point Likert scale. The Cronbach α for each subscale was above 0.70, with overall reliability at 0.929. Section C included six open-ended questions about the TCTP's link to the "new" lower secondary CBE curriculum.

Data collection began with participant consent; those who declined could not proceed. A total of 38 responses were received, indicating a low online response rate. Completed forms were retrieved as Excel files and imported into SPSS for analysis.

Participants' ratings of TCTP aspects were interpreted using frequencies, percentages, means, and standard deviations. Mean scores were categorized as low (1.00—2.33), moderate (2.34—3.73), and high (3.74—5.00). Qualitative data from open-ended questions were analyzed using an interpretative phenomenological approach to generate themes around challenges and strategies.

Data planning, collection, and processing adhered to ethical considerations. Participants consented to participate and could withdraw at any time. They were assured of privacy, confidentiality, and anonymity. Sources of information, including journal articles and reports, were duly credited.

3.0 Results

3.1 Participant Demographics

The demographic information on the participants' gender, age, highest academic qualification, designation, years of experience, status of employment, and subject trained in at the time of the TCTP were sought. The results are presented in Table 1.

Table 1

Demographic Characteristics of the TCTP Participants

Characteristic	Category	Frequency	Percent
Gender	Male	24	63.2
	Female	14	36.8
Age at the time of the TCTP	30-39	12	31.6
	40-49	17	44.7
	50-59	9	23.7
Highest academic qualification at the time of the TCTP	Bachelor's degree	32	84.2
	Master's degree	6	15.8
Designation in the Ministry of Education and Sports at the time of the last TCTP	Assistant Education Officer	3	7.9
	Education Officer	28	73.7
	Senior Education Officer	7	18.4
Years of experience in the position of designation by the last TCTP	0-5	5	13.2
	6-10	6	15.8
	Above 11	27	71.1

Status of your employment at time of TCTP	Permanent	38	100.0
Subject trained in during the TCTP	Biology	8	21.1
	Chemistry	8	21.1
	Mathematics	13	34.2
	Physics	9	23.7

Table 1 shows that most respondents (and likely TCTP participants) were male (63.2%), reflecting the general prevalence of male educationalists, especially teachers. The majority were aged 30–50 (76.3%) and held bachelor’s degrees (84.2%), with 73.7% serving as education officers. Most had over 11 years of experience (71.1%) and were full-time teachers (100%) during the TCTP. The distribution of respondents by subject was even, with a slight emphasis on mathematics.

3.2 Quantitative Results

The quantitative results indicate the evaluations, by agreement and disagreement, of the generally positive assessment of the course content, course structure, course delivery, course instructors, course timing, and their own learning experiences. Each of these is looked at separately in the following subsections.

3.2.1 Course Content

The participants’ evaluation of the suitability of the TCTP course content to CBE was assessed and the results are presented in Table 2.

Table 2

Course Content Evaluation of the TCTP Relative to CBE

Aspect	SD	D	N	A	SA	<i>M</i>	<i>SD</i>
The course aligned with my expectations for CBE.	0(0.0)	0(0.0)	0(0.0)	15(39.5)	23(60.5)	4.61	0.495
The quality of course content was suited to the demands of CBE.	0(0.0)	0(0.0)	0(0.0)	13(34.2)	25(65.8)	4.66	0.481
The course content was adequately engaging as expected in CBE.	0(0.0)	0(0.0)	0(0.0)	22(57.9)	16(42.1)	4.42	0.500

The variety of the course content was satisfactory for CBE.	0(0.0)	0(0.0)	5(13.2)	17(44.7)	16(42.1)	4.29	0.694
The course content was detailed enough for the needs of CBE.	0(0.0)	0(0.0)	1(2.6)	19(50.0)	18(47.4)	4.45	0.555
The course content was helpful in delivering CBE.	0(0.0)	0(0.0)	0(0.0)	21(55.3)	17(44.7)	4.45	0.504
The methods of course assessment were satisfactory for CBE.	0(0.0)	0(0.0)	4(10.5)	18(47.4)	16(42.1)	4.32	0.662

Table 2 results show that most respondents rated the TCTP course content highly, finding it critical to the Competency-Based Education (CBE) curriculum in the “new” lower secondary curriculum. Specifically, they agreed that the courses aligned well with CBE expectations ($M = 4.61$, $SD = 0.495$) and that the course quality met CBE demands ($M = 4.66$, $SD = 0.481$). Respondents felt the content was adequately engaging ($M = 4.42$, $SD = 0.500$), offered sufficient variety ($M = 4.29$, $SD = 0.694$), and met CBE requirements in detail ($M = 4.45$, $SD = 0.555$). Participants also agreed that the course content was helpful for CBE delivery ($M = 4.45$, $SD = 0.504$), and that assessment methods were generally satisfactory ($M = 4.32$, $SD = 0.662$).

3.2.2 Course Structure

The structure of the TCTP courses was evaluated for organisation, sequencing, manageability, completeness and ease of progression through the content. The results are presented in Table 3.

Table 3

Course Structure Evaluation of the TCTP

Aspect	SD	D	N	A	SA	<i>M</i>	<i>SD</i>
The course was well structured.	0(0.0)	0(0.0)	0(0.0)	17(47.7)	21(55.3)	4.55	0.504
The flow of the course was systematic.	0(0.0)	0(0.0)	0(0.0)	19(50.0)	19(50.0)	4.50	0.507
The course structure was manageable.	0(0.0)	0(0.0)	0(0.0)	34(89.5)	4(10.5)	4.11	0.311

The course was easy to complete.	0(0.0)	6(15.8)	3(7.9)	20(52.6)	9(23.7)	3.84	0.973
It was clear when one unit ended and a new one started.	0(0.0)	0(0.0)	0(0.0)	30(78.9)	8(21.1)	4.21	0.413
The course milestones were clear.	0(0.0)	0(0.0)	6(15.8)	23(60.5)	9(23.7)	4.08	0.632
I felt like I was making adequate progress through the course.	0(0.0)	0(0.0)	0(0.0)	21(55.3)	17(44.7)	4.45	0.504
I felt equally engaged in every section of the course.	0(0.0)	0(0.0)	3(7.9)	17(44.7)	18(47.4)	4.39	0.638
I was satisfied with the number of assessments.	0(0.0)	0(0.0)	1(2.6)	29(76.3)	8(21.1)	4.18	0.457

Overall, the course structure was well-organized ($M = 4.55$, $SD = 0.504$), systematic ($M = 4.50$, $SD = 0.507$), manageable ($M = 4.11$, $SD = 0.311$), and easy to complete ($M = 3.84$, $SD = 0.973$). The course milestones ($M = 4.08$, $SD = 0.632$) were clear, aiding progress ($M = 4.45$, $SD = 0.504$) and engagement ($M = 4.39$, $SD = 0.638$), with adequate assessments ($M = 4.18$, $SD = 0.457$). Six participants (15.8%) disagreed on ease of completion, indicating that some found certain materials and concepts challenging due to initial exposure.

3.2.3 Course Delivery

The participants' evaluation of the course delivery yielded mixed reactions in different aspects. The results are presented in Table 4.

Table 4

Course Delivery Evaluation of the TCTP

Aspect	SD	D	N	A	SA	<i>M</i>	<i>SD</i>
The course delivery was fantastic.	0(0.0)	0(0.0)	4(10.5)	26(68.4)	8(21.1)	4.11	0.559
The course materials were engaging.	0(0.0)	0(0.0)	1(2.6)	27(71.1)	10(26.3)	4.24	0.490

The course delivery was accessible, that is, paced to my speed of understanding.	0(0.0)	0(0.0)	4(10.5)	28(73.7)	6(15.8)	4.05	0.517
There were excellent opportunities for collaboration during the course.	0(0.0)	0(0.0)	0(0.0)	18(47.4)	20(52.6)	4.53	0.506
The course met my expectations for interactivity.	0(0.0)	5(13.2)	0(0.0)	20(52.6)	13(34.2)	4.08	0.941
I would have preferred more interactivity.	0(0.0)	7(18.4)	5(13.2)	20(52.6)	6(15.8)	3.66	0.966
The size of the training group I was in was appropriate.	0(0.0)	5(13.2)	1(2.6)	14(36.8)	18(47.4)	4.18	1.010
The course felt welcoming.	0(0.0)	5(13.2)	0(0.0)	21(55.3)	12(31.6)	4.05	0.928
I felt like I was a part of a community during the course.	0(0.0)	0(0.0)	5(13.2)	13(34.2)	20(52.6)	4.39	0.718

Table 4 shows that participants generally rated the course delivery highly, agreeing it was fantastic ($M = 4.11$, $SD = 0.559$), with engaging materials ($M = 4.24$, $SD = 0.490$), appropriate pacing ($M = 4.05$, $SD = 0.517$), and excellent collaboration opportunities. However, some respondents disagreed that the course met expectations for interactivity (13.2%), group size appropriateness (13.2%), and a welcoming environment (13.2%). These reservations suggest that certain delivery techniques were unfamiliar and challenging for some participants to adapt to.

3.2.4 Course Instructors

Another aspect of TCTP that the participants evaluated was the competence of the course instructors. The results of the evaluation are presented in Table 5.

Table 5

Evaluation of Course Instructors of the TCTP

Aspect	SD	D	N	A	SA	<i>M</i>	<i>SD</i>
--------	----	---	---	---	----	----------	-----------

The level of instruction given during the course was very satisfactory.	0(0.0)	0(0.0)	0(0.0)	28(73.7)	10(26.3)	4.26	0.446
The instructors' delivery of the course material was excellent.	0(0.0)	0(0.0)	0(0.0)	23(60.5)	15(39.5)	4.39	0.495
The instructors had effective communication skills.	0(0.0)	0(0.0)	0(0.0)	22(57.9)	16(42.1)	4.42	0.500
The instructors had very good expertise in the content.	0(0.0)	0(0.0)	0(0.0)	21(55.3)	17(44.7)	4.45	0.504
It was easy to ask the instructors questions.	0(0.0)	0(0.0)	5(13.2)	13(34.2)	20(52.6)	4.39	0.718
I felt very comfortable expressing problems to the instructors.	0(0.0)	0(0.0)	5(13.2)	28(73.7)	5(13.2)	4.00	0.520
I was very confident in the instructors' ability to help me.	0(0.0)	0(0.0)	7(18.4)	11(28.9)	20(52.6)	4.34	0.781
The instructors gave (me) quality feedback.	0(0.0)	0(0.0)	5(13.2)	17(44.7)	16(42.1)	4.29	0.694
The instructors met my expectations.	0(0.0)	0(0.0)	5(13.2)	15(39.5)	18(47.4)	4.34	0.708

Table 5 results indicate unanimous agreement (100%) on the instruction level ($M = 4.26$, $SD = 0.446$), delivery quality ($M = 4.39$, $SD = 0.495$), communication effectiveness ($M = 4.42$, $SD = 0.500$), and instructors' expertise ($M = 4.45$, $SD = 0.504$), reflecting careful instructor selection and preparation. However, some participants were neutral about the ease of asking questions 5 (13.2%), instructors' helpfulness 7 (18.4%), feedback quality 5 (13.2%), and whether instructors met expectations 5 (13.2%).

3.2.5 Course Timing

Evaluation of the course timing yielded mixed findings. Some participants disagreed with certain statements, others were reserved, though majority largely agreed. The results are presented in Table 6.

Table 6

Evaluation of Course Timing of the TCTP

Aspect	SD	D	N	A	SA	M	SD
The time taken (duration) to complete the course in full was adequate.	0(0.0)	3(7.9)	7(18.4)	19(50.0)	9(23.7)	3.89	0.863
I was very satisfied with the length of each lesson.	0(0.0)	3(7.9)	4(10.5)	20(52.6)	11(28.9)	4.03	0.854
The length of the course fitted my expectations.	0(0.0)	0(0.0)	6(15.8)	24(63.2)	8(21.1)	4.05	0.613
I was able to fit my learning around my other commitments during the course.	1(2.6)	3(7.9)	0(0.0)	20(52.6)	14(36.8)	4.13	0.963
I was very satisfied with the length of the course assessments.	0(0.0)	0(0.0)	7(18.4)	20(52.6)	11(28.9)	4.11	0.689
I was able to complete the assessments in the allotted time.	2(5.3)	1(2.6)	12(31.6)	10(26.3)	13(34.2)	3.82	1.111

Table 6 shows that 73.7% agreed the overall course duration was adequate, while 26.3% disagreed or were uncertain. Additionally, 18.4% disagreed or were undecided about the adequacy of individual lesson lengths. Some participants (10.5%) indicated they couldn't balance learning with other commitments, suggesting a desire for more flexibility. Notably, 39.5% expressed difficulty completing assessments within the allotted time, reflecting a hands-on, minds-on approach rather than a traditional theoretical focus.

3.2.6 Learning Experiences

A highly sought after aspect of the TCTP evaluation was the learning experiences of the participants. The results are presented in Table 7.

Table 7

Evaluation of Course Participants' Learning Experiences during TCTP in Relation to CBE

Aspect	SD	D	N	A	SA	M	SD
--------	----	---	---	---	----	---	----

I feel that I achieved my learning goals.	0(0.0)	3(7.9)	2(5.3)	18(47.4)	15(39.5)	4.18	0.865
I was very satisfied with the course.	0(0.0)	0(0.0)	5(13.2)	22(57.9)	11(28.9)	4.16	0.638
The course fully met my expectations.	0(0.0)	0(0.0)	5(13.2)	22(57.9)	11(28.9)	4.16	0.638
I feel like my skills greatly improved as a result of the course.	0(0.0)	2(5.3)	0(0.0)	16(42.1)	20(52.6)	4.42	0.758
I can easily utilize the lessons learnt from the TCTP in delivering CBE in Uganda	0(0.0)	3(7.9)	0(0.0)	15(39.5)	20(52.6)	4.37	0.852
I would willingly consider taking another TCTP course in the same location.	0(0.0)	2(5.3)	3(7.9)	18(47.4)	15(39.5)	4.21	0.811
I highly recommend the TCTP course I took to friends in the CBE.	0(0.0)	0(0.0)	0(0.0)	21(55.3)	17(44.7)	4.45	0.504

Most participants agreed they achieved their learning objectives (86.9%), felt the course met their expectations (86.8%), significantly improved their skills (94.7%), could readily apply lessons to deliver CBE in Uganda (92.1%), would consider another TCTP course at the same location (86.9%), and would recommend it to colleagues in CBE. This suggests that the TCTP courses effectively (re)tooled participants to advance a practical and reflexive pedagogical shift aligned with CBE goals.

3.3 Qualitative Findings

The open-ended questions from the respondents yielded a number of hindsight, insight and foresight from the TCTP which can positively inform the CBE of the new lower secondary curriculum in Uganda. These are categorized into four themes: (a) TCTP Content for Inclusion in CBE Curriculum, (b) How CBE Expectations can be Met through TCTP, (c) Challenges with TCTP in Light of Uganda's Lower Secondary CBE Curriculum,

and (d) Support Systems for Implementation of TCTP Knowledge and Skills in CBE. Each of these themes is separately considered below.

3.3.1 TCTP Course Content for CBE Curriculum

Participants identified several TCTP elements beneficial to Uganda's education system that could foster essential knowledge, skills, values, and attitudes in graduates. One participant highlighted the need for lesson planning that anticipates learner misconceptions, shifting from a didactic "sage on the stage" approach to a "meddler in the middle" role, promoting activity-based, learner-centered lessons focused on outcomes. Another emphasized combining formative and summative assessments, particularly life skills. Participants also noted the need to retrain Ugandan teachers in journal use, reflective practice, and integration activities, with a focus on action verbs to meet 21st-century learning outcomes. Additional insights included integrating ICT, project-based learning, and developing textbooks that are activity-based, inclusive, and free of biases, ensuring they reflect curriculum, teacher, and learner dynamics.

3.3.2 How CBE Expectations can be met through TCTP

Regarding how knowledge and skills from TCTP can drive CBE, participants unanimously agreed on the need to integrate the content into the CBE working documents of their institutions. Some suggested that participants should present lessons learned to top management for potential policy adaptation, particularly in STEM education.

Another strategy to achieve CBE expectations is through exchange visits and benchmarking, with a call for more teachers to participate in TCTP. Additionally, participants noted that the SESEMAT INSET program should be strengthened to promote learner-centered, practical lessons. This includes enabling Ugandan teachers to collaborate with international peers and engage in field training.

Participants highlighted that integrating ICT in teaching and learning is a critical aspect of TCTP that can enhance CBE. They advocated for ongoing professional development to improve technology adoption in education, emphasizing the need to update training

content regularly to keep pace with technological advancements. Research-based teaching was proposed as a solution to outdated didactic methods.

3.3.3 Challenges with TCTP in Light of Uganda's Lower Secondary School CBE

Participants identified several challenges affecting the effective adoption of TCTP knowledge and skills in Uganda's lower secondary school CBE curriculum. A primary issue is the lack of support from education stakeholders. Some participants expressed that certain school administrators and educationists do not appreciate CBE for undisclosed reasons. Additionally, owners of private schools were cited as frustrating curriculum implementation to maintain an examination-driven approach that benefits their businesses.

Another challenge is the limited participation in TCTP, with few teachers acquiring this essential knowledge. One participant emphasized the need for more teachers trained in TCTP to effectively implement CBE.

Other obstacles include large class sizes, inadequate group work, financial constraints, lack of material resources, and limited creativity in utilizing available materials. The shortage of computers and ICT equipment was particularly highlighted, along with poor internet connectivity as significant barriers to ICT integration.

Furthermore, poor educational leadership and management were noted as challenges, including inadequate supervision, lack of continuous professional development programs, low funding, and poor timing and provision of learning materials.

3.3.4 Support Systems for Implementation of TCTP Knowledge and Skills

The study participants proffered a number of strategic support systems for enhancing the implementation of TCTP knowledge and skills in CBE in Uganda. The most resounding strategies included the following:

- Government and its partners should include the CBE implementation in the budget. This would abate the financial constraints affecting the programme.
- The Ministry of Education and Sports should ensure a timely reporting system of activities during which presentations are made and key action areas identified, and key players are assigned to adopt action points in relevant departments.

- Immediately after a TCTP there should be enough time devoted to cascading the content from the TCTP specifically.
- There is need to create more streams with small class size so as to achieve good designs of activities.
- There needs to be more engagement of MoES officers, Head teachers, Teachers and more collaboration with higher education institutions in the implementation of the CBE content.
- Cost sharing should be encouraged among individuals and the government in order to subsidize the costs of implementation of the TCTP course content in the CBE.
- Recruiting more science teachers coupled with continuous professional development should be encouraged. Teachers need to be retooled to first understand the requirements of the curriculum and then all stakeholders at different levels should implement their duties, for instance support supervision should be regularly provided to the teachers.
- Government intervention is required to help schools with computers.
- Government should make an enabling law about use of smart phones in secondary schools.
- Government and private partners need to provide adequate ICT infrastructure and materials for training teachers and learners in CBE.
- Individual schools need to source TCTP participants as facilitators to share information from the TCTP. Such knowledge and skills as team teaching, mobilization of instructional materials, support by school administrators, and collaboration amongst the staff can be shared to effect an attitude change among the teachers and learners.
- The government and schools need to avail computers to enable learners and teachers to make research.
- In addition to CPD, schools need to give a platform to talk to teachers, have a one-on-one interface with some teachers for attitude change, organize special training

session to take teachers through best practices in teaching and learning, and encourage and promote INSETs of SESEMAT and refresher CPD at school level.

4.0 Discussion

The demographic profile of participants reflects the gender imbalance in Uganda's STEM education, with fewer female teachers than male, echoing the sociocultural bias favoring males in science and mathematics. Studies show many female students hold negative attitudes toward these subjects, leading to higher failure rates in sciences and mathematics at UCE, limiting female enrollment in advanced science combinations. Research cites a female-to-male instructor ratio of 1:5, necessitating a rigorous review of Sustainable Development Goal 4 on inclusive education. Thus, TCTP-based gender-sensitive programs should be supported.

Participants' evaluations of TCTP were largely positive regarding course content, structure, delivery, and timing, highlighting its relevance for CBE in Uganda. Penuel (2016), drawing on social practice theory, notes that the diversity of practices individuals engage in is a valuable part of learning, not a hardship. Traversing diverse practices allows for exploring varied issues and realizing new action options (Dreier, 2008). Additionally, Engestrom & Sannino (2010) state that problems and contradictions drive learning and development. Through adaptation and new forms of participation (O'Connor & Allen, 2010; Dreier, 1999), individuals can innovate within their practices (Calabrese et al., 2009; Gutiérrez & Vossoughi, 2010). Participants valued the international experience TCTP offers, seeing it as crucial for advancing CBE and developing a scientifically literate populace, which is essential for Uganda's socioeconomic transformation.

TCTP knowledge aligns well with promoting practical, reflexive teaching within Uganda's CBE curriculum, particularly through constructivist strategies. Bamanga (2017) highlights how TCTP transforms participants' teaching perspectives, encouraging learner-centered approaches that foster active student engagement and critical thinking. Expanding teacher access to interactive learning methods through TCTP can support constructivist pedagogies, underscoring the need for government and agency investment in interactive educational methods.

The transfer of TCTP knowledge into CBE could be strengthened by adopting approaches from advanced educational systems that prioritize learner-centered methods. Continuous

professional development (CPD) is key to driving this educational shift, particularly when combined with pedagogical and technological skills. Shove (2012) argues that competence is more influenced by daily life events than major life events, suggesting that while TCTP tactics for promoting CBE are numerous, their implementation must be strategic and phased. Testing each approach on a broad scale will help assess its effectiveness. Shove further contends that large-scale, normalized practices, driven by social consumption patterns, ultimately shape societal behavior.

Challenges related to limited human, financial, and infrastructural resources hinder the integration of TCTP knowledge in CBE. Welch (2016) emphasizes that individual agency is often constrained by infrastructure, collective norms, and access to resources, suggesting that educators can only apply TCTP skills when sufficient resources are available. Thus, government and development partners need to invest in resources that enable educators to transfer TCTP knowledge to others effectively.

Documentation of support systems for TCTP adoption in CBE revealed strategies at individual, institutional, and national levels. King (2019) notes that individuals reinforce practices through repeated actions, indicating that isolated initiatives may fall short of desired outcomes. For broader TCTP adoption in Uganda, strong national support structures are necessary. Spurling et al. (2013) observe that practices are inherently social, relying on shared meanings and skills. Chatterton (2016) views practices as “abstract behavior as a social phenomenon,” while Schatzki (2016) and Welch (2016) assert that human agency primarily occurs through social practices, underscoring the need for collective, strategic action among stakeholders to realize CBE’s goals.

5.0 Conclusion

The aim to increase STEM access for equitable education is commendable, as a science- and technology-literate citizenry is essential for societal progress. However, Uganda’s previous curriculum focused on superficial cognitive learning rather than competency-based education with practical, reflexive pedagogies. Through the lens of social practice theory, we argue that learner agency is key to acquiring diverse 21st-century skills. This requires broad programmatic exposure to cross-cultural practices, as seen in third-country training programs (TCTP). TCTP can transform educators’ and citizens’

perspectives, yet implementing TCTP within CBE, especially in STEM, faces challenges. Addressing these requires robust institutional and governmental support.

6.0 References

- Astalin, P. K. (2013). *Qualitative research designs: A conceptual framework*. *International Journal of Social Science & Interdisciplinary Research*, 2(1), 118-124.
- Bamanga, A. A. (2017, July 31). Aisha Aminu Bamanga Nigeria. In S. Yanagisawa (Ed.), *Global Collaboration of Reflective Lesson Study and Professional Learning Communities of Teachers Newsletter*, 101.
- Calabrese, G. (2009). *Best performance-best practices: the case of Italian manufacturing companies*. *International Journal of Business Performance Management*, 11(3), 203-215.
- Chatterton, T. (2016). *An introduction to theories of behaviour*. In *Beyond Behaviour Change* (pp. 27-48). Policy Press.
- Dreier, O. (1999). *Personal trajectories of participation across contexts of social practice*. *Outlines. Critical practice studies*, 1(1), 5-32.
- Dreier, O. (2008). *Psychotherapy in everyday life*. Cambridge University Press.
- Engeström, Y., Sannino A. (2010). *Studies of expansive learning: Foundations, findings, and future challenges*. *Educational Research Review*, 5, 1-24.
- Gutiérrez, K. D., & Vossoughi, S. (2010). *Lifting off the ground to return anew: Mediated praxis, transformative learning, and social design experiments*. *Journal of Teacher Education*, 61(1-2), 100-117.
- King, L. M. (2019). *Applying social practice theory to contemporary working practices in sustainable office buildings: Implications for the performance gap* (Doctoral dissertation, University of the West of England).
- King, L. M. (2019). *Applying social practice theory to contemporary working practices in sustainable office buildings: Implications for the performance gap* (Doctoral dissertation, University of the West of England).
- O'Connor, K., & Allen, A. R. (2010). *Learning as the organizing of social futures*. *Teachers College Record*, 112(13), 160-175.
- Penuel, W. R., DiGiacomo, D. K., Van Horne, K., & Kirshner, B. (2016). *A Social Practice Theory of Learning and Becoming across Contexts and Time*. *Frontline Learning Research*, 4(4), 30-38.

- Schatzki, T. (2016). *Practice theory as flat ontology*. In *Practice theory and research* (pp. 44-58). Routledge.
- Spurling, N., McMeekin, A., Shove, E., Southerton, D., & Welch, D. (2013). *Interventions in practice: Re-framing policy approaches to consumer behaviour*. University of Manchester, Sustainable Practices Research Group.
- Taliba, C. (2018). *Knowledge co-creation program (KCCP) under technical cooperation with the Government of Japan. Report on INSET Management in Africa (Anglophone Countries)*.
- Welch, D. (2016). *Social practices and behaviour change*. In *Beyond behaviour change* (pp. 237-256). Policy Press.
- Yanagisawa, S. (Ed.). (2017, July 31). *Global Collaboration of Reflective Lesson Study and Professional Learning Communities of Teachers Newsletter*, 101.

Article 35

An Investigation on The Extent of Utilization of Social Networking Sites in
Crises Management of Public Secondary Schools in Nairobi County,
Westlands Subcounty

Martin Mungai Ndung'u¹; John Kitur²; Rosemary Mbogo³

martmunga@gmail.com

Abstract

This study investigated the role of Social Networking Sites (SNS) in communication during crises in public secondary educational institutions within Westlands Sub County – Nairobi County. There has been increased usage of communication tools such as the Social Networking Sites (SNS), that is, virtual communities where users create profiles to interact with people on shared interests. Every organization encounter crises at some point or another, and public schools are no exception. In those situations, SNS have been used to either propagate or diminish?? crisis. The objectives of the study were to: investigate the extent of utilization of SNS by public schools, determine the kind of information shared through SNS by public schools and to find out how management the use of SNS during a crisis. The research was done using a mixed method approach,, incorporating qualitative and quantitative data. Data was collected from principals, teachers, parents, union and MOE officials within the Nairobi County, Westlands Sub-County, using questionnaires and interviews. Data was presented descriptively analyzed and reported through percentages, figures and tables. The results showed that 78% of the respondents identified SNS as communication platforms used in crisis management in public secondary schools in Westlands. The results depicted high usage of platforms such as WhatsApp and Facebook. In addition, 71% of parents preferred venting their grievances on SNS before addressing them with the school; however, they were reluctant to communicate directly with the administration on the same platforms. About (15%) administrators used the SNS platforms for communication during a crisis. The study findings will be useful to managers

of public schools and other stakeholder of education in Kenya on how SNS can be managed and used for effective communication during crises.

Key Words: Communication, Crisis management, Public secondary schools,. Social Networking Sites, Information Management

Introduction

Organizations such as public schools face many crises emanating from within or outside of the school. These crises, when inappropriately handled, may lead to more dire repercussions. Crisis management is part of the normal school environment since problems or disasters are deemed to arise at any point during the institution's life cycle (Ndana, 2015). Crises could arise from within the organization or outside, including administrative and stakeholder-related problems. Ndana (2015) notes that head teachers in secondary schools in Kenya face crises as minor as: students' disagreements to disasters as severe as destructive lawsuits. Therefore, crises management processes present important frameworks for handling such situations. There have been many approaches which have been used to respond to the crises. One such technique is the use of Social Networking Sites in crisis management.

Social Networking Sites (SSN) refer to the employment of mobile and web-based technology to create highly interactive platforms through which individuals and communities share, co-create and modify user-generated content (Kietzmannn, 2012, pp. 16-21). Boyd defines SSN as virtual communities where users can create individual public profiles, interact with real-life friends, and meet other people based on shared interests. They are "web-based services that allow individuals to: (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system" (Boyd, 2008).

Kaplan and Haenlein (2010) classified Social Networking Sites into six different classes as follow: Collaborative Projects, (Wikipedia and google docs), Blogs and Microblogs (Twitter, Instagram, TikTok) ,Content Communities, Social Networking Sites (Facebook; 2go; BB chat) ,Virtual Game World (World of warcraft) and Virtual Second World (Second life) . Technology includes blogs, picture sharing, music sharing, crowdsourcing, e-mail, instant messaging and voice over. These services could be integrated via social network

aggregation platforms. People use SNS platforms since they are simple and with minimal dynamics. These platforms are simple to use yet they have profound interaction complexities such as Artificial Intelligence (AI). They can lead to the dissemination of information to masses of people in one instant, hence their imperativeness in crisis management.

Jie Xu (2020) notes that a respectable number of studies have emphasized the nexus between crisis management and SNS. Most of the studies maintained that public relations practitioners have adopted social media in running an organization and this has also been extended to manage crises. Alanezi (2020) indicates that SNS have brought a new face to crisis communication. Therefore, when a crisis occurs, the public opts to the utilization of SNS to solicit emotional support bundling up virtually to share information and demand solutions (Alanezi, 2020). Globally, crisis management in public institutions has been managed through effective use of SNS to give correct information effectively and efficiently to the stakeholders and the general public. A study in Kuwait middle schools on the use of social networks by Principals in managing a school crisis found a low degree of dependence by principals on social networks in general and across all stages of a crisis. The most used social networks included WhatsApp (69.7%), Twitter (24.2%), and Facebook and Instagram (up to 3%) (Alanezi, 2020).

The study is concentrated in the secondary education sub-sector which consists of public schools and is crucial because it forms the critical base from which manpower is generated for national development and for participation in the global economy. Public schools have students, teachers and parents as the main stakeholders; however, the suppliers and general public also play a crucial role in the management of these institutions. Therefore, accurate and timely information sharing, and management needs to be done systematically to avoid speculations when an issue arises in the school. Some of the common issues that happen in public secondary schools are: fire outbreaks, welfare of the students, bullying, injuries from sporting activities, student unrest and other emergencies. These issues may create crises within the public secondary schools (Ndung'u & Njenga, 2016).

Literature Review

The principles of this research were informed by literature from the following fields: . 1) Public Educational Institutions, 2) Management in Educational Institutions, 3) Some Social Networking Sites, 4) Communication in educational institutions during crisis and 4)

Context: Public secondary Schools in Nairobi County. An exploratory strategy was used in the review to get a better understanding of the function of Social Networking Sites and the relationship that exists among them in handling a crisis at a public secondary school. As of January 2020, there were 22.86 million internet users in Kenya. This number had increased by 3.2 million between 2019 and 2020. This increment accounts for 16% add up within a year (Matanji, 2020). As of the same January of 2020, internet penetration in Kenya stood at 43%. Social Networking Sites usage alone, accounted for almost half of the total internet utilization percentage, with a whopping 8.80 million users as per January data. The number of Social Networking Sites users experienced an increase of 1.0 million, which is roughly 13%, for the period of April 2019 to January 2020 (Matanji, 2020). Social Networking Sites penetration in Kenya, therefore, stood at 17% for the same period. Mobile connections enable most of the internet connections in Kenya, and as of January 2020, there were 52.06 million mobile connections.

Secondary school education in Kenya is guided by sector policies articulated in the Sessional Paper No. 1 of 2005, Kenya Education Sector Support Program (2005-2010), Economic Recovery Strategy for Wealth and Employment Creation (ERSWC, 2003) and the Vision 2030. Vision 2030, in particular, underscores the importance of secondary school education in laying a firm base for skills development at higher levels of education, including technological adaptation, innovation and technology. It is noted that a great number of people have subscribed to the online networks and have embedded them into their lives and that due to this, communications and interactions between individuals and groups have changed in significant ways. Internet use of platforms like Facebook can be interactively fertile, rich, diverse, and expanded according to both ethnographic and survey studies. Walt (2012) says that it is hardly unthinkable that one can make the case that authentic relationships cannot be realized through the contribution of Social Networking Sites. In America alone, statistics show that out of the marriages that took place in 2011, one in eight of those couples met online. But yet still, the superficial nature of online communities is scoffed at by many.

In Ghana, a study done by Mahama (2020), sought to investigate how government communicators take advantage of social media channels in conveying policy narratives while expanding or containing coalitions. With the positive effects of social media,

attention has been focused on expanding the frontiers to areas such as the direct benefit of social media to citizens. For government policies and processes to be more effective and efficient, the government must invest social and human capital into social media's usage in order to generate the necessary feedback that will inform policy.

In Nigeria for instance, Social Networking Sites such as Twitter, Facebook and WhatsApp easily created tension between state authorities and networked citizens. The recent banning of Twitter by the Nigerian government is an indicator that distorted information can easily be a source of conflict. Differences expressed in online forums can generate responses in real-time, in the real world. Some challenges accompany the use of platforms with massive audiences. Yet the benefits can outweigh the risks if governments recognize that it gives them greater reach to their citizens (Adegoke, 2019).

In Kenya, a study conducted by Kabura (2019) found that Social Networking Sites is a better communication platform in crisis management and it reaches the intended audience on time during a crisis situation. She further presents that the SNS are moderately effective during a crisis and the main reason attributed by Safaricom is that queries by social media users are responded on time and to their satisfaction. The use of SNS in crisis management in Kenya is largely done in the corporate sector and in a few public institutions; many public schools have however not embraced the use of SNS. This is because communication in the public schools is done through conventional means such as, newsletters, phone calls and Instant Messaging (IM). The use of SNS is confined to WhatsApp. The information largely shared may include but not limited to, fees structure, opening and closing dates, scheduled meetings, academic reports among others. However, in the event of a crisis, the public schools rarely use the SNS extensively to communicate to the stakeholders and the general public.

Crisis such as bullying and other deviant behaviors in public secondary schools have been reported and amplified through Social Networking Sites (as reported in the local print dailies and electronic media (Standard Newspaper, 2019). This crisis was first sighted in social media before the mainstream media amplified it. A disgruntled parent shared information of their child being bullied in one of the schools on the Social Networking Sites and this information was quickly shared around the different groups in those platforms. There was a public uproar on the issue and crisis management was employed by the schools affected, although a bit late (Muia, 2016). This and other cases, the researcher tried to find out the role of SNS in amplifying this crisis and the response

from the school management, government, and the general public on how this can be addressed to help promote good management practices in public secondary schools.

Methodology

This study targeted respondents in all the ten public secondary schools in Westlands Sub-County that had Social Networking Sites interactions. There were ten (10) secondary schools in Westlands, according to the MOE records (Kituko,2020). Therefore, the research targeted some of these schools which included: two boys' boarding schools, two girls' boarding schools and one day school. The researcher administered questionnaires in Google forms to the sample size of Westlands Subcounty public secondary schools as they are distributed in the schools within Nairobi County. The breakdown was on Principals (10), teachers (42), parents (114), union officials (3) and MOE officials (2) Data were analyzed descriptively using percentages and standard deviations. Regarding inferential statistics, correlation Analysis was run to establish the nature and significance of the relationship between independent and dependent variables and multiple linear regression was conducted to establish the extent of the influence of independent variables on the dependent variable. The benchmark of rejection or failure of rejection of the null hypotheses was based on the 5% alpha.

Demographic Data

The demographic data that was analyzed in this section was respondents age, gender and the type of school. The Demographic data in this study was to help provide the context of the participants involved in this study.

Age

According to Table 7, the distribution of the age bracket of the respondents was as follows: (48.3%) of respondents were aged 50 years and above. Furthermore, the results recognized that (34.5%) and (13.8%) were between the ages of 40 and 49 as well as 30 and 39 respectively. The 20-29 age group made up the smallest portion of this set of participants, accounting for just (3.4%) of the total. These findings implies that respondents above 50 years were the major participants who might have experience in matters relating to Social Networking Sites. However, (3.4%) of respondents constituted those within 20-29 years. This finding implies that that age group might not be

experienced with how SNS affect crisis management. This finding agrees with that of Drouin, McDaniel, Pater and Toscos (2020) results who found that the vast majority of social media participants over the age of 65 only use Facebook, despite younger age groups exhibiting a predisposition to utilize a wider range of online media, particularly including Snapchat and Instagram.

Table 7: Corresponding Ages

Age stratum	Frequency	Percent
20-29 years	2	3.4
30-39 years	8	13.8
40-49 years	20	34.5
Above 50 years	28	48.3
Total	58	100.0

GENDER

Respondents' gender was descriptively analysed as shown in Table 8 below. The results showed that (55.2%) of respondents were males while (44.8%) constituted female respondents. The quality of the research is improved and the market acceptance of innovation is improved by the inclusion of gender analysis in the research content. This study shows proportional differences between male and female participants in crisis management. As it has been observed, more males participated than females, as males are more inclined to the use of technology than females. The finding is presented in Table 8.

Table 8: Gender Analysis

	Frequency	Percent	Chi-square (χ^2)	p-value
Male	32	55.2	0.621	0.431
Female	26	44.8		
Total	58	100.0		

Type of School

It was observed that (37.9%) of participants were from girls boarding. Furthermore, (34.5%) and (27.6%) were from mixed and boys' boarding schools respectively. The results are shown in Table 9.

Table 9: Gender and Type of School Crosstabulation

			Type of School			
			Boys Boarding	Girls Boarding	Mixed School	Total
Gender	Male	Count	10	10	12	32
		% of Total	17.2%	17.2%	20.7%	55.2%
	Female	Count	6	12	8	26
		% of Total	10.3%	20.7%	13.8%	44.8%
	Count		16	22	20	58
	% of Total		27.6%	37.9%	34.5%	100.0%

Type of Social Networking Sites

The study indicates that (52%) of participants typically used WhatsApp while Facebook and Instagram users represented (47%) of the participants respectively. In addition, it was also noted that (21%) never used Twitter. Furthermore, (14%) notably argued that they never used Facebook. In conclusion, it was observed that the type of social networking site mainly used was WhatsApp (Mean = 3.18; SD = 0.92) while Twitter remained to be the least used by participants (Mean = 2.87; SD = 1.20). According to the data, Facebook and WhatsApp are the two social media platforms that are most frequently used. This study agrees with Maweu and Yudah's (2020) findings, which were based on research done in Kenya at the University of Kabianga with a sample size of 103 students and indicated that Facebook and WhatsApp were the most popular Social Media platforms for student information sharing. Table 10 shows the finding.

Table 10: Type of Social Networking Sites

Type of SNS	Never	Rarely	Sometimes	Always	Mean	SD
I typically use WhatsApp	2%	29%	17%	52%	3.18	0.92
I mostly use Twitter	21%	16%	19%	45%	2.87	1.20
I regularly use Facebook	14%	12%	28%	47%	3.06	1.07
I mostly use Instagram	10%	22%	21%	47%	3.03	1.05

The sampled head teacher participants had the following views concerning the types of SNS they use. They affirmed that: The prominent Social Networking Sites used in school were Facebook, Twitter and WhatsApp. However, the school rarely uses SNS to communicate to its users unless it's a WhatsApp communication.

This finding agrees with the quantitative data that showed that schools were yet to fully embrace usage of Social Networking Sites in crisis management. Due to the social sharing feature and the enormous number of people that regularly use the platforms, social media can assist spread information quickly in times of need.

The objective was to ascertain how the extent of Utilization of various forms of Social Networking Sites networks affect Crisis Management of public secondary schools in Nairobi County, Westlands Subcounty.

The study found that (58%) of participants affirmed that they use SNS in publishing information regarding their school such as academic clinics among others. This implies that SNS could enhance information sharing within a given defined network. In addition, (74%) affirmed that they use SNS because it breaks news faster as compared to the traditional broadcast media. Social media is thought to spread information to a sizable number of people who are connected to one another either directly or indirectly but who are part of the same network. This viewpoint is in line with that of Aillerie and McNicol (2016), who affirm that SNSs offer a significant quantity of data as well as different sorts of information compared to that available from many other sources and covering a broad variety of themes. Therefore, SNSs can be thought of as efficient information centers.

It may seem important to use social media during the crisis response phase to deal with the immediate and operational impact of a crisis. The current study established that (76%) of participants agree that they use SNS to reduce the tension of the situation within our school. Furthermore (69%) of respondents assert that they used SNS to provoke participation among stakeholders in their school This perspective is consistent with that of Eismann, Posegga, and Fischbach (2021), who emphasize that social media give organizations the chance to integrate information, knowledge, and collaborative processes that exist outside of their established structures in addition to allowing them to learn about a crisis as it is happening (i.e., intra-crisis learning). They can therefore enable organizations to support crisis management.

The use of modern technology to communicate with parents quickly, easily, and in a variety of ways indicates their potential to improve ties between different contexts, such

as home and school. According to the finding, (43%) of respondents agreed that they used SNS to a considerable extent since it remained the most preferred tool for communication among the target audience. Furthermore, up to 33% of participants indicated that they used SNS to a considerable extent since it allowed real-time messaging among the stakeholders. These findings indicate that social networks that allow real-time feedback are usually preferred by the clients. These findings are in line with those of Ogie et al. (2022), who affirms that using social media for crisis response work has advantages such as enabling remote posting of updates by schools, facilitating discussion and support, providing access to resources, and enhancing community perceptions of a caring and helpful school culture.

The many benefits of social media during and after school emergencies must be acknowledged by administrators and members of the crisis response team. From the findings, it was noted that (29%) of respondents affirmed that the use of SNS enabled their institution to distract rumors and propaganda to a very large extent. The results of this study are in line with those of Kerr and King (2018), who stress the ability of social media to swiftly reach a larger group. They assert that by using social media to share crisis information, the school can more swiftly refute rumors and correct inaccuracies.

However, in a parallel dimension, the study also sought to determine the level to which the parents would go to air their grievances regarding the school. Surprisingly, a greater percentage of the parents presented their complaints on social media platforms before addressing them with the school administration. The finding is given in Table 15.

Table 15: Extent of Utilization of Social Networking Sites.

Statement	NA	LE	SE	LE	E	VL	Me	SD
I use SNS in publishing information regarding our school such as academic clinics among others.	3%	38%	12%	36%	10%		3.12	1.14
I use SNS because it breaks news faster as compared to the traditional broadcast media	9%	17%	22%	36%	16%		3.32	1.19
I use SNS to reduce the tension of the situation within our school	2%	22%	16%	38%	22%		3.56	1.12
I use SNS to provoke participation among stakeholders in our school	7%	24%	14%	33%	22%		3.39	1.26
I use SNS to allow real-time messaging among the stakeholders	12%	19%	28%	24%	17%		3.15	1.26
I use SNS because it is the most preferred tool for communication among the target audience	10%	16%	16%	43%	16%		3.37	1.22

Use of SNS has enabled our institution to distract rumors and propaganda	10%	24%	9%	28%	29%	3.41	1.40
--	-----	-----	----	-----	-----	------	------

NA=Not at All; LE=Little Extent; SE=Some Extent; LE=Large Extent; VLE=Very Large Extent

Qualitative data for extent of utilization of SNS

The sampled head teacher respondents regarding the current social networking site usage opined that: The platform is essential but unmanned. Moreover, SNS is important, but efforts have not benefitted through active use by the school. On the other the Ministry of Education officials observed that: "We usually use WhatsApp as the chief mode of communication with head teachers. However, during delicate crisis situations, we minimize this mode of communication and resort to other traditional mode of communication." They cited the policy on communication from the Ministry of Education that guided on the mode of communication.

Regarding utilization of SNS, the qualitative data showed that the majority of parents averred that: "I prefer other methods of communication such as instant messaging, mobile phones, or face to face, with very few instances where I have ever communicated with the school through SNS platforms. However, I find WhatsApp to be the prominent SNS to use".

Furthermore, the survey also aimed to ascertain the extremes to which parents were willing to go in order to voice their concerns about the school. Surprisingly, parents also reported that:

"Majority of us find it easy to post a complaint on social media platforms before addressing them with the school administration. It is only a few who can use a face-to-face channel of airing grievances."

This qualitative data concurs with the quantitative that were collected from teachers who had affirmed that they utilized SNS to a lesser extent in communicating with the stakeholders. The researcher found out that, not many parents were still unable to present their grievances through face-to-face method of communication, perhaps due to the fear of intimidation from their superiors afterwards.

Utilization SNS In Regards To Crises

The study established that (39%) of the participants indicated that they used SNS to assess the magnitude of disaster or crisis. It is crucial that school officials respond to allegations of a crisis. This entails determining the crisis's severity. Furthermore, (38%) of participants

reported that they used SNS to a large extent in monitoring social media mentions for appropriate action.

Instantaneous and effective communication between institutions and the populations they serve is essential. According to the findings, up to (43%) of participants reported that they used SNS, to a large extent, to provide instant feedback to the clients. This suggests that to notify the general public about the mitigation techniques in a crisis situation, the school administration thought they must act quickly. These technologies' benefits include being free, quick, and simple to use. They also reduce workload and time waste by sending out mass communications.

Information sharing on social media in schools is becoming more and more widespread. To lessen the effects of a crisis, school officials must respond quickly and accurately following an incident. According to this current research, (34%) of participants asserted that they use SNS to provide emotional support and healing when a relevant crisis has happened. Furthermore, 31% of the participants acknowledged that they used SNS in rebuilding confidence by engaging the public directly. This implies that when SNS is used appropriately, organizations can rebuild confidence and trust from the clients. In this context, schools could make use of SNS to share information about the crisis, as well as to demonstrate their support and the actions they plan to take to resolve it. Table 20 shows the finding.

Table 20: Response to Social Networking Sites Content

Statement	NA	LE	SE	LE	VLE	Mean	SD
I use SNS to assess the magnitude of disaster or crisis	7%	26%	28%	29%	10%	3.10	1.11
I use SNS to provide Instant Feedback to the clients	17%	14%	12%	43%	14%	3.22	1.33
I use SNS to Provide emotional support & healing when a crisis is mentioned	3%	19%	21%	34%	22%	3.53	1.14
I use SNS in Rebuilding confidence by engaging the public directly	9%	24%	22%	31%	14%	3.17	1.20
I use SNS in Monitoring social media mentions for appropriate action	5%	26%	10%	38%	21%	3.43	1.22

NA=Not at All; LE=Little Extent; SE=Some Extent; LE=Large Extent; VLE=Very Large Extent

Qualitative Data For Analysis Of A Crisis

The heads of schools who were chosen shared the following thoughts about their response on social media queries. The affirmed that:

SNS is a good platform, but we rarely utilize it to analyze the size of disasters or crises. In addition, SNS can be a great venue to provide supportive care when a crisis is revealed. This is because using SNS to monitor social media mentions and take relevant action is an effective method. This result agrees with the quantitative data in which teacher respondents acknowledged that schools should use Social Networking Sites (SNS) to disseminate the news about a situation or crisis, as well as to express their solidarity and the steps they are taking to address the problem.

Crisis Management

The dependent variable for the study was analyzed and presented in Table 20. The main indicators for this variable include: Disaster planning and training, Problem solving, decision making and information dissemination. The study established that (40%) of participants indicated that they use Social Network Sites in response, planning and training concerning a crisis to a large extent. However, up to (29%) lamented that they never use Social Network Sites in crisis management. This implies that in order to send out timely messages and identify spreading rumors, SNS officials must constantly monitor public postings on social media. Moreover, (43%) of participants averred that they use Social Network Sites in problem solving regarding a crisis. This suggests that Social Networking Sites continue to be an essential tool for providing prompt attention to problems affecting learning institutions. These findings are in agreement with those of Kabura (2019), who discovered that Social Networking Sites are a better communication medium for crisis management and that they effectively reach their intended audience when a crisis occurs.

In times of crisis, an organization should use SNS to make decisions and offer solutions. In this research, it was found that 28% of respondents assert that they used Social Network Sites to a large extent in decision making as regards to a crisis. Additionally, 33% of participants stated that they used Social Network Sites to Provide updates on critical issues that have arisen. Also (29%) asserted that they used Social Network Sites in information dissemination relating to a crisis. This finding is in line with that of Lachlan et al. (2015), who note that increased social media use during a crisis, coupled with the public's expectation of receiving information quickly and, at the same time, the natural tendency of rumor spreading on social media, can foster the spread of false disaster-related information. Social networking site administrators must quickly correct fraudulent remarks that are posted on social media sites.

Table 30: Crisis Management

Statement	N				VL	Me	S
	A	LE	SE	LE	E	an	D
I use Social Network Sites in response, planning and training concerning a crisis	3%	26%	16%	40%	16%	3.37	1.13
I use Social Network Sites in Problem solving regarding a crisis	21%	7%	17%	43%	12%	3.18	1.34
I use Social Network Sites in decision making as regards to a crisis	10%	16%	22%	28%	24%	3.39	1.29
I use Social Network Sites in Information dissemination relating to a crisis	12%	16%	26%	29%	17%	3.24	1.26
I use Social Network Sites to Provide updates on critical issues that have arisen	3%	28%	14%	33%	22%	3.43	1.21

NA=Not at All; LE=Little Extent; SE=Some Extent; LE=Large Extent; VLE=Very Large Extent

Conclusion

SNS have influenced crisis communication; hence, crisis management in the social media realm has become more complex by the virtue that school are not actively utilizing this space while the rest of the world is using it effectively. Schools have allowed themselves to be points of discussion in times of crisis without the benefit of an appropriate avenue for responding to the interested parties on critical matters that are the basis for a crisis. Furthermore, schools have lost opportunities to benefit economically and socially from the community by not positioning themselves strategically in the social environment.

The study showed that schools are present in SNS platforms and update their information; however, they do not necessarily use these platforms as the primary sources of crisis communication. Furthermore, schools do not actively address the grievances of most parents who are active in the SNS. The parents together with the general public, complain and sometimes compliment these schools on platforms such as WhatsApp, Facebook and Twitter without any credible response from the school. When a school is in crisis, some teachers, parents, and the non-teaching staff would go to their social media pages and update the public on the conditions of the school. However, the school itself does not actively participate in the communication process on those platforms. As a result, information regarding a crisis situation goes directly to the public without any control of the content by the school management.

Formal methods such as letters and person to person communication are still preferred in the schools to communicate the status of the institutions to the public. Schools, especially public secondary schools, need to adapt and ensure that social media is

effectively used in crisis communication to facilitate proper crisis management. Therefore, these schools should ensure their SNS platforms are user-friendly, constantly active with live updates, and provides all relevant information in good time during a crisis. This is an essential aspect that schools have been lacking in their utilization of Social Networking Sites in crisis management. Thus far, social media has been used by everyone else during a crisis, except the schools themselves. The impact is that the crisis escalates in the SNS platforms with minimal to zero communication from the schools' representatives. Biegon (2017), agrees with the statement that, the SNS platforms are fast methods to disseminate information to the public. Failure to effectively manage information distributed by other parties other than the school management is catastrophic to the crisis management efforts by the school.

Recommendations

This research recommends that school principals start prioritizing the use of social media in efforts to enhance effectiveness and efficiency in crisis management. The ministry is obligated to add a new role in public secondary schools, known as a *social media controller*. The school's social media controller is more like a public relations person, only that they operate on the SNS platforms. This employee's role is to communicate effectively to the public and any other concerned stakeholder, especially during a crisis. The employee is mandated to gather facts from the school and regarding the school in times of crisis, then convey these facts in a manner that is effectively regarded by the concerned parties.

Crisis management in public secondary schools defines a benchmark for crisis management in all schools in Kenya. Therefore, crisis management in schools can also be enhanced by encouraging teachers, parents, the non-teaching staff, and other stakeholders to the schools to fully utilize SNS in communicating crises in a manner that positively affects the general public. These stakeholders should be guided on how to treat confidential and sensitive information in the public domain through efficient laws and guidelines on SNS use. These laws and guidelines should emanate from the unions and the Ministry of Education down to the schools. The principals/managers of the public schools will be better equipped during a crisis management through accurate, timely, and relevant communication.

References

- Adegoke, Y. (2019). *Social media, citizen journalism and the crisis of governance in Nigeria*. *Journal of African Media Studies*, 11(1), 1-17. DOI: 10.1386/jams.11.1.1_1
- Aillerie, Carine & Mcnicol, Sarah. (2016). *Are Social Networking Sites information sources? : Informational purposes of high-school students in using SNS*. *Journal of Librarianship and Information Science*. 50. 1-12. 10.1177/0961000616631612.
- Alanezi, A.(2020). *Using Social Networks in School Crisis Management: Evidence from Middle School Principals in Kuwait*. Department of Educational Administration and Planning, College of Education, Kuwait University, Kuwait. <https://doi.org/10.1080/03004279.2020.1817964>
- All Kenyans. Nairobi: Government Printer
- Biegon, T., (2017). *The Extent of Ict Integration in Public Secondary School Management and The Stakeholders' Perception on the Usefulness of the Technology in Nairobi County Kenya* (Doctoral Dissertation, Kenyatta University).
- boyd, D.M.; Ellison, N.B. (2008). *Social network sites: Definition, history, and scholarship*. *J. Comput. Mediat. Comm.* 2008, 13, 210-230.
- Eismann, Kathrin, et al.,(2021), *Opening organizational learning in crisis management: On the affordances of social media*. *Journal of Strategic Information Systems*, vol. 30, no. 4, Dec. 2021, p. NA. Gale Academic OneFile, <link.gale.com/apps/doc/A684055608/AONE?u=anon~158cddb8&sid=bookmark-AONE&xid=ee2887e8>.
- Internet World Stats: Usage and Population Statistics. Africa Top 10 Internet Countries 2015 Q2*. Miniwatts Marketing Group, Bogota, Colombia, 2015. Accessed 30th November, 2019. <http://www.internetworldstats.com/stats1.htm>.
- Kabura, I. N., (2019). *Influence of Social Media on Crisis Management Among corporate organisations in Kenya: A case study of Safaricom Public Limited Company*. University of Nairobi.
- Kaplan, A. M., & Haenlein, M. (2010). *Users of the world, unite! The challenges and opportunities of Social Media*. *Business horizons*, 53(1), 59-68.
- Kituko, S. C. (2020). *Kenyan Education in the Wake of Consumerism: Effects On Funding And Quality*. *Journal of Education and Practice*, 4(1), 73-79.

- Lachlan, Kenneth & Spence, Patric & Lin, Xialing & Najarian, Kristy & Greco, Maria. (2015). *Social Media and Crisis Management: CERC, Search Strategies, and Twitter Content*. *Computers in Human Behavior*. 54. 10.1016/j.chb.2015.05.027.
- Mahama, W.N, (2020). *Social Media Technologies in Policy Communication: A Case Study of Ghana's Information Services Department*. Walden University.
- Matanji, F. (2020). *WhatsApp and Mobile Money: Ameliorating Crowdfunding for Social Change in Kenya*. *Asia Pacific Media Educator*, 29(2), 237-248. <https://doi.org/10.1177/1326365x19894780>
- Maweu, G. and Yudah, O. (2020) *Utilization of Social Media Platforms among Information Science Students at University of Kabianga*. *Open Access Library Journal*, 7, 1-11. doi: 10.4236/oalib.1106090.
- Mugenda O. and. Mugenda A., (2003), *Research Methods: Quantitative and Qualitative Approaches*. Nairobi: Acts Press.p.57
- Mugenda, A. and Mugenda O., (2013). *Research methods: Quantitative and qualitative approaches*. Nairobi: ACTS Press.
- Ndana J.M., (2015), *The Administrative Problems that Public Secondary School Head Teachers Face in Kenya: A Case Study of Kitui Sub-County*
- Ndung'u, P. M., & Njenga, J. M, (2016). *Assessment of the Causes and Effects of School Fires in Public Secondary Schools in Kenya*" published in the *Journal of Education and Practice in 2016*.
- Ogie et al., (2022). *Social Media Use in Disaster Recovery: A systematic literature review*, Statista- The Statistic Portal. Number of Social Network Users Worldwide from 2010 to 2021 (in billions). Statista, Inc., New York, 2018. Accessed 30th November, 2019. <Http://Www.Statista.Com/Statistics/278414/Number-Of-Worldwide-Social-Network-Users/>.
- Success, Seattle, WA: Dissertation Success LLC.
- Walt, Jonh D. "Social Wisdom for Social Media, Part 1." *The Seedbed Blog*, February 7, 2012. <http://seedbed.com/?s=social+media>. Accessed 30th April, 2015.
- Xu, J., & Wu, Y. (2020). *Countering Reactance in Crisis Communication: Incorporating Positive Emotions Via Social Media*. *International Journal of Business Communication*, 57(3), 352-369.

- Education and Development Self-Determination of Behavior, Psychological Inquiry, 1.(4:227-268)*
- Smith M. A. and Schmidt, K. 2012. Teachers are making a difference: Understanding the
Some Selected Secondary Schools in Southwestern Nigeria. *European Journal of Scientific*
- Stadler, H., Duit, R., and Benke G. 2000. Do boys and girls understand physics differently? *Physics Education. 35(6):417-422.*
- Werbach, K., & Hunter, D. 2012. *For the win: How game thinking can revolutionize your business.* Philadelphia, PA: Wharton Digital Press.
- Zichermann, G., & Cunningham, C. 2011. *Gamification by design: Implementing game mechanics in web and mobile apps.* O'Reilly Media.