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Strengthening Mathematics and Science Education in Africa

SMASE-AFRICA

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

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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 [COMSTEDA 19] was held on 22nd -25th, November 2022 in Uganda. 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 19 was a wonderful learning experience and look forward to seeing more research papers in COMSTEDA 20 in Ghana.

COMSTEDA 19 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 CEMASTEA. 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 SMASE-WECSA 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 19 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

Strand 1: Teacher Professional Development in Africa: Developing Knowledge, Skills and Values in STEM teaching and learning engagements

Article 1

Presented by *Petronila Anyango* the paper titled**: Enhancing Quality Teaching Through Professional Teaching Standards and Professional Learning Communities in Kenya**, focused on improving quality teaching through the integration of Professional Teaching Standards (PTS) and Professional Learning Communities (PLC). Anyango began by acknowledging the critical role of teachers in student outcomes and global efforts to enhance teaching quality. She critiqued selective entry systems for teacher professional development programs that disfavored teachers in practice and those actively enrolled in undergraduate degrees. She emphasizes ongoing professional development as crucial for effective teaching quality. The core of Anyango's research explored the PLC model, highlighting collaborative learning among teachers to improve instructional practices. Various PLC structures like Lesson Study and Quality Teaching Rounds were discussed, emphasizing active learning methods proven to enhance teacher efficacy and student outcomes. Integration of PTS competency descriptors into PLC activities emerged as a central strategy. By aligning lesson planning, teaching practices, and post-lesson reflections with these descriptors, teachers enhance their pedagogical skills and meet regulatory standards effectively. Expected outcomes included improved teacher competence, enhanced student achievement, and higher staff morale through collaborative professional development. Anyango recommends widespread adoption of PLCs integrated with PTS to foster continuous improvement in teaching quality. Overall, Anyango's study advocates for a holistic approach to enhancing teaching quality through collaborative professional development and adherence to professional teaching standards.

Strand 2: School Culture and Learning in STEM

Article 2

When the Didactics of Mathematics Reaches Out to the Teaching of Human Sciences: Case of History and Sciences of Society in the Democratic Republic of Congo was presented by S. *Ekombe Isenkangi*. This study examined the application of "didactic transposition" to history education in the Democratic Republic of Congo. The research reveals a significant disconnect between current scholarly historical knowledge and the history taught in DRC schools. School materials present outdated and sometimes inaccurate information about population groups. The study concludes that "school time" lags behind "scholarly time" in DRC history education. This study recommended updated, research-aligned content in history education.

Article 3

The paper titled '**Mathematics Teachers' and Students' Perceptions towards Remote Learning**

during Covid-19 School Closure' was presented by *Edith Musonda and Asiana Banda* from Zambia. They had conducted a case study in Kitwe district, Zambia. The study revealed that both mathematics teachers and students had positive perceptions towards online learning. The study further revealed that there was no significance statistical difference between mathematics teachers' and students' perceptions towards online learning. One key finding was that mathematics teachers' and students' preference for WhatsApp platform was outstanding. This finding was supported by 54.3% and 61.5% of mathematics teachers and students respectively, whose perception was positive towards online learning in mathematics. One of the recommendations was that online learning should continue. Another recommendation was for WhatsApp platform to continue being used for teaching and learning mathematics.

Article 4

The paper titled '**Mathematics Application's in The Quality Management System (QMS)**' was presented by *Nzempia Ngila Herito*. The study was necessitated by the fact that majority of the youth were continuously losing interest in mathematics. The findings revealed that applied mathematics such as statistics, mathematical analysis, and operations research would encourage and improve the attitude of students towards mathematics. The study further revealed that applied mathematics would encourage academic internships in institutions where it is applied. The study concluded that students in the field of mathematics would find greater interest in mathematics if it was applied in the Quality Management System. The study therefore recommended application of mathematics in the field of management for realization of proper handling of the QMS.

Article 5

The paper titled, **'Limited Linguistic Competency in the English Language as an Obstacle to Equity and Access in STEM Education'** was presented by *Maryline Chepngetich Kirui*. The focus was on effect of language and performance on learning of STEM subjects. In essence, the study examined difficulties faced by learners with limited competency in English language. Secondly, the presentation discussed relationship between competence in English language, acquisition, synthesis and retention of knowledge in STEM subjects. The study revealed that most learners could not comprehend concepts well if only English language was used throughout the learning process. Learners preferred some explanations in Kiswahili in order to enhance understanding. Further, it was revealed that performance in STEM subjects was largely dependent on learners' competence and confidence in the language of instruction. The study concluded that there was a direct link between competency in English language and performance in STEM subjects. As a result, the study recommended that more emphasis to be put on learner's mastery of English as a language of instruction to improve performance in STEM subjects.

Article 6

The paper on **Creating Learning Spaces for STEM Learning and Engagement: Building Learners' Capacities to Use Imaging Affordances of Their Own Digital Devices In And Out**

Of School by *Francis W Mureithi and Anil Khamis, PhD* noted the significance of mobile smart devices usage in enhancing learning, communication and collaboration. The study explored the readiness of a low-resourced, public secondary school in Kenya, to implement the Bring Your Own Device (BYOD) initiative. Approaches used for the study involved Qualitative research (QR) and the participatory action research (PAR) design. Data was collected via interviews, focus-group discussions, photographs, observations and document analysis methods. Reflections and experiences were documented via a photo-voice technique and analyzed using standardized statistical methods. The findings showed that more girls than boys were able to access devices and bring them to school on daily basis. BYOD implementation can be positively supported in schools if communication was purely formal and the gadgets are utilized well. The paper recommended expansion of spaces for STEM learning and application, in and out of school and teachers to support learners in accessing and digital devices, in line with the objectives of the 21st-century pedagogy. There is a need for a shift in focus to allow learners to access and use their own digital devices in formal learning environments.

Article 7

The paper titled **'Role of the teacher as an innovator for inclusive classroom environment: Promoting inclusive STEM learning'**, was presented by *Peter Mureithi Ndiritu* a teacher at Mt Kinangop Girls Secondary School in Kenya. It presented an innovative DV kit creatively made to bridge the gap among physically challenged learners on their hands. The DV kit solved the problems related to manipulating apparatus during practical sessions such as titration in chemistry. In order to produce vibrations necessary in shaking of conical flask, 12 students were sampled from a form three class of 65 students. Each of these learners were expected to carry out titration experiment using free hand as control. The student then carried out the experiments using DV kit in shaking of the conical flask's solution. Experimental data was collected and it was found that the average mean of burette volumes using deterministic vibrator had a percentage error of 1.604%, off the control experiment. The study recommended use of DV kit in shaking of conical flask during titration in chemistry. It was also recommended that, the teacher was an innovator for the best practices in education by creating an inclusive learning space. Further, it was recommended that regular school laboratories be equipped with special needs technological assistance for inclusivity in STEM learning.

Article 8

The paper entitled, **'Evaluation of Negative Ethnicity on Institutional Leadership in Public Secondary Schools in Kajiado County, Kenya'**, was presented by *John N. Purdul*. The focus was on assessing the influence of ethnicity on institutional leadership in public secondary schools in Kajiado County. The study adopted the mixed methodology combining qualitative and quantitative approaches. Concurrent triangulation design was used for data collection. Quantitative data of descriptive statistics was analyzed using frequencies and percentages and presented using tables. Inferential statistics was analyzed using multiple regressions and presented in tables.

Qualitative data was analyzed thematically and presented in narrative form and direct quotations. The study concluded that ethnic identities and groups play a major role in the selection, promotion and recruitment of principals and teachers. The study suggests that to get out of negative ethnicity, diversity, citizenship and respect of other people's culture should be embraced. The Teachers Service Commission policy (2017) on appointment and deployment of institutional administrators as contained in circular No.1 of 2020 should be adhered to.

Article 9

The paper entitled, '**The Place of Climate Change in The Practical Teaching of Climatology**: The Need for a Mini Meteorological Station for Didactic Use at ISP Gombe/Kinshasa DRC', was presented by *Makaya Samba Beatrice*, Institut Supérieur Pédagogique de la Gombe, Kinshasa DRC. The paper focused on the predominance of theory over practice in the teaching of climatology. This study was based on analytical and bibliographical methods, supported by documentary and interview techniques. The findings revealed that there is underutilization of equipment in the department. Apparatus for measuring climate elements are limited to the teachers to adequately carry out the practical part of the program. The recommendation was that there should be installation of a mini meteorological station for didactic use in the courtyard of the ISP/Gombe.

Article 10

Répertoire des scientifiques femmes de la République démocratique du Congo dans le domaine de STEM, Identification de leurs innovations à impact visible (Directory of women Scientist in Democratic Republic of Congo in STEM, identification of their innovations and visible impact) was presented by *Mvondo Pashi Falangani Christine* from Democratic Republic of Congo (DRC). The paper focused on identification and celebration of the significance of women scientists in the Democratic Republic of Congo whose innovations and inventions have made visible impact on the Congolese society. The study sought to address the problem of lack of directory or database of women in science and achievements in DRC. Findings revealed the need to establish a directory of Congolese women scientists and an inventory of great women who have distinguished themselves in various fields of Science, Technology, Engineering and Mathematics in the DRC. The women emphasized the need for particularity of each one and writing monographs of women that have worked for the development of DRC. It was recommended that knowledge of great women scientists and actions at various levels of STEM would encourage young girls to follow in the footsteps of great women by imitating the know-how and examples in STEM fields at secondary, higher and university levels.

Strand 3: STEM Curriculum Development Implementation and Assessment

Article 11

Importance of Early Learner Participation in the Wavumbuzi Entrepreneurship Challenge was presented by *Dr. Roselyn Marandu-Kareithi, Allan Kimaina, Stephen Mangira and Martha Wamuyu*. The study sought to assesses the impact of repeated participation in the Wavumbuzi

Entrepreneurship Challenge, an online program implemented in Kenyan secondary schools to develop students' entrepreneurial thinking. Results showed that repeat participants demonstrated significantly higher engagement levels than first-time users, submitting more challenges and earning more points. The study concludes that repeated exposure to the challenge leads to increased engagement and skill development. It recommends that stakeholders, including educators and parents, should encourage and support lower grade secondary school students to participate in the challenge as early as possible to maximize its impact and reach.

Article 12

Isaac Opio and *Isaac Habumugisha* presented a paper based on a study on **'Astronomy for Development: Investigating Learners' Experiences and Attitudes Towards Astronomy in The New Lower Secondary School Curriculum of Uganda: A Case Study of Kabale Municipality'**. The study investigated learners' experiences and attitudes towards the inclusion of astronomy concepts in Uganda's new lower secondary school curriculum. A total of 160 participants were involved in the study. Opio and Habumugisha reported that 67% of the learners had basic knowledge of astronomy, while 33% were unfamiliar with the concept. Additionally, 81% of the students expressed a high level of interest in astronomy, indicating a positive reception towards its inclusion in the curriculum. The presenters concluded that learners demonstrated a general interest and basic understanding of astronomy, suggesting that the inclusion of astronomy in the curriculum was well-received. The study recommended providing of refresher courses to further equip physic teachers to integrate the concepts. Additionally, expand the scope of astronomy and astrophysics within the curriculum was advised to enhance learners' knowledge and interest in the fields.

Article 13

The paper on '**Assessing Students' Acquisition of Twenty-First-Century Skills' During Biology Lessons: Case of a Secondary School in Lusaka Zambia'** was presented by *Thumah Mapulanga.* The study assessed students' acquisition of 21st-century skills—specifically communication, collaboration, critical thinking, and creativity-during biology lessons at a secondary school in Lusaka, Zambia. Mapulanga reported that the study involved 24 grade 11 students and six biology teachers, employing lesson studies to gather data. The findings revealed that learner-centered biology lessons effectively promoted collaboration and communication skills among students. However, development of critical thinking and creativity was less prominent. Mapulanga concluded that although the 4Cs could be successfully integrated into biology lessons, there was need for a more explicit focus on critical thinking and creativity. It was recommended that biology lessons should explicitly include assessments that target development of the skills in readiness for future challenges.

Article 14

The paper on **'Implementation of Secondary Science and Mathematics Teachers' (SESEMAT) Programme and Academic Performance in Science and Mathematics in Lango Region –**

Northern Uganda' presented by *Joshua Ewo Moi.* The study evaluated the implementation of SESEMAT Programme and its impact on academic performance in science and mathematics in the Lango region of Northern Uganda. Moi reported that the study used a mixed-methods approach, collecting data from 784 respondents through questionnaires, interviews, and focus group discussions. The findings indicated that implementation level of SESEMAT Programme's was low, at 25.7%, which correlated with poor academic performance in science and mathematics among students in the region. Moi concluded that low level, implementation of SESEMAT Programme was a significant factor contributing to students' underperformance in these subjects. Moi recommended shift from current cascade training system to a more inclusive and system-wide approach involving all educational stakeholders. The recommendation will ensure effective implementation of the programme and enhance students' academic performance in science and mathematics.

Article 15

The presentation by *Bibomba Tshiananga Nancy and Kapenga Kazadi Ntundula Jean-Marie* titled **'Report of Students in Transition Secondary/University to Knowledge Relating to Preliminary Concepts on Functions'**. This study examined how first-year university students understood basic concepts in functions as they transition from secondary school. The presenters found that students often struggle with understanding the domain of definition and parity of functions due to limitations in how these concepts are taught. The findings indicated that institutional constraints in teaching these concepts, such as viewing the domain of definition as a union of intervals and limited exploitation of parity concept caused significant misunderstanding among students. An analysis of secondary school programs and textbooks revealed heavy reliance on set and graphic registers of functions, without adequate integration, which hindered students' comprehension. Recurring errors were identified suggesting that separation of these registers and lack of transition between them hindered students' grasp of functional concepts. Both priori analysis of questionnaires and subsequent posteriori analysis confirmed these issues highlighting consistent pattern of mistakes related to the domain of definition and parity of functions. The study concluded that there are substantial gaps in teaching methods and materials related to functions, contributing to students' persistent errors. The authors emphasized need for holistic approach that includes various registers of representation to improve students' understanding. The presenters recommended starting with real-life phenomena to illustrate dependence concept, followed by thorough explanation of function definitions and related tasks. Additionally, they proposed a more integrated approach that transitions smoothly between the set and graphic registers to foster better comprehension among students.

Article 16

Mr. Evaristo Tukamuhabwa, Dr. Bashir Kishabale and Dr. Grace Lubaale conducted a study on **School Environment and Physics Teacher Effectiveness in Kigezi Sub-Region, Uganda**. It primarily focused on the relationship between school environment and physics teacher effectiveness in secondary schools in Kigezi Sub region, Uganda. It employed a mixed-research

design (quantitative and qualitative techniques) where both types of data were collected and analyzed sequentially. Data was collected from 234 Physics teachers, fourteen (14) head teachers and Six (06) education officials which was analyzed through the statistical software programs SPSS to see if correlations between the variables existed. Findings showed that a conducive school environment brought about by administrative support, collegiality and professional development had a strong positive relationship with physics teacher effectiveness. The study recommended that teachers should create appropriate environments to present new thoughts by creating standards of administrative support, exercise companionship and cooperation between colleagues. They should also seek to improve professionally by participating in forums like educational seminars, workshops and conferences.

Article 17

Determination by the Analytical-Graphic method of the center and the radius of a circle inscribed in a triangle where projections are known by *Bibomba Tshiananga Nancy and Ngoyi Faustin* posits that the solutions of problems provided by the analytical-graphical method and analytical method are the same. The study showed that the proposed analytical-graphic method, which utilizes both algebra and geometric constructions is easy to understand and apply in solving descriptive geometry problems compared to the more difficult analytical approach. This was proved by findings from several trials which showed that only 10 percent of students using the analytical method performed well owing to its complex techniques. The study recommended usage of the analytical-graphical method which proved to be simpler and quicker for fifth and sixth secondary students to properly assimilate in descriptive geometry.

Strand 4: ICT Integration in STEM Education

Article 18

The paper on **'The Wavumbuzi Entrepreneurship Challenge'** presented by *Stephen Mangira, Martha Wamuyu, Allan Kimaina and Dr. Roselyn Marandu-Kareithi* from Allan & Gill Gray Philanthropies (AGGP) Kenya. The study evaluated the effectiveness of gamified learning platform in developing entrepreneurial competencies among secondary and high school learners in Kenya. The program engaged students in real-world problem-solving tasks through interactive challenges. To measure the impact, pretest-posttest experimental design was implemented, involving 447 learners who completed both pre- and post-surveys. The data analyzed revealed significant improvement in six key entrepreneurial competencies i.e. entrepreneurial experience, intention to start a business, future business planning, structured tasks adherence, positive entrepreneurial mindset and initiative. These findings validated the effectiveness of the gamified approach in enhancing these competencies, aligning with existing literature on game-based learning. The study concluded that the Wavumbuzi Entrepreneurship Challenge successfully fostered entrepreneurial skills through an engaging and learner-centric approach, shifting away from traditional teacher-led methods. The approach not only increased student engagement but also prepared them for real-world challenges. Recommendations included conducting further research with more rigorous statistical methods and exploring the approach's applicability in

various cultural and educational contexts.

Article 19

The paper **'SMART Table: Virtual Environment for Teaching Mathematical Lessons'**, was presented by *J.N Nyagwencha* of United States International University Africa (USIU-A), USA & Auburn University, Kenya. The study sought to establish whether creation of a multi-platform environment or tool such as the SMART table can entice and increase student motivation for learning mathematics. The method for the study involved collection of data using pre and post questionnaires. Analysis of data was done using Ben Schneider's criteria (of presenting a greater user experience to the user) and the 5.0-point Likert scale. Results obtained a score of 4.5 on a 5.0-point Likert for users who were computer literate and highly favorable to the idea. The findings showed 96% agreeing that K12 students can learn better through interactive hands-on activities than through traditional learning. On usability, the game had a 4.0 score on a 5.0 Likert scale for not being terrible nor frustrating on satisfaction with 69% of users likely to use if availed as a teaching tool. The study supports the idea that a Multi-Touch environment offers the user a total control to accomplish a well-defined task to completion through manipulation of objects. It recommends the virtual environment for imparting knowledge and understanding of mathematical concepts in the classroom.

Article 20

The paper **'Use of GeoGebra and Pre-Service Teachers Performance in Geometry in Colleges of Education in Ghana'** was presented by *Zutaah Puotier, Ph.D., Professor Samson R. Ondigi & Dr. Miheso_O'Connor, K. Marguerite.* The study sought to find out the difference in geometry performance between pre-service teachers' who are taught using GeoGebra and those who are taught without using GeoGebra. The study used a quasi-experimental design with a nonequivalent (pre-test and post-test) control group design. The study gathered the data using a geometry achievement test. Data were analyzed using independent samples t-test and paired samples t-test. The results revealed a significant difference in geometry performance between the experimental and 34 control groups with the group that used the GeoGebra performing better than those who didn't apply it. The findings of this study revealed that teaching and learning geometry using GeoGebra provided Pre-Service Mathematics teachers with new learning experiences. It enables them to think, analyze, and visualize abstract geometric concepts and in turn relate them to real life. The study recommended that GeoGebra should be used in teaching and learning geometry in colleges of education in Ghana.

STRAND ONE

Teacher Professional Development in Africa: Developing Knowledge, Skills, and Values in STEM teaching & learning engagements

1.School-based Teacher Professional Development: Policy, Strategies and Practices
2.Teacher Professional Development for Competency Based Education
3.Promising Approaches in Teacher Professional Development

Article 1

Enhancing Quality Teaching Through Incorporating Professional Teaching Standards (PTS) Using Professional Learning Communities in Kenya

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Abstract

School systems worldwide recognize that the quality of teaching is paramount in influencing student outcomes. Globally, concerns over teaching quality are increasingly addressed through two distinct approaches, each with significant political backing. The first approach advocates for elevating teaching quality by admitting only top-performing students from national examinations into the profession. The second approach focuses on enhancing teaching quality by implementing rigorous assessments to remove underperforming teachers while drawing lessons from exemplary practitioners. Teaching is a dynamic process requiring continual personal and professional development to enhance instructional quality. Various Teacher Professional Development (TPD) models exist, with the Professional Learning Community (PLC) emerging as particularly effective in elevating teaching standards. The PLC model views learning as a social and contextual endeavor, emphasizing collaborative planning and real classroom implementation as optimal learning environments for teachers to refine their teaching practices. Numerous studies have investigated the impact of standardized content delivery, immediate feedback mechanisms, and reflective practices on teaching quality within TPD programs, and their correlation with improved learning outcomes.

1.0. Introduction

Quality teaching and student achievement have been pivotal themes in educational debates and research, particularly within the American education system. Globally, educational systems recognize that teaching quality significantly impacts student outcomes. Brandt (1993) highlighted that the emphasis on teacher professional development emerged in the mid-1980s, driven by policymakers identifying teachers as crucial to student learning. They argued that student learning

quality hinges on the quality of instruction, which, in turn, depends on teacher quality. Consequently, teaching is a dynamic process that necessitates continuous professional development to enhance instruction quality. Quality teaching is thus defined as effective instruction that promotes high-quality student learning outcomes through best practices, focusing on teacher actions that affect student achievement.

Many countries have established regulatory frameworks to ensure quality teaching in schools, requiring teachers to meet societal demands for accountability and credibility. Some nations improve teaching quality by restricting entry into the profession to top students in national examinations (Weldon et al., 2015). This approach, gaining traction in Europe and Asia, views teaching quality through the lens of academic credentials, skills, and personality traits. However, it overlooks the needs of practicing teachers and the importance of pre-service training.

In Kenya, the public teaching workforce includes approximately 312,000 teachers (TSC, 2018), with over 42,000 teachers enrolled in undergraduate education programs (Kenya National Bureau of Statistics, 2018). Enhancing the support and development of both practicing teachers and trainees is essential for improving teaching quality. Numerous countries, including Kenya, have developed comprehensive Professional Teaching Standards for teachers and instructional leaders, serving as benchmarks for monitoring and improving teaching quality through high-quality professional development programs. This paper explores the role of Teacher Professional Development (TPD) in achieving quality teaching in Africa by integrating the competency descriptors of Professional Teaching Standards with the practice of professional learning communities (PLCs).

2.0 Methodology

2.1 Teacher Professional Development: Professional Learning Community Model (PLCM)

A substantial body of research on Teacher Professional Development (TPD) has directly linked development activities to outcomes such as teacher satisfaction, attitude change, commitment to innovation, self-efficacy, and student achievement (Tzivinikou, 2015). However, strong evidence is emerging that effective approaches to TPD involve teachers as both learners and practitioners, take place within the school, integrate into practice, align logically with system policies, and promote collaborative practice rather than mere accountability (Kennedy, 2005).

The success of any TPD program is influenced by existing educational policies, the school's learning culture, and individual teachers' pedagogical knowledge, skills, and dispositions towards learning. Most governments, through their line ministries or agencies, develop Professional Teaching Standards and related competency descriptors to guide the outcomes of Teacher Professional Development Programs, aiming to improve teaching quality by updating teachers' competencies against these standards.

There are several models of Teacher Professional Development, with one notable model being the Professional Learning Community (PLC). A PLC consists of a team or group of teachers and educational professionals who work together intentionally and collaboratively to achieve a common goal for which members hold themselves mutually accountable. Typically practiced at

the school level, PLCs can be applied across all subject areas. They aim to support teachers in improving their practice while enhancing their efficacy, well-being, and professional engagement. PLC members meet regularly with a specific focus on improving teaching and learning outcomes within their subject matter domains.

PLCs come in various forms; some are highly structured while others are more loosely connected. Highly structured PLCs involve teachers collaboratively engaging in cycles of inquiry aimed at enhancing student learning outcomes. A structured PLC cycle may consist of four or more sequential sessions occurring over one or more days. This sequence typically starts with planning sessions, followed by actual lesson delivery, lesson observation, and concludes with post-lesson discussions and reflections. Examples of highly structured PLC models include Lesson Study, Teachers Research Groups, and Quality Teaching Rounds. Lesson Study originated in Japan but is now practiced globally, including in Africa, Europe, and America. Teachers Research Groups are prevalent in Shanghai, China, and other Asian countries, while Quality Teaching Rounds serve as a structured PLC model in Australia and New Zealand.

2.2 Learning Pyramid and PLC

The structured design of PLC models is rooted in the principles of the Learning Pyramid, which illustrates the percentage of learner recall associated with various teaching approaches (National Training Laboratory, Bethel, Maine). According to the Learning Pyramid, the first four levels (lecture, reading, audio-visual, and demonstration) represent passive learning methods, whereas the last three levels at the base (discussion, practice doing, and teaching others) are active learning methods. Retention of learned material is highest when active learning methods are employed.

PLC models adopt active learning methods through group discussions during joint lesson planning, actual teaching by one group member (practice by doing), and reflections during post-lesson discussions. Each member, including the instructor, provides individual feedback on the lesson, which is documented to enhance subsequent lessons on the same topic. The refined lesson plans are then shared with colleagues, including those outside the PLC, during lesson demonstrations, thereby facilitating "teaching others."

3.0. Integration of Professional Teaching Standards with Professional Learning Community Models to Achieve Quality Teaching.

3.1 Introduction

The integration of PLC models (such as Lesson Study, Teacher Research Groups, or Quality Teaching Rounds) with competency descriptors of professional teaching standards is rooted in Lave's (1988) theory of social and situated learning. Lave argued that learning occurs within the context of activity and culture, emphasizing the crucial role of social interaction within a "community of practice" where learners adopt specific beliefs and behaviors. As teachers engage in PLC models like Lesson Study and Teacher Research Groups, they participate in a social and situated learning process, collaborating to plan and improve teaching practices within their own classrooms.

In Kenya, Lesson Study is a prominent PLC model. A complete Lesson Study cycle typically encompasses four stages, beginning with collaborative planning of a research lesson. During this stage, teachers collectively explore content knowledge, strategize competency mastery for students, devise effective teaching methods, prepare instructional materials, and meticulously design lesson plans to optimize learning outcomes. This collaborative process encourages interaction among teachers of varying experience levels, fostering mutual learning and skill enhancement.

3.2 Competency Descriptors and Lesson Study

Competence, defined by the Oxford dictionary as the ability to perform a job effectively, is fundamental to effective teaching. Competency descriptors, aligned with Professional Teaching Standards, provide structured guidelines for assessing and developing teachers' abilities. For instance, the Kenya Professional Teaching Standards outline competency descriptors for various aspects of teaching, such as pedagogical content knowledge (TPD Policy Framework, 2018). Integrating these descriptors into Lesson Study enhances teaching quality by focusing planning, teaching, and reflection stages on specific competency areas.

In the second and third stages of Lesson Study, teachers observe one member teach the planned lesson while noting student responses, engagement levels, and overall classroom dynamics. These observations align closely with competency descriptors related to pedagogical content knowledge, instructional strategy diversity, and creating inclusive learning environments. Post-lesson reflections in the fourth stage enable PLC members to assess the lesson's effectiveness against these descriptors, identifying areas for improvement and refining subsequent lessons accordingly.

3.3 Expected Outcomes

The primary outcome of integrating competency descriptors with Lesson Study is enhanced teaching quality, evidenced by improved student achievement over iterative cycles of practice and reflection. This integration supports teachers in meeting the standards' expectations through structured lesson preparation, observation, analysis, and post-lesson discussion.

3.3.1 Secondary Outcomes

i) Staff Morale: Participation in a collaborative PLC environment enhances team spirit, enthusiasm for teaching, and a sense of achievement among teachers.

ii) Competency Requirements: By embedding competency descriptors into lesson planning and implementation, teachers fulfill regulatory demands for competence as outlined in Professional Teaching Standards.

iii) Performance Appraisal: Teachers are likely to view performance appraisal more positively as integrated competency descriptors provide evidence of meeting performance targets, fostering professional dialogue and recognition.

3.4 Benefits of Integrating Competency Descriptors with Lesson Study

i) Specificity: Competency descriptors provide clear guidelines for teachers, boosting confidence and focus in achieving teaching excellence.

ii) Evidence-Based Results: Documented evidence from integrated practices can be utilized for performance appraisals, streamlining assessment processes and eliminating redundancy.
iii) Interdependence: Recognizing the interconnectedness of Professional Teaching Standards encourages a holistic approach to teaching, enhancing overall educational effectiveness.
By integrating competency descriptors of professional teaching standards with PLC models like Lesson Study, educators in Kenya and beyond can effectively enhance teaching quality, foster professional growth, and ultimately improve student learning outcomes.

4.0 Conclusion

This paper has emphasized how TPD models like PLC can be effectively integrated with competency descriptors from professional teaching standards to enhance teaching quality at the school level. Successful integration offers several benefits:
i) Practice-Based Approach to Quality Teaching: By aligning key commitments in Teacher Professional Development, Teacher Performance Appraisal, and learner outcomes, integration promotes a focused, practice-oriented approach to improving teaching effectiveness.
ii) Boosting Staff Morale and Recognition: Collaboration within PLC models, guided by competency descriptors, fosters a supportive environment where teachers feel valued and recognized for their contributions to professional growth and student achievement.
iii) Alternative Measure of Teaching Effectiveness: Integration provides an alternative method to assess teaching effectiveness beyond traditional year-end learner outcomes, emphasizing continuous improvement and reflective practice.

5.0 Recommendations

i) Encourage Integration of PLC Models and Competency Descriptors: Educational institutions and regulatory bodies should promote the integration of PLC models with competency descriptors from Professional Teaching Standards. This approach supports teachers in meeting regulatory requirements while continuously enhancing teaching strategies through reflective practice, thereby improving learning outcomes.
ii) Align Appraisal Targets with Competency Descriptors: Performance appraisal tools should explicitly measure teacher performance against competency descriptors outlined in specific Professional Teaching Standards. This alignment ensures that appraisal processes reflect the comprehensive skills and qualities expected of effective educators.
iii) Conduct Empirical Studies on Integration Effects: Further research should investigate how factors such as teachers' experience, age, and gender at different career stages influence the integration of competency descriptors. These studies will provide insights into optimizing integration strategies and addressing diverse professional development needs.

By implementing these recommendations, educational institutions can advance the quality of teaching through systematic integration of PLC models with competency descriptors, fostering a culture of continuous improvement and excellence in teaching practice.

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STRAND TWO

School Culture and Learning in STEM

1. Leadership for Learning & role of professional associations: Case Studies on Support and Supervision
2. Creating Space for in / out of school STEM Learning and application
3. Equity and Access in STEM Education
   a. Gender-based STEM Education
   b. Inclusive STEM Education for Learners with Special Needs
   c. Increasing STEM Learning Outcomes for Vulnerable Children

Article 2

When the Didactics of Mathematics Reaches Out to the Teaching of Human Sciences: Case of History and Sciences of Society in the Democratic Republic of Congo

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Abstract

For nearly four decades, entirely new issues have emerged in didactic research, including that of "didactic transposition". These issues reveal a gap between what the so-called "learned" world produces and the school world, which consumes the "learned" product. At the time of its theorization, the "didactic transposition" triggered a lively controversy in the ranks of didacticians. While some have reproached Y. Chevallard for this "mimicry" which states that a theory born from the teaching of mathematics can be extended to other disciplines, in particular through his "anthropological theory of didactics", others on the other hand have maintained the validity of this approach in all teaching disciplines at the secondary level. A specialist in history didactics, the author is one of those who have benefited from Chevallard's work in the examination of certain specific issues in the teaching of history in the DRC. To do this, he studied a "socially lively question", namely the "settlement" included in the National History Programme, as well as the textbooks that translate it. Through an analysis of the contents, he cross-read the scholarly literature and the school textbooks in force. He noted the delay of "school time" over "scholarly time". In a nutshell, the history taught in schools in the DRC is an obsolete history, totally out of phase with the most advanced research.

Keywords: Didactic transposition: A socially lively question; School history; Learned History; Settlement; Didactics of history; National History Program; Teaching.

1.0 Introduction

For nearly four decades, entirely new issues have appeared in didactic research, including that of “didactic transposition”. These issues reveal the gap, the gap between what the so-called “scholarly” world produces and the academic world, consumers of the “scholarly” product. At the time of its theorization, the “didactic transposition” triggered a lively controversy in the ranks of didacticians. Some have criticized. Chevallard for this "mimicry" who wants a theory born from the teaching of mathematics to be extended to other disciplines, notably through his "anthropological theory of didactics", others, on the other hand, supported the validity of this approach in most teaching disciplines at the secondary level.

This article aims to show how teaching of history has been able to take advantage of the work of Yves Chevallard in the examination of certain specific problems in the teaching of history in the DRC. The study focuses on a question considered as “socially lively”, namely the “population” included in the National History Program, as well as the textbooks which are its translation. Through an analysis of the contents, it is a question of making a cross-reading between the scholarly literature and the school textbooks in force, to observe this delay of “school time” on “scholarly time”. In a nutshell, the history taught at school in the DRC is an obsolete history, totally out of step with the most advanced research. Unlike Y. Chevallard, following Mr. Verret, who asked questions about the origin of new knowledge, the study affirms the existence, for decades, of scholarly historical knowledge which should have been transposed into the Congolese school system.

1.1. Didactic Transposition (DT), QUID?

Didactic Transposition refers to “the activity by which “scholarly” knowledge is transformed in such a way that it can be taught to learners who are more or less novices in the subject”. This operation therefore brings into play, according to Y. Chevallard, “scholarly knowledge”, “knowledge to be taught”, “knowledge taught” and “knowledge learned”. “Scholarly knowledge” is understood as being that which emanates from research and “taught knowledge” is that which the observer encounters in class practices. DT is based on the principle that the knowledge produced at university cannot be taken directly as it is to secondary school; it must undergo these series of transformations to be adapted to the cognitive level of the pupils.

It is a question here, as Ph. De Carlos (2015, p.25), of “mobilizing the DT model of Verret and Chevallard to address the question of the distance between current scholarly knowledge (scientific/historical knowledge in current state of knowledge) and the knowledge to be taught (transposed knowledge as presented in school programs and textbooks)".

2.0 Origins and controversies

2.1. Origins

DT assumes that "the discourse of the scholar is not transparent and cannot be understood as it is by the student" (Bkouche, s.d.), because there is always restructuring of the content for pedagogical

purposes. It was born from the observation of the "delay" of "school time" on "scholarly time" which continues to increase. The problem of "didactic transposition" also reveals, on the one hand, the gap between what the so-called "scholarly" world produces and the school world, and on the other hand, the growing gap between "school culture" and the society (Chervel 1998). Under other skies indeed, “school disciplines are deeply destabilized by changes in the modes of socialization which are at work societies”, whose primary mission is to build social imaginaries (Audigier 1995).

It is the same point of view supported by F. Audigier (1998) who affirms the autonomy of school knowledge, that "the school is indeed a place of production and reproduction of commonsense", relying on the model used in the works of science educators. Chevallard's work fueled a very lively debate in the circles of specialists in didactics.

2.2. Controversies and disputes

For lack of space, we will not dwell too much on the controversy aroused by the theory of DT. We will nevertheless highlight some of them which allow us to justify the positive echo aroused by this theory among historians. P. Perrenoud (1995) disputes “the illusions developed by the work of mathematicians”. For him, it is not always the scholars who are at the source of DT: in the formation of the knowledge to be taught, naïve knowledge, every day knowledge, more or less stabilized professional knowledge, know-how, soft skills, attitudes, values, practices. To take into account the sole reference to “scientific knowledge” is to overlook the meaning of the knowledge taught, its accessibility. In "an attempt at clarification", D. Bordet (1997) had evoked the problematic (even polemical) nature for some and an attitude consisting of (metaphorically) plugging one's ears while cursing against didactic jargon, of a "notion without issue or notion – foil which, like all didactic reflection, often arouses indifference or, worse, rejection. He argues, "by schematizing, when it comes to explaining the evolution of programs".

Among the severe critics of the "theory" of DT, figure Ph. Lombard who does not see a priori what the didactic problems of mathematics can really exchange with the "branch of ethnology which studies the anatomical and biological characteristics of 'man considered in the animal series'. Ph. Lombard alludes here to the “anthropological theory of didactics” (ATD) of Y. Chevallard. He even speaks of "unique thought which would like the question to go through this famous "theory of TD", which is almost now considered as a new branch of epistemology". According to him, “mathematics didactics” would only be a “so-called science”.

3.0 Mathematics at other horizons: expansion of DT

As if to answer those who cling to the model of school discipline and dispute the validity of DT in history, this very simple question can be asked: can a UNESCO GHA volume of plus or minus 1,000 pages or Ndaywel's History of the Congo (nearly 900 pages) in front of the students, or use it to prepare a lesson sheet? The answer to this problem lies in this question. We have already mentioned the "mimicry" of which R. Bkouche accused Chevallard and his team. This led S. Johsua (1997), a mathematics teacher like Chevallard, to reflect in an article whose title constitutes

in itself an attempt to respond to these criticisms: "Can the concept of DT extend its scope beyond didactics of science and mathematics?".

This author began by clearing up what he calls “a misunderstanding”. For him, the concept of DT must be conceived as a tool helping to model didactic phenomena. Like any theoretical model, “it contributes to creating the objects it accounts for, but does not exhaust all the features of the phenomenology considered”. Like any theory, the important thing was to test it on many other disciplines, even if it means realizing their "falsifiability". A. Legardez (2011) draws attention to the self-legitimation of teachers, the “mythification of the sciences which leads to their sacralization”, in a “culpable excess of confidence vis-à-vis the “masters”, the “scholars”, “experts”, in short, “holders of knowledge”.

4.0 What about the story?

Faced with this question, didacticians found themselves faced with two paradigms: the paradigm of DT and the paradigm of “school discipline” (Chervel 1998). The latter claims the autonomy of school knowledge and makes the school system the creator of its knowledge. We start from the idea that the epistemological value of DT will paradoxically be based on the argument of one of Y's opponents. Chevallard, namely Ph. Perrenoud. Indeed, if we can concede to Ph. Perrenoud the multitude of sources of school knowledge, the fact remains that the history taught at school draws its source essentially from scholarly history, as we will see in the following lines.

In Africa, in fact, we observe certain [learned] works sometimes used in secondary school, are produced for higher education. As far as history is concerned, we can quote for information only:

- The abridged version of the General History of Africa - HGA - (UNESCO), Black Africa - History and Civilizations (under the direction of Elikia M'bokolo, Hatier - AUPELF, 1992);
- the History of Africa by J. Ki-Zerbo (1973) are good syntheses that are useful for teachers. But they are not intended to provide secondary education with all the services expected of a textbook”.
- The Black African World of J. Ki-Zerbo, 1963 (Mokhtar Ba 2015).

This observation therefore highlights the difficulty faced by school systems in the area of textbooks. Apart from this difficulty, with regard to the GHA, UNESCO had in 2008 obtained Libyan funding of $2M to start the Project on the “Pedagogical Use of the General History of Africa”. It was decided on this occasion that discussions on the production for the benefit of African schools of standardized educational materials drawn from the 8 volumes of the GHA be initiated. The actual work for the educational use of the HGA was only really launched in March 2009, i.e., 20 years after the publication of the last volume and constitutes Phase 2 of the HGA (Dépêche Panapress 2010).

This involves UNESCO developing, at the request of member countries of the African Union, common educational content, including textbooks, teachers' guides and accompanying material

based on the volumes of the' HGA. The process for the educational use of the GHA continued in Tripoli in June 2010.As early as 1992, i.e., 3 years after the publication of the last volume (vol. VIII, 1989), J. Copans had called for the development of a scientific and educational policy for African history. It therefore seems that the start of work on volume IX is part of this desire. Without saying it formally, the work commissioned by the African Union for the educational use of the GHA constitutes the beginning of a didactic transposition operation. And the 2017 IDLP workshops in Kinshasa produced some educational sheets.

5.0 Education of the people of the DRC at the secondary

5.1. A case of bankruptcy of the didactical transposition

As we have analyzed it, the question of “Population” has been part of what has been called for a little over three decades “Question Socialement Vive” (QSV). The “Population” of the Congo is included in the National History Program (PNH) and the text books that translate it. The question of settlement is all the more acute in that it collides with the myths of the origins of each culture or each people: we know how much and how the question of the supposed anteriority of some in relation to others in a space, the “I was there before”, is at the origin of identity conflicts that are sometimes and often bloody. The theme of the QSV is integrated into the problematization, insofar as, like the problem, it is also about the questions to be solved which lend themselves to discussion. In the context of TD, “to access scientific knowledge, it is not only to access a “good” solution with regard to scholarly knowledge, it is also to move from an opinion to problematized knowledge”. This is the “power of the question” of O. Maulini (2002). The situational problem is constructed by confronting an enigmatic initial situation which will confront the students with an obstacle or “benevolent trap” that they will have with the help of generalizable, transferable intellectual tools. Isn't scientific dynamism part of a dialectic of problematization insofar as all knowledge is presented as a response to problems and poses new problems (Fabre 2012).

Even if it is sometimes judged to be "disparate" in history (De Carlos 2015), the theory of social representations (TSR) and no longer the fact of science education, but which has made significant progress for more than two decades now. We will see this in the analysis of the question on which is based this attempt to bring together the didactics of history and the tools provided by the didactics of mathematics. The Congolese education system has remained, for the most part, on the sidelines of the innovative issues to which most countries of the world are trying to respond. The interest shown in this type of question and their support by education systems are part of these innovative practices. This silence is all the more deafening as some countries that have had experiences somewhat similar to that of the DRC have taken steps to move in the direction of "Never again". This brings us into a “prospective dimension”. As mentioned above, this contribution makes a cross-reading between scholarly history, in the light of developments in the most advanced historical research, and school history as it appears in school textbooks. It notes the discrepancy between school knowledge and the reference discipline at university level.

In the history programs and textbooks in force in the DRC, the announced "settlement" is not

taught, whereas scholarly literature has evolved considerably on this question, as evidenced by the references to scholarly literature included in the bibliography. From one of the text books analyzed. Instead of this settlement, students learn more about “Empires and Kingdoms”. This hiatus is also observed in the chapter on “African and Congolese migrations”: in reality, only “Bantus” are taught there, like these were the only group to have migrated: the school textbooks in force in the DRC have always only taught about “Bantu migrations”. Excluded here, the “Others”, the “non-Bantus”, who are an integral part of the population of the Congo. On this "Bantu" question, some of the most recent studies tend to call into question everything we have taught so far: this is the case of this "Genetic history of Bantu language populations" carried out as part of a program which brought together several institutions, including the CNRS, the Institut Pasteur and the University of Montreal. The findings of this study support our argument of a disconnect between scholarly research and school history.

Thus, as it appears in scholarly literature, the theme of settlement has no relation to its counterpart in school curricula and textbooks. This question is based on “the metaphor of the iceberg”: a questioning of unknown facts based on known facts (Mostafa Hassani Idrissi, s.d.). This iceberg is the “Population of the Congo”, which ultimately appears as an object that is actually little known, misunderstood, and even unknown. Indeed, the most flagrant case that ignores advances in research is the description found in Longo Kazumba's "Classes terminales" manual of "pygmies or negrilles" are characterized by their small size (1.30 to 1.50 m) where the trunk takes the main place, their big head, their brownish or coppery skin, their very flat nose, their thin lips, their very developed hair systems (hairy chest). (Longo, 2005, p.46). In the current state of knowledge, these descriptions cannot be found in the scholarly literature. This observation is all the more interesting since, the expression 'indigenous people' - 'politically correct' which since the 1990s has replaced 'indigenous peoples', 'primitives', 'natives' – is problematic because it does not define the historical scale of this anteriority which according to this point of view, can be expressed in centuries, in thousands of years or in tens of thousands of years. It attributes an autochthony to these populations alone, denying the existence and the cultural riches of other minority peoples, who have also been settled most times in the same forest lands or their borders, in particular the rivers (Epelboin 2012). This is what led Kimankata Mayalele (2013) to ask herself this question: “the Pygmies of Central Africa: migrants or natives”. He takes up, among other theses, that of Mumbanza for whom “the Pygmies are certainly not the only first occupants of the spaces where they are currently located and that this presentation does not conform to historical reality”. It is therefore observed concerning the pygmies, that their "autochthony" and their “anteriority” so proclaimed and taught on this space which we call today DRC are no longer obvious: there is no scientific proof that their installation is prior to that of all other groups. Where is it from? Moreover, no people in the world stayed put: all came from somewhere. The history of migrations is there to attest to this.

This is what makes Bahuchet (Omasombo 2017) say that "in the current state of knowledge, it is not possible to say exactly how long the Batshwa have lived in the Kasai region", even if the researchers seem unanimous to recognize that they are among the oldest inhabitants of Africa.

Moreover, the term "Pygmy" tends to disappear more and more, quite simply because today, we agree that "Pygmies" do not exist. Those that exist bear very diverse names that reflect the singularity of each community which has its own history, language, customs, conflicts, uniqueness, ambitions, and relations with its neighbours (Robillard & Bahuchet 2012). The same observation also applies to the “Bantous” issue, of which the magazine Jeune Afrique devoted a dossier in April 2016. Also, the manuals available to teachers and the program deserve an overhaul and adaptation, as Professor Noël Obotela (2021) very appropriately suggests.

6.0 Conclusion

If we consider history as a "science of change, in many respects a science of differences", how then can we continue to teach children things that are no longer the same, different from those had before and even of those they live before their eyes? Shouldn't we constantly question research? It turns out that "the lag of "school time" over "scholarly time" continues to grow: education has difficulty, because of its institutionalized nature, in keeping up with the flow of knowledge", because "a large part of the programs lead to teaching “dead things”, outdated knowledge or obsolete questions”, in a “growing disconnection between the most elaborate scientific knowledge and the knowledge conveyed by the school system”. The source of school knowledge from which teachers and students drink is the textbook and the teacher's book, which are supposed to have been written after a didactic transposition operation. The exploitation of research results is likely to allow an update of school knowledge and avoid issues such as "Diego Cao discovered the mouth of the Congo River " or "Christopher Columbus discovered America" that are still found in textbooks. It would save us from continuing to write "Shamba Bolongongo" instead of "Shyaam Mbul a Ngong", or even the description that the 6th secondary text book gives of pygmies, which recalls the 5th primary textbook (Noella de Roover) which had been taught, to name but a few examples.

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Article 3

Mathematics Teachers' and Students' Perceptions Towards Remote Learning During Covid-19 School Closure: A Case of Kitwe District, Zambia

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Abstract

COVID-19 pandemic disrupted the traditional way of teaching and learning. Mathematics teachers and students were unprepared for remote teaching and learning. This study will help contribute to already existing information on teachers' and students' perceptions towards remote teaching and learning. This study is under school culture and learning in STEM. This article reports the findings of a descriptive survey research that explored secondary school mathematics teachers' and students' perceptions towards remote learning during COVID-19 school closure. The study involved 35 mathematics teachers and 234 grade 12 students selected from six secondary schools in Kitwe district of Zambia using the cluster random sampling, simple random sampling and purposive sampling methods.

A mixed method approach which followed a descriptive survey study design, was used. Data was collected using semi-structured questionnaires and semi-structured interview schedule. Data collected using questionnaires, was analyzed using Descriptive Statistics and Inferential Statistics namely, spearman correlation analysis and independent samples T-test. Research findings show that both mathematics teachers and students had positive perceptions towards remote learning. The findings also showed that there was no statistically significant relationship between mathematics teachers' perceptions and students' perceptions towards remote learning ($r = -0.013$, $p = 0.830>0.05$). It was also found that mathematics teachers and students preferred WhatsApp platform and recommended that it be used continually for teaching and learning mathematics. The results also show that 54.3% of mathematics teachers and 61.5% of students recommended remote learning in mathematics to continue.

Keywords: *Remote learning, teachers' perceptions, students' perceptions, perceived usefulness, perceived ease of use.*

1.0 Introduction and Literature review

COVID-19 outbreak was first identified in Wuhan, China in December 2019 (Chirinda et al., 2021). The pandemic affected the education system of different countries including China, Italy, and Japan (Wajdi et al., 2020). The outbreak resulted in the closure of tertiary, secondary and primary schools in many countries as one of the ways to minimize in-person transmission of the coronavirus. Education systems worldwide reacted to COVID-19 by turning to remote learning options for their students to prevent loss of learning time. According to Munoz-Najar et al. (2021), most countries begun to deliver remote learning through online media and TV, followed by paper-

based take home materials, and mobile phones.

To mitigate the impact of COVID-19, the Ministry of General Education (MoGE) in Zambia started working on establishing practical distance learning options for learners at home and continue providing guidance to teachers. The good news was that Zambia had a history of radio instruction programs. In the early 2000s, the government launched "Learning at Taonga Market" to deliver distance education to children who had never been to school (Pearson, 2016). On 13th April 2020 a new initiative was launched by the Zambian Ministry of Education only this time it was for secondary school learners in form of a television network called Edu TV. This was in an effort to continue teaching secondary school students through a dedicated channel during the lockdown. Olugbade and Olurinola (2021) defined remote learning as learning that occurs when the learner and instructor are separated by distance, therefore cannot meet in a traditional classroom setting. In support of this definition, Ewing and Cooper (2021) have defined remote learning as equal and inclusive education where students and teachers are geographically rather than temporarily separated (Stenman & Pettersson, 2020).

Over the past years, there has been an increase in the studies on remote learning and perceptions during COVID-19. Most studies have looked at teachers and students separately and not in one study. For example, studies conducted by Jegede, 2020; Bamoallem & Altarteer, 2021; and Gokhale, 2021 looked at students' perceptions of the impact of COVID-19 on Education, and studies conducted by Olugbade & Olurinola, 2021; and Almodaires et al., 2021 investigated teachers' perceptions on the use and effectiveness of Microsoft teams. In Zambia a study on remote learning conducted by Mukuka et al., 2021 investigated students' experiences with remote learning during COVID-19 school closure. To date, from the literature reviewed, there has been a few studies that have discussed both teachers' and learners' perception of remote learning in the period of COVID-19 at the same time e.g. Silva & Sousa, 2020. In addition, there have been calls by authors to extend the study of perceptions from developed countries like Australia (Ewing & Cooper, 2021) to study other countries which had transitioned from traditional to remote learning in response to the pandemic.

It is from this background therefore that this study attempted to investigate how secondary school learners and mathematics teachers perceived the use of remote learning, as well as what platforms were used and how comfortable the students and mathematics teachers were with the platforms.

1.1 Theoretical framework

The theory that was employed was technology acceptance model two (TAM2) which was developed by Venkatesh and Davis (2000) as structure to support the research study.

1.2 Research Objectives

This study was guided by the following specific objectives:

i) To find out what platforms mathematics teachers and students used for remote learning during COVID-19 school closure.
ii) To explore mathematics teachers' perceived usefulness of remote learning during COVID-19 school closure.

iii) To explore mathematics teachers' perceived ease of use of remote learning platforms during COVID-19 school closure
iv) To explore students' perceived usefulness of remote learning in mathematics during COVID-19 school closure.
v) To explore students' perceived ease of use of remote learning during COVID-19 school closure.

1.3 Hypothesis

H0: There is no statistically significant relationship between mathematics teachers 'and students' perceptions towards remote learning.
H1: There is a statistically significant relationship between mathematics teachers' and students' perceptions towards remote learning.

2.0 Method

2.1 Research design

Descriptive survey research design was employed in this study. This design was appropriate for the study because it was found useful in the collection of data on perceptions of mathematics teachers and students, as perceptions cannot be directly observed. Mixed method research was employed by using both quantitative and qualitative methods in collecting, analyzing and interpreting the data. Data collection using questionnaires was done in five (5) weeks from 9th May to 7th June, 2022. Interviews were conducted from 24th June to 30th June, 2022.

2.2 Population and Sample

The target population of this study was secondary school mathematics teachers and grade 12 students from six selected public schools of Kitwe district in Copperbelt Province. Cluster random sampling method was used to select the six public secondary schools within Kitwe district. Cluster sampling is typically used when it is not possible to get information about the population as a whole, but we can get information about the clusters (in the present study, the secondary schools). From each selected school, Grade 12 classes were put into clusters, one cluster which is one Grade 12 class from selected school was then randomly selected. Secondary mathematics teachers from the six selected schools were purposively selected.

2.3 Research Instruments

The instruments employed in this study were questionnaires and interviews. The questionnaires contained both open and close-ended questions. An interview guide of open-ended questions was used to collect detailed information from 6 mathematics teachers and students focus group discussion was conducted.

2.4 Reliability and validity of data collection instrument

To test for validity of the questionnaires, a draft questionnaire was sent to experts for validation. The experts were invited to give their opinion regarding the clarity and appropriateness of

individual items. The reliability of the two questionnaires was determined by computing Cronbach's Alpha through SPSS version 21.0. The overall reliability for the two questionnaires were 0.789 for the learners' and 0.812 for the teachers' questionnaire. According to Muijs (2011), reliability greater than 0.70 is ideal for the researcher to proceed with data analysis. Since both values are greater than 0.70, data was deemed reliable.

3.0 Results and Findings

3.1 Platforms mathematics teachers and students used during COVID-19 school closure.

Results displayed in Table 3.11 below reflect that WhatsApp was the most used platform (88.6%) for delivering mathematics lessons among all respondents. The second platform used for delivering lessons was Zoom with 48.6%. The third platform used for delivering lessons was YouTube (20%). Mathematics teachers used to post their lessons on YouTube for the students to watch. The fourth platform that was used was Facebook with 17.1%. The fifth platform were assignments where 8.6% of mathematics teachers gave their students assignments to do during COVID-19 school closure. Google classrooms was the least platform that was used with 6%.

Table 3.11: *Learning Platforms used by mathematics teachers*

Learning Platform	**School type**	**Number of Teachers(N)**		**Response**
			Yes N (%)	**No N (%)**
YouTube	Combined	9	5 (55.6)	4 (44.4)
	Rural	11	0 (0)	11 (100)
	Urban	15	2 (13.3)	13 (86.7)
	Total	35	7 (20)	28 (80)
WhatsApp	Combined	9	7 (77.8)	2 (22.2)
	Rural	11	9 (81.8)	2 (18.2)
	Urban	15	15 (100)	0 (0)
	Total	35	31 (88.6)	4 (11.4)
Facebook	Combined	9	3 (33.3)	6 (66.7)
	Rural	11	1 (9)	10 (91)
	Urban	15	2 (13.3)	13 (86.7)
	Total	35	6 (17.1)	29 (82.9)
Zoom	Combined	9	9 (100)	0 (0)
	Rural	11	2 (18.2)	9 (81.8)
	Urban	15	6 (40)	9 (60)
	Total	35	17 (48.6)	18 (51.4)
Google classroom	Combined	9	0 (0)	9 (100)
	Rural	11	2 (18.2)	9 (81.8)

	Urban	15	0 (0)	15 (100)
	Total	35	2 (6)	33 (94)
Others (Assignments)	Combined	9	3 (33.3)	6 (66.7)
	Rural	11	0 (0)	11 (100)
	Urban	15	0 (0)	15 (100)
Total		35	3 (8.6)	32 (91.4)

Note: The numbers indicated in brackets are the corresponding percentages based on the sample size, N, or the row totals.

WhatsApp platform was not only the most used platform but it was also the most recommended platform to continue using to teach and learn mathematics by both mathematics teachers and students. When students and teachers were asked to justify their preferences, it was revealed that this learning option was not only the easiest to use but also affordable.

Below are quote from some of the actual reasons within this category of respondents:

Student respondent 88: WhatsApp is easy to access
Teacher respondent 9: Because almost every individual has the smart phone and it is easily accessible.

3.2 Mathematics teachers' perceived usefulness of remote learning during COVID-19 school closure.

Findings in Table 3.20 below indicate that 48.6% of the respondents were in agreement to items 1 "Remote learning system improves students' performance in mathematics" 22.9% of respondents were in disagreements to the statement while 28.6% were neutral (undecided). Mathematics teachers' responses for item 2 "Remote learning system makes mathematics learning effective" were given as follows: those that strongly agreed or agreed to the statement stood at (14.3%) and (37.1%) respectively and when put together gives a total of (51.4%) of all those who said that remote learning system makes mathematics learning effective, (34.3%) were neutral (undecided), (0%) and (14.3%) of the learners strongly disagreed and disagreed to the statements respectively. Findings in Table 3.20 below further indicate that 45.7% of the respondents were in agreement to items 3 "Remote learning system makes teaching mathematics easier" 37.2% of respondents were in disagreements to the statement while 17.1% were neutral (undecided). Mathematics teachers' response for item 4 "Remote learning system is useful for teaching mathematics" were given as follows : those that strongly agreed or agreed to the statement stood at (22.9%) and (40.0%) respectively and when put together gives a total of (62.9%) of all those who said that remote learning system is useful for teaching mathematics , (14.3%) were neutral (undecided), (2.9%) and (20.0%) of the teachers strongly disagreed and disagreed to the statements, and when put together gives a total of (22.9%) respectively.

Results from Table 3.20 and the responses from the interviews reveals that majority of mathematics teachers have a positive perceived usefulness of remote learning. Below is an excerpt of the interviews (written without editing) suffice to illustrate the point:

Except: I think remote learning was useful and effective. During lessons using Zoom, I used to interact with my students as if they were physically present. The students were active throughout the lessons and they were also motivated to learn.

Table 3.20: *Mathematics teachers 'perceived usefulness of remote learning (n =35)*

S/n	Statement	% Rating					Mean	Standard
		SD	D	N	A	SA	(M)	Deviation
1	Remote learning system improves students' performance in mathematics	**0**	**22.9**	**28.6**	**25.7**	**22.9**	**3.49**	**1.095**
2	Remote learning system makes mathematics learning effective	**0**	**14.3**	**34.3**	**37.1**	**14.3**	**3.51**	**0.919**
3	Remote learning system makes teaching mathematics easier	**8.6**	**28.6**	**17.1**	**25.7**	**20.0**	**3.20**	**1.302**
4	Remote learning system is useful for teaching mathematics	**2.9**	**20.0**	**14.3**	**40.0**	**22.9**	**3.60**	**1.143**
	Total	**11.5**	**85.8**	**94.3**	**128.5**	**80.1**	**3.45**	

3.2 Mathematics teachers' perceived ease of use of remote learning platforms during COVID-19 school closure.

Findings in Table 3.21 below indicate that 51.4% of the respondents were in agreement to items 1 "I consider remote learning system is easy to use" 28.6% of respondents were in disagreements to the statement while 20.0% were neutral (undecided). Majority of the teachers (65.7%) were in agreement that remote learning system is flexible to interact with 22.9% of the teachers were neutral (undecided) while 11.4% were in disagreement. The analysis of responses on the statement "The interaction with remote learning system in mathematics is clear and understandable" Of the mathematics teachers responding (n = 35), those that strongly agreed or agreed to the statement stood at (14.3%) and (28.6%) respectively and when put together gives a total of (42.9%) of all those who said that remote learning in mathematics is clear and understandable, (37.1%) were neutral(undecided), (2.9%) and (17.1%) of the mathematics teachers strongly disagreed and disagreed to the statement and when put together gives a total of (20%) respectively. Item 4

"Interacting with remote learning system does not require a lot of mental effort" results revealed that majority of the mathematics teachers (48.6 %) were in disagreement, 14.3% were neutral (undecided) while 37.1% were in agreement to the statement respectively.

Results from Table 3.21 and the responses from the interviews reveals that majority of mathematics teachers have a positive perceived ease of use of remote learning. Below is an excerpt of the interviews (written without editing) suffice to illustrate the point:

Except:

Actually, it's not difficult to learn and use a new learning platform, but of course we have to learn first. I myself, I learnt how to use Google classroom and Zoom meeting. I learnt by myself and it is not hard. And, actually I want to learn many other platforms.

Table 3.21: *Mathematics teachers' perceived ease of use of remote learning (n=35)*

S/n	Statement	% Rating					Mearn	Standard
		SD	D	N	A	SA	(M)	Deviation
		5.7	**22.9**	**20.0**	**25.7**	**25.7**	**2.97**	**1.294**
1	I consider that remote learning system is easy to use							
2	The remote learning system is flexible to interact with	**5.7**	**5.7**	**22.9**	**51.4**	**14.3**	**3.34**	**1.027**
		2.9	**17.1**	**37.1**	**28.6**	**14.3**	**3.63**	**1.003**
3	The interaction with remote learning system in mathematics is clear and understandable							
4	Interacting with remote learning system does not require a lot of mental effort	**8.6**	**40.0**	**14.3**	**20.0**	**17.1**	**3.43**	**1.267**
	Total	**22.9**	**85.7**	**94.3**	**125.7**		**71.4**	**3.34**	**1.148**

3.3 Students' perceived usefulness of remote learning in mathematics during COVID-19 school closure.

Findings in Table 3.31 below indicate that 37.2% of the respondents were in disagreement to items 1 "Remote learning system improves my performance in mathematics" 35.9% of respondents were in agreements to the statement while 26.9% were neutral (undecided).Students' response for item 2 "Remote learning system makes mathematics learning effective" were given as follows : those that strongly agreed or agreed to the statement stood at (15.0%) and (31.6%) respectively and when put together gives a total of (46.6%) of all those who said that remote learning system makes mathematics learning effective, (24.8%) were neutral (undecided), (9.4%) and (19.2%) of the learners strongly disagreed and disagreed to the statements and when put together gives a total of (28.6%) respectively.

Findings in Table 3.31 below further indicate that 42.7% of the respondents were in agreement to items 3 "Remote learning system makes learning mathematics easier" 37.6% of respondents were in disagreements to the statement while 19.7% were neutral (undecided). Students' response for item 4 "Remote learning system is useful for learning mathematics" were given as follows : those that strongly agreed or agreed to the statement stood at (22.2%) and (32.5%) respectively and when put together gives a total of (54.7%) of all those who said that remote learning system is useful for teaching mathematics , (20.9%) were neutral (undecided), (8.1%) and (16.2%) of the students strongly disagreed and disagreed to the statements, and when put together gives a total of (24.3%) respectively.

Table 3.31: *Students' perceived usefulness of remote learning (n = 234)*

S/n	Statement	% Rating					Mean	Standard
		SD	**D**	**N**	**A**	**SA**	**(M)**	**Deviation**
1	Remote learning system improves my performance in mathematics	**12.8**	**24.4**	**26.9**	**21.4**	**14.5**	**3.00**	**1.248**
		9.4	**19.2**	**24.8**	**31.6**	**15.0**	**3.24**	**1.194**
2	Remote learning system makes mathematics learning effective							

3	Remote learning system makes learning mathematics easier	**11.5**	**26.1**	**19.7**	**28.2**	**14.5**	**3.08**	**1.259**
4	Remote learning system is useful for learning mathematics	**8.1**	**16.2**	**20.9**	**32.5**	**22.2**	**3.44**	**1.229**
	Total	**41.8**	**85.9**	**92.3**	**113.7**	**66.2**	**3.19**	**1.233**

From the results in Table 3.31 and the responses from the interviews reveals that students had a positive perceived usefulness of remote learning. Below is a response from the focus group discussion to support the point:
"Remote learning system was useful as it helped us to continue learning, it also helped my performance to improve because I had time to research more using YouTube".

3.4 Students' perceived ease of use of remote learning platforms during COVID-19 pandemic school closure.

Findings in Table 3.41 below indicate that 49.6% of the respondents were in agreement with items 1 "I consider remote learning system is easy to use" 33.3% of respondents were in disagreements to the statement while 17.1% were neutral (undecided). Majority of the learners (44.8%) were in agreement that remote learning system is flexible to interact with, 21.8% of the teachers were neutral (undecided) while 33.4% were in disagreement. The analysis of responses on the statement "The interaction with remote learning system in mathematics is clear and understandable'' Of the students responding (n = 234), those that strongly agreed or agreed to the statement stood at (13.7%) and (23.1%) respectively and when put together gives a total of (36.8%) of all those who said that remote learning in mathematics is clear and understandable, (29.1%) were neutral(undecided), (14.5%) and (19.7%) of the students strongly disagreed and disagreed to the statement and when put together gives a total of (34.2%) respectively. Item 4 "Interacting with remote learning system does not require a lot of mental effort" results revealed that majority of the students (42.7%) were in disagreement, 19.7% were neutral (undecided) while 37.6% were in agreement to the statement respectively.

Table 3.41: *Students' perceived ease of use of remote learning (n = 234)*

S/n	Statement	% Rating					Mean	Standard
		SD	D	N	A	SA	(M)	Deviation

1	I consider that remote learning system is easy to use	**9.8**	**23.5**	**17.1**	**33.8**	**15.8**	**2.92**	**1.339**
		9.0	**24.4**	**21.8**	**28.6**	**16.2**	**3.02**	**1.250**
2	The remote learning system is flexible to interact with							
		14.5	**19.7**	**29.1**	**23.1**	**13.7**	**3.19**	**1.229**
3	The interaction with remote learning system in mathematics is clear and understandable							
4	Interacting with remote learning system does not require a lot of mental effort	**17.9**	**24.8**	**19.7**	**22.6**	**15.0**	**3.22**	**1.247**
	Total	**51.2**	**92.4**	**87.7**	**108.1**	**60.7**	**3.09**	**1.266**

From the results in Table 3.41 and the responses from the focus group discussion reveals that learners had a positive perceived ease of use of remote learning. Below is a response from the focus group discussion to support the point:
"It was easy to use because it made learning mathematics to be clear and understandable. Where I was not able to understand in class, I could watch lessons on YouTube and also ask friends".

3.5 Students and mathematics teachers' perceptions towards remote learning

In order to determine the difference between teachers' and students' perceptions towards remote learning, independent samples t-test was used. Table 3.51 below gives a summary of the results.

Table 3.51: *T-test for Differences among Teachers' and Students' Perceptions towards remote learning*

Group	N	**Mean**	**Std. Deviation**	**Std. Error Mean**	**t**	**df**	**Sig.(2tailed)**
Teachers	35	2.17	0.822	0.139	0.718	227	0.473
	234	2.06	0.862	0.056			

Students				

As shown in Table 3.51, the mean score of the teachers' perceptions (M= 2.17, SD= 0.822) was close to the mean score of the students' perceptions (M= 2.06, SD= 0.862), with mean difference of 0.112. Table 3.51 further shows that the t-statistics is t (0.718), P>.05(two-tailed), the difference is non-significant. From this analysis it can be concluded that mathematics teachers and students have the same perceptions towards remote learning.

H0: There is no statistically significant relationship between mathematics teachers' and students' perceptions towards remote learning.

Spearman correlation analysis was used to test if there is a relationship between mathematics teachers' and students' perceptions. Results displayed in Table 3.52 below, (r = -0.013, p = 0.830>0.05) reveals that there is no statistically significant correlation between the teachers' and the students' perceptions towards the use of remote learning. Hence the null hypothesis (H_0) is not rejected and conclude there is no statistically significant relationship between mathematics teachers' and students' perceptions towards remote learning.

Table 3.52: Spearman Correlations between Teachers' and Students' perceptions

			Teacher perception	Student perceptions
Spearman's rho	Teacher perception	Correlation Coefficient	1.000	-.013
		Sig. (2-tailed)	.	.830
		N	35	269
	Student perceptions	Correlation Coefficient	-.013	1.000
		Sig. (2-tailed)	.830	.
		N	269	234

4.0 Discussion and conclusion

The findings of this study revealed that WhatsApp, YouTube, Facebook, Zoom, Google classroom, lessons broadcasted on Television (TV) and hard copies such as assignments and past papers were used. The results further revealed that WhatsApp was not only the most used platform but was also the most recommended platform to continue using to teach and learn mathematics. Results from

mathematics teachers' and learners' responses revealed that majority of them preferred WhatsApp because it is easy to use. Budi and Iwan (2021) in their study also found that WhatsApp was the most preferred platform. Nsabayezu et al. (2020) in their study revealed that WhatsApp been the most recommended platform. Nsabayezu et al. (2020) found that WhatsApp application is useful in helping students to construct their knowledge and inspire students to participate in their learning. Nsabayezu et al. (2020) also found that by using WhatsApp, the collaboration between teachers and students' increases. In this study after WhatsApp, YouTube was the second used platform by the learners while for the teachers it was zoom platform. Both teachers and students were asked if they were comfortable with these platforms. The results revealed that majority of them were comfortable using them. The finding of this study also revealed that majority of mathematics teachers and learners recommended that remote learning should continue to be used. This finding is consistent with previous study by Al-Hattami (2020) who reported that teachers were willing to use eLearning in the future. However, the findings of this study are in contrast to the findings of Oktaviani et al. (2020). Oktaviani et al. (2020) in their study, their results revealed that 45% of students chose Google Classroom,28% of students chose Zoom and 9% of students chose WhatsApp. These results revealed that WhatsApp was the least preferred and recommended.

The study findings also revealed that there was general agreement among the mathematics teachers that remote learning was useful during Covid19 school closure. The findings also revealed that from the 6 mathematics teachers interviewed 4 expressed a positive perceived usefulness of remote learning. Mathematics teachers expressed that remote learning was effective and useful during COVID-19 school closure. These results are consistent with the study conducted by Rahayu and Wirza (2020), the researchers investigated teachers' perception of online English language learning in Indonesia using Technology Acceptance Model (TAM). This study's findings revealed that the participants showed a positive perception of the usefulness of online learning systems during pandemic Covid-19. The findings of this study are also consistent with the findings of Aldossary (2021) whose study revealed that teachers had a positive perception towards the use of online learning during COVID-19 pandemic. From the 6 mathematics teachers interviewed 4 expressed a positive perceived ease of use of remote learning. These results are consistent with the study conducted by Rahayu and Wirza (2020), the researchers investigated teachers' perception of online English language learning in Indonesia using Technology Acceptance Model (TAM). This study's findings revealed that the participants showed a positive perception of ease of online learning systems during pandemic Covid-19. However, more than half of teachers didn't agree on the effectiveness of online learning.

The study findings indicated that there was general agreement among the students that remote learning was useful during Covid-19 school closure. The focused group discussion also revealed that majority of the students perceived remote learning to be useful and effective. The study findings further revealed that there was also general agreement among the students that remote learning was ease of use during Covid-19 school closure. The focused group discussion also revealed that majority of the students perceived remote learning to be: "ease to use", "helped to

learn", clear" and "understandable". Students also reported that remote learning helped them to continue learning and have access to learning material. This finding is consistent with those of Alwahoub et al. (2020), who concluded that eLearning gave students easier access to materials and contributed to their learning. The overall results from the independent samples t- test in chapter four revealed that there is no statistically significant difference between mathematics teachers' and students' perceptions towards remote learning. The findings of this study revealed positive perceptions towards remote learning from both mathematics teachers (M = 2.17) and students (M = 2.06), with mean difference of 0.112. These results are also supported by the study conducted by Alwahoub et al. (2020) which aimed to identify teachers' and students' perceptions of e-learning in primary schools in a technology supportive school in Riyadh-Saudi Arabia. The findings of their study revealed positive perceptions of e-learning from both teachers (M=4.07) and students (M=4.08).

One of the key findings of this study is that secondary school mathematics teachers and students had positive perceptions towards remote learning. However, there was no statistically significant relationship between mathematics teachers' and students' perceptions towards remote learning. Despite COVID-19 compelling countries to take up remote learning and mathematics teachers and students not prepared to start using it, they expressed positive perceptions towards remote learning. Mathematics teachers and students recommended that remote learning should continue to be used, however these results cannot be generised to all the schools. Future studies on this subject should include private schools so that a comparison of perception is done on them with government schools.

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Article 4

Mathematics Application's in The Quality Management System

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Abstract

Mathematics is an area in which young people are less and less interested and the Democratic Republic of Congo (DRC) is no exception. This disinterestedness begins at school, reaches higher education and impacts the professional world. How can we remedy this in the field of management?

Our hypothesis is that the difficulty related to the explicit presentation of applications constitutes the major cause of this tendency to waiver by most of the young people. The preponderant parameter in learning has always been motivation; and in our case, it is easily determinable through the range of professional opportunities and their job descriptions.

Thanks to the analytical method and documentary and interview techniques, our attention was focused on the Quality Management System (QMS), a novelty in the field of Institution/Company management. This process begins with the study of the existing SWOT analysis of management in an organization; the resulting negative points motivate the implementation of iterative correctives which will be respectively monitored, evaluated, and reapplied so that the subject of organizational management reaches the state of ultimate perfection and remains there as a permanent regime.

We have retained as branches of mathematics applied to the QMS: statistics, mathematical analysis and operational research.

We believe that this specific benchmark will inspire management students to improve their math skills. This will be encouraged with academic internships in institutions where the QMS is applied.

Keywords: *QMS – Management – Statistics – Mathematical analysis – Operational research– Optimization – Optimization scheduling*

1.0 Introduction

Culture can be defined as a set of knowledge of a particular domain resulting from an enrichment of the mind through intellectual exercises. Over time, it becomes so ingrained in us that it becomes an ideology or a tradition. "Learning" is an activity that can be compared to "getting cultured"; hence a better way to learn is to provide cultural benchmarks based on concrete facts. Could this not be the reason why young people are less and less interested in Mathematics, especially in the Democratic Republic of Congo?

Indeed, the difficulty related to the explicit presentation of the applications of mathematics tends more than ever to mystify this interesting field.

Thanks to the analytical method and documentary and interview techniques, we have given

ourselves the task of theoretically creating an academic cultural benchmark linked to the learning of Mathematics by referring to the professional field of management. Focusing on an issue of the era in the field, we have titled our research paper as: « ***Application of Mathematics in Management through the Quality Management System*** » In this article, it is a question of raising all forms of mathematics highlighted in the application of the Quality Management System. The latter constitutes a latest novelty in the field of management which, considered as a procedural set, begins with the study of the existing SWOT analysis of management in an organization, the negative points arising therefrom will motivate the implementation of iterative (perpetual) corrections which will be respectively monitored and evaluated so that the subject of organizational management reaches the state of ultimate perfection and remains there as a permanent regime (steady state).

This work fits into a double niche (i) didactic: allowing teachers in the field to enlarge their batches of practical examples; and (ii) andragogical: dedicating to learners a foretaste of the multiple uses of mathematics in the professional world.

The body of this work will be articulated on developments of roles that can play the aforementioned mathematical components, while revisiting the impact/effects in the traditional management until arriving at the QMS.

2.0 Mathematics applications in the SMQ

Mathematics is a transversal discipline that is also part of the field of Management and Administration. As Ivar EKELAND says: « *We are heading towards a situation where mathematicians will no longer have the monopoly of mathematics, but where economists, managers and merchants will all do mathematics…* ». (www.dicocitations.com, 2023) [12] But to do this, it requires demonstrative involvement on the part of teachers and math professionals in order to show its usefulness.

This learning benchmark is made on the demonstration of how mathematics can be used within an administration in which the QMS is operational.

Thus, we will tackle, from our personal experience, on 3 mathematical aspects, namely:

- Mathematical analysis;
- Statistics;
- And Operational Research.

The choice of the latter is most based on the opportunity of teaching at the higher level (the last door before the professional world). Indeed, there are many sub disciplines of Mathematics but often these 3 mentioned above often come up in the training of a manager: mathematical analysis, the first year; statistics, the first two years (descriptive and inferential); and operational research, at the end of the cycle.

2.1 La statistique

The Larousse Dictionary defines Statistics as a set of methods which aim to collect, process and interpret observation data relating to a group of individuals or units (www.larousse.fr ; 2023). We add that beyond the methodological aspect, it enjoys a notoriety of technique and art, so much it

is used and appreciated by all. This efficiency for management above all, has as its base first the nature of the information it processes.

Indeed, a company combines three essential nouns: innovation, production (of a good or service) and marketing (for the private sector) or payment for a service (for the public).

An institution is established according to its corporate purpose; it is then responsible for the concretization of the goods or services they offer while delivering them (by marketing or by obligation) to consumers. In addition, it must continuously reassure itself of the effect or the impact, the effectiveness or the durability or better still the profitability of its product with consumers in order to seek to optimize in a perpetual manner the satisfaction of the latter. This information is acquired through the collection of statistical data by surveys. However, as the target population turns out to be quite large (telecom customers or taxable persons, etc.), this adventure turns out to be costly and robust. Statistics comes again in order to sample, to work on the sample and to extrapolate the results to the entire population. Note also that the observations to which we can have access through experience are imprecise, tainted with error and random; from where it will be necessary to manage the risk, the uncertainty and the calculation of the errors through tests of hypotheses.

Here, the manager in his statistician cap has the duty to correctly interpret the results of his studies at the risk of exposing the decision-makers to poor decision-making concerning the evolution of the institution, its production and its exploitation's profit. Indeed, through the various parameters, histograms, scatter plots, it must find the best correlations/regressions to the limit allowing to predict the future behaviour of explanatory variables considered following the contingency matrix of each survey. (DEHEUVELS P., 2002) [3]

In particular, statistical analyses are also used in market research (downstream and upstream). The aim here is to be able to study:

- A group of individuals with its characteristics and overall behaviour;
- A trend, its evolution and its impact in a given market environment;
- Competition in a sector of activity and the distribution of competitors' market shares;
- The importance of each criterion of a product or service for potential customers;
- The relationship between different economic, marketing, commercial and advertising factors.

Thus, with the statistical analysis of the market, companies identify the strategic marketing and communication axes and the competitive positioning to adopt to sustain an offer in their sector of activity.

A second usefulness of Statistics can be seen in ***Human Resources Management*** (HRM) in general and the ***Forecast Management of Workforce, Jobs and Skills*** (FMWJS) in particular. They together constitute the keystone of any institution or company constituted in this case of human capital.

In every organization there is ***the human resources statistical table*** which presents the way in which we use people, we train them, we remunerate them, we create approaches with which they identify and we create systems to motivate and retain.
Thus, statistics intervene there in particular for the follow-up and evaluation of the points conditioning the quality of the organizational activity, such as:

- Définition des positions;
- Recruitment;
- Career Management;
- Training;
- Payroll and compensation management;
- Performance management;
- Motivation and involvement of staff;
- Working conditions, etc.

Personal experience has helped us to realize that, for example, it is necessary to collect data relating to the performance of one's employees. This will allow him to foresee and predict the rises and falls of the different performances, in order to make appropriate strategic/operational decisions relating to his level of hierarchy.
The use of statistical methods in HRM is motivated by the following reasons:

- A dashboard with statistical reports is easy to interpret and allows the re-evaluation of budgets and resources;
- Assistance in setting up a more targeted selection of the data necessary for the analysis;
- Grading and classification (the HAY method for example);
- Data objectivity, etc. (BAHMED L., 2012) [1]

When we talk about human resources, directly we also see material resources on the other hand. The management of the latter forms a third intervention of Statistics within an organization. This is part of logistics, in which statistics are the cornerstone of revealing figures and their meaning in operations such as counting, inventory management, supply, etc.

Finally, comes the Management of Business Processes (better in English Business Process Management) that we can cite as an area of application of Statistics in management. The latter constitutes computerized monitoring of the business processes (activities) of the organization and their interactions with a view to optimizing and automating them as much as possible. Statistics matter for many of these manipulations whose goals are clearly defined above. Even though the processes would have a more qualitative aspect, they can be quantified in order to detect certain anomalies relating to the improvement and management of the processes.

Note that a private company (or the public in a privatized environment), not living inwardly because it is immersed in an economic and social atmosphere, must study external data (economic conditions, different markets, marketing,). This is why, today, the related statistical studies are of great importance in the field of economic intelligence (related to competition). Also, for the sake of transparency and good governance, most institutions increasingly tend to make certain statistics

related to their organizations available to everyone (on the internet). (PEPE P., 1962) [7]

As conclusion, statistics has moved management from an emotional perception (subjectivity) to concrete and objectivity based on real data relating to the organization. Three major tools are necessary for decision-making in this sense: data collection, measurement tools and analysis mode. Thus, it is important to create in an organization (private or public) the statistical spirit and to spread it there. It should be noted that it also happens that the data are overabundant to the point that it is difficult to extract any structure of predictability. This is the problem of « data mining ».

2.2 Mathematical analysis

Here, it is a question of the study of a function. Indeed, after having collected management data, a manager must be able to model them in functions because the latter will be able, thanks to their mathematical studies, to provide very important characteristics for the said management carried out by the manager. The study of a real function reveals important specificities, in particular: the domain of definition, the asymptotes, and the optima (maxima and/or minima), these guarantee the manager a micro and macro view of the analyses that he can perform.

Apart from most rudimentary notions of financial mathematics such as interest calculations (simple or compound), capitalization, amortization, etc., mathematical analysis intervenes in the most beautiful way in the managerial field: modelling. When we talk about modelling, we see the design of a model followed by its analysis. We know better how to observe it through two main notions in management:

- the notion of equilibrium on the market (for a good or a set of goods);
- and the analytical study (for a good or a set of goods).

As for the first, the market is composed of supply and demand, its analysis will be based on those of economic functions relating to these two components. The pooling of two analyses will make it possible to highlight the minimum point of equilibrium that a company should ideally reach (market equilibrium). It follows the determination of the factors influencing the conditions at equilibrium. It constitutes a priori calculations.

The second part is established as a posteriori calculation. Indeed, it is the analytical study of costs and margins, as functions, obtained by the sale. It follows the determination of the marginal cost which is defined as the derivative of the total cost function, of the technical optimum when the average cost of production is minimal, of the elasticity of demand, and of the economic optimum (maximum profit). Beyond all this, it is important to note that analysis is carried out more easily and quickly thanks to a graph; with the latter, one principle always applies: the more precise the drawing, the more certain the analysis will be.

2.3 Operational Research

Regarding this last component, we can say that it constitutes the cornerstone of the primary philosophy of any organization: “the maximization of satisfaction”. This satisfaction should be

considered at two levels: (i) the person for whom the good/service is intended (consumption in quantity and quality) and (ii) the person who produces the good/service (interests despite the constraints). Thus, optimization studies must be carried out both upstream and downstream depending on the corporate purpose of an organization/company, either deterministically or stochastically. The Quality Management System, which is an integral part of the functioning of an institution, also tackles this reflection by bringing it more objectively; especially since the estimation of quality is more than important in this process. The latter must also be or become subject to optimization because it is essential today to have a qualified efficient management system to make an activity profitable (whatever it is). From there, it will create an ***optimized optimization system***. But if we really have to be concrete, we think that the theory of Operations Research is more applied through graph theory in the field relating to the ***scheduling of tasks*** in a project. Indeed, in order to be able to evaluate and monitor the impacts or results of the systems put in place by a QMS approach, it is necessary to consider all the processes of an organization as a long-term project. Thus, each process, broken down into activities, must be defined according to a corresponding schedule of activities; milestones or development indicators (objectively verifiable), and especially the time that will allow to follow the pace of the process from the beginning until the complete realization. According to a common characteristic such as time often, this situation is modelled mathematically with ***the theory of scheduling*** which is intrinsically linked to the ***theory of graphs***.

Scheduling refers to the process by which successive priorities are given to different tasks; As for time, it consists of organizing the completion of a sequence of tasks over time. (FAURE R.,1996) [4] Scheduling theory is a branch of operations research that focuses on calculating optimal task execution dates. The scheduling is defined by the task execution schedule "order" and "calendar") and the allocation of resources. It is often represented by a GANTT chart or the PERT network. Note also that the optimization approach assumes that the candidate solutions to a scheduling problem can be rationally ordered according to one or more numerical evaluation criteria, constructed on the basis of performance indicators.

This is what makes that in itself, in institutions applying the QMS, weekly and/or monthly meetings relating to the monitoring and evaluation of the activities of each process according to the departments/directions cannot be missed: it is analysed progress of a task scheduling diagram of one or more processes while taking into account compliance with the indicators initiated in the organic framework of the current project.

3. Conclusion

Mathematics is a more than important area in school and academic training. Being in the second case which comes closest to the professional field, it is necessary to familiarize the student with more than concrete examples so that he can create benchmarks intrinsically to the learning of Mathematics or auxiliary courses. Wanting to work in this direction, we presented, from our personal experience, the major applications of mathematics in the new management sector called

Quality Management System: (i) Statistics, (ii) Mathematical Analysis (Study of function) and (iii) Operational Research.

The first is initiated in the collection and manipulation of data, objects of information necessary for the functioning of any organization. The latter will be able to generate graphical representations that will have to be studied with the second application. Finally, the last is part of the optimization of double satisfaction (customer/organization); and in the monitoring/evaluation of any process which, considered as a project, is made up of activities/tasks: the scheduling of tasks.

For effective support of this benchmark, we recommend: (i) teaching mathematics according to the situation-based approach in the field of administration/management; and (ii) assignments of academic internships in public or private institutions in which the QMS is applied.
In short, we are not saying that without Maths it will not be possible to deploy and/or make the Quality Management System, but rather that Mathematics constitutes a major asset for a manager in the application of the Quality Management System. Our prayer is that students allying themselves with this field may become more and more aware of the importance of Mother Science and thus take more interest in it in order to make their background sufficiently robust.

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Article 5

Limited Linguistic Competency in the English Language as an Obstacle to Equity and Access in STEM Education

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Abstract

This paper examines equity and access to STEM Education as a result of the special needs of learners. Language can either be an agent of inclusion or exclusion depending on context. English is the medium of instruction and testing of STEM and all other subjects, yet not all learners are competent in the language. The study aimed to establish whether there is a relationship between competence in English language for learners and performance in STEM subjects. It examined the difficulties faced by learners with limited competency in English language and how to mitigate the limitation and ensure they have the same opportunities as those with excellent competency in the language. The research was conducted through questionnaires and focused discussion groups among learners in Kenyan Secondary Schools in Kericho County. The study is critical in assessing the importance of language in the acquisition of content as it found that learners are more receptive to lesson content if language of instruction is friendly to them. Learners need to understand the language of instruction in order to follow the lesson, express themselves, do a presentation and write an exam. Limited language competencies also impede learners from participating in out-of-class activities like science and engineering fairs. There is therefore a direct link between linguistic competency in the English language and performance in STEM subjects. More emphasis and resources should be allocated towards helping learners master the subject of instruction in order to perform better.

Keywords: *STEM, language competence, language proficiency, linguistic competence performance.*

1.0 Introduction

STEM education has been argued to be important in driving Africa's economic and agricultural performance. Lobe (2015) views STEM education as important in dealing with Africa's long-term development challenges like AIDS, Malaria amid other health challenges. Marginson et al (2013) term it as pivotal to increasing a nation's productivity. In Jamme's (2015) view, Africa's future depends on STEM education. While agreeing that STEM education is important to the development of Africa, it is also important to note that this Education has not been easily accessible to all students. One of the basic objectives of STEM Africa is equity and accessibility. Osita (2022) notes that inequity in access and quality of education in secondary schools in African schools has been a major challenge in the teaching and learning of STEM Subjects. Sichangi (2018) explains

that students require skills such as "collaboration, communication, self-efficacy, citizenship, creativity and tech-innovation" to achieve sustainable development goals. Sichangi goes on to explain that learners need to be equipped with knowledge and skills to solve real-life problems through gathering, and making sense of information. Osita (2022) posits that if Africa is to compete on the world stage, the tool of empowerment in STEM education is English since it is a language spoken by more than half of the world's population thus getting Africa into the conversation. The importance of English in teaching and learning STEM subjects cannot, therefore, be emphasised enough.

Most learners have not been able to learn and choose STEM subjects because of several factors, including a lack of educational infrastructure, staff shortages, and a lack of electricity and water supply. The study argues that language has also greatly hindered learning of STEM subjects. English is the medium of instruction in all schools in Kenya. Apart from Kiswahili, all other subjects are taught in English. Limited linguistic competency in English has limited learners' ability to follow the lesson, make presentations in the classroom and even write exams. This has led to poor performance and therefore limited enthusiasm to study STEM subjects. Aina et al. (2013) posit that a lack of English proficiency contributes to poor performance in Mathematics. Therefore, proficiency in English language determines students' performance in science-related subjects and mathematics.

The study defines learners with special needs to mean learners who have limited linguistic competency in English and therefore are marginalized when it comes to the acquisition and processing of lesson content. There are several reasons for the lack of competency in the English language for most learners that in turn come to affect their performance. Narueni (2019) outlines some of the difficulties that affect the learning of English including; difficulty in understanding grammar and vocabulary, the influence of the first language in learning pronunciation, accents and native language interference during the study, learners' attitude toward the language, teachers teaching methods and their native language interference, among others. English in Kenya is acquired as a second language to some. For others, it is acquired as a third language after vernacular and Kiswahili. The problems that accompany the learning of English translate to usage and acquisition of knowledge. Not many learners are allowed to master English before they are required to adopt and use it to learn other subjects, do presentations and write exams. Though English is taught in all Kenyan schools from primary to secondary school, the importance of mastering it in my view is not emphasized enough.

English is taught as an individual subject in the curriculum, a subject that they have to pass to pursue other courses or continue to pursue in college. The completion of syllabus is also overemphasized. During revision, learners are given areas of prediction; where the national examination may be set from, owing to trends in setting of English examinations over the last couple of years. As such, excelling is prioritized, albeit there is no emphasis on its connection to the learning and retention of content of other subjects. No one for example tells the learners that

their understanding and competence in the English language translates to their performance in other subjects. This paper argues that performance in science-related subjects might not necessarily translate to the intellectual capacity of the learner or their ability to acquire and retain knowledge but rather their linguistic competence in the language of instruction.

2.0 Research Methodology

The study took a qualitative approach to study the relationship between competence in the syntactic structure of English to the acquisition, synthesis and retention of knowledge in STEM subjects. The study also set out to examine linkages between proficiency in English and performance in STEM subjects. This study was conducted in three secondary schools in Kericho County, Kenya; Ainamoi Secondary, Poiywek Secondary and Chepkoiyo Secondary School, where English is taught as a subject in the curriculum and is also used as a medium of instruction for all other subjects except the Kiswahili subject. At least ten learners from every class from form one to form four were sampled and given questionnaires, focused group interviews were also conducted in three groups, each containing ten students. Learners' performance was analysed to determine their performance in the two fields, language and stem subjects over a period of time. Purposive sampling of the students to focus on those students who perform relatively well in the English subject and those who perform dismally visa vie those who perform relatively well in a STEM subject and those who also perform dismally. The intention was to examine whether their performance in the English language affected their grades in STEM subjects.

3.0 Findings and discussion of findings

Data was collected and analysed as follows:

3.1 Content acquisition during lessons and writing tests.

The majority of learners thought that there was a link between performance in English as a subject and performance in the STEM subjects since it is used to teach and test all STEM subjects.

Yes, they are connected because English is used to teach all subjects

Yes, they are connected because English is used to ask questions in exams

Most learners who have lower grades in English said they could not follow lessons when only English was used. They would prefer if some examples and explanations were given in Kiswahili.

Interviewer: Can you follow the lesson entirely if English was used throughout the lesson or would you prefer some explanations to be given in Kiswahili?

Student: Sometimes it is hard to follow. I understand better when examples and explanations are given in Kiswahili

For some learners, learning English was way easier than learning the science language and therefore had no relationship at all. Other learners said that they only worked hard to learn English and pass it in examinations because it was essential to their joining of colleges or universities and not so that it can help them improve in other subjects. An assessment of their academic performance, however, revealed that the learners who had better grades in the English subject also

had better grades in the STEM subjects and vice versa.

It is, therefore, evident that there is a direct relationship between the mastery of the language of instruction (English) and the performance of the STEM subjects. Acquisition of science concepts is pegged on the learners' mastery of the language of instruction and therefore poor mastery can lead to misconceptions. Lack of adequate mastery of English which is the language of instruction leads to inadequate understanding of the teachers' speech because of a poor vocabulary.
Most learners also view the mastery of content in STEM subjects as more important than mastering the language that is used to teach and acquire that content. The two cannot be separated. Aina et al (2013) rightly contends that mastery of the English language is important in learners' performance, in terms of writing texts and conducting practicals. The biggest part of learning or performing well in STEM subjects is the learners' ability to synthesize information, analyse, evaluate and think critically. According to Aina et al (2013), many students do not regard their knowledge of the English language as having anything to do with their performance. Learners feel that what is of utmost importance to them is the mastery of the content of the STEM subjects and that everything is subordinate to that fact. However, performance in STEM subjects is largely reliant on the learners' self-reliance and thus their competence and confidence in the language of instruction.
Learners also erroneously assume that English is only a problem for those who intend to major in English-related courses in college and that what is important for them is the mastery of the content in the STEM subjects and not necessarily the structures or syntax of the language. Competence in English is important in accessing the material in books. All the materials available for learning STEM subjects are in English, if they are not competent in the language, they cannot understand and synthesise information thus making it unreachable to them

Competency in English significantly also determines performance in academic tests. Limited linguistic competency in the language is one of the factors that contribute to poor performance in STEM subjects. Learners need a great mastery of the language to write tests. Poor performance in STEM subjects can be linked to poor reading ability and comprehension of the questions, especially in application questions where learners are supposed to analyse and synthesize information and cannot because of their linguistic shortcomings. Learners cannot effectively express themselves if they cannot use the language freely as a way of expression.

3.2 Teachers' language proficiency and teaching self-efficacy

Some learners reported that sometimes it was hard for them to follow lessons because of teachers' accents. For most learners, heavy accents affected teachers' pronunciations of some words and terminologies making it difficult for them to take dictated notes.
Student: Sometimes I cannot understand what the teacher is saying because of how he pronounces words. That makes it hard for me to make notes
This, therefore, meant that they cannot get the correct terminologies which might make it harder for them to write exams using these words.
Teachers' mastery of English also affects the delivery of content. Heavy mother tongue influence

on the teacher's side also has a bearing on how learners acquire content.

However, it is important to note that language competency is bound to many factors. Faez et. al. (2019) contend that teacher language proficiency and what level of proficiency is required for teachers to be effective is a complicated matter. They point out that though the teachers' proficiency in the language is important other factors were important to determine teaching self-efficacy including classroom management, student engagement and teaching methods. Language proficiency in their view is hard to define and contexts in which this proficiency is measured are important. Faez et al were, however, analysing the link between the teachers' proficiency in English and their efficacy in teaching the English language. In my view, the same rules do not apply to teachers of other subjects since language structure is not the issue but rather what is passed on to learners through it. It is also hard to determine what constitutes language competency. Many teachers understand the language structure and can use it as a medium of instruction and language of expression. Other variables such as accents, and mother tongue influences are however also at play. Using the language correctly does not mean not having an accent. The problem in my case is the effect of the teacher's accent and mother tongue influence in the teaching of STEM subjects.

3.3 Linguistic Competence, Confidence during presentations and self-esteem

Most of the learners with a lower performance in English reported that they found it hard to do a presentation in it because sometimes it was harder to construct whole sentences which made to alternate between using English and Kiswahili. The learners with above-average performance said they could make their presentations in English without problems. These learners with above-average performance also have greater proficiency and felt more confident while doing presentations than those with lower performance. Most learners, however, explained that they were greatly affected by mother tongues' influence on their pronunciations, therefore making it difficult for them to do presentations. When they do presentations, in the classrooms or during Science and Engineering Fairs, other learners would laugh at them. As such, they felt humiliated and would prefer to only participate in written competitions other than oral ones.

Language competency has created a feeling of otherness in most learners, especially those who come from rural areas. Other learners especially those who live in urban areas, sometimes are taught English as their first language and though it is a second language for some of them, they have greater fluency because of the resources at their disposal that are constantly used to help them master the language. Most learners coming from rural areas have very limited resources. The competency in the language has therefore greatly affected the self-esteem of the learners especially when they have to participate in out-of-class activities like workshops, symposia and Science and Engineering fairs. A learner who can use English very well not just as a way of communicating but also as a means of expression is more confident, hence can deliver better. Learners who have low linguistic competence may develop low self-esteem and may thus shy away from presentations or any activity that may require them to speak publicly.

Learners often group themselves into different classes during out-of-class, mostly according to the schools they come from and its performance in the Kenya Certificate of Secondary Education examinations (KCSE). Those who post better results are juxtaposed against those who perform dismally and there is a general feeling that those who come from well-performing schools have a greater proficiency in the use of the English language, which is often true. While these groupings are often involuntary, they also become a target for marginalization. The 'elite' groups use this chance to mock their counterparts about everything, from their grooming to location of their schools, the language they speak and even how they pronounce words in English. This lowers their confidence and self-esteem making them recoil and withdraw from all these activities. There is a relationship between shyness, language anxiety, readiness to communicate and proficiency in English. Limited linguistic competency in English destroys their confidence even in using it to write exams. There is always a deep-seated feeling that they cannot write better than their counterparts who can express themselves quite well thus despairing and as a result performing poorly.

Language can be used to construct identity. Temples (2010) asserts that identity learners can use language to construct new identities by borrowing linguistic features of the language to construct their own identities. Temples continue to explain that learners are more motivated and successful when they feel they have become competent users of the target language especially if their competence 'aligns with their overall sense of whom they want to be' pg. 6. Chun et al (2017) language is used to negotiate human relations and affiliations. The mastery of English thus opens up learners to develop new relationships that would have been impossible to form and exposes them to a wider group of people and material. The opposite is also true where poor mastery of the same marginalizes these learners and ultimately affects their performance overall.

4.0 Conclusion

There is a direct link between linguistic competency in English and performance of STEM subjects. If a learner understands English then they would have confidence in using it as a way of expression, following the lesson, making presentations and writing exams. Students fail STEM subjects and lose the motivation to continue learning them not because of their intellectual capabilities but because of language handicap. More emphasis and resources should therefore be put towards ensuring the learners master the language of instruction for them to perform better in STEM subjects.

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Article 6

Creating Learning Spaces for STEM Learning And Engagement In Kenya: Building Learners' Capacities To Use Imaging Affordances Of Their Own Digital Devices In And Out Of School

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Abstract

For continuity, engagement, relevance and affordability in the learning experience, education had to adjust to rapid changes in the past two years. These changes were catalyzed by the COVID-19 pandemic and climatic and manmade disasters which include flooding, drought and Civil strife. These factors necessitated a rapid engagement with, as well as the adoption of technology and the evolving digital ecosystem. Digital devices enabled education – from elementary, through high school to tertiary levels - to continue even with shutdowns. Prior to the pandemic, this research sought to support teachers and learners to use their own smartphones with the skills, knowledge and attitudes to appreciate and utilize the ever-expanding affordances of these ubiquitous digital devices. The experiences of the pandemic make this study even more relevant and supports the move towards online, blended, and digital learning. This qualitative study used the participatory action research (PAR) method to engage a purposively sampled group of learners from a high school in Nakuru, Kenya. The participants were allowed to bring their own digital devices, which they used to carry out Photo voice activities in school. Numeric and graphic data were collected, coded thematically, and analyzed using standardized statistical methods. The study shed light on the fact that: 1) Spaces for STEM learning and application, in and out of school, are expandable and 2) such expansion requires teachers to support learners to build capacity in using the imaging capability of the digital devices, among other affordances, in line with the objectives of the 21st-century pedagogy. Further, digital devices enable knowledge creation, assessment for learning, evaluation and collaboration. Implications relate to education policies and pedagogical frameworks, particularly the Competency-Based Curriculum (CBC), with the need for a paradigm shift to allow learners to access and use their own digital devices in such learning spaces is required and an urgent matter.

Keywords: *STEM, Learning Spaces, BYOD, Photo voice, Competence Based Curriculum (CBC)*

1.0 Introduction

As the Competence Based Curriculum CBC framework is under review in Kenya (GOK 2022), there is a need for a paradigm shift concerning adopting the use of and access to technology across the education system. Such a shift has the potential to expand the learning spaces both for the in

and out of school learning for the Languages, Literacy, numeracy, and other subjects within the Science, Engineering and Mathematics (STEM) subjects combination (Gallou & Abrahams, 2018). Arguably, with East African regionalization, it can be argued that STEM supports the building of greater capacity to overcome ICT integration challenges in education with a cohort of students who have relevant educational experience whilst at school. The digital gaps arise from a lack of infrastructure and an inadequate teacher-student ratio. Insufficient digital literacy among available teachers makes it difficult for most schools to meet the need for access to education for in and out-of-school children. This study attempts to address how creating capabilities of digital mobile technology use to provide solutions to the changing needs of learners, especially for the sustainable learning space to support the learning of STEM.

In its contribution to this conversation on learning spaces, this article explains key concepts and practices related to the theme of the conference. Part 1 will tackle understanding learning space and especially its uniqueness for STEM while Part 2 explores the digital imaging affordances of mobile smart devices. The Bring Your Own Device (BYOD) to school initiative will be explained next before concluding with the basics of how to engage learners to use mobile technology through the Photo voice approach. The paper is based on qualitative research done using the Participatory Action Research approach where 40 students were allowed to carry to school digital smart devices of their choice for use in researcher-guided photography. The collection of over 500 images was categorized into several thematic areas. Study participants in a school in Nakuru, Kenya later made comments on some selected photographs in line with the conventions of Photo voice as required.

2.0 Background to the Study

The COVID-19 pandemic and national governments' responses provided lessons, emanating from the health sector, which affected the education system. Particularly, the enforcement of health protocols to contain the spread of the pandemic, which were applied to the education sector resulting in a complete cessation of schooling (Lee & Campbell, 2020; WHO 2020). Whilst the health needs of people were prioritized during the crisis, the education sector the world over was significantly disrupted. With this in mind, it is evident that despite the current 'return to normal face-to-face learning, we must both anticipate more disruption as well as use the available technology to improve current educational provision.

Certain adjustment measures taken to mitigate changes in learning space for the access and delivery of learning content are now clear and some governments are beginning to respond. This study responds to infusing technology in teaching-learning focused at the school level. Initially, teachers and learners explored previously underutilized and unfamiliar-to-many virtual learning spaces or platforms to continue with their academic engagement and studies with immeasurable success. It was clear that mobile devices and online platforms were poised to provide sustainable stop-gap solutions for learners and educators to create and share educational resources for all levels of education. This necessitated the acquisition of relevant digital literacy and the opportunity to apply it in real situations; these needs were supported by training tailored to these particular

situations.

While digital literacy is, for some adult users, instinctive, haphazard or spontaneous, the young learners - digital natives - adapted to the altered circumstances smoothly and enthusiastically took up the new learning space. These young learners gained greater access to more sophisticated devices and diverse learning resources. The new stimulus made learning for them more engaging and self-regulated. The digital nativity in the 21st-century learner needs to be harnessed, enhanced and customized with ready access to mobile devices to learn with the learning space affordances. The tempo of the current ongoing paradigm shift needs to be maintained, sustained, diversified and safeguarded by being responsive development of educational policies, curriculum designs and classroom practices. One key innovation recommended in this paper is to adopt in all public schools the 'Bring Your Own Device (BYOD), which is the focus of this study. The learners, who are now deeply familiar with the ever-expanding features of mobile smart devices, can have the opportunity to create and share content for STEM learning or assessment. The rest of the paper justifies what learners can achieve if allowed to bring their devices to school. Implications of the study are also noted, particularly the support for infrastructure development in the digital ecosystem, training of teachers and building support structures for learners in the home and community, and creating partnerships for development with career progression in the unfolding knowledge economy across the East African region.

3.0 Literature Review

3.1 Learning Spaces

The Learning space, commonly referred to as a classroom, is regarded as both spatial and environmental. It should satisfy certain expectations for both the learners and teachers which include a student's environment and learning styles (Kolb, 2005). Whether outdoor or indoor, they should come in designs that consider basic behaviour and comfort for the learners (Cooper & Wischemann 1987). Kral & Schwab, 2012 regard learning space as a continuum from local to global where learners work individually or collaboratively with peers (Ingerman & Booth, 2018). In every pedagogy space, safety and protection for the learners should be a guaranteed and unconditional (Sellars, 2020) prerequisite. The technological revolutions of the 21st century have caused the learning space to evolve from the physical four-wall classroom with books and teachers as the basic source of knowledge, to the innovative Multilevel User Virtual Environment (MUVE) where learning resources, activities and interactions are exchanged virtually on internet connected platforms, in ways that make learning more efficient, effective and affordable (Codier, 2016).

This study can draw some parallels from (Kral & Schwab, 2012)'s experiences in Australia where there is a common belief that education, from whatever learning space, should provide knowledge and tools necessary for economic participation of the young learners' transition to adult life. To respond to such a need and to provide for continuity of engagement, aboriginal communities there have formed learning spaces where young people are choosing to engage in modes of learning that give them the creative freedom to explore and express who they are and what they want to be in

future.

Learning space should also constitute and provide an opportunity for self-expression to the learners both to their peers, teachers and the rest of the world. STEM subjects are highly practical and one way of enhancing retention of what is being learnt is to commit visual representation of concepts to one's mind. This can be done easily when learners are in school using devices they can use later at home, before or after learning the concept. An ideal learning space should therefore move the knowledge with the child's real-time environment. This makes the child realize the relevance of a strand or sub-strand in their everyday environment.

3.2 Imaging Affordances

Although this study emphasizes the use of pictures created with learners' own cameras or mobile phones, there are other sources where images are available in various forms (Council of Europe, 2020):

Photographic images that can be downloaded or shown on the internet, copied from books, cut out from magazines and brochures, or created with one's own camera/mobile phone which is the emphasis for this study.

- Drawn or painted images, in cartoon or 'artistic' style that can be found on the internet, copied or cut out of comics and other publications such as art gallery leaflets and postcards, or drawn on paper or on a board.
- Representational signs and symbols that can be found in public places, on doors (e.g., toilet doors), or as emoticons on mobile phones etc.

3.3 What is Affordance?

Affordance can basically be defined as a quality, feature, property, or characteristic of a device that makes it usable for a given purpose, either by default, modification or adoption. The mobile phone imaging affordances are a key feature which makes the use of these devices very ideal for the STEM learning space. Phones with varying specifications have proliferated the market making them affordable to users across the social-economic divide. From basic cell phones through mid-range feature phones to high-end smartphones, Phones have greatly improved the image quality capabilities from as low as 1.5 Megapixels in feature to current over 100 Mega Pixels for some brands. Since the camera feature is one of the main specifications which drive the market prices and thus also a strong point for influencing buying of the device, many users with middle-range phones are still able to capture significantly clear images for learning, teaching, and achieving (GSMARENA 2020). Today's learners take a very short time to learn how to use the cameras of virtually any phone with little or no reference to the hardcopy user manual. Given the opportunity to bring such a device to school, the learners can be engaged by the teachers in capturing items or activities in a context they are familiar with and use these in a project-based activity to check the achievement of learning outcomes or to create additional resources related to a strand or its sub-strand.

To appreciate fully the imaging capabilities of the mobile phone cameras, the participants –both

teachers and student - were taken through the basics of quality photography and camera handling as well as understanding how to use various lighting conditions, angles, and perspectives to obtain photographs with depth, composition, and emphasis in each image. An appendix of the images taken after the short training has been displayed to demonstration of skills learned (Moran, Mary, & Tegano, 2005).

3.4 The Photo Voice Process

Photo voice was first introduced by Wang and Burris in the early 1990s as a data collection method in Participatory Action Research. It involves engaging the research participants in selecting an issue that requires a change in their community. The researcher would then issue them with cameras to take photographs of various people, places or activities related to the learning strand. The critical point of departure from that traditional photo voice projects is that in this study the participant students were asked to bring their own cameras to use in the photography process.

After sorting out the photographs into particular thematic categories, the participants would write comments or caption the photographs about how they are affected by what is depicted in the photo. They then set up a gallery display of some of the photographs, and invited other members of their community, especially those in the position of policymaking, for an exhibition, so that they can discuss how to take action over issues exposed in the photographs. (Wang et al., 1998; Wang & Burris, 1997).

The following are the key conventional questions called SHOWED questions which guide the photo voice procedure:

1. What do you see here?
2. What's really happening here?
3. How does this relate to our lives?
4. Why does this problem, concern, or strength Exist?
5. What can we do about it?

4.0 Methodology

The Place of Photo voice in STEM Learning Spaces

Images have a strong impact on any learning process, especially during the early years of education. These are the years, according to Piaget's cognitive development stages, where the child tries to concretize the world around them as they move towards stages of mature reasoning, abstraction and problem-solving (Berger, 2008). Here, their world revolves more on what they see for them to learn. This study asserts, in many ways, that perception modifies learning and reasoning. As aptly put by (Arnheim, 1969), there is much evidence that truly *productive thinking* in whatever area of *cognition*, in our case STEM, takes place in the realm of imagery. The universality of images responds to the inclusivity needs of a learning space. Therefore, learners need to constantly interpret and relate what is to be or has been learned using images. Photographs bring authenticity to a learning experience.

Photo voice projects were mainly centered on health promotion (Wang et al., 1998; Wang & Burris, 1997; Wang & Pies, 2004) but have been used successfully in other areas like community

development (Brazg et al., 2011; Hergenrather, 2009; Nykiforuk, Vallianatos, & Nieuwendyk 2011), Information Communication Technology (Akther & Dirckinck-Holmfeld, 2018; Ng & Cumming 2016; Porter et al., 2016), language literacies and even in mathematics (Anon, 2021; Garba et al., 2019).

Guided activities ensure that students use their devices to achieve the learning objective without distraction. During our research, students were able to access mobile devices which included cell phones, a laptop and a dedicated camera. As a part of their response to how the school promoted their health and wellness, the students took over 500 photographs of facilities, installations, structures, individuals and even activities around the school, on different days for three weeks.
The management of devices brought by students is very crucial so that students maintain their focus on the use of their devices for only the desired activity (Mahon, 2014) and within established device policy in the school (McCrea, 2015). For instance, the student participants brought their devices and deposited them with me every morning which were well labelled, switched off and kept in my closet till after classes when I would require them to use them.

Fig 1: *Students own mobile phones kept by the researcher*

5.0 Findings

The key participants in the photo voice were students selected on a voluntary willingness to participate in the study.

Age patterns of sampled student participant

The average age of entrance in high school is 13 years if a child entered into primary school education within the recommended entry age of six years.

Age Group	Sample Size	%
13	1	3
14	2	6
15	10	30
16	12	36
17	6	18
18	2	6
Undeclared Age	5	

More girls than boys were able to access devices which they brought to school. Students maintained a high likelihood of bringing their own device on daily basis with slightly over 20% of the phones available with the participants released by adults at their homes solely for the purpose of the research implying that almost a half of the providers are ready to support the BYOD implementation if positive support is shown from school. The school's formal communication about the research with students' caregivers elicited a positive expectation that the devices would be used for educational purposes. It will suffice to present one major finding here that speaks to the power of Photo Voice, whereby students investigated their surroundings and expressed their learning environment and reflected critically on its impact on their learning. As the images at the end of this article show, the effect of the BYOD reflects the need for and the potential to engage in school health promotion.

The mobile phone proved an ideal tool for investigating school health. Photo voice give learners the opportunity to investigate their situation at school and interrogate their environment capturing photographic images of what concerned them. The 39 participants took 500 images and worked collaboratively to categorize and reflect on the images – see Table 1 below.

Table 1: *Students categorization of 500 in thematic areas – Focus on school health*

No.	**Theme**	**No of photos**
1.	Values and life skills	70
2.	Gender-based issues	20
3.	Child rights Child protection Child responsibilities	27 20 7
4.	Water Sanitation Hygiene	77 70 7
5.	Nutrition	105
6.	Disease prevention Disease control	7 20

The findings in this area indicate a reflective engagement by the learners, build their STEM skills, and empower children to take action based on learning opportunities enhanced by the smart phones / devices used for pedagogical purposes.

6.0 Discussion

Why policy change for BYOD is long overdue in Kenya

With an imminent global economic recession at hand in 2023 (Guénette, Kose, & Sugawara, 2022) developing countries will have to brace for harder times in financing development projects, especially in the education sector. That may imply a possible decline in the supply of educational

technology infrastructure including digital devices. Recent updates from the World Bank on Kenya's state of economy indicate that the country may be headed for challenging economic times. Despite recovering the economy hit by the covid-19 pandemic, now the war in Ukraine is posing a more dangerous economic crisis in this country owing to its imbalance of trade with Ukraine (World Bank, 2022).

Without putting the cart before the horse, the education policies still banning students from bringing any digital communication gadget to school will have to be lifted before a fuller realization is done to expand the learning space for our learners. There can be a lot of benefits in closing the digital divide in our schools where learners bring the technology they are familiar with to school. Schools will not have to worry about procurement budgets for availing of devices at school. Owners will take off the burdens of buying the gadgets, the security of the devices or training learners on how to use them, and maintenance upgrade replacement.

Two main challenges remain: One key challenge is the attitude of parents, teachers, and other stakeholders toward the benefit of BYOD. Many are more concerned with the possibilities of deterioration of conduct, loss of focus on studies, and crimes of theft of devices. Ironically these outspoken adults are the same allowing students at home to have unlimited, uncontrolled access to devices and uncensored content by the same students they purport to protect once gone to school. The second problem facing the teachers is their view that technology adds value to the rote learning of the current educational framework. There is still an overreliance on textbooks and memorization where teaching is more teacher-centered rather than learner-centered. Many teachers are also ignorant of the many affordances of mobile smart devices in supporting learning and making it more engaging for learners.

As Kenya transitions fully to the CBC framework, the curriculum design should place the role of the mobile phone as critical to acquiring competencies for the current learning expectations and beyond the school aspirations of the learners. The debate on whether to lift or keep the ban active has remained on for almost a decade without seemingly conclusive actions. Kenya Secondary Schools Heads Association, Teachers' Unions, and the examination body such as Kenya National Examination Council (KNEC) have sustained a push-pull battle over BYOD (Kimutai, 2016; Nyaundi, 2019).

Interestingly, in its report on monitoring learners' progress in grade 3 of 2019, the KNEC appreciated that mobile phones took a 44% share of *the type of connectivity used to connect to the internet* in public institutions against 33.8% for private counterparts. On the contrary, private schools led in the use of modems for connectivity to the internet with 24% against 11% for the public sector (KNEC 2020). Another report from KNEC on the *Percentage Of Pupils' Home Possessions* for learners of Grade 3 shows that in some homes without electricity, the mobile possession generally surpassed that of other basic home possessions like electricity, charcoal, and firewood, while data on the *Percentage of Pupils Having Used Phone/Computer/Laptop/Tablet*

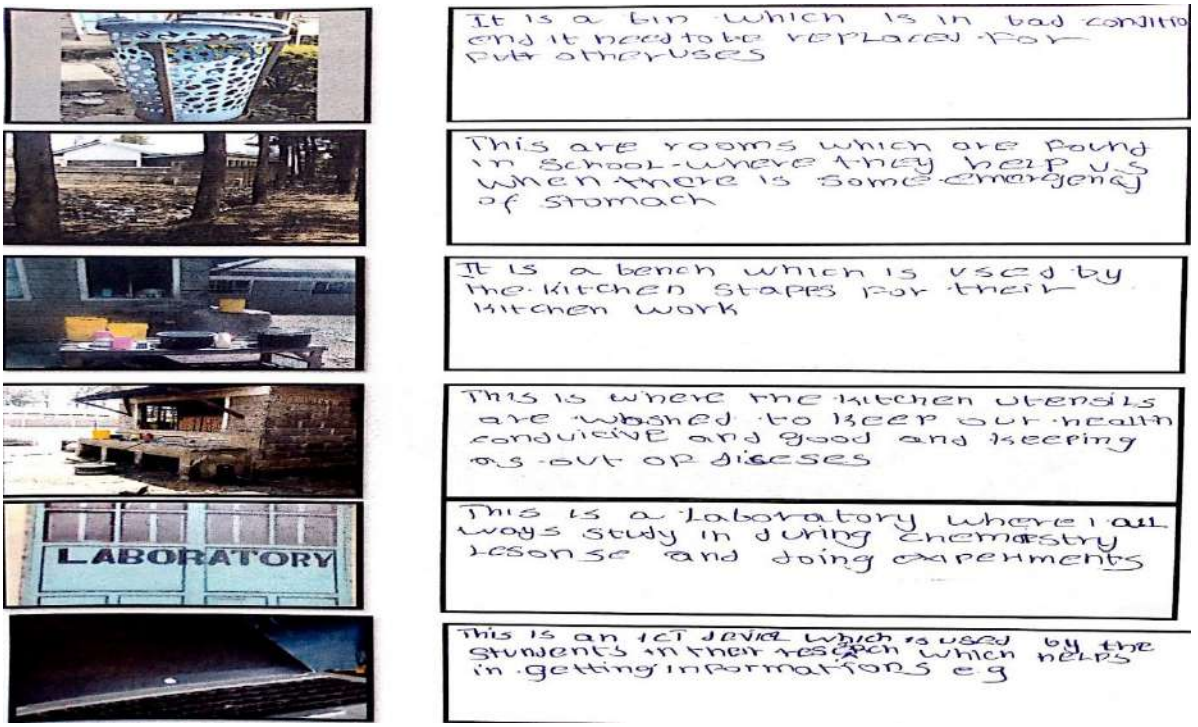
indicated higher percentages in mobile phone usage for all the counties(KNEC, 2016). This shows that mobile phone penetration in Kenya has reached reliable levels and that it is still the preferred choice of connectivity, even for low-income families and learning institutions in Kenya.
These statistics alone justify the piloting of the BYOD approach with projected success indicators of above average.

7.0 Conclusion

From the many issues raised here, it is important to delineate the central arguments that this study makes. We appreciate the fact that a lot of learning takes place equally effectively away from the four walls of a physical classroom. Inevitable circumstances may drift educators and learners to the need to interact away from the physical face-to-face environment. Such a circumstance should not compromise the quality of knowledge to be shared among the two stakeholders. When such an interaction occurs greater care must be taken to ensure that each side gives its full potential to the other: the teacher shares maximally the planned knowledge and the learner immerses their curiosity to learn fully in the modified learning space created. Learning spaces, whether device-related or platform-based should fully engage the learner in and out of school with opportunities to decide how to learn as well as demonstrated that they have acquired it. Photography is an ideal opportunity to express knowledge in a flexible personalized manner, which promotes deep learning. This implies the need to become more liberal and independent of limitations of policy and attitude into accepting that the mobile phone, our greatest instrument for change, is the best tool to change how human beings relate and interact.

Appendices

Appendix 1: *Sample of captioned Photovoice photograph*



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Article 7

Role of the teacher as an innovator for inclusive classroom environment: Promoting inclusive STEM learning

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Abstract

Physical disabilities have an impact on the performance of learners with special needs to some extent. Students who are physically disabled on their hands may have problems related to grasping or manipulating apparatus during practical sessions such as titration in chemistry where conical flask and burette are manipulated simultaneously. Such learners are not able to come up with expected correct burette reading of volumes as apparatus manipulation is not simultaneous leading to wrong calculations. This does not promote inclusivity in learning of chemistry as a STEM subject. Most of school laboratories do not have special equipment to help these learners in bridging the gap. In titration experiments, conical flask solutions are mixed through vibration, rotational and translational motions of liquid molecules when shaken. This can be mechanized to help special needs learners by integration of vibrations through a vibrating kit. A rotating12v DC brushless fan, loaded with 100 grams mass adjustable from the origin, was used to generate vibrations in DV kit in shaking the conical flask. Experimental data was collected by shaking a conical flask using free hand as control and a DV Kit respectively. The average mean of burette volumes of 12 sampled students, from a class of 65 students, using deterministic vibrator had a percentage error of 1.604%, off the control experiment. In conclusion, the deterministic vibrator works with the help of oscillating vibration frequencies generated on a body vibrating on multiple degrees of freedom. Therefore, school labs should be equipped with special needs apparatus for inclusivity.

Key words: *Inclusivity, Lab, STEM, Titration, vibrations*

1.0 Introduction

The 2030 Agenda for sustainable Development builds on the principle of “leaving no one behind” which is a holistic approach to achieving sustainable development for all. Sustainable Development Goal 4 (SDG4) aims at ensuring inclusive and equitable quality education and promotes life-long learning opportunities for all. Therefore, it is the responsibility of the teacher to become innovative for best practices which holds greater significance in improving the quality of education (Hebbar 2019). Children with disability have fundamental rights to education just like any other child (KISE 2018). In regard to this, it’s imperative that in the world today, we should create awareness among children in classroom and to those who teach them that everyone deserves to be recognized and valued for their individuality and diversity (Neilson & Brink, 2008). Therefore, for a teacher to develop an inclusive learning space, he/she must develop the right

attitude, knowledge and skills. The right attitude demands certain knowledge or level of understanding and the knowledge demands the right skills in order to apply it in a practical situation.

1.1 Physical Disabilities

Physical disability is a condition that substantially limits one to perform basic physical activities in life. These limitations hinder the person from performing tasks and are highly individualized. Hand disabilities can occur in bones, joints or as a result of imbalance of different group muscles by nerve dysfunction or congenital defects. The anomalies occur early in pregnancy. Depending on the type and extent of hand malformation, some babies may have little trouble in adapting and functioning well. Others, however, may face various challenges related to grasping and manipulating objects as they grow and learn.

1.2 Statement of the problem

Physical disability may have an impact on the performance of a learner in some or all practical experiments related to chemistry. Students who are physically challenged on their hands may have problems related to grasping or manipulating apparatus during practical experiments. In chemistry, learners are expected to manipulate both conical flask and burette contents simultaneously during titration to come up with correct burette reading of volume used. This poses a challenge to learners who are physically challenged on one or both hands as they cannot manipulate the conical flask and burette simultaneously. This results to incorrect volumes of burette readings, leading to wrong calculations. Yet, in most school laboratories there are no special equipment or operational systems that can help these learners in their practical work of titration. This can lead to poor performance in their chemistry practical exams resulting to low performance in the subject. This does not promote inclusivity in learning of chemistry as a STEM subject as some of these learners get disadvantaged during practical sessions. This calls for an intervention to bridge this gap for inclusivity in chemistry learning for learners with physical disability.

1.3 Purpose of the study

The purpose of the study is to promote inclusivity in chemistry learning as a STEM subject. There is an existing gap for learners with physical disabilities of hands during chemistry practical sessions. Learners with physical disability of one hand can never get the correct volume of the titrant used since they are expected to shake conical flask content and control burette tap simultaneously. In titration experiments, conical flask solutions are mixed through vibrational, rotational and translational motions when the conical flask is shaken. This can be mechanized to help learners whose hands are physically disabled to shake the conical flask content through the integration of vibrations.

1.4 Research Question

1. How can shaking of conical flask content be mechanized during chemistry titration practical for learners who are physically challenged on their hands for an inclusive learning space?

2. How do vibrations cause mixing of miscible liquids in a container?

2.0 Literature review

2.1 Creating an inclusive learning space

Education is an inalienable right of every child, which should underpin the 21st century education systems and societies deemed democratic (Sanchez et al, 2019). In regard to this, children with disabilities are among the most vulnerable facing multiple forms of exclusion linked to education. It's therefore important for the teacher to play the role of helping the learners in identifying and bridging these psychomotor gaps early enough by creating an inclusive learning space which promotes learners cognitive growth. Inclusive education is an approach to schooling in which students with many different kinds of disabilities and learning needs are educated in classes with non-disabled and developing children (Kirschner & Suzanne 2015, Gagare, 2018, Atinbhai 2019).

Inclusive teaching and learning recognizes students' entitlement to a learning and experience that respects diversity, enables participation, removes barriers, anticipates and considers a variety of learning needs and preferences without directly or indirectly excluding anyone (Draffan et al 2018). Because every child has the ability to learn and the right to reach their highest potential, an inclusive learning space should expose all learners, regardless of their ability differences, to new learning experiences which motivates them to learn more actively by taking charge of the process of their learning (Ndiritu 2019). As a result, the classroom teacher must thoroughly understand the individual needs & exceptionalities of all students in class (Sloik 2018). In order to meet the needs of every learner, the teacher must provide activities and lessons which meet the same standards with varied strategies and methods. In this case, an inclusive learning space should aim to engage all learners and give everyone an equal opportunity to participate. In this regard, an inclusive learning space is a welcoming, accepting and affirming environment where all students have equal access to barrier-free learning experiences.

Inclusive learning space can be based on the premises that all learners have individual traits which can hinder or promote their learning curve. Hence, creating an inclusive learning space means not just putting students with disabilities into the space, but also finding ways to help all learners benefit in learning without exclusion (Tammy, 2014). Therefore, it's the responsibility of the teacher to ensure that, the inclusive learning space helps all learners in making links between the domain of ideas and the domain of real objects (Laurinda & Dourado, 2013).

2.2 Role of the teacher

The role played by the teacher in providing learners with academic support is very essential. In order for learners to have an experience in an inclusive learning space, Marochi and Marina (2014) argue that, the activities involved in learning should not only be about demonstration of concepts, laws and procedures, but also the use of multiple types of instruments in order to reach a conclusion. Since teachers are very crucial in determining what happens in classrooms, Tyagi (2016) notes that they play a key role in;

i. Developing positive attitude between abled and disabled children.

ii. Bridging the barriers for children with disabilities in order to involve them in almost all activities in the classroom.

2.3 Innovativeness through application: Application of Newton's second law of motion & Centrifugal force scientific principles in production of vibrations for shaking liquids

Newton's second law of motion states that the acceleration of an object is dependent upon two variables, i.e., the net force acting upon the object and the mass of an object(f=ma). With reference to Newtonian mechanics which applies Newton's second law of motion, a body moving in a circular path experiences a force which arises from the body's inertia which appears to act on the body and is directed away from the center around which the body is moving. This force is called centrifugal force (F=mv2/r). According to Merriam-Webster dictionary, centrifugal force is an apparent force that is felt by an object moving in a curved path that acts outwardly away from the center of rotation... Behzad et al, 2004, argues that the centrifugal force acting on a propeller shaft increases the vibrational frequencies of various harmonics. Machines like electric motors, pumps, fan & cloth driers have rotating elements with unbalanced mass which generates centrifugal type harmonic vibrations on the machine.

Vibrations have been applied in various aspect of life such as in microphones, speakers, electrocardiogram, immersion vibrators, compactors, washing machines, electric toothbrush, dentist drills etc. In school laboratories where titration experiments are carried out, learners with physical disability of hands are always disadvantaged as they cannot mix solutions by grasping and manipulating apparatus involved such as conical flasks and burettes that requires simultaneous manipulation effectively. In such case where solutions require mixing, mechanical vibrations can be integrated to serve this purpose. Vibratory system comprise means for storing potential energy (springs) means for storing kinetic energy (mass or inertia) and means by which the energy is gradually lost(damper). Ribeiro et al, 2006, argues that in a dynamic modeling of a structure, machine, suspension etc., often has to incorporate some kind of damping, in order to simulate adequately and accurately the real behavior of a system.

Vibrations of a system involve the alternating transfer of energy between its potential and kinetic energy forms. This results to a vibrating object moving to a certain maximum distance on either side of its stationary position. As a mechanical system vibrates, it does so on degrees of freedom which refers to number of independent displacement or rotations that specify completely displaced or deformed position and orientation of a body or system. Vibrations can be introduced into a system in which they would not naturally occur, (Graham 2011). Where the vibrations are initiated by an initial energy present in the system and no other source in present the resulting vibrations are called free vibrations. But if vibrations are caused by an external force or motion the vibrations are called forced vibrations (Singiresu, 2011)

Forced vibrations results to production of a restoring force which acts to bring a body back to its equilibrium position. The restoring force is a function only of the position of the mass or particle

and it's always directed back toward the equilibrium position of system. This is the force that tends to restore a system on parts thereof to equilibrium after displacement. Restoring force pushes the mass back towards its equilibrium position causing it to accelerate backward. Repeated forward and backward motion of a body results to production of oscillating vibrations with a certain frequency of varying amplitudes. A vibrating object moves to a certain maximum distance from its equilibrium on either side. This is called amplitude which determines the intensity of vibrations.

3.0 Methodology

This involves experimental approach in scientific study of the production of determinstic vibrations that aids in mixing of the solutions.

3.1 Requirements

3.1.1 Apparatus

1. 21cm*21cm*2cm Medium-density fibreboard (MDF).
2. 16.5cm*16.5cm*0.5cm playwood.
3. 4 spiral springs, 5.5cm long & 2.3 cm diameter.
4. 4 cork stoppers, 2.3 cm in diameter .
5. 1, 12v DC brushless fan.
6. 1, 4Ω magnet.
7. A cylindrical 100g metallic body weight.
8. 12v rechargable battery.
9. 5 m black and red coated copper connecting wires.
10. A switch.
11. 50Ω variable resistor.
12. Conical flask base holder.
13. 250ml conical flask.
14. 25ml pipette.
15. Pipette filler.
16. 50ml burette.
17. Super glue.
18. Spray paint.
19. 21cm*21cm*0.5cm polyurethane foam material.

3.1.2 Reagents

1. 150cm^3 of 0.1M ammonium iron (ii) sulphate solution.
2. 150cm^3 of 0.02M acidified pottasium permanganate solution.

3.2 Procedure

3.2.1 Procedure 1: Constructing Deterministic Kit

Medium-density fibre board was cut to size, then a polyurethane foam material was fitted on lower side of the MDF board to act as a damper. On the upper side of the board, four holes of diameter 2.3cm and 1.0 cm deep were drilled on the MDF board at length of 14cm and width of 14cm. Then, four spiral springs were fitted on the MDF board to make a multiple degrees of freedom system.

Four cork rubbers were fitted on top of each spring and the ply wood was mounted on them and fixed.

Then, a brushless fan was mounted on top and at the centre of the plywood. Wiring was done to connect it to the battery using connecting wires that were connected with a switch and 50Ω variable resistor.

Figure 3.1 : *Constructing DV kit*

A 4 Ω magnet was placed on top of rotating fan blades and fixed using superglue such that as the blades rotated, the magnet too rotated. After, a 100g metallic body mass was attached to the magnet. Then, the fan was switched on, and the adjustment of metallic mass on the magnet was done by increasing or reducing its radius distance from the center of origin of the magnet to induce centrifugal force until desired vibrations were produced. Finally, the conical flask base holder was mounted on the flame of the fan and fixed.

***Figure 3.2**: Conical flask base holder mounted on brushless fan*

3.2.2 Procedure 2 : Titration experiment

Twelve form 3 students, sampled in a class of 65 from Mt Kinangop girls secondary school, were involved in carrying out experimental titration practical. Each student carried out two separate redox reaction titrations. In titration one, titrant in the conical flask was shaken by one hand while the other hand controled the burette tap simulteneously. This was the control experiment. In titration two, the titrant in the conical flask was shaken using DV kit while only one hand was used to control burette tap.

3.2.2.1 Titration 1

Each student pipetted 25cm^3 of 0.1M ammonium iron (II) sulphate solution using a pipette and transferred it into a conical flask. Then, they filled burette with 0.02M acidified pottasium permanganate up to zero mark. They started titrating by controlling the burette tap with one hand and shaking the conical flask with the other hand simulteneously until the solution in conical flask turned permanently pink signifying the endpoint. They read the burette reading and recorded it in titration table below. Each repeated this experiment 2 more times and data collected averaged.

3.2.2.2 Titration 2

Each student pipetted 25cm^3 of 0.1M ammonium iron (II) sulphate solution using a pipette and transferred it into a conical flask placed on the conical flask base holder of the DV kit, then switched on the kit to shake conical flask content. Then each, sequentially, filled burette with 0.02M acidified pottasium permanganate up to zero mark. As the titrant in the conical flask was being shaken by the DV kit , each student, separately, started titrating by controlling the burette tap with one hand until the solution in conical flask turned permanently pink signifying the endpoint. They read the burette reading and recorded it in titration table below. Each repeated this experiment 2 more times and data collected averaged.

Titration	1	2	3
Final burette reading (cm3)			
Initial Burette reading (cm3)			
Volume used (cm3)			

***Table 3.1:** Titration table*

3.3 Data Collected

Number of titrations done	Averaged Volume (cm^3) for Control Experiment	Averaged volume (cm^3) while using DV Kit
1.	23.3	24.3
2.	26.6	26.4
3.	26.4	26.4

4.	24.5	24.3
5.	24.5	25.7
6.	26.6	25.5
7.	23.6	25.8
8.	24.4	26.6
9.	24.1	24.0
10.	26.3	26.1
11.	24.3	24.4
12.	24.5	24.2
Average Mean	**24.925**	**25.325**

Table 3.2: *Experimental data collected*

4.0 Data Analysis

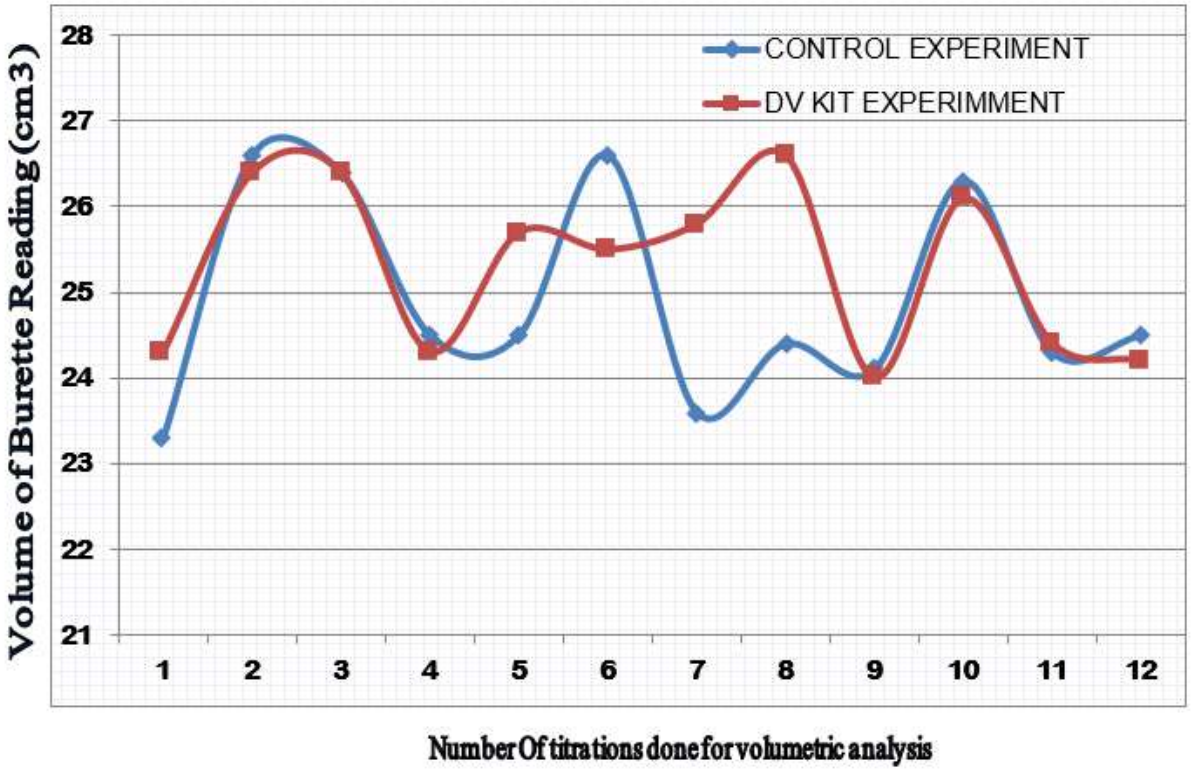

Figure 4.1. *Comparision of difference in averaged burette volumes obtained when the titrant in the conical flask was shaken using free hand and using DV kit .*

4.1 Discussion from the findings

From the data obtained, the average mean of 12 titrations for the control experiment carried out was 24.925 while the one obtained when DV kit was used was 25.325. The deviation of the average volume mean of DV kit experiments from that of control experiment was + 0.4. This meant that, since the control experiment average mean volume was treated to be the correct value, the DV Kit experimental average volume accuracy deviated by +0.4. In regard to this, using the average mean

of control experiment and that obtained from DV kit, it translated to a percentage error of;

$$\frac{(25.325-24.925)\times 100}{24.925} = 1.6048\%$$

From the percentage error calculated above, it's a clear indication that the DV kit was effective in shaking the titrant in conical flask during titration experiment with a margin error of 1.6048%. This was with reference to the burrete average volume obtained from shaking the conical flask using free hand which was the control experiment.

5.0 Conclusion

Liquids mix through vibrational, rotational and translational motions. If a body vibrates on a multiple degrees of freedom with less damping of energy, it results to production of vibrational amplitudes responsible in the mixing of solutions that are deterministic. The determinstic vibrator kit applies both principles of Newton's second law of motion(f=m.a) and centrifugal force(f=mwr). With reference to the second Newton's law of motion, when the mass of a rotating metallic body mounted on the fan was increased, the acceleration of the fan reduced hence increased force of rotation.As a result, the rotating mass acquired less kinetic energy. But ,when the mass of the moving body was reduced, its acceleration increased which resulted to the rotating mass acquiring more kinetic energy.When the distance of the rotating body mass was increased from its origin, the centrifugal force increased which resulted to reduced oscillational vibrational frequencies. This led to high amplitudes of the vibrating liquids resulting to the mixing of the solutions.

With application of the right knowledge and skills, the existing gap experinced by learners with physical disability of hands that affects them during titration experiments has been effectively bridged with the use of DV kit in shaking of a conical flask. Learners with special needs of physical disability of hands require adapted technology with respect to their disability for inclusive curriculum. Therefore,the teacher as innovator for the best practices in education has an important role in identifying and addressing barriers to learning engagement. In order to create an Inclusive learning space, it is important to recognize all students entitlement to learning experience that respects diversity, enables participation, removes barriers and consider variety of learning needs and preferences.

5.1 Recommendation

Physically disabled learners in Kenya face various learning challenges in their course of chemistry which is practical based subject. The learners are expected to manipulate apparatus during practicals .Learners with physical disability of hands are not in a position to carry out these practicals effectively.This acts as a barrier to inclusivity in chemistry learning .Therefore , its necessary to equip our school laboratories with special needs apparatus and systems that can assist special needs learners in their practicals.

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Article 8

Evaluation of Negative Ethnicity on Institutional Leadership in Public Secondary Schools in Kajiado County, Kenya

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Abstract

This study focused on assessing the influence of ethnicism on institutional leadership in public secondary schools in Kajiado County. The researcher was guided by the following objective: to assess the influence of ethnicism on institutional leadership in public secondary schools in Kajiado County, in Kenya. The researcher adopted the mixed research methodology and the concurrent triangulation design. The sample size comprised 25 principals, 25 deputy principals, 5 education officers and 185 secondary school teachers. The study employed the simple random sampling techniques and purposive sampling for selection of participants and stratified sampling techniques for selection of public secondary schools. Questionnaires and interview guides were used to collect quantitative and qualitative data. Quantitative data were analyzed descriptively and inferentially while qualitative data were analyzed thematically. The study concluded that, language as a channel of communication has created barriers and identities that has typically identified "others" as being different from "us", 'them" and "they". Language defines ethnicism and ethnic identities through "badges" such as ethnic screenings, coded language stereotypes communities use against each other, ethnic nepotism and sectionalism that are used for safeguarding ethnic interests. The researcher recommends transparency, fair treatment and meritocracy to be upheld at all times during the appointment, recruitment, selection, transfers and promotions of principals, teachers and support staff. The researcher further recommends the full implementation of the Teachers Service Commission (TSC) policy 2007 on identification, selection, appointment, deployment and training of heads of post primary institutions and the TSC policy (2017) on appointment and deployment of institutional administrators.

Keywords: *Ethnicism, ethnic identity, ethnic screening, ethnic group, institutional leadership.*

1.0 Background to the study

Globally, school principals are bestowed with duties such as administering the approved curriculum, managing school finances, staff supervision, teaching and school- community relation (Budohi, 2014). The role of school leadership rests on the principals as the leading professional. The school exists to meet the demands of the society while the cultural values of a community give it an identity of its own (Wachira, 2012). Leadership dynamism in education provision has posed a great challenge to the whole world (Musyoka, 2018). Schools in Africa operate in different philosophical backgrounds since the African background is different from the schools in developed countries. There are also leadership dilemmas in Africa given that cultural diversities influence school leadership (Ssekamwa, 2001). The traditional cultural dynamics dominates and continues

to control how people think, talk, behave, interact and also determines what one opposes or supports (Adeyanyu, 2014).

In Kenya, the cultural diversity of human beings has been one that involved the interaction of various communities for hundreds of years. The importance of culture lies in the fact that it is a link between people and their valuable systems, which might vary from society to society. The traditional and cultural foundation of the communities around the schools can determine the institutional leadership. While culture dictates the way of life, education shapes the life of an individual (Wachira, 2012). Hence, culture and education should run in harmony.

In Kajiado County, allegiance to culture and traditions has played a significant role in influencing the nature and composition of principalship in each particular public secondary school (Purdul et al., 2016). Localization of appointments, promotion, recruitment and deployment of principals and teachers according to tribal and ethnic group interests is a reality in Kajiado County. As a result, principals are being faced with many ethical and institutional challenges in the running and management of their schools. When personal or group interests are promoted or favored in public institutions or schools, the overall objectives of the existence of such institutions or schools are compromised and manipulated to suit individuals or ethnic group motives.

According to Abdalhadi (2013), people become engulfed within their ethnic groups to advance their goals and vindicate their interests. "People" put "teachers" and "principals" without thinking whether such a person is fit to deliver. Hence, when other people do come in and work amidst different ethnic groups from the one they belong, they find themselves strangers who are apparently branded as 'out-groups' or 'out siders'. The culture and traditional customs continue to dominate the social standing of the Maasai people that thrive on the assumption that if school leadership and work force is not from their tribe, clan or ethnic group, then it does not benefit the school and the community at large. When recruiting professionals like teachers, issues such as acquaintances, ethnic/family associations, tribal markings, ethnic groupings, ethnic screenings, territorialism and godfatherism should not be encouraged at the expense of qualifications, meritocracy and transparency.

1.1 Statement of the Problem

In spite of the concerted efforts by the Teachers Service Commission (TSC) to identify, select, recruit, appoint, promote and install principals and teachers, and the Ministry of Education (MOE) role in the education sector, effective institutional leadership still seems to lack in public secondary schools in Kajiado County. This is evident from the nature of influence the external and internal social environments has over the public secondary schools. Allegiance to culture and traditions has played a significant role in influencing the nature and composition of leadership in each particular public secondary school in Kajiado County. Since schools are closely linked to the society, kinship and personal relationships are used to limit opportunities for those deemed as outsiders. Ethnicism has thus brought unwarranted ethnic screening of people, ethnic territorialism and regionalism, which has affected the governance, and administration of the public secondary schools.

Evidence from public schools shows that the Board of Management (BOMs) and Parent Teachers Association (PTAs) influence institutional leadership and has affected the recruitment, promotion, appointment and posting of teachers within Kajiado County. A study by Thinguri & Kengere (2019) established that, most BOMs are based on clanism, ethnicism, cronyism, nepotism or political and religious inclinations. As a result, the composition of principals, deputy principals, teachers and subordinate staff in the public secondary schools heavily relies on which tribe, ethnic group, who knows whom, which geographical region one comes from as well as the incumbent political leaders. There is very little evidence of research done to investigate the influence of ethnicism on institutional leadership in public secondary schools in Kajiado County. This study strived to fill that knowledge gap.

1.2 Objective of the Study

To assess the influence of ethnicism on institutional leadership in public secondary schools in Kajiado County, in Kenya.

2.0 Literature Review

2.1 Institutional leadership and principalship

In Africa, school principals should primarily be a professionally trained teacher who has experience in classroom instruction. Africans by nature are tribalistic. The cultural issue is one that is traditional and has been held by most African tribes in high esteem for many years. According to Aquiline (2007), ethnic identity is one of the most difficult concepts to grasp and one of the most essential in understanding Africa. Many people in Africa at large are not ready to forsake their tribal allegiance because it has been a rivalry that has existed since time immemorial. Many people (teachers included) are presently comfortable when inside and being surrounded by their tribal and ethnic cocoons. In turn, the influence of ethnicism has infiltrated institutional leadership in the public secondary schools. In Africa, persons without the required professional managerial and leadership skills manage some secondary schools (Musembi, 2016). Hence, fighting ethnicism is like fighting against the indigenous cultures and traditions of the people.

In Kenya, principalship in public secondary schools has taken ethnic and tribal dimensions. A study by Ombanda (2018) found out that, 61% of organizations in Kenya whether public or private have a cultural inclination of tribe by show of mother tongue or regional inclination. According to Ondieki (2011), the emergence of ethnization has introduced new and untold challenges to the traditional authority of secondary school principals. Some school leaders have been executed mercilessly by the unforgiving society through condemnation, blame and harsh judgement for their internal failures leading to their resignation, transfer or demotion (Kiongo & Ruth, 2014). Many institutional leaders fail to see the strength of a multi-ethnic society. Ethnicity gaps continue to exist and widen whereas minorities continue to be greatly underrepresented in the teaching profession and other upper leadership positions within the education sector.

A principal, being the driver and captain of leadership in the institution will never fail to have diverse enemies amongst parents, students, colleagues, politicians and local community members

(Kiongo & Thinguri, 2014). A study by Moraa et al (2017) found out that, the area Member of Parliament (MP) or local authorities appointed 61.9% of the BOMs and PTAs with the highest percentage being selected right from within the school community. Politicians and godfathers (influential relatives) influence such appointments so that a person of their choice can be appointed. A school is as good as its board of management (Kengere & Thinguri, 2019). People believe that if one of theirs holds a high post, it is held in trust for the benefit of the ethnic community (Aquiline, 2007).

In Kajiado County, public secondary schools institutional leadership has become moving targets and goals to favour and suit certain individuals, tribal and ethnic group interests. Principals do not have control of events that take place in the community, which affects the learning process in the school. A study by Ongeri (2013) found out that majority of BOMs in Kajiado County lack adequate supervisory competencies because they have not been exposed to management training. As such, the ever-changing community demands on the school according to Greenfield (1990) in Ondieki (2011) are one of the major causes of uncertainty in schools. The challenges of the 21st Century in the educational sector demands a professional education administrator who will be able to face new experiences, initiate actions, avert crisis, resolve difficulties, overcome obstacles and make significant positive contribution to the national development (Oluremi, 2013). As a result, principals must be ready to handle critical incidents that typically occur with little or no advance warning that have found their way into schools.

2.2 Ethnicism on institutional leadership

Traditionally, ethnicity constituted a fundamental feature of the society and that ethnic identity was natural and unalienable. In Africa, one is born with ethnicity (Yieke, 2010). The continent of Africa is multi-ethnic. Most African nation states are multi-ethnic owing to the historical circumstances that led to their birth (Idang, 2004). In Africa, ethnicity is such a strong power that can even move mountains. Ethnicity thus defines individuals who are believed to share general characteristics that distinguish them from the other collectivities in the society. Ethnic groups constitute a natural social unit through which people identify with when they are acting in certain competitive situations. Ethnicity according to Yieke (2010) is a tool to fight for the social interest of group members. Felicia and Akuva (2013) further assert that, ethnicity is the deliberate and consciousness of tracing of one's identity to a particular ethnic group and allowing such feeling to determine the way one relates with people and things. In Africa, people can be seen as belonging to ethnic groups, which define their identity and distinguish them even within the context of the African continent (Idang, 2014). According to Aquiline (2007), many African nations have failed to change ethnic identification in favour of the national identity without undermining the diversity of ethnic identities. Hence, ethnic identity becomes harmful when it is manipulated for self-interest.

Kenya being a multi-ethnic society has over forty ethnic communities who have been living side by side for very many years until recently when the dominant ethnic groups versus the minority ethnic group gap has become increasingly visible (Aquiline, 2007). Martin (1999) attests that

members of an ethnic group see themselves as a community, maintaining the feelings of 'we' (group members) as opposed to 'they' (non-group members). Negative ethnicity has made Kenyans to look at themselves as belonging to "this" ethnic community and not the "other" ethnic community (Yieke, 2010). Language, culture and society are inter-related and inseparable. Language is the visible part of culture, which serves a very good role in defining group identities and has been used as a medium for identifying the "self", "us" and "we" from the "others" and "they". The lack of channels of communication has typically identified others as being "different" from "us", thus making language a prominent factor in defining ethnicity and ethnic identity (Yieke, 2010).

Ethnicity focuses more on sentiments of origin and descent rather than geographical consideration of nations (Felicia & Akuva, 2013). Ethnic demarcation and regionalism has been promoted by ethnic leaders thus creating ethnic discrimination, which then labels non-ethnic members as 'foreigners' or 'strangers' (Aquiline, 2007). Each ethnic group wants to have its own education officers, principals, teachers, and deputy principals to head their schools. According to Sussy et al (2012), ethnicity has assisted many to get good jobs, promotion to higher positions or grades, career advance and so on. The TSC formulated a policy on appointment and deployment of institutional administrators (2017), however it is hard to prove that the selection and appointment procedures by the TSC are watertight and fool proof from any influence of ethnicism bearing in mind that culture is the part of the fabric of every society, which shapes "the way things are done".

In Kajiado County, ethnicism has continued to sideline and discriminate many deserving principals and teachers to-be during recruitment, promotions and appointment to leadership positions in public secondary schools. Ethnic identities acts as a pole around which members of the Maasai ethnic groups and tribal sections are mobilized and made to compete effectively for power, resources and leadership positions against other ethnic groups that have in-migrated and settled in Kajiado County. According to Musyoka (2018), devolution of education moved decision making closer to people giving them greater say in education decision. Devolution has also been linked to increased ethnicism in Kajiado County as people fight for "what belongs to them". This has largely been fueled by competition over scarce resources due to in-immigration by non-ethnic Maasai groups and clan networks quest for leadership positions.

Ethnicism affects the allocation of resources; some regions are allocated more resources than others (Felicia & Akuva, 2013). Ethnic demarcation and regionalism, as promoted by ethnic leaders revolve around the practice of ethnic discrimination (Aquiline, 2007). The Maasai community has managed to retain much of their traditional culture despite the challenges from processes such as globalization and modernity (Allison, 2013).

3.0 Research methodology

The study adopted the mixed approach of research (Tashakkori & Teddlie, 2003) and the concurrent-triangulation design. Both quantitative and qualitative approaches were used in data collection by use of questionnaires, interview guides and document analysis checklists. The sample

size comprised 25 principals, 25 deputy principals, 5 education officers and 185 secondary school teachers. The study employed the simple random sampling techniques and purposive sampling for selection of participants and stratified sampling techniques for selection of public secondary schools. Quantitative data were analyzed descriptively and inferentially. Descriptive statistics were analyzed using frequencies, percentages, means and standard deviations and reports presented using tables. Inferential statistics were analyzed using multiple regressions and presented in tables. Qualitative data were analyzed thematically and presented in narrative form and quotations.

4.0 Research Findings and Discussions

4.1 Discrimination of people by looking at the dress, dialect or tribal marks

Ethnic demarcation, territorialism and regionalism have promoted ethnicism which in turn has led to the labeling and discrimination of people. This has denied many people their rights to equality and equal opportunities as shown in Table 1.

Table 1: *Discrimination of people*

Responses	***f***	**%**
Strongly agree	40	30.3
Agree	53	40.2
Disagree	19	14.4
Neutral	9	6.8
Strongly disagree	11	8.3
Total	**132**	**100**

Table 1 shows that, overall, 93(70.5%) of the teachers agreed that a person can discriminate another person without uttering a single word by simply looking at the dress code, language or tribal mark while 30(22.7%) disagreed. 9(6.8%) of the teachers chose to remain neutral. Samuel (2016) posits that ethnicity involves displaying sentiments of bias to a special set of group one belongs to. The implications of this findings are that ethnicism has assisted many to get good jobs, promotions to higher positions or grades and career advances as pointed out by Sussy, Abwire and Simon (2012). However, many deserving individuals have also missed opportunities because of the negative effects of ethnicism.

4.2 Ethnic identities

Ethnic identities is significant in the mobilization of tribes and ethnic groups to compete effectively for resources and leadership positions against other ethnic groups as presented in Table 2.

Table 2: *Ethnic identity*

Ethnic identity	***f***	**%**
Strongly agree	26	33
Agree	44	33
Disagree	37	28
Neutral	14	11

Strongly agree	11	8
Total	**132**	**100**

Table 2 shows that, overall, 70(53%) of the teachers agreed that ethnic identities such as families, clans, language, territory and ethnic groups play a major role in the selection, promotion and recruitment of principals and teachers. However, 48(36%) of the teachers disagreed whereas 14(11%) of the respondents remained neutral. Literature demonstrates that ethnic identity be it in urban or rural has remained a powerful force to reckon with and it cannot be suppressed by the state. It may also implicate negatively on service delivery. These findings imply that ethnic identity should be made unalienable.

4.3 Language and ethnicism

Language is linked to ethnic identity as it serves a very good role in defining a groups' identity. Language identifies others as being different from us presented in Table 3.

Table 3: *Influence of language on ethnicism*

Responses	***f***	**%**
Strongly agree	31	23.5
Agree	60	45.5
Disagree	27	20.5
Neutral	8	6
Strongly agree	6	4.5
Total	**132**	**100**

Table 3 shows that, overall, 91(69%) of the teachers agreed that language has been linked to ethnic identity where it is used to define individuals as "us" "we" from "they" and "them". Overall, 33(25%) of the teachers disagreed. Language clearly plays a significant role in identity construction and is probably the most powerful symbol of ethnicity. In a study conducted by NCIC in 2012, it was revealed that all communities used coded language and stereotypes against each other. These codes and stereotypes further widened the ethnicism gap between communities.

4.4 Ethnicism in Kajiado County

Ethnicism can be a convenient resource that can be exploited for selfish purposes. The influence of ethnicism poses challenges to principals as shown in Table 4.

Table 4: *Views of teachers on the influence of ethnicism in Kajiado County*

Ethnicism in Kajiado County	***f***	**%**
Getting worse	79	60
Remain unchanged	16	12
Has improved very much	12	9
Slightly improved	25	19
Total	**132**	**100**

Table 4 shows that 79(60%) of the teachers indicated that the influence of ethnicism in Kajiado County it is getting worse, 25(19%) said it has slightly improved while 16(12%) said it has remained unchanged. Only 12(9%) of the respondents said it has improved very much. According to Samuel (2016), ethnic groups are informal interest groups whose members are distinct from the members of other ethnic groups within the larger society because they share kinship, religious and linguistic ties. People believe that if one of theirs holds a high post, it is held in trust for the benefit of their ethnic community (Aquiline, 2007). These findings imply that ethnicism and power exists in a symbiotic relationship each depending on the other.

4.5 Positive effects of ethnicism

Ethnicism has positive qualities that can be exploited and its potential used to serve the interests of the public secondary schools as presented in Table 5.

Table 5: *Views of principals on the positive effects of ethnicism*

Responses on positive effects of ethnicism	***f***	**%**
Cohesion and integration	2	10.5
Resource for national development	1	5.3
Formation of government	5	26.3
Creates diversity	11	57.9
Total	**19**	**100**

The results in Table 5 show the views of the principals on the positive effects of ethnicism. 11(57.9%) of the principals admitted that ethnicism creates diversity with 5(26. 3%) indicating that it is useful in the formation of government. 1(5.3%) of the principals admitted that ethnicism is a resource for national development. According to Samuel (2016), ethnicity is one of the phenomena associated with interactions among communal groups (ethnic groups). As a result, ethnicity makes it very difficult for different ethnic groups to agree on anything. This sentiment implies that if ethnicism is embraced, it is a powerful ingredient for the creation of diversity, however if manipulated wrongly it can be a major cause of discrimination and territoriality.

To verify the possibility of the influence of ethnicism on institutional leadership in public secondary schools' data was collected from secondary school teachers. The statements used were meant to verify the presence of ethnic screening during recruitment and whether ethnicism influenced institutional leadership in public secondary schools. The results are depicted in Table 6.

Table 6: *Statistical measurement on the influence of ethnicism on institutional leadership*

Dependent variable: Institutional leadership		
Regression statistics		**Model 1: Ethnic screening**
Predictor: Ethnicism	R	.701
	R-squared(R^2)	.491
	Adjusted R squared(R^2)	.487
	Beta β	.701
	p-value	.000
	Standard error of estimate (E)	.35613

Constant	7.781

Model 1 in Table 6 portrays results of a simple linear regression analysis on the perception of ethnicism (predictor) on institutional leadership in public secondary schools in Kajiado County. The Pearson's R=.701 indicates that there was a strong positive relationship between ethnicism and institutional leadership in public secondary schools in the study locale. The R-squared (R2) computed yielded a value of .491 suggesting that ethnicism explained 49.1% of the variations in institutional leadership in public secondary schools in Kajiado County, with 50.9% being explained by other factors not included in the model. The p-value computed by SPSS yielded a value of.000 which is less than the significance level of p<.001. This led to the conclusion that there was a statistically significant relationship between ethnicism and institutional leadership in public secondary schools in Kajiado County.

Further analysis of qualitative data collected from principals revealed that ethnicism greatly influences institutional leadership. One principal from a boy's secondary school admitted that ethnicism affects service delivery. According to him, ethnicism breeds laxity for those with influential relatives or "godfathers". He reported that: "Disciplining colleagues from the same ethnic group or those with influential people becomes a problem. Some members of staff are untouchables" (P10,18 May 2017)

From the foregoing quotation, it is apparent that the tendency to manipulate ethnic identities has prevailed in many secondary schools in Kajiado County. According to Yieke (2010), ethnicity is a tool to fight for the social interest of group members. Similar responses based on the interviews with the principals supported the view that locals want to have their "own principals" and "teachers" as echoed by another principal who explained that: "It has created biasness where some people are labelled as strangers or an outsider. Ethnicism is like an identity tag which one carries with him/her everywhere. You will always be exposed by your language the moment you speak." (P04, 24 May 2017). Similarly, another female principal who confessed to have been a victim of the post-election violence of 2007 admitted to ethnicism breeding hate and insecurity due to tribal clashes. She was quick to state that: "I hate ethnicism because I was forced to relocate during the post-election violence of 2007. Now I come from a cosmopolitan County and I am settled." (24 May 2017).

From the foregoing comments, it is true to say that because of negative ethnicity, people continue to view themselves as belonging to "this" ethnic community and not the "other" community (Yieke, 2010). In addition, the research further revealed that some tribes intimidate others. According to one Maasai principal, he reported that: "Other tribes are fond of taunting the Maasai by looking at them as primitive due to their culture." (26 May 2017). One Education Officer complimented the above sentiments by saying: "There are stereotype attitude towards certain tribes in Kenya." Review of related literature demonstrates that through ethnic discrimination, non-ethnic members are labelled as "foreigners" or "strangers" (Aquiline, 2007).

5.0 Conclusion

The study concludes that, language as a channel of communication has created barriers and identities that has typically identified "others" as being different from "us", 'them" and "they". Language clearly plays a significant role in defining ethnicism and identity construction through "badges" such as ethnic screenings, coded language stereotypes communities use against each other, ethnic nepotism and sectionalism are used as markers of group membership and to safeguard ethnic interests. Ethnicism and power exists in a symbiotic relationship each depending on the other. The way out of negative ethnicism is to embrace ethnic diversity, citizenship and respect of other people's culture, while at the same time casting out individualism, mediocrity, self-interest and ethnic divisions.

5.1 Recommendations for practice

Arising from the findings of the study, the researcher recommends that, efforts should be made to ensure transparency; fair treatment and meritocracy are upheld at all times during the appointment, recruitment, selection, transfers and promotions of principals, teachers and support staff either by the TSC and the BOMs. In addition, modernisation and education should be used to protect and preserve the culture and useful indigenous knowledge from our communities.

5.2 Recommendation by policy

Arising from the findings, the researcher recommends the full implementation of the 2007 policy on identification, selection, appointment, deployment and training of heads of post primary institutions by the TSC. It is vital for TSC to identify, appoint and train the right people to head institutions. The researcher further recommends the TSC policy (2017) on appointment and deployment of institutional administrators as contained in circular No.1 of 2020 should be executed to the latter.

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Article 9

The Place of Climate Change in The Practical Teaching of Climatology: Need for A Mini-Meteorological Station for Educational Use At ISP-Gombe/Kinshasa DRC

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Abstract

The Higher Pedagogical Institute of Gombe (ISP/Gombe) trains qualified teachers in Applied Pedagogy in the secondary cycle in Kinshasa. It dumps hundreds of professionals annually. Among its 16 Departments is that of Geography-Environmental Management (GGE) whose finalists will be geography teachers for whom knowledge of climatology remains essential. Three courses related to climatology are included in the program of the GGE option: (i) General physical geography; (ii) Applied Climatology; and Eco climatology. The program of the teachers' lessons provides for a large hourly volume of practical work, observations of climate-related phenomena and manipulations in a meteorological station. The guided tour with the students in the facilities of the METELSAT center in BINZA constitutes the only experience of manipulation and learning outside the auditoriums. The under-equipment of the department with a device for measuring the elements of the climate does not allow teachers to properly carry out the practical part of their program. Such is the case of the General Climatology course which provides for samples, calculations and field observations, which are difficult to achieve. Our work, consisting in demonstrating the predominance of theory over practice in the teaching of climatology, is based on analytical and bibliographic methods, supported by documentary and interview techniques.
Hence, we recommend the establishment of a mini-meteorological station for didactic use in the courtyard of the ISP/Gombe. At the end of this text that is to say at the conclusion, we specify what we propose to resolve the lack of a mini station in schools. Readers will find the significant date scope, main findings and recommendation in the final part of this research. Teachers will attend capacity building and refresher workshops. This research proceeded by compiling date from exclusion and guided tours as well as interviews with those in charge.

Keywords: *Learning, Theoretical teaching, Eco climatology, Applied climatology and Meteorological station*

1.0 Introduction

Climate change is a problem that concerns us all in the world. This change can gradually lead to the destruction of the planet and only we can prevent this catastrophe from happening. In this space you can find all kinds of information on the subject of climate change, the causes, the consequences and all kinds of details to be informed. the problem statement is the lack of meteorological observation equipment which makes the teaching of climatology difficult. the approach to conducting our study is analytical. We cannot forget that every little grain of sand can be a big step

towards improving our planet and in this space, you will be able to find the information necessary to contribute to this change. We must be aware that we are putting our planet at risk and that each of us can contribute to improving it.
(https://www.meteorologiaenred.com/fr/Catégorie/changement-climatique).

Education is key to promoting climate action. It helps people understand and combat the effects of climate change, equipping them with the knowledge, skills, values and attitudes they need to become learners of change. The international community recognizes the importance of education and training in dealing with climate change. The United Nations Framework Convention on Climate Change, the Paris Agreement and the related Action for Climate Empowerment program call on governments to empower all stakeholders and important groups with education and the means to take action and invest in climate change policies and actions.

UNESCO is working through its Education for Sustainable Development Programme, to make education a more central and visible part of the international response to climate change. The Organization, which acts as a global advocate for Climate Change Education (CCE) and intends to strengthen the capacity of governments to ensure quality CCE, generates and shares knowledge. It provides its Member States with advice on policies and technical support, and implements projects on the ground. UNESCO promotes innovative approaches and strengthens non-formal education programs through media, networks and partnerships. Climate action is one of the key thematic priorities of "Education for Sustainable Development 2030", the global framework for education for sustainable development for the next ten years. (https://www.unesco.org/fr/education/sustainable-development/climate-change).

Through its Education for Sustainable Development Programme, UNESCO is working to make education a more central and visible part of the international response to climate change. Based on the recommendations by UNESCO to promote educational competence in schools and academies on climate change education, the way of working must change. The Higher Pedagogical Institute of Gombe, has agreed to inculcate and teach students the right methods and techniques to enable them solve problems related to climate change.

- How to teach climate change?
- What are the contents that can teach students?
- What are the methods and techniques that can be useful, necessary and appropriate for experimentation and clear, clear and understandable transmission for students?

1.1 Purpose of our research

The general objective pursued in this research is based on the creation of a space for the learning and application of STEM outside the School. Mini Climatological Station for didactic use in the institutions and universities with climatological courses will be established.
Apart from the General objective, the specific objectives that accompany it are to:

- Make the teaching of climatology and climate change more practical;

- Set up a mini-meteorological station for didactic use at ISP-Gombe;
- Multiply the activities outside the audiences by taking samples and manipulations in the mini-meteorological station;

  List the number of scientific excursions carried out at the Department of Geography-Environmental Management at Isp-Gombe from the 2002-2003 academic year to the 2021-2022 academic year to demonstrate the insufficiency of field activities in outside the audiences.
- Make available to the authorities of Isp/Gombe and potential donors the assembly elements of a mini climatological station for didactic use and demonstrate to them its importance in the training of students in the geography and environmental management sector.

2.0 Methodology

How did we solve the problem of the absence of a mini educational weather observation station? It is using the methods and techniques below:

2.1. Methods and techniques

The methods of observation over a long period associated with the analysis of the statistics table of excursions as well as the comparison helped us to resolve the identified problem.

Through the courses of applied climatology and Environment, the methods and techniques clear and understandable for the students, being able to be useful, necessary and appropriate for the experimentation as well as the transmission, we thought of using the methods and techniques below:

a. Historical, analytical, experimental, observation over a long period, location, description, theoretical transmission and application method.

b. Techniques: observation, documentary, audio and visual video, photography (images), interview, excursion and scientific visit to real sites. We used ICT equipment such as computers, projectors, CDs, USB keys, telephone, works, Connection.

3.0 The place of climate change in the practical teaching of climatology

To better teach climate change, teachers need to identify the key points of climate change education and illustrate them. This can be done through games, education for sustainable development (online games and cards), videos and pictures. Sites for a good experience within the school can be created (e.g. a mini-garden for practice, assembly of a mini climatological station for didactic use).

The contents that we can teach to students: case of the Geography Management of the Environment sector at the Higher Pedagogical Institute of Gombe. Regarding the Content, they must be based on the resources of the Office for Climate Education; the animation will be the moment to address the key points of education for sustainable development, in particular on the theme of the climate. It will also make it possible to discover resources and to consider their organization for educational purposes, in schools as well as in universities and colleges. (OCE workshop with Canopé: Tools to teach climate March 29, 2022).

4. Importance of theoretical knowledge on climatology: Review of the literature

It is in this part of the research, the analysis of the collective work of the experts of the SADC (Southern African Development Community) worded as follows: Basic work on teaching the concept of climate change in the education systems and teaching programs of SADC countries; "Godwell Nhamo and Soul SHAVA: Climate Change education in the SADC Schok Curriculum". From page 13 to page 282, the authors present under the title: "climate change education in Seychelles, South Africa, Swaziland, Tanzania and Zambia", the place of theoretical lessons on Climate Change in education systems and curricula. Education in the SADC member countries.is about the natural climatic context. Five other SADC countries feature in the collective work which summarizes a very detailed analysis of good practice in curriculum innovation and reform in Botswana, Lesotho, Malawi, Mauritius and Namibia. The cases of the last three countries, including Angola, Mozambique and the Democratic Republic of Congo, appear in the experts' study as points of view on the existing situation.

The result of this collective dissertation is a verified assertion: "the fight against global warming is underpinned by an awareness based on the achievements of a teaching of the theoretical growths integrated into the various teaching programs of kindergarten, university, primary and secondary school. (Godwell N. and Soul S., 2015).

5. Creating a space for STEM learning and application outside of school and audiences: A mini climate station for educational use

After having inspected on the ground, in the universities related to the sectors concerned, we found no space for the learning and application of STEM outside the School.

5.1 Importance of a mini weather station and descents on the ground

The acquisition of a mini meteorological station for essentially didactic use is a prerequisite for the quality of teaching and learning outside the school. The field trips and the taking of measurements of temperature, precipitation, humidity and wind direction strengthen the capacities of learners. These as future secondary school geography teachers will introduce their students to various measurements and manipulations. The evaluation of the number of outings carried out at the Department of Geography - Environmental Management will also be analyzed.

This article responds to the theme of the 19th COMSTEDA from the perspective of learning outside of school and audiences. Hence the presentation of the state of need for the assembly of the mini meteorological observation station for financing by potential donors (partners of the 19th COMSTEDA). The two tables below are numerical indicators of the importance of field trips, experimentation and manipulation. The second table indicates the location of a mini meteorological observation station as well as the costs of its installation

Number of excursions to the Department of Geography-Environmental Management at ISP-Gombe from the academic year 2002-2003 To the academic year 2021-2022

Table 1: *number of excursions made to the department of GGE from 2003 to 2021-2022*

Number	Academic Years	SITES
1.	2002-2003	Kongo central
2	2004-2005	Kongo central
3	2008-2009	Isp/gombe/ climate day
4	2009-2010	Kongo central
5	2010-2011	Kongo central
6	2011-2012	Kongo central Kinshasa/metelsat Kinshasa/regideso
7	2012-2013	Kongo central
8	2013-2014	Kongo central Kinshasa/regideso Bandundu/kikwit
9	2014-2015	Kinshasa/igc Kinshasa/Botanical garden Kinshasa/igc Kongo central/Kimpese
10	2016-2017	Kongo central
11	2017-2018	Kongo central
12	2018-2019	Kongo central
13	2020-2021	KINSHASA/METELSAT KONGO CENTRAL
14	2021-2022 -	REGIDESO visit; -The visit of the Botanical and Zoological Gardens; -exit from Pool-Malebo with the students of L1 old system, -The outing of Pool-Malebo with the students of L1LMD/GGE.

Data source: *GGE department report, 2022*

The table above clearly explains that the Department of Geography-Environmental Management at ISP-GOMBE organized 25 scientific outings from 2002 to 2022.

The third and final recommendation addressed both to the authorities, to potential donors and to the staff of the 19th COMSTEDA and SMASE is to support the installation of a mini-meteorological station for didactic use on the ISP campus. /Gombe.

Below is the indicative table for this purpose.

Table 2: *The elements the components of a mini - service station*

N°	Components	Uses	Cost/Budget Usd
1	rain gauge	measures rainfall;	500
2	Hygrometers	Measure humidity	500
3	ground recording thermometer	temperature and humidity measurement;	500
4	electrical resistance thermometer		500
5	bimetal	The most modern. used by electronic circuits	500

	thermometer	to convert small voltage variations obtained into numbers. This way the recorded temperature will appear on the screen	
6	Digital thermometer		200
7	alcohol thermometer		300
8	mercury thermometer	It is a sealed glass tube with mercury inside. This instrument was invented by Gabriel Fahrenheit in 1714	500
9	Anemometer	direction measurement	1000
10	manometer.	measurement of fluid pressure. also measured a reference pressure, usually atmospheric pressure.	1000
11	Weathercock	measures wind speed;	500
12	Weather balloons	provides indications of the strength and direction of the wind depending on the altitude.	500
13	a heliograph	measurement of sunshine.	500
14	Mercury barometer measuring atmospheric pressure		1000
15	Weather radars	determine the location and distance of an object by the time it takes for a centimeter or decimeter light wave to travel the distance that separates the transmitting-receiving antenna from the object reflecting it	2000
16	weather satellites	the environmental study satellite in geostationary orbit sees almost half of the Earth!	5000
17	snow gauge	measure the amount of snow that has fallen at a given time	1000
18	Laser manometer		2000
19	Acoustic Manometer		1000
20	Solar panel		3000
TOTAL			22.000

Sources of funds: own funds (self-financing), partner and donors.
Data source: *search for authors (compilation)*

6.0 Recommendations

The first recommendation remains institutional: it concerns the involvement of all stakeholders. After having briefly explained and clarified our contribution to the world to solve the climatological problem mentioned in this document so high, we take this opportunity to propose

through the conference which launched this call: (COMSTEDA, as well as the three other structures SMASE, AFTRA and U.A) as well as the United Nations, of: take into account our concern in wanting to train the Congolese child, in particular, and those of other countries in general with methods and techniques appropriate to their respective sectors; help the Institution with several new collections of scientific works related to climate change and climate change; help students to make scientific tourism in relation to their program of climatological, geographical and environmental courses (Scientific excursions), also carry out some visits to Reforestation sites such as: Mount Ngaliema: (Nursery of the billion tree initiative), Notion of MEDD, (embellishment of Boulevard LUMUMBA through reforestation and anthology.) Descent to the FFN (National Forest Fund) and ERASFNGOs (IBI village: carbon sink).

By highlighting scientific excursions and visits, we will teach students about good initiatives to fight against global warming through different supports. State universities such as (ISAV, ISP/Gombe, ISTA, UNIKIN and UPN) who have the following courses: Agronomy, Environment and Geography NGOs (through Reforestation services) and companies and industries…technical development partners of all that has just been stated above, the Department of Geography Management of the Environment (GGE) of ISP/Gombe, remains the crucible of future Geography teachers capable of explaining the realities of climate change to secondary school students following practical training in general climatology, eco-climatology and applied climatology.

The second recommendation concerns the organization of excursions, visits and scientific trips with a view to making the teaching of climatology more practical outside the auditoriums.
The table below, for information purposes, gives the cumulative listing of these descents from the field. A classic case of insufficient learning outside of audiences.

7.0 General Conclusion

From the above, the authors have just subscribed to the logic of the 19th COMSTEDA which aims to develop the assailant profession in STEM/STIM; in this case, the research was conducted on improving the teaching of climatology through activity outside of school and audiences in schools, we suggest that students spend their practical work at the min meteorological station. The installation of a meteorological observation station for didactic reasons remains a necessity at ISP-GOMBE. Research with a didactic scope whose significant data are summarized by the subject of physical geography in the current program. The main results we reached are: the low scores of climatology evaluations and the non-existence or absence of manipulation. The funding request is aimed at potential partners interested in STEM/STEM education. In conclusion, the establishment of a mini weather observation station is a necessity. Three main recommendations at the end of this communication, namely: increase financial resources, i.e., the budget allocated to the geography department, set up a bankable project which will be financed by own resources, by partners and donors; Finally, to erect a mini weather observation station to capitalize on the practical sessions with teacher refresher training.

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Article 10

Directory of women scientists from the DRC in STEM and identifying visible impactful innovations

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Abstract

Are there women in science in the DRC? And what are their innovations with visible impact on society? Answering these two questions leads to establish a directory of Congolese women scientists. The aim of this study was to make an inventory of some of the great women who have distinguished themselves in the different fields of mathematics, science, technology and engineering in our country, emphasizing the particularity of each. Through the documentary method and the interview with some of these women, we have discovered that the women of STEM have established a database of 362 women, which will be updated every year. This study aims to make this category of women visible, so that their actions are known to society and young people, especially girls, can take them as role models by embracing STEM fields in their enrollment in studies. Through this study, we discovered that the Ministry of Primary, Secondary and Vocational Education has modified the curriculum in the science sections to standardize the options and give all students the chance to succeed and adapt. As for the University, girls enrolled in STEM fields get a scholarship. In conclusion, the achievements of women scientists are becoming increasingly known and highly appreciated by the public. These women are mainly active in higher and university education as teachers, but also in private and state-owned companies, and as entrepreneurs.

1.0 Introduction

For a long time, society in general and Congolese society in particular, considered that the place of the woman was at home: the girl to help her mother and the latter to take care of her husband and children. All attention was focused on the boy, especially for studies. However, between 1960 and 1972, the so-called "golden years" of education in the Democratic Republic of Congo, enrollment in schools increased significantly. Girls also benefited from this training; indeed, during this period the female student population tripled. But only boys were oriented towards sciences, mathematics, biology, physics, engineering, while girls were oriented towards social fields such as teaching, nursing, sewing, social homes to prepare them for a family life and auxiliary jobs. 1

As Albertine Tshibilondi points out, "Enrolment in secondary education is discriminatory: scientific humanities in large colleges and technical schools for boys. The girls in the normal or pedagogical education. In the technical schools, the girls follow the sewing and trade. These are the so-called female sections in the schools. Very few girls are enrolled in the male sections, such

as science, mathematics, physics, etc.

In higher education, girls are mostly enrolled in nursing, secretarial, or sewing-cutting degrees, options that are considered to be of short duration of studies and that have the appearance of ease (success without much effort), these institutions are compatible with the female nature, girls have little ambition, little aptitude for abstract thinking, little creative imagination...2
Girls' enrollment was therefore subject to stereotyping and prejudice.
But since then, things have changed? It has been proven that women are capable of working in fields that were once reserved for men. We find women in all fields formerly reserved for men.

1.1 Objectives of the study
The objective of this study is twofold: first, to make an inventory of women who excel in STEM and to make them known, while at the same time inventorying their innovations and inventions that contribute to the development of society; second, to show how society, i.e., the authorities, contribute to giving young girls a taste for embracing STEM fields in their choice of studies.

2.0 Work methodology
To carry out our study we used two methods: the documentary method: reading articles, magazines and other documents allowed us to discover information about these women; The interview method, we interviewed some women in science for extensive testimonials about themselves and their colleagues.

2.1 Work delimitation
Given the time constraints, we will only present 10 women. We have chosen those whose achievements have a clear visible impact. The idea of bringing together women in science takes shape on April 20, as part of the 6th edition of the Science and Technology Week, at the initiative of the president of women in STEM, Professor Raïssa MALU who explains: "This initiative launched earlier this year aims to bring together women in Science, Technology, Engineering and Mathematics (STEM or STEM in French) in the DRC in a network in order to deconstruct stereotypes about women and science, to facilitate the sharing of information and opportunities, and to promote mentoring and positive representation.

Our "Science Amazons" are science educators, computer scientists, entrepreneurs (Biologists), researchers (biologists), physicists, geologists, developers and pilots. We currently have 397 women enrolled with 362 in STEM. Women under forty are the most numerous. In high school, the majority chose science options, 49% were in biology-chemistry and 23% in mathematics-physics.

At the university, among those who were in mathematics-physics, we find the majority
of female physicists (8 out of 11) and mathematicians (9 out of 11), a quarter of female computer scientists (21 out of 83) and 40% of female engineers. Women physicists and mathematicians together represent only 6% of our sample! Yet, in the context of the 4th Industrial Revolution, the

DRC and Africa will need "armies" of female mathematicians and physicists with female computer scientists. Fortunately, the latter field is of interest to women in the DRC. They are the most numerous in our database, with 23% of computer scientists.

Among those who studied biology and chemistry in high school, we find ALL chemists (18) and the majority of biologists (44 of 54). The others specialized in geology and petroleum sciences (12 out of 16), in environmental sciences (12 out of 18) and in agronomy, bioengineering and agri-food sciences (31 out of 49). For a country where agriculture is a priority sector, with nearly 80 million hectares of arable land, we need more than 14 (proportion in our database) of women specializing in agronomy, bioengineering and agri-food sciences! Also in this category are a quarter of the female computer scientists (19 out of 83) and a third of the female engineers (18 out of 53) who have a secondary education in biology and chemistry. Let's go back to the computer scientists. The other women in this category have secondary education in Commercial and Administrative (16 out of 83), Technical and Vocational Education (8 out of 83), Latin-Philosophy and Literary (12 out of 83) and General Pedagogy (5 out of 83).

General Pedagogy is an option "traditionally" chosen by those who are afraid, hate, say they suck at math. Well, apart from computer scientists, there are also agronomists (5 out of 18), biologists (2 out of 18) and engineers (3 out of 18). As for the 24 literary students, that other option for those who "suck at math or science", half became computer scientists! The other 12 became doctors, biologists, Agronomists, specialists in petroleum sciences and techniques, specialists in environmental sciences and engineers. For people who supposedly "suck at math", this is not bad!

We see that the choices made in high school do not 100% determine the options in which students will best thrive in higher education and college. But a good education in high school can avoid many pitfalls later on. With this in mind, experts from the Ministry of Primary, Secondary and Vocational Education have just proposed the merger of the mathematics-physics and biology-chemistry options in secondary school into a single option, the Scientific option, with an adaptation of the pedagogical regime of the science learning area. The DRC wants to better prepare its youth for university studies. This merger will be tested in pilot schools starting in the 2020-2021 school year with the Science Learning Domain programs of the 5th and 6th general secondary schools (Humanités scientifiques 3 and 4) modernized by the Education Project for the Quality and Relevance of Secondary and University Level Education (PEQPESU). Similarly, a new strategic framework for secondary education is being developed in order to rethink the courses of study in the country's context for a more efficient Congolese education system.

As for the sectors in which these STEM DRC women work, they are mainly found in the school, university and higher institute environment. As students (23%) or teachers, supervisors, researchers and doctoral students (7%). The others are employed in the private, public and

associative sectors. 10% are CEOs/Managers/Executives.

In terms of geographic distribution, they are mostly located in Kinshasa (233 out of 362) and in the diaspora (48 out of 362). They are also located in North Kivu (25), South Kivu (27), Haut-Katanga (10), Kongo-Central (6), Tshopo (5), Ituri (2), Kasai- Oriental (2) and Lualaba (1).

The ten STEM women chosen:

1. Professor Raïssa MALU

Its motto: "science is fun, join us". Trained as a physicist, physics and mathematics teacher, she is an author and international education consultant. In 2006, she created the company Plenisciences in Belgium, specialized in school support and home lessons.

In 2010, she launched the collection "Les Indispensables". To date, the collection has three titles: Indispensables of Physics (2010), Indispensables of Mathematics (2010), and Indispensables of General Chemistry (2013). Raïssa Malu has written and co -written extensively in the field of science. Notably, in 2012, she published with her sister Mano Malu "Physicians and Physicists, from Archimedes to the 19ème century". Professor Raissa works more in curriculum innovation in science education and in many projects in this field. Professor Raïssa Malu, excerpt from the speech given at the launch of the 6th edition of Science and Technology Week.

In 2011, it is organizing with the Ministries of Primary, Secondary and Technological Education and Scientific Research the first edition of the Science and Technology Week to develop a scientific and technological culture among young people and the general public. In 2017, she was appointed NEXT EINSTEIN FORUM Ambassador for the DRC In 2019, she is launching the STEM women's database in DRC. Since 2022, she has been in charge of the areas of youth education, science, technology and innovation.

2. Professor Marie Claire YANDJU

Doctor in science (biology) from the University of Kisangani. Nutritionist researcher, professor at the Faculty of Sciences, Department of Microbiology. Honorary CEO of the National Institute of Arts and Crafts (ISAM), winner of the first Joseph Kabila prize for Congolese inventories in 2011, Coordinator of the Congolese Network of Innovation Actors (RCAI). Professor Marie Claire Yandju, a specialist in molecular biology, did a thesis on cassava. She is a specialist in food technology and management of nutritional diseases. It estimates the production of cassava in the Democratic Republic of Congo to date at between 20 and 30 million tons per year, although specialized institutions such as the Central Bank of Congo or the Ministry of Agriculture still mention a production of nearly 15 million tons of cassava per year. This rare cassava specialist has always fought for cassava to reach the table in the form of bakery products, which is why she believes that the decision taken by the Congolese government to introduce cassava flour up to 20% in the manufacture of bakery products is a saving decision that will not only help the country to cope with the current crisis but also to fight against the famine that strikes the country.

"Producing bread or other bakery products with locally produced flour will also allow Congolese peasant women living in rural areas to sell with added value to fight against poverty, promote the empowerment of women but above all, fight against malnutrition that strikes the Democratic Republic of Congo," said Ms. Marie Claire Yandju in an exclusive interview granted to Zoom-eco.net. For her, "this is a great victory in a fight she has been waging for several years to get cassava on the table. On the national level, she considers that the Congolese government has realized that the Congolese economy should also be based on local production. She affirms that to date; the cultivation of cassava is being industrialized with the presence of several entrepreneurs who are increasingly working in this sector.

"Today, with the expansion of the cassava market, especially with the introduction of bread flour in the manufacture of bakery products, this will automatically force producers to increase production," said Professor Marie Claire Yandju.

3. Engineer Thérèse IZAY KIRONGOZI

Congolese industrial engineer in electronics from the Institute of Applied Sciences and Techniques (ISTA). She is the founder of a Congolese Association of Women Engineers Technology, which regulates traffic on several streets in Kinshasa. In 2015, five robots were in use in Kinshasa and only one in Lubumbashi. The use of robots as traffic lights may be unique in the Democratic Republic of Congo. Main activity: Industrial engineer, entrepreneur from a young age, Therese became interested in road safety after seeing her brother run over by a vehicle. The local population has accepted the robots with enthusiasm. She is responsible for Women's Technology (Wotech), the association that makes these robots. The new generation of robots designed by the inventor has cameras placed in their "eyes" and "shoulders" that film the traffic continuously. Thanks to the antenna attached to the top of their head, the data can be transmitted to a control center via an IP (Internet Protocol) transmission. Thérèse Izay is already considering the manufacture of robot soldiers, road cleaning robots, robots that can intervene in a toxic environment, etc. She is the proof that women have an important role to play in the industrialization process of the African continent, and that they are just as talented as men.

4. Pamela MINZILA SEB

Bachelor's degree in nutrition, public health and epidemiology. As a nutritionist at the Mount Amba Hospital, she has developed three varieties of fortified porridges based on local foods for better management of malnutrition and an ongoing campaign for self-management in line with the MDGs. It has contributed to the rehabilitation of 500 patients from all diseases.

5. Mrs. Suzy NSIMUNDELE LEMBE

Bachelor's degree in Applied Geology, petroleum field. She has experience in the oil exploration industry. She was an exploration geologist and head of the Geosciences Department at SOCO DRC for the Nganzi Block exploitation permit in Central Kongo and Block V of the Lake Albert Graben. She contributed to the revision of the petroleum considerations (Block VII by SOCO DRC of the

Central Cuvette of the Democratic Republic of Congo, an intracratonic basin, bringing new hypotheses with regard to the analogies made on the petroleum basins of Gondwana (very old). It advocates that the DRC's oil policy, which has been put to the test, should be revised to create a winning partnership between the Congolese state and investors.

6. Mrs. Carine LOFELE BIONGE

Chemist of formation of the faculty of sciences of the University of Kinshasa. She is passionate about renewable energies and natural substances. She is not only a woman of science, she also evolves in the political world within the Congolese parliament, precisely in the Senate. She is also a woman entrepreneur.

Its fields of activity and inventions are the following:

- The Cleaner specializes in surface cleaning since 2014
- Cold electricity since 2014
- Production and sale of cosmetic and food products with medicinal properties under The slogan "Beauty in the natural secret" since 2017
- Lotions based on snail slime and others
- Elixirs based on ginger and other plants containing several therapeutic virtues
- Essential oils from different plants
- Hair products for hair care and treatment
- Anti-burn lotions, creams, oils and ointments
- Anti-acne lotions, creams, oils and ointments
- Anti-stretching lotions, creams, oils and ointments
- Beauty powders made of clay and dried natural plants.
- Beauty soaps made with snail slime, aloe Vera sap, Sulphur, mint and clay
- Shower gels made from snail slime and others.

She has published papers on the synthesis of water hyacinth fuel and a synthesis of refined palm oil biofuel. It intends to undertake research on the production of fuel from plastic waste.

7. Professor Yvonne IBEBEKE BOMANGWA SAILA

Doctor of Science, option Chemistry (organic chemistry and natural substances); she is a professor at the National Pedagogical University. She has, in parallel to her scientific career, worked at RGIDESO from 1990 to 2019 as design attaché at the central laboratory, head of the Water Quality Division and central laboratory, national production manager (first woman to hold this position). An expert in water quality and drinking water treatment, she contributed to the design of the second module of the Ngaliema water treatment plant, the third module of the Ndjili water treatment plant and the new plant under construction in Ngaliema. It introduced Agaefloc19S, a product that has improved the quality of the water produced by the Lukunga plant. Her research focuses on water treatment, water quality and phytochemistry. She is president of the Global Water Partnership DRC, an organization that promotes integrated water resources management (IWRM).

8. Professor Céline SIKULISIMWA POLE

The professor of the faculty of science of the University of Kinshasa (UNIKIN), Céline Sikulisimwa, calls the Congolese population to stop transforming rivers into dumps. This call is part of its awareness campaign "SOS River" for the safeguard and protection of rivers, against all activities that can pollute them. The appeal comes at the celebration of the World Water Day celebrated every March 22.

"We have to stop turning rivers into dumping grounds. This must be done through awareness and waste management measures that must be taken. We need sustainable sanitation to save the rivers. It is absolutely necessary that the actions are carried out in synergy. Any waste that we have must go to an appropriate place for its elimination, for its recovery, its recycling or its transformation. You have rivers that are surface waters but these rivers are in contact with groundwater, rivers feed the water tables. If the rivers are polluted, they will have difficulty feeding the groundwater in good conditions," said Professor Celine Sikulisimwa.

And to continue:

"The river needs a certain concentration of oxygen to allow life to continue in it. There the rivers are at zero that is to say that there is no more oxygen, how do you want that it can have fish which live inside. Worse still, there is a system in Kinshasa called Nyeterie where all the false sceptics are directed. It is more than 40 years that the rivers have been transformed into Nyeterie or place of dumping of false sceptics". On the same occasion, the Dr. in water technology proposed some solutions to avoid asphyxiating the rivers. It is the creation of a provincial ministry in charge of sanitation and the mobilization of resources for the progressive depollution of rivers.

9. Lisette NTUMBA

Bachelor's degree in math-info from the University of Kinshasa. She is the head of the IT department at CIDEP. A blogger, Ms. Lisette is the coordinator of Lis Training Center, an NGO that aims to empower youth and women through STEM and entrepreneurship. She is the author of "ROBES OF PIXELS" a film that presents some Congolese women and girls who inspire in the fields of science and technology (STEM) and evolve without taking into account the prejudices of the society towards them.

10. Mrs Priscille NZAZI GULEMVUGA

Environmentalist. Founder and President of the Vison Environment Agency. This agency is intended to bring the Congolese population and particularly its youth to think environment, to become eco-citizens. The Agency aims to raise environmental awareness through participation in environmental management, to impart knowledge and skills on environmental issues and challenges. Actions carried out in the field: television programs, conferences on environmental themes with the participation of various personalities.

3.0 Conclusion

STEM women are numerous, their innovations and inventions too, but most remain unknown to the public. It is urgent that these personalities come out of silence and anonymity. Our work can contribute in a small way to make them known. They have carved a path in the rock", says Professor Céline SIKULISIMWA. Indeed, if at the beginning the woman underwent many prejudices and stereotypes to choose her field of study, become a STEM woman, these prejudices did not leave her. The language has changed: she is not pretty, she is not a woman, that's why she does STEM.4. It took these women fighting hard to prove to the world that STEM is not a male domain. Innovation and invention move the world forward. Science and technology contribute to the development of societies, providing us with tools, techniques, and a way of approaching and thinking about problems that allow us to build a better and sustainable world for us today and for those who will be here tomorrow. The man of science is in action: he creates, invents, and produces works of the mind. His work must contribute to the development of society. We must not be surprised by innovations and inventions, but we must be pioneers. With all the social burden and responsibilities that weigh on her shoulders, as it is a fact that men and women have the same intellectual capacities and that prejudices are purely social, why can't the woman and particularly the woman-stem face this battle of the development of the country? On December 19, 2019 took place in Kinshasa the first day called "Master Class" whose objective was to bring out of the shadows the Congolese innovators and inventors (among which were women), and to prove that there is not only the Weapons that sound in the DRC, had indicated the Prime Minister at the time, Ilunga Ilunkamba.

With the data base established and continuing to be established by the STEM women themselves, the education program is being changed to favor STEM fields, with Ms. Raissa Malu leading the way as the Ministry's expert on the subject, at the University girls enrolled in science fields are getting scholarships, these are the results that this study has uncovered. And we hope that this will go forward and that in the near future we will see an explosion of women in STEM and that the journey and experience of those identified will inspire others, girls and boys, men and women.

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STRAND THREE
STEM Curriculum Development Implementation and Assessment
1.Learner Engagement: Evidence-based Lessons on STEM / STEAM Education
2.Pre-Service Teacher Development: Abilities, Skills and Values

Article 11

Importance of Early Learner Participation in the Wavumbuzi Entrepreneurship Challenge

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Abstract

Entrepreneurship contributes to prosperity by increasing productivity, reducing unemployment, and improving livelihoods. In the past, African educational systems prioritized preparing young people for employment, over entrepreneurship. With the aim of contributing towards early development of learners' entrepreneurial thinking, in 2019, the Allan & Gill Gray Philanthropies (AGGP) and its partners – mandated to work in secondary/high schools in Kenya – began implementing the free online 6-weeks Wavumbuzi Entrepreneurship Challenge. Wavumbuzi presents new Challenges every year, which are in line with the Competency Based Curriculum (CBC) and the Basic Education Curriculum Framework goals (BECF, 2017). The Wavumbuzi Knowledge and Research Unit, conducted a study to assess the effect of learners re-engaging across two iterations using a longitudinal retrospective study methodology. Data of 4,982 learners (46% female; 54% male) was analyzed. Of these, 2,978 (60%) were first-time participants and 2,004 (40%) were repeat participants. The median age was 16.9 years. Results indicated that on average, first-time users submitted four Challenges while repeat users submitted eleven Challenges. On the class grades, Form 1 & 2/Grade 8 & 9 learners had the highest propensity of re-engaging in subsequent iterations compared to Form 3 & 4/Grade 11 & 12 learners. However, descriptive statistics revealed that learners who had just started secondary/high school had a low participation rate. Repeated exposure to the Challenges increases the likelihood of learners improving their entrepreneurial competencies. Therefore, it is recommended that educators and parents/guardians should concertedly encourage and support lower grades secondary/high school learners to participate & actively engage in the Wavumbuzi Entrepreneurship Challenge.

Key words: *entrepreneurial mindset development; entrepreneurial thinking; learners; early participation; Kenya*

1.0 Background

According to the African Development Bank Group (AfDB), one-third of the 420 million young people in Africa are unemployed, a third is vulnerably employed, and only one in six youths are gainfully employed (AfDB, 2018). Additionally, 10-12 million young people join the workforce yearly in Africa while only 3.1 million jobs are created annually, leaving most of the young people unemployed [1]. The International Labour Organization (ILO) reported that globally, youth unemployment is more than three times as prevalent as adult unemployment and that the youth unemployment rates in Africa continues to be lower than the global average[2].

In the meanwhile, globally, the labour force is experiencing a paradigm shift with more unique skills and competencies required to venture into the competitive fields (ILO, 2020). It is envisioned that in the future some current jobs will be obsolete rendering many people jobless; whilst new opportunities will arise, which will be taken up faster by those who are creative, confident and have an entrepreneurial mindset.

However, the education systems, especially in Africa have, for a long time, prioritized preparing learners for employment over entrepreneurship. The education system in Kenya, for example, has been criticized for training learners to be job seekers as opposed to job creators (Langat, 2018). Further, although there are some successful entrepreneurs in Africa, research shows that they are mainly minority foreigners or diaspora with international education, past corporate experiences or of upper-middle-class family backgrounds (Nkontwana, 2022). There is need to explicitly change these trends as entrepreneurship contributes to prosperity by increasing productivity, reducing unemployment, and improving livelihoods[3].

1.1 Developing young people's entrepreneurial thinking

Nurturing entrepreneurial mindsets among the young people is crucial to ensuring that they are well equipped for the evolving economic world (Farr, 2014). A British Council report recommended the revision of the secondary education curricula to provide learners with skills that are well equipped for the competitive working environment (Hall, 2017). Further, to improve the pipeline of future entrepreneurs, it is crucial that young people's entrepreneurial thinking is developed at an early age, more so innate competencies. Entrepreneurial competencies are defined as a set of skills that are required to develop, maintain, and expand a business (KICD, 2022).

Stimulating learners' ability to think entrepreneurially is a continuous process. Kolb's theory explains that concrete experience, reflective observation, abstract conceptualization, and active experimentation form a four-stage process (or cycle) transformed into effective learning - as summarized in **Figure 1**. It provides a basis for learning and development by describing ideal

[1] https://www.un.org/africarenewal/magazine/april-2018-july-2018/african-youth-demand-seat-table
[2] https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/briefingnote/wcms_853322.pdf
[3] https://www.dbsa.org/article/how-youth-entrepreneurial-development-can-uplift-africa#:~:text=It%20also%20plays%20a%20central,through%20coaching%20and%20training%20programmes

processes where knowledge is generated through experience and repetition (Kolb, 1984).

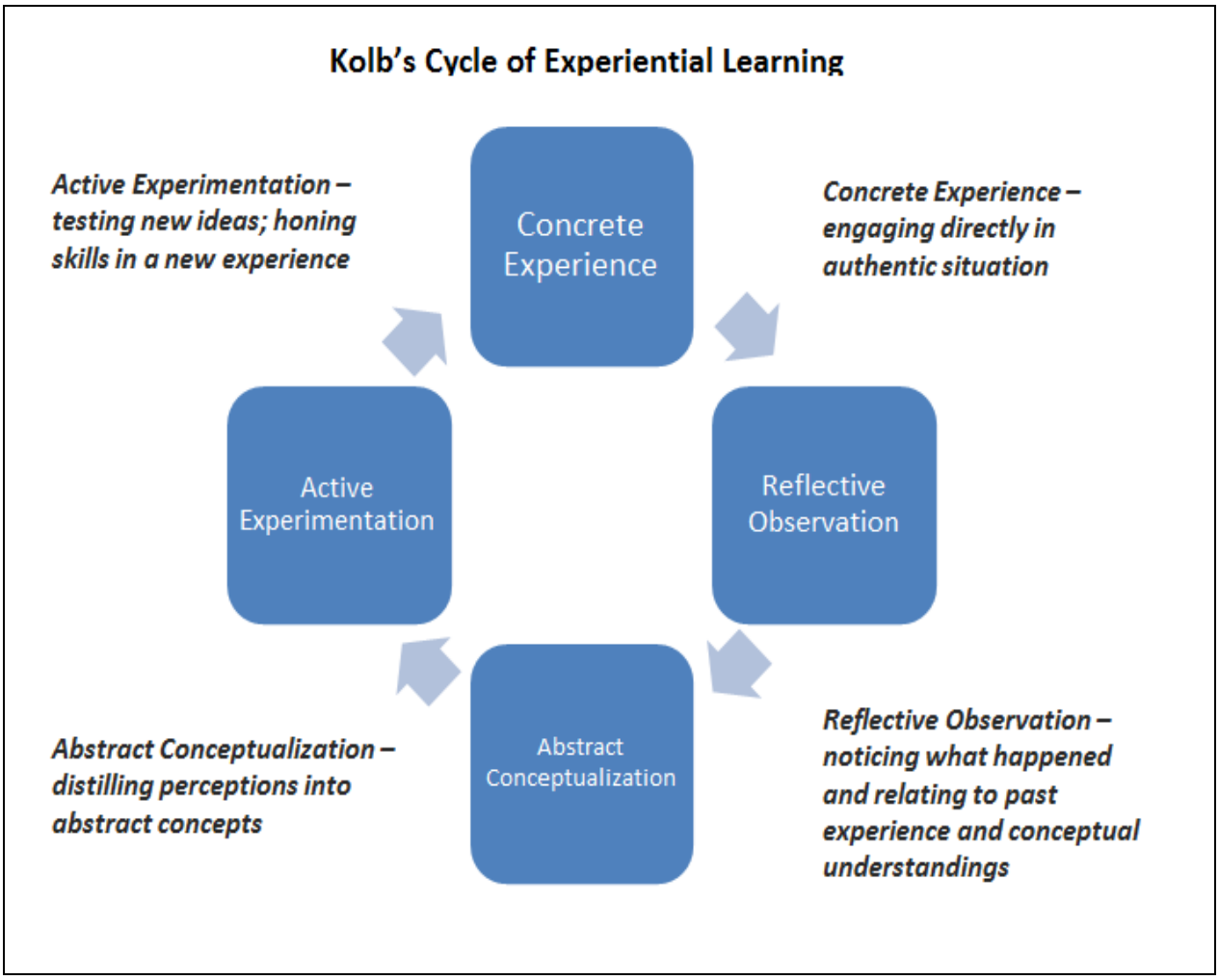

Figure 1: *Kolb's Cycle of Experiential Learning*

The future requires young people to efficiently see problems in society and effectively innovate and implement solutions. Applying Kolb's learning theory has benefits for learners, as repeated stimulation of learners' entrepreneurial thinking is essential to concretize the practice into becoming an automatic ability.

1.2 The Wavumbuzi Entrepreneurship Challenge

It is against this background that the Wavumbuzi Entrepreneurship Challenge – a free online six (6) weeks annual Challenge is offered to learners in all secondary/ high schools across Kenya to contribute to developing the entrepreneurial thinking of young people at an early age (Wavumbuzi, 2022). Wavumbuzi is currently supported by the Allan & Gill Gray Philanthropies (AGGP). In 2019, Wavumbuzi and its partners - mandated to work in secondary/ high schools - began to implement the annual Wavumbuzi Entrepreneurship Challenge. The Challenge is designed to equip Learners with competencies to be the next generation of global leaders, change-makers, and

innovative thinkers hence acquiring knowledge and skills required in job creation; a priority area in Kenya's Vision 2030[4] and Kenya Kwanza Plan[5].

Learners are not taught. Instead, learners get sets of Challenges - which they can access via computers or mobile phones - that stimulate them to think like entrepreneurs. Each task requires learners to apply new concepts and utilize their knowledge and skills in solving real-world challenges.

Teachers are trained on how to guide and encourage learners to engage in and complete the Challenges (Kareithi, R. M. & Mangira, S., 2021). These practices are in line with the Teacher Service Commission (TSC) Standards guiding Professional Development of Teachers (TSC 2019).

As summarized in **Figure 2**, learners are presented with online content that has been carefully researched and developed that cover different contemporary industries and topics of interest to the learners and are based on global and national themes. The content is carefully designed to help the learners think critically and imaginatively and learn how to collaborate and work in teams in accordance with the competencies envisaged by the Basic Education Curriculum Framework (BECF, 2017). The more learners engage in the Challenge, the more they are stimulated to think like an entrepreneur. Some of the entrepreneurial competencies embedded in the Challenge include self-efficacy, resilience, proactively acting and taking initiative, need for achievement, innovative problem-solving and value-driven service[6].

Figure 2: *Learners Entrepreneurial Mindset Development*

The learners access the Challenge through their mobile phones or computers and proceed to the tasks that require the learners to apply new concepts and utilize their knowledge and skills in solving real-world challenges. Experience shows that learners have the desire for entrepreneurial mindset development which calls for stakeholder and policy makers to create conducive environments to nurture the learners from an early age (Kareithi, Jenkins, & Hampton, 2019).

[4] https://vision2030.go.ke/publication/kenya-vision-2030-popular-version/
[5] https://uda.ke/downloads/manifesto.pdf
[6] https://wavumbuzi.africa/kenya/

2.0 Methodology

Wavumbuzi's Knowledge and Research Unit (KRU) conducted a longitudinal retrospective study to scientifically quantify the effects of learners re-engaging in the annual Wavumbuzi Entrepreneurship Challenge across two iterations. Since the study was longitudinal in design, probabilistic record linkage was utilized to merge learner engagement data collected between 2019 and 2021.

A comparative analysis between first-time users and repeat users was then conducted to evaluate statistical differences in engagement metrics such as the number of submissions made, Challenge points garnered, system logins count, and other engagement indicators. Finally, to estimate predictors of re-engagement, a multiple logistic regression model was fitted while adjusting for effect modifiers and other potential confounding variables. Odds ratios, p-values (significance level of <0.05), and the corresponding 95% confidence interval were reported.

2.1 Research design

The study adopted a longitudinal retrospective design, enabling the research team to track and evaluate the engagement behavior of learners over time, specifically from 2019 to 2021.

2.2 Data linkage and preparation

Probabilistic record linkage techniques were employed to merge distinct sets of engagement data collected from the years 2019 through 2021. This approach ensured that individual learners' data points could be accurately matched and analyzed over the two-year study period.

2.3 Variables of interest

The key metrics assessed in this study included the number of submissions made; Challenge points garnered; System logins count; And other relevant engagement indicators

2.4 Comparative analysis

A comparative analysis was performed to evaluate the engagement metrics between two categories of users: First-time users and repeat users. This step primarily aimed to reveal any statistical differences in engagement based on the frequency of participation in the Challenge.

2.5 Statistical modelling and significance

To identify variables that could predict re-engagement, a multiple logistic regression model was fitted to the data. The model was adjusted for effect modifiers and potential confounding variables to ensure robustness. To determine statistical significance, a p-value threshold of less than 0.05 was used. Odds ratios and the corresponding 95% confidence intervals were reported to offer a comprehensive view of the findings.

3.0 Results and discussions

Of the 4,982 learners' data (46% female; 54% male) included in the study, 2,978 (60%) were first-

time users, while 2,004 (40%) were repeat users. The median age was 16.9 years. Findings established that there were substantial differences in engagement between first-time users and repeat users. As depicted in **Figure 3**, on average first-time users submitted only four Challenges while repeat users submitted 11 Challenges - a difference of seven Challenges. Similarly, repeat users recorded higher average points per challenge (47.3 points) compared to first-time users (18 points); logged in nearly four times more than first-time users, and gained nearly three times average points per week (665.9 points) compared to first-time users (246.1 points).

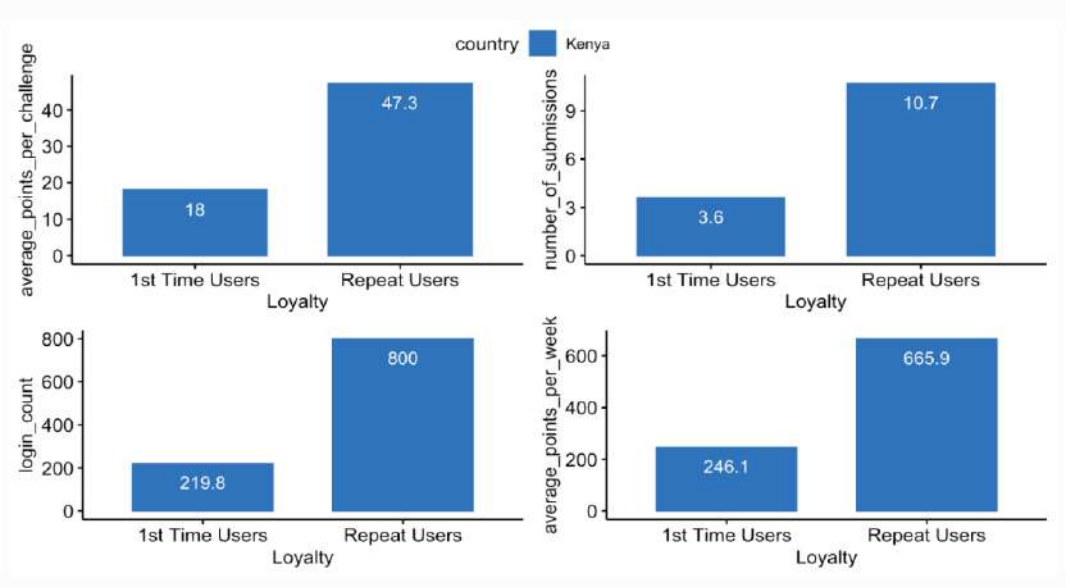

Figure 3: *Learners Engagement Indicators*

The findings confirm that there are advantages to secondary/ high school learners being encouraged and provided with the opportunity to think like an entrepreneur repeatedly. The initial concrete experience develops their muscle memory, which is essential because previously trained muscles are more responsive to training than untrained muscles (Blocquiaux S. et al, 2022). Secondly, learners feel more confident to re-engage in the annual Challenge as their digital skills have been enhanced, they are familiar with the Challenge-world / Wavumbuzi platform and therefore they are able to navigate through more easily. Experience also shows that learners aim to perform better than they did previously and emerge as top achievers in their school or at County level or nationally (Wavumbuzi, 2022). These factors contribute to rising the desire of learners to re-engage in the annual Challenge hence setting them along the path of effective learning (Kolb, 1984).

On the class grades, Form 1 & 2/ Grade 8 & 9 learners had the highest propensity of re-engaging in subsequent iterations compared to Form 3 & 4/ Grade 11 & 12 learners. However, descriptive statistics revealed that learners who had just started secondary / high school had a low participation rate. Learners reported that due to the limited access to computers with internet connectivity, learners in the higher grades in secondary/ high school have the first priority to participate in

Wavumbuzi.

Personally, I am going to be honest, what motivated me to join Wavumbuzi is that when I was in Form 1… we did not have the opportunity as Form 1's to access the computers and the laptops because the Form 3's and Form 4's used to want it for themselves. So, in 2021 I was like I have to join this because right now I am in Form 3. So, I can also do it.
- Hilda Jepliting, Form 4, Moi Tea Girls Secondary School, Kericho County (Source: Wavumbuzi, 2022).

4.0 Recommendation

These insights confirm that learners' repeated exposure to the annual Wavumbuzi Entrepreneurship Challenge can lead to increased engagement and related treatment effects. However, whilst learners who have just started secondary / high school have the highest propensity of re-engaging in subsequent iterations, they have a low participation rate. Therefore, to improve the likelihood of re-engagement, Wavumbuzi stakeholders including partners, educators and parents/ guardians should sensitize and support the lower grades learners to participate and actively engage with the Wavumbuzi Entrepreneurship Challenge as early as possible. This strategic effort will increase the reach and impact of the Challenge in improving learners' entrepreneurial mindset and competencies.

5.0 Acknowledgement

Our profound gratitude goes to Wavumbuzi Partners without whom this work would not have been a success. Thank you to the Ministry of Education (MoE), Kenya Institute of Curriculum Development (KICD), Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), Teachers Service Commission (TSC), Kenya Private Schools Association (KPSA), Kenya Association of International Schools (KAIS), Compassion and Family Group Foundation (FGF). This work was supported by AGGP. Our deepest appreciation goes to the Gray Family for their long-term commitment to motivating and supporting individuals in Africa to become high-impact, responsible entrepreneurs. Further we thank Anthony Farr, CEO AGGP Africa, as well as all members of the Wavumbuzi team namely Aline, Phumlani, Ruti, Katharina, Njoki, Noel and Rafiki among others for their dedicated efforts. Finally, we thank the anonymous reviewers. Your useful suggestions have contributed to improving the quality of this paper.

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Article 12

Astronomy For Development: Investigating Learners' Experiences and Attitudes Towards Astronomy in The New Lower Secondary School Curriculum of Uganda: A Case Study of Kabale Municipality

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Abstract

Astronomy is the first natural science that is magnificently rich in concept. It is embedded in the various fields of modern 21st century; Science, Technology, Engineering and Mathematics (STEM). Slightly before the onset of Covid-19 pandemic (February 2020) in Uganda, the government rolled out the new lower secondary education curriculum (LSC). The aim of LSC was to equip learners with an enhancement skill training as opposed to the old curriculum which was designed on colonial system. Interestingly, concepts on astronomy for beginners were included in the New LSC, but do learners have any experience in the content and how interested are they towards it. That is why this study investigated the learners' experience and attitudes towards Astronomy concepts. A total of 160 students from six secondary schools in Kabale Municipality (St. Marys' College-Rushoroza, Ndorwa Secondary School, Trinity College, Kabale Brainstorm High School, Rock High School, and Kigezi College-Butobere) were randomly sampled. A questionnaire-with carefully chosen set of questions was administered. Majority of the learners (67%) were found to have heard basic knowledge on astronomy, with 33% not conversant with astronomical concepts when first introduced in class. 81% of them were highly interested in Astronomy. Additionally, learners stated that they heard about astronomy from various sources like T.V programs, YouTube videos, among others; so, to develop learners' astronomical knowledge, school takes the lead. Thus, thorough facilitation in teaching of Astronomy and Astrophysics is required. We recommend Physics teachers to be given refresher courses and the scope of astronomy and astrophysics expanded.

***Keywords*:** *Astronomy, attitude, curriculum, experience, STEM*

1.0 Introduction

Astronomy has over decades had a significant impact on science in general and it is the first natural science that is magnificently rich in concept. It is deeply embedded in the various fields of modern 21st century; Science, Technology, Engineering and Mathematics (STEM). Its inclusion in a curriculum helps in acquisition of scientific knowledge through student participation and integration (Anguma S. a., 2004). In most countries, astronomy content at secondary school level is basically the solar system. Salimpour (Salimpour, 2021) stated that topics in astronomy are found in the Earth and Space Science section with a few applicable standards in the physical science section in the USA National Science Education Standards, NSES (Council, 1996). Early

secondary school (Ages 11-14) students build upon the skills they developed in elementary school. Consequently, this age group can use models to explain patterns of motion of the Sun, Moon, and stars. In addition, they view the Sun in the solar system as one of the billions of stars within the Milky Way galaxy. According to (Pruitt, 2014), astronomy concepts that are abstract in nature are taught at the upper secondary levels (Ages 15-18) as they require higher-level thinking. These students are to learn about the electromagnetic energy spectra and brightness of stars as it determines the composition of stars, their movements, and measurement of their distance from Earth.

In Uganda, the new lower secondary curriculum was implemented in 2022 with reasonable content on astronomy and astrophysics. The astronomy content in the New LSC, begins from the analysis of earth formation stretching back to the Big Bang has some contents included. The content is found at senior two (S.2) and three (S.3) under the theme of "Earth and Space Science". This is broken into topics of: The Solar System at S.2 third term, Stars and Galaxies, Satellites and Communication at S.3 third term. However, there has always been a challenge of low attitudes towards astronomy and Space Science and science in general (Anguma S. , 2000).

In the last 20 years, many authors were interested in studies about learners' attitudes towards science/ astronomy content (Osborne, 2003), (Kind P. a., 2007), (Bektasli, 2013) . For example, (Bektasli, 2013), stated that the main concern for conducting much of the research related to science attitudes was to find out possible answers for the decreasing number of students that prefer to study science. This decrease clearly indicates that over that period, students had developed negative attitudes towards science (Durrani, 1998). This means that if learners are to develop positive attitudes towards science, then it means to guide learners should be put in place earlier as concepts are introduced. It is for this reason that this study intended to analyze the learners attitude towards the newly introduced content on astronomy, astrophysics and space science in the new LSC.

2.0 Methods

This study is a survey model which aimed at gaining understanding of opinions, motivation or attitudes of learners towards Astronomy. Consequently, in this study, it was majorly quantitative approach or technique (a type of survey research designs) that was used in data collection. This provided deep insights into the problem and helped in developing ideas for potential quantitative research.

2.1 Population and sample

Here, the target population of this study was the students and teachers in the Lower secondary from South-Western Uganda. The accessible population in this study was the Lower Secondary level learners from senior one and senior two to be specific, since the curriculum has been running for two years. A sample space of 160 students was selected from six schools. This required that at least 28 students were chosen from each of the six schools purposely selected (for different

reasons) within Kabale Municipality. The chosen schools were: St. Marys' College-Rushoroza, Ndorwa Secondary School, Trinity College Kabale, Kabale Brainstorm High School, Rock High School, and Kigezi College-Butobere. To be gender sensitive, 14 boys and 14 girls were sampled in the research process from every school from both senior one and senior two. In a particular class, participants were selected by grouping students into two main groups, that is the group of Boys and that of Girls, then seven (7) participants were picked from each of the two groups to make 14 participants. In other cases, an alternative approach was used where participants were randomly selected from a given class in a particular school.

2.2 Data collection instruments and data analysis

2.2.1 Questionnaire

In order to study students' attitudes towards astronomy as a content of Physics in the New LSC, our questionnaire consisted of nine (9) questions, categorized into **two** (noting that the name for each category does not necessarily define the beliefs contained within the categories);

i. The first category of the two was, *"Experience",* which consisted of five (5) statements to assess students' experience in Astronomy so far.
ii. The second category was, "*Interest*" which consisted of four (4) statements assessing the learners' interest in astronomy, which greatly influence their success and involvement at the Advanced level of their education.

2.2.2 Data analysis

The data was analyzed using Statistical Package for Social Sciences, SPSS, also known as IBM SPSS Statistics, which greatly helped in analyzing the data statistically. The responses (answers) were presented on an *alternative scale*: The positive attitude was indicated by a "yes", "true", and "agree" while the negative answers were indicated by a "no", "false", and "disagree". Further, any positive response as was done by Bektasli Behzat (Bektasli, 2013) were coded positive response as "1" while negative response coded as "0", for instance, if the response was either a yes (true) or a no (false), then it was coded as "1" for yes (true) and "0" for no (false).

3.0 Results and discussion

In this section we present the findings from students and teachers on astronomy education. The average ages of the respondents (students) were found to be 15 years. This is a rightful stage for students to make further choices in career. The schools were coded as "P" for St. Marys' College-Rushoroza, "Q" for Ndorwa Secondary School, "R" for Trinity College Kabale, "S" for Brainstorm High School, "T" for Rock High School, and "U" for Kigezi College-Butobere. The overall results were summarized in *Table 1.*

Table 1: *Learners' attitudes towards astronomy, by analyzing their experience and interest towards astronomy; statistics results for all the six schools sampled*

	Number (%) of students' responses

	Positive response	Negative response
Experience on Astronomy		
1. **It is not my first time to hear about Astronomy**	107 (66.9)	53 (33.1)
2. **I heard about Astronomy:** (a) **from my parents and friends**	32 (20.0)	128 (80.0)
(b) **Seminar organized by the school**	15 (9.4)	145 (90.6)
(c) **From a T.V program**	75 (46.9)	85 (53.1)
(i) **From YouTube videos**	37 (23.1)	123 (76.9)
(ii) **From a website I visited one time**	17 (10.6)	143 (89.4)
(iii) **From a cultural gathering**	09 (5.6)	151 (94.4)
3. **I have ever observed the night sky using a telescope**	09 (5.6)	151 (94.4)
4. **I think the study of Astronomy is necessary to me as a young growing scientist**	150 (93.8)	10 (6.2)
5. **My school have ever organized a seminar in Astronomy**	07 (4.4)	153 (95.6)
Interest towards astronomy		
6. **I am highly interested in Astronomy**	160 (100)	00 (00)
7. **I would like to be taught Astronomy as a subject itself**	98 (61.3)	62 (38.8)
8. **Astronomy should have separate specialized teachers at Secondary Level**	130 (81.2)	30 (18.8)
9. **Astronomy should be examined separately by UNEB**	106 (66.3)	54 (33.8)

3.1 Learners' experience in astronomy

The statistics of those students who said it was their first time to hear about astronomy (ref Table 1) were found to be approximately 70% of the 160 sampled students. It was interesting to find out that the 30% who knew about astronomy had used a variety of sources as indicated in the results. The analysis on the 160 sampled students basing on each of the different sources was plotted on a bar chart as in ***Figure 1***.

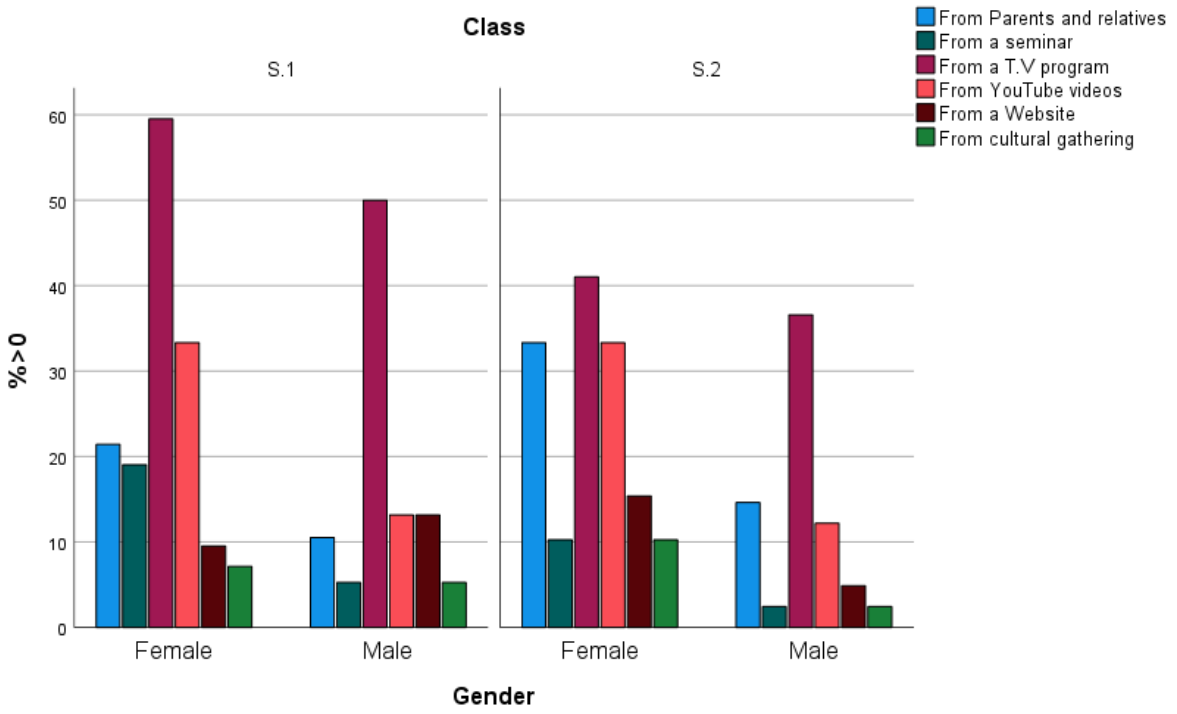

Figure 1: *Other sources of astronomy information apart from school; results for S.1 and S.2 Male and Female: from parents and family (blue), seminar (dark green), T.V program (purple), YouTube videos (orange), website (indigo), and from a cultural gathering (green).*

It was noted that a greater percentage of students both boys and girls mentioned that they heard about astronomy from a T.V program (46.9%), followed by YouTube videos (23.1%). This is contributed due to the fact that most learners these days have access to the internet and some T.V programs at their homes show modern science and technology of which astronomy is inclusive. The variation of results from senior one (S.1) and two (S.2) is attributed to due to the fact that S.1 spend much of their times watching TVs' when home. In addition, they still have other experiences from primary level of education where brief introductory concepts of astronomy are shared.

Further, from the graph, it was clearly identified that seminars (9.4%), websites (10.7%), and cultural gatherings (5.6%) contributed very low significance to learners' knowledge (experience) on astronomy. The results for seminar showed that most or almost all schools have never organized a seminar on astronomy for both students and teachers. This was proved when asked of whether their school have ever organized a seminar or not. Here, only 4.4% gave positive response and this clearly makes one conclude that no seminar has been held on astronomy in any of the sampled schools.

When asked whether they had ever observed the night sky using a telescope, very high percent (89.4%) of the sampled population gave negative response. The statistic bar in Figure 2 showed that a cumulative (94.4%) percent; 46.4% and 47.9% for S.1 and S.2 respectively have never used a telescope in their school. This indicated that schools had no astronomy instruments/ equipment,

and materials and thus the expertise to view the night sky.

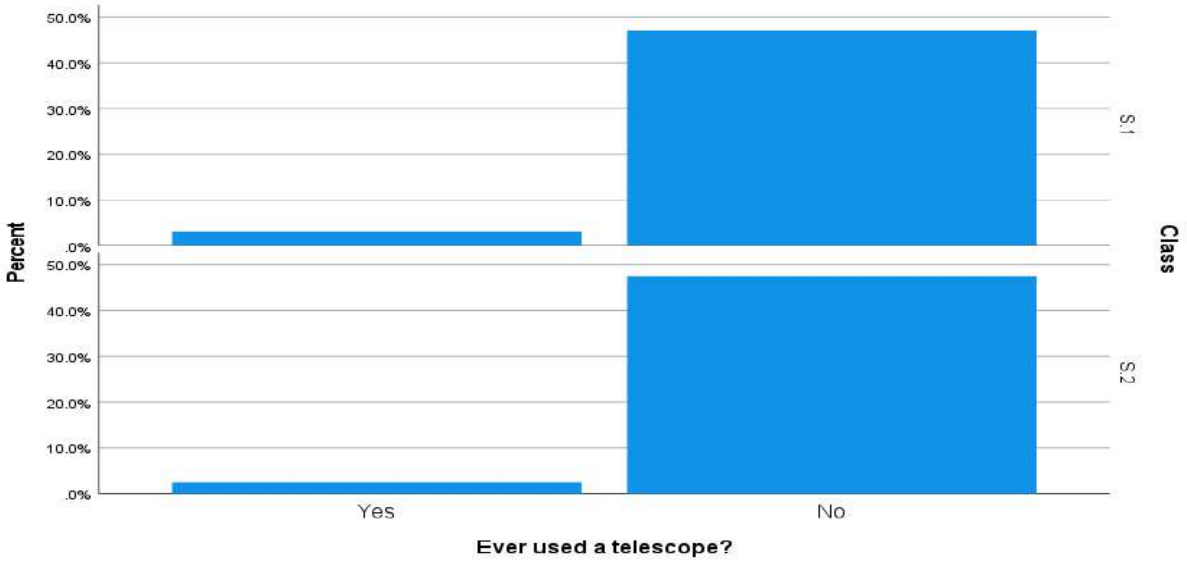

Figure 2**:** *Students experience in the telescope usage: responses on whether students ever used a telescope in the classes sampled.*

Concerning the learners' view about astronomy, the statistics showed that most of the students (93.8%) stated that astronomy is a very good science to the young growing scientist in the 21st century. No significant change in responses was seen in the two different classes.

3.2 Learners' interest in astronomy

This sub-section presents the result of learners' interest in astronomy. On trying to measure how they were interested, there was majorly three scale measure used, and these were; “Not interested”, “Interested” and “Highly interested”. The results were summarized on the chart in Figure 3. The percentage of those who stated that they were highly interested dominated the results. We can observe that almost every student is interested, though others were not highly interested.

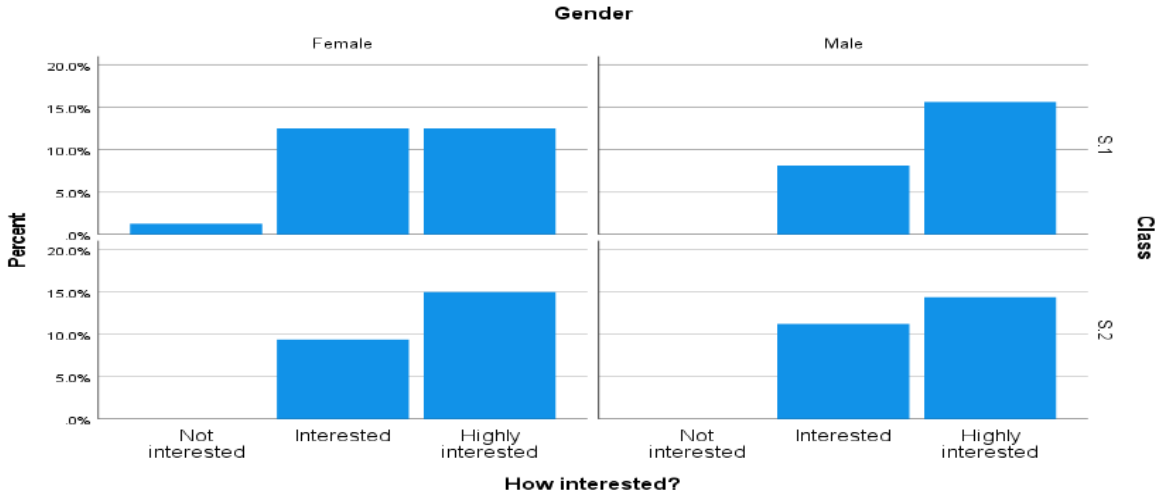

Figure 3: *Learners’ interest in astronomy for both male and female gender in senior one and two.*

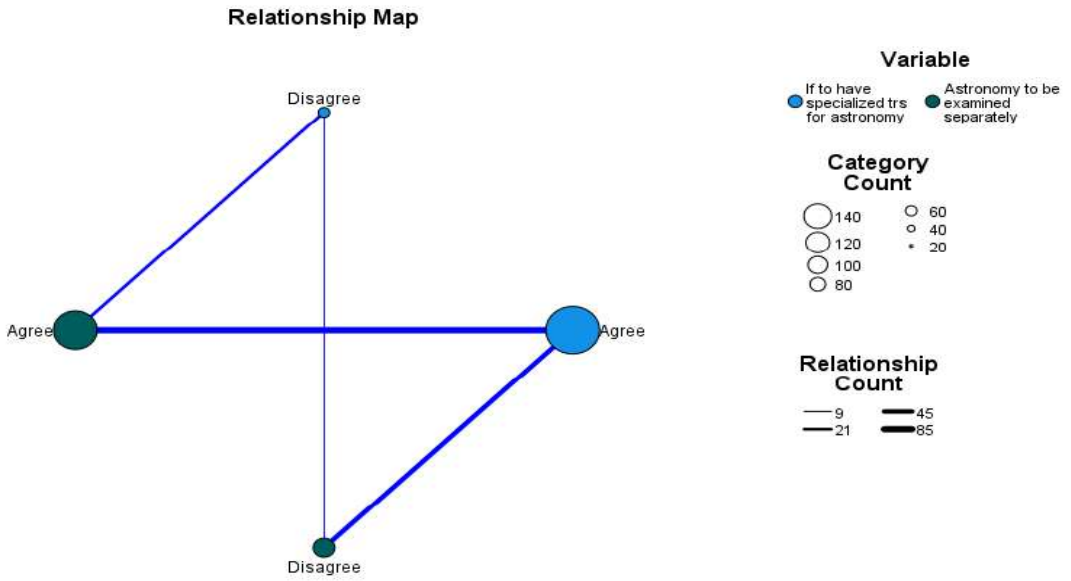

Figure 4: *The relationship between learners' quest for specialized teachers in astronomy, and astronomy being examined separately by Uganda National Examination Board (UNEB).*

When asked on how to be taught astronomy, the results showed that 61.3% of the sample students wanted astronomy to be taught as a subject itself. It also showed that 81.2% of learners wanted astronomy to have specialized teachers other than the Physics teachers in the service. The analysis of the relationship that exists between the learner's quest for specialized astronomy teachers and astronomy being examined separately by UNEB is shown in Figure 4. The Category count clearly shows that greater percentage of students "agreed" in both cases respectively, indicated by the big colored circles. In addition, the Relationship Count was represented by the blue colored lines. The highest count was seen between agreeing in both the two variables and the least count was seen between disagreeing in all the two cases. This result therefore shows that learners are highly interested in astronomy to the extent that they want it to have specialized teachers, and also to be examined separately by the examining body in Uganda, the Uganda National Examination Board (UNEB).

3.3 Discussion

Developing positive attitudes plays an important role on students' achievement (Kind P. K., 2007). Attitudes are hard to change, however the results of Bektasli's study showed that students' attitudes toward astronomy can change significantly even after a semester long astronomy class (Bektasli, 2013). In the definition of attitude; Cognitive, affective, and behavioral components were presented by (Bloom, 1976), (Kind P. K., 2007), and (Bagozzi, 1979), where the cognitive component is related to knowledge and beliefs. If students develop positive attitudes toward science, they might be more likely to prefer studying science in the future (Bektasli, 2013).

In this study, positive attitudes of learners towards astronomy were witnessed with a percentage of as high as 81%. Learners generally have high interest in this content though with little experience

they have so far. This was in line with the findings of Osborne (Osborne, 2003), and (Bektasli, 2013), where Bektasli for example, mentioned that if learners are to develop positive attitudes towards science, then it means learners' guidance should be adopted earlier as concepts are introduced.

4.0 Conclusions and recommendation

In this study, we have analyzed learners' attitudes, experience and interest towards astronomy. Learners' experiences in Astronomy content greatly contribute to the level of interest a learner may have towards astronomy. Leaving school as an exception, different sources such as Televisions, YouTube videos, and websites, among others are major contributors to the learner's interest in astronomy. It was revealed that learners would like to be taught astronomy as a separate subject, with specific specialized teachers. We therefore recommend that in future, instructors (Physics teachers) be given refresher courses with a deep scope of astronomy and astrophysics. Workshops on astronomy be organized by schools, providing wireless internet (Wi-Fi), computer laboratory to enhance research, facilitating teachers and students to carry out simple astronomy related research projects. This study can be carried out in different regions of the country, apart from South-Western Uganda- Kabale Municipality and in such a study a wider sample size should be considered.

5.0 Acknowledgment

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Article 13

Assessing Students' Acquisition of Twenty-First-Century Skills' During Biology Lessons: Case of A Secondary School in Lusaka, Zambia

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Abstract

The twenty-first-century skills are required by citizens of all ages and nations to manage the sophisticated problems of the century. Among these skills are communication, collaboration, critical thinking, and creativity and innovation herein referred to as the 4Cs. To help learners acquire these skills, teachers require complex professional knowledge to inform their pedagogical decisions. Although the Zambian secondary school syllabi do not provide for their explicit teaching and assessment, these skills ought to be taught alongside the content subjects, such as biology. Also, there is a dearth of research demonstrating the teaching-learning of twenty-first-century skills in Zambia. Therefore, this study used the case study design to describe opportunities for effective teaching and assessing the 4Cs during a lesson study conducted at a secondary school based in Lusaka District of Zambia. Data were collected from twenty-four grade 11 case students who were purposively selected. Six biology teachers participated in the two lesson study cycles. A 4Cs' checklist consisting of indicators for each of the 4Cs was used to measure students' acquisition of the 4Cs as observed during two research lessons. The results showed that the learner-centred biology lessons promoted students' acquisition of the 4Cs. The findings show that collaboration and communication were the most acquired skills while critical thinking and innovation were the least acquired by the students. It was concluded that all the 4Cs were acquired and demonstrated by the students. The study recommends the explicit assessment of the 4Cs during biology lessons.

Keywords: *21st century skills, research lesson, lesson study, secondary school, biology*

1.0 Introduction

The complexities of the twenty-first (21st) century and the fast-changing technology-based economy have continued to put pressure on the global citizenry. This pressure demands that citizens of all ages be empowered with the skills needed for their successful survival, work, and life, (Chu et al., 2016). In response to this pressure, governments through their respective departments (ministries) of education are promoting teaching these essential skills alongside the knowledge and understanding of key subjects such as biology. For example, the ministry of general education (MoGE) in Zambia revised the school curriculum to emphasize the teaching of skills to students (Curriculum Development Centre, 2013). Similarly, Rwanda and Kenya have adopted curriculums that emphasize the soft skills in subjects such as mathematics (Busaka et al., 2022).

This is because for students to be ready for college and careers, they must be provided learning that goes beyond the learning core subjects and includes twenty-first-century skills (Partnership for 21st Century Skills, 2010).

As such, twenty-first-century skills have received wide attention in the education sector and research community (Kim et al., 2019). Learning and innovation skills or 4Cs, i.e. communication, critical thinking, collaboration, and creativity and innovation skills, and problem-solving are the widely studied twenty-first-century skills. Although these skills are well articulated in many school curricula, the teaching of the skills receives little or no attention as the focus is mainly on teaching the content. This may be because the teaching and assessment of the skills are not made explicit in school curricula. However, researchers advocate for integrating soft skills while teaching various subjects (Busaka et al., 2022; Stauffer, 2020).

Teaching in the twenty-first century requires the use of methods that emphasize active learner involvement (learner-centered lessons), and this requires the teachers to possess advanced professional knowledge. One such professional knowledge domain is pedagogical content knowledge (PCK) - a specialized teachers' knowledge that enables them to transform content to become comprehensible to learners (Behling et al., 2022). Therefore, teachers need the right quality of PCK to conduct lessons that acquire intended learning outcomes (content knowledge) and twenty-first-century. As such, the current study focused on teaching and assessing twenty-first-century skills (4Cs) during a biology lesson study.

1.1 Defining twenty-first-century skills

Twenty-first-century skills comprise the knowledge, skills, and expertise that students should master for them to succeed in work and life in the twenty-first century (Battelle for Kids, 2019). According to Binkley et al. (2012), learning and innovation skills, also known as soft skills or 4Cs are the gold standard for student abilities and are required for them to meet the demands for success in work and life. These skills include communication, critical thinking and problem solving, collaboration, and creativity and innovation skills. They are defined in ***Table 1.***

Table 2: *Definitions of the 4Cs (soft skills)*

Skill	Definition
Critical thinking and problem solving	"one's ability to effectively analyze and evaluate evidence, arguments, claims, and beliefs; solve different kinds of non-familiar problems in both conventional and innovative ways" (Tabach & Trgalová., 2019)
Communication	"The ability to articulate thoughts and ideas effectively using oral and written communication skills in a variety of forms and contexts" (Tabach & Trgalová., 2019)
Collaboration	"The ability to work effectively and respectfully with diverse teams"
Creativity and	"Ability to use a wide range of idea-creation techniques to create new

innovation	and worthwhile ideas" (Tabach & Trgalová., 2019)

In addition to knowing how to use various teaching strategies, twenty-first-century teachers also have to know when to use specific teaching strategies in varying contexts to achieve learning goals (Kim et al., 2019). Darling-Hammond (2006) adds that teachers require a deeper knowledge to address the diversity among learners, and use more developed pedagogical actions to inform their decisions. Considering the significance of the 4Cs, it is inevitable to integrate them into the teaching of subject areas, such as biology. As Busaka et al. (2022) assert, the inability to integrate the 4Cs may lead to graduate's incapable of communicating, innovating, creating, and thinking critically. However, the Partnership for 21st Century Skills (2010) asserts that many education systems have failed to impart these twenty-first-century knowledge and skills fully.

1.2 Problem statement

Although there is agreement that citizens need to be empowered with essential skills for them to lead successful lives in the twenty-first century (Kim et al., 2019; Partnership for 21st Century Skills, 2010), there is a paucity of research investigating the teaching and assessment of these skills in sciences, particularly in biology, at the secondary school level. Furthermore, despite these skills being emphasized in the Zambian biology syllabus (Curriculum Development Centre, 2013a), there is a lack of research demonstrating how they can be taught and assessed. Therefore, this study serves as a precursor by investigating students' demonstration of the 4Cs during biology lessons.

1.3 Research questions

Based on the above, this study was guided by the following research questions;

1. What 4Cs do secondary school students demonstrate during biology lessons?
2. What activities enhance the students' demonstration of the 4Cs during biology lessons?

2.0 Methodology

2.1 Research approach and design

This study adopted the qualitative research approach and used the case study design which enabled an in-depth description of students' demonstration of the acquired soft skills (Creswell, 2013). In this study, the case refers to the teachers of biology and students who participated in the lesson study at the selected secondary school in Lusaka district of Zambia.

2.2 Sampling and ethical considerations

The sample comprised 24 students who were purposively selected from two classes in which research lessons were taught. Six biology teachers (3 males, 3 females) who taught biology at the school participated in the planning, teaching and observation of students during the lesson enactment. Two grade 11 classes were purposively selected based on their ability – one low-ability and one high-ability class. The teachers voluntarily gave consent for them and their students to participate in the study. They were assured that the identity of the school, teachers, and students would not be disclosed. Before data collection, the author obtained a research permit from the

Ministry of Education and the head teacher of the school involved. Based on Dudley (2014), 24 case pupils were observed in-depth during the two research lessons. Thus 12 case pupils were purposively selected in each class based on their abilities including four (4) low-achieving (case pupils A), four (4) medium-achieving (case pupils B), and four (4) high-achieving (case pupils C).

2.3 Instrument and data collection procedures

The study used the lesson study approach to investigate the teaching and assessment of the 4Cs. The research team planned to enhance their teaching and assessment of the 4Cs in their biology lessons through two lesson study cycles described below. Two research lessons were delivered to two grade 11 classes (11E and 11B) in the first term of 2022. The data were collected using a checklist developed by the researcher and validated by two biology education lecturers, and the research team. Each skill had five indicators (activities that represented the demonstration of the skills). The checklist required the observers to mark the presence of the activities during the lesson. The author guided the teachers on using the checklist when observing the case students and noting the evidence of the acquired and demonstrated 4Cs.

2.3.1 Lesson cycle 1

During the first lesson cycle, the research team prepared a biology lesson on types of tissue respiration based on the learning outcomes stipulated in the Zambia secondary school biology syllabus of 2013 (Curriculum Development Center, 2013a). The research team planned a learner-centered lesson capable of imparting the 4Cs (Curriculum Development Center, 2013b). After planning the first 120-minute research lesson, it was presented in grade 11E (with 56 students) by one of the teachers herein referred to as the demonstrator, while the other teachers carefully observed the lesson with particular emphasis on the behavior of the pupils. The teachers (observers) completed a 4Cs' checklist by marking the activities they saw the case students demonstrate during the lesson (Kim et al., 2019). The teachers also recorded the case students' reactions, questions, written work, and behavior such as lack of concentration, yawning, and so on. The research team then met for a post-lesson discussion where the research team reflected on the students' acquisition of the 4Cs and areas of possible improvement in the first research lesson.

2.3.2 Lesson cycle 2

During the second cycle, the research team collaboratively improved the first research lesson based on the observations and suggestions resulting from the first post-lesson discussion, the product of which was the second research lesson which was presented to grade 11B (with 60 students) by the same demonstrator. Similar to cycle 1, the other teachers carefully observed the lesson with particular emphasis on the behavior of the case students. The teachers (observers) completed a 4Cs' checklist by marking the activities they saw the case students demonstrate during the lesson. The teachers also recorded the case students' reactions, questions, written work, and behavior such as lack of concentration, yawning, and so on. The research team then met for a post-lesson discussion where the research team reflected on the students' acquisition of the 4Cs and areas of possible improvement in the second research lesson.

2.4 Data analysis

All four skills (4Cs) had five indicators which were enumerated by teachers (observers) by entering a frequency of one (1) for each indicator (activity) observed by each teacher (observer) and summing them up to find the overall score of the skill. The frequency scores for the respective skills were then added up and expressed as percentages. The following formula was used to compute the percent demonstration of each skill;

$$\%\ skill\ demonstration = \frac{\text{f}\ (number\ of\ observations)}{number\ of\ indicators * number\ of\ observers} * 100$$

To determine the activities that contributed to students' demonstration of each of the skills, a tick was placed against each observed activity or indicator, a blank means the activity was not observed. This represented the frequency of that activity. Therefore, the total frequency for each activity was obtained by counting and summing all the frequencies (ticks) indicated for all the two lessons, and expressing it as a percentage. The percent contribution of each activity to the demonstration of the skill was determined using the formula below;

$$\%\ contribution\ of\ each\ activity = \frac{\text{f}\ (number\ of\ observations/ticks)}{9\ (number\ of\ observers)} * 100$$

2.5 Trustworthiness

Similar to Poti et al. (2022), sseveral measures were observed to ensure the trustworthiness of the current study. For instance, credibility was ensured through prolonged immersion with the data and member checking with the research team members. Transferability was ensured through the in-depth description of the context of the study to enable readers to compare with the settings in their contexts. To ensure dependability and confirmability, the data collection and analysis procedures were described in depth. Therefore, the findings are relevant in demonstrating how secondary school teachers can be supported to teach and assess the 4Cs during biology lessons.

3.0 Results and discussion

This section presents the results and discussion of the study's results under two subheadings - skills acquired and demonstrated by the students, and activities that enabled the acquisition and demonstration of 4Cs.

3.1 Skills acquired and demonstrated by the students

The study found that the students demonstrated all 4Cs i.e., communication, collaboration, critical thinking and creativity, and innovation. The findings agree with Susilawati et al. (2020) who also found that these skills were among the soft skills that are important for students. The twenty-first-century skills empower students for success in their future careers and life and contribute to increasing their confidence, self-worth, and self-efficacy beliefs. *Figure* ***5*** shows that communication was the most acquired and demonstrated skill (39%) followed by collaboration (27%), critical thinking (12%), and creativity and innovation (10%).

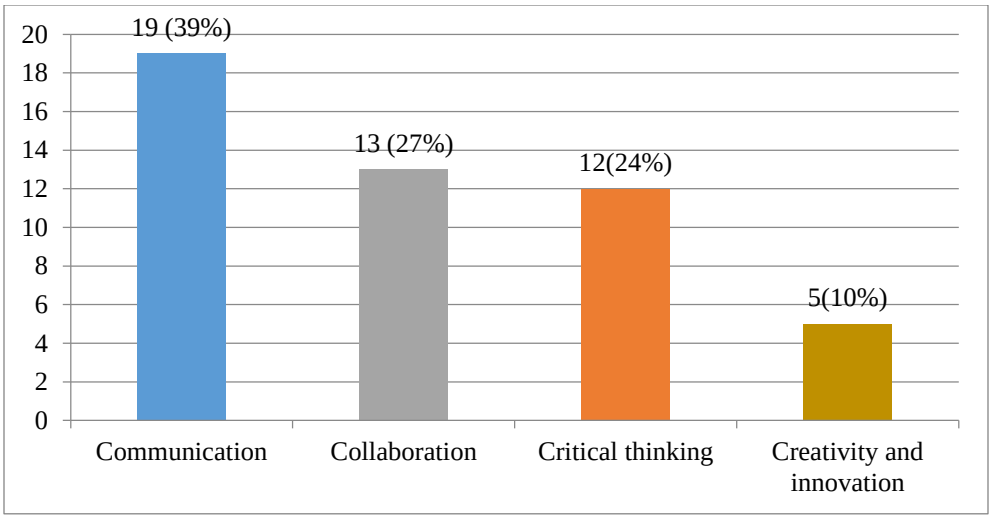

Figure 5. *Acquired and demonstrated twenty-first-century skills (4Cs)*

The results indicate that communication was the most acquired and demonstrated skill, while creativity and innovation skills were the least acquired and demonstrated skills.

3.2 Activities that enabled the demonstration of the 4Cs

The study also established the various teaching and learning activities that enabled the students to demonstrate soft skills. These activities were a result of the planned delivered learner-centred lessons which employed the group activity. This agrees with Yeoh and Otsuka (2019) who assert that students who are engaged in active learning will continue to achieve the outcomes expected in twenty-first century learning. The specific activities that enhanced students' acquisition and demonstration of each skill are highlighted below.

a) Communication

The study established that communication was the most demonstrated skill among the students. This contradicts the findings by Susilawati et al. (2020) who found that most science teachers perceived critical thinking as the most important skill students need. Communication skill is an important part of teaching and learning science as it enables students to communicate scientific ideas. According to Tang et al. (2015), communication skills help students to formulate both verbal and written communication to express ideas clearly and systematically. The current study also established the activities through which students demonstrated communication skills. Table 3 shows that the students demonstrated the acquired communication skills mostly by communicating in class/group discussion (56%) and making a presentation in class (67%) as shown in Table 3. In accordance with Tang et al. (2015) who state that the soft skills are needed to facilitate learning science, the current study's findings could have promoted students' learning of respiratory concepts.

Table 3: *Activities through which students demonstrated communication skills*

Activities	Lesson 1					Lesson 2				
	T1	T2	T3	T4	T5	T1	T2	T3	T4	f (%)

1. Making a presentation in class	✓	✓	✓	✓	✓	✓	6 (67)
2. Communicating in class/group discussion	✓	✓	✓	✓	✓		5 (56)
3. Giving an oral answer in class	✓	✓	✓				3 (33)
4. Listening attentively to others (including the teacher)	✓	✓	✓				3 (33)
5. Engage in conversation and discussion							

b) Collaboration

Collaboration was the second most demonstrated skill among the soft skills. This finding contradicts Ilma et al. (2020) who reported that students' collaboration skills were at the basic level. To enhance students' collaboration skills, the students were engaged in active learning through group activities. Through group activities, students were able to work together and support each other. The students shared ideas on word and chemical equations of tissue respiration. The study found that the students demonstrated collaboration skills mostly by taking leadership roles (33%), responding to others in groups or class (33), and cooperating with others in groups or the class (44%) as shown in Table 4. Imparting collaboration skills is critical in science education because they contribute to not only cognition but also the acquisition of knowledge. Collaboration also enhances students' problem-solving skills (Boholano, 2017).

Table 4: *Activities through which students demonstrated collaboration skills*

Activities	**Lesson 1**					**Lesson 2**				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**f (%)**
1. Responding to others in groups or class	✓	✓		✓						3 (33)

2. Showing responsibility and productivity	✓								2 (22)
3. Showing flexibility when dealing with others						✓	2 (22)		
4. Cooperating within the group or class				✓	✓	✓	✓	4 (44)	
5. Taking leadership roles	✓	✓	✓	3 (33)					

c) Critical Thinking

For critical thinking skills, the students demonstrated the skills mostly by giving reasons for or supporting their ideas (33%), and giving a constructive argument in class or group (33%) as shown in Table 5. Critical thinking skills are needed to further students' learning of science ideas. In line with this, Susilawati et al. (2020) report that most science teachers perceived critical thinking as the most important skill students need. As critical thinking plays a significant role in finding appropriate solutions to scientific problems, there is a need to empower teachers with the tools needed to impart and assess critical thinking skills effectively.

Table 5: *Activities through which students demonstrated critical thinking skills*

Activities										**Lesson 1**	**Lesson 2**
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**f (%)**	
1. Reacting to other pupils' answers									✓		

2. Giving or constructive questions arguments in class or group		✓																2 (22)	
3. Giving reasons for or supporting their idea			✓														✓		3 (33)

d) Creativity and Innovation

Nakano and Wechsler (2018) assert that creativity and innovation skills have the potential to promote an individual's potential by evoking some positive aspects of the individual. According to Daud et al. (2012), creativity can help students to generate and explore new ideas in greater depth thereby developing their existing talents and abilities. However, creativity and innovation skills were the least demonstrated and acquired skills in this study. Table 6 shows that only three of the five activities were identified by the observers. Generating ideas in groups or class contributed the most (33%) to the overall score of creativity and innovation skills. However, there was no evidence of students working creatively with others, and refining their own or other pupils' ideas. The results may be explained by the nature of the teaching sessions as they did not provide many opportunities for students to demonstrate these skills. This suggests a need for teachers to engage the students in learning activities that would promote creativity and innovation skills.

Table 6: *Activities through which students demonstrated creativity and innovation*

Activities	**Lesson 1**					**Lesson 2**				
	T1	**T2**	**T3**	**T4**	**T5**	**T1**	**T2**	**T3**	**T4**	**f (%)**
1.	✓					✓				2 (22)

	2. Working creatively with others			✓		2 (22)
3.	✓	✓	✓	3 (33)		

4.	Refining own or other pupils' ideas	✓		✓		2 (22)
5.		✓	✓	✓	3 (33)	

4.0 Conclusions and recommendations

The study established that the students demonstrated all four 4Cs during the research lessons. Communication and collaboration were the most demonstrated skills while critical thinking and innovation were the least demonstrated. Further, the study has established the various activities that contributed to students' demonstration of the 4Cs. The findings are significant as they demonstrate how teachers can teach and assess the twenty-first-century skills needed for successful lives in and out of school as stipulated in the syllabi. Furthermore, the findings add to the existing literature on the teaching and learning of twenty-first-century skills in science lessons. The study recommends enhancing the teaching and assessment of the 4Cs through the use of deliberate teaching and learning strategies such as student-centred teaching approaches. The study also recommends conducting professional development activities to enhance teachers' pedagogical content knowledge needed for effective teaching in the twenty-first century. Since the teachers in the study tested the teaching and assessment of the 4Cs in the classroom and observed the students' learning outcomes, their attitudes and beliefs toward teaching and assessing twenty-first-century skills may be changed (Agricola et al., 2020).

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Article 14

Implementation Of Secondary Science and Mathematics Teachers' (SESEMAT) Programme and Academic Performance in Science and Mathematics in Lango Region – Northern Uganda

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Abstract

The purpose of the study was to assess the level of academic performance of ordinary-level students in Science and Mathematics measured from the level of the implementation of the SESEMAT Programme in Lango region. SESEMAT Programme emphasizes: Activity-based learning, student-centered learning, encouragement, improvisation and improvement. The specific objectives were to:- find out the level of implementation of SESEMAT-based teaching/learning approaches in selected secondary schools in Lango region; analyze the trend in the academic performance of students in Science and Mathematics at ordinary level national examinations from 2007 through 2017 in the selected secondary schools and then compare the level of academic performance of ordinary level students in Science and Mathematics with the level of implementation of SESEMAT Programme in the selected secondary schools in the region. The study employed both qualitative and quantitative research methods with qualitative method being dominant. The population of the study was 1,008 comprising students, teachers and school administrators with a sample of 784 respondents. Data were collected using questionnaire forms, focus group discussion guide and interview guide. Data collected were analyzed using Statistical Package for Social Sciences (SPSS). The study found that the level of implementation of SESEMAT Programme was low at 25.7% and the poor academic performance of ordinary level students in Science and Mathematics in Lango region being attributed to the low level of implementation of SESEMAT Programme in the region. It is recommended that SESEMAT Programme be changed from the cascade system to an inclusive system-wide approach involving all stakeholders in education.

1.0 Introduction

1.1 Background to the Study

Secondary Science and Mathematics Teachers' (SESEMAT) Programme was launched in 2005 by the government of Uganda through the Ministry of Education and Sports and technical support from the government of Japan through Japan International Cooperation Agency (MoES, 2008). The major purpose of the programme is to improve teaching/learning in the disciplines of Physics, Chemistry, Biology and Mathematics (MoES, 2008). SESEMAT pilot project (Phase I) was implemented in three districts of Masaka, Tororo and Butaleja for three years from August 2005 to July 2008 (SESEMAT Joint Terminal Evaluation Report, July 2017). SESEMAT Programme national expansion plan (Phase II) was implemented from August 2008 up to July 2012

(SESEMAT Joint Terminal Evaluation Report, July 2017). The Joint Terminal Evaluation Report of July 2017 further reveals that in Phase II, there was the establishment of SESEMAT Programme Regional Management Committees mandated with, among other responsibilities, management of SESEMAT funds to ensure sustainability of the programme. In September 2013, Phase III started with the aim of consolidating INSET and introducing SESEMAT Activities Region-Based (SARB) as a try-out in selected regions.

The major concepts studied in this research were implementation of SESEMAT and academic performance in Science and Mathematics. Implementation is defined as a process that involves decisions, actions and corrections in order to deliver a programme through a series of activities geared toward a mission and results (Fixsen *et al*., 2005). Academic performance, according to the Cambridge University Reporter (2003), is frequently defined in terms of examination performance as a measure of learning achievement. Academic performance, which is measured by the examination results, is one of the major goals of a school and as Hoyle (1986) argued: schools are established with the aim of imparting knowledge and skills to those who go through them and behind all this is the idea of enhancing good academic performance.

The theory that guided this study is constructivism. The term constructivism encompasses a variety of theoretical positions: cognitive constructivism, social constructivism and radical constructivism (Geelan, 1997) and has mainly been applied to learning theories focusing on learning as a conceptual change (Driver & Oldham, 1986) and to curriculum development and teaching mainly in science (Osborne & Wittrock, 1985). This study was informed by cognitive constructivism as supported by Wadsworth (1997), who stated that children learning science through the constructivist approach are noticeably different from children learning by a more passive method; they are generally confident speakers, prepared to listen to the ideas of others and to argue their own point of view; work collaboratively and set about finding ways of checking whether their ideas are valid.

In a broader context, there is a continuous general decline in the academic performance of ordinary level students in Science and Mathematics in Uganda as indicated by UNEB analysis of UCE results of 2016 compared with those of 2015 shown in the table below. The results were analyzed using the lower limits of each grading category, that is, D2 for the distinction category, C6 for the credit category, and P8 for the pass category in order to make sense of what percentages of the candidates were able to score the lowest grade in each category.

Subject	**2016**				**2015**			
	No. of Candidates	**Percentage** D2	C6	P8	**No. of Candidates**	**Percentage** D2	C6	P8
Mathematics	314,597	3.1	28.9	60.7	304,055	3.0	32.2	79.2

Physics	313,950	0.4	9.3	31.9	303,237	0.5	15.4	41.7
Chemistry	314,110	1.3	11.4	40.1	302,792	1.3	13.9	42.8
Biology	314,157	0.1	16.1	45.1	303,458	0.3	13.0	40.7

Table (i)

Comparison of U.C.E. Examinations results 2015 and 2016 **Source:** UNEB

1.2 Statement of the problem

The poor academic performance in secondary Science and Mathematics in Uganda and particularly in Lango region has always caused great concern to all education stakeholders including learners themselves. An analysis carried out by UNEB regarding 2015 and 2016 UCE results shows that only Biology had a slight improvement at the credit and overall pass level compared to 2015 – *Table (i).* Failure to address the continuous decline in academic performance of learners in Science and Mathematics will lead to challenges of unemployment due to lack of specialized skills in the broader scope of Science and Technology hence socio-economic inequality in Lango region and Uganda as a country.

1.3 General research objective

The study was carried out to assess the level of academic performance of ordinary level students in Science and Mathematics in line with the level of implementation of SESEMAT Programme in Lango region.

1.4 Specific research objectives

The specific objectives of the study were to:

(i) find out the level of implementation of SESEMAT-based teaching/learning approaches in selected secondary schools in Lango region.

(ii) analyze the trend in the academic performance of students in Science and Mathematics at Uganda Certificate of Education (U.C.E.) examinations from 2007 through 2017 in the selected secondary schools in Lango region.

(iii) compare the level of academic performance of ordinary level students in Science and Mathematics with the level of SESEMAT Programme implementation in the selected secondary schools in Lango region.

2.0 Literature review

2.1 Constructivist theory

Constructivist theory of cognitive development emphasizes the active role of learners in building their own understanding of reality. Leinhardt (1992) states that the essence of constructivist theory is the idea that learners must individually discover and transform complex information if they are to make it their own. The constructivist view is one of the traditions in educational psychology that rest on the views that a learner's existing ideas are all important in responding to, and making sense of, stimuli. The learner makes sense of experience by actively constructing meaning (Osborne & Wittrock, 1985).

2.2 Educational programme implementation

Early studies on educational programme implementation suggest that many programme, even when fully implemented, were not solving the problems for which they were created (Odden, 1991). Research has found common gaps and challenges that education institutions face when implementing new initiatives, which include poor program conceptualization, poor alignment of supporting infrastructures in the system, changes in priorities, and a lack of buy-in and ownership (Datnow, 2005; Elmore, 1996; Supovitz & Weinbaum, 2008). Several studies reveal that implementing programme and initiatives is a highly complex process, and whether the new programme succeeds or not depends on the people and places involved (Honig, 2006).

2.3 SESEMAT Teaching/Learning approaches

2.3.1 Activity-based learning or active learning

Bonwell and Eison (1991) define active learning as an instructional method that engages students in meaningful activities during the process of learning. Ebert *et al.* (1997) views active learning as a way of improving students' learning in the classroom by involving the students directly in the learning process. From the two definitions above, active learning, therefore, is the act of engaging students in some activities that stimulate them to think about and react on the information presented. Students are required to develop skills in putting into use concepts learned and to analyze, synthesize, and evaluate the provided information in discussion with other students, through asking questions, or through writing (Malik & Janjua, 2011).

2.3.2 Student-centered pedagogy

Student-centered learning is the arrangement of learning content with an emphasis on the interests, knowledge and needs of the learners (Lea *et al*., 2003). It aims at making students attain the skill to explore their learning features and learn how to learn in this process (Saban, 2004). Student-centered instruction attempts to engender active learning by using methods such as cooperative learning, open-ended assignments, critical-thinking exercises, simulation, and problem-solving activities (Felder & Brent, 1996).

2.3.3 Encouragement from teachers to learners

Educational encouragement is positive feedback that focuses primarily on effort or improvement rather than outcomes. Given the crucial role of teachers in a learning situation, they must affect students' interest in Science and Mathematics, like in all other subjects. A student's desire for knowledge, need for achievement, ego-involvement and interest in a particular subject matter are all explained by motivational attitudinal behaviors (Akinboye, 1996) and such behaviors critically influence a student's attentiveness, degree of commitment and concentration on learning.

2.3.4 Improvisation of instructional materials

Improvisation in the view of Aremu (1998) is a technique of originating a totally new tool, instrument, materials, device or modifying existing ones for serving a particular purpose. When students are involved in the production of improvised instructional materials through their creative ability and imagination, it gives a new concept of things outside the range of ordinary experience

to the students and makes learning last longer in their memory. For students to be able to improvise, they must be innovative, resourceful and creative in both thinking and manipulative skills (Igwe, 2003).

3.0 Methodology

3.1 Research design

This study was conducted basing on a mixed research design. Both qualitative and quantitative research methods were used. The dominant research method in this study was the qualitative research method.

3.2 Data source

Data were collected from two sources: primary data source and secondary data source. The data collected by administering questionnaires to teachers, interviewing school administrators and having focus group discussions with lower ordinary level students constituted the primary source of data. Students' scores in the national examinations formed the secondary source of data.

3.3 Population of the study

The overall population of the study was 1,008 respondents comprising school administrators, teachers and students. There were 6 teachers and 120 ordinary level students per selected school per district throughout the eight districts that make up Lango region.

3.4 Sample size and sampling design

Basing on a population of 6 teaching staff and 120 students per school, the sample size of the teaching staff remained 6 and that of the students was 92 at 95% level of confidence according to Krejcie & Morgan (1970) sampling technique. All in all, a total of 784 respondents participated in this study. The researcher used purposive sampling technique to select the 6 teaching and administrative staff for the study because their areas of expertise matched with the objectives of this study (Bernard, 2002). The 92 students were selected using simple random sampling technique without replacement since the population of the students was homogeneous basing on the fact that they were all ordinary level students and all of them were studying Science and Mathematics as per the Compulsory Science Policy of 2004.

3.5 Data collection instruments

The researcher used questionnaire forms, interview guides and focus group discussion guides.

3.6 Data analysis

Both nominal and ordinal data collected using the questionnaire forms were analyzed using Descriptive Statistical Data Analysis method available in Statistical Package for Social Sciences (SPSS) software. Data obtained from the focus group discussions and interviews were analyzed using Constant Comparison Analysis method developed by Glaser and Strauss (Glaser, 1978, 1992; Glaser & Strauss, 1967; Strauss, 1987) in order to compare the strengths of the responses given by the respondents. The academic scores of the students were analyzed using Microsoft Office Excel data analysis package.

4.0 Data presentation, analysis, interpretation and discussion
4.1 Presentation of data by objectives
4.1.1 Objective 1: Implementation of SESEMAT Programme
4.1.1.1 Frequency of application of SESEMAT teaching/learning approaches

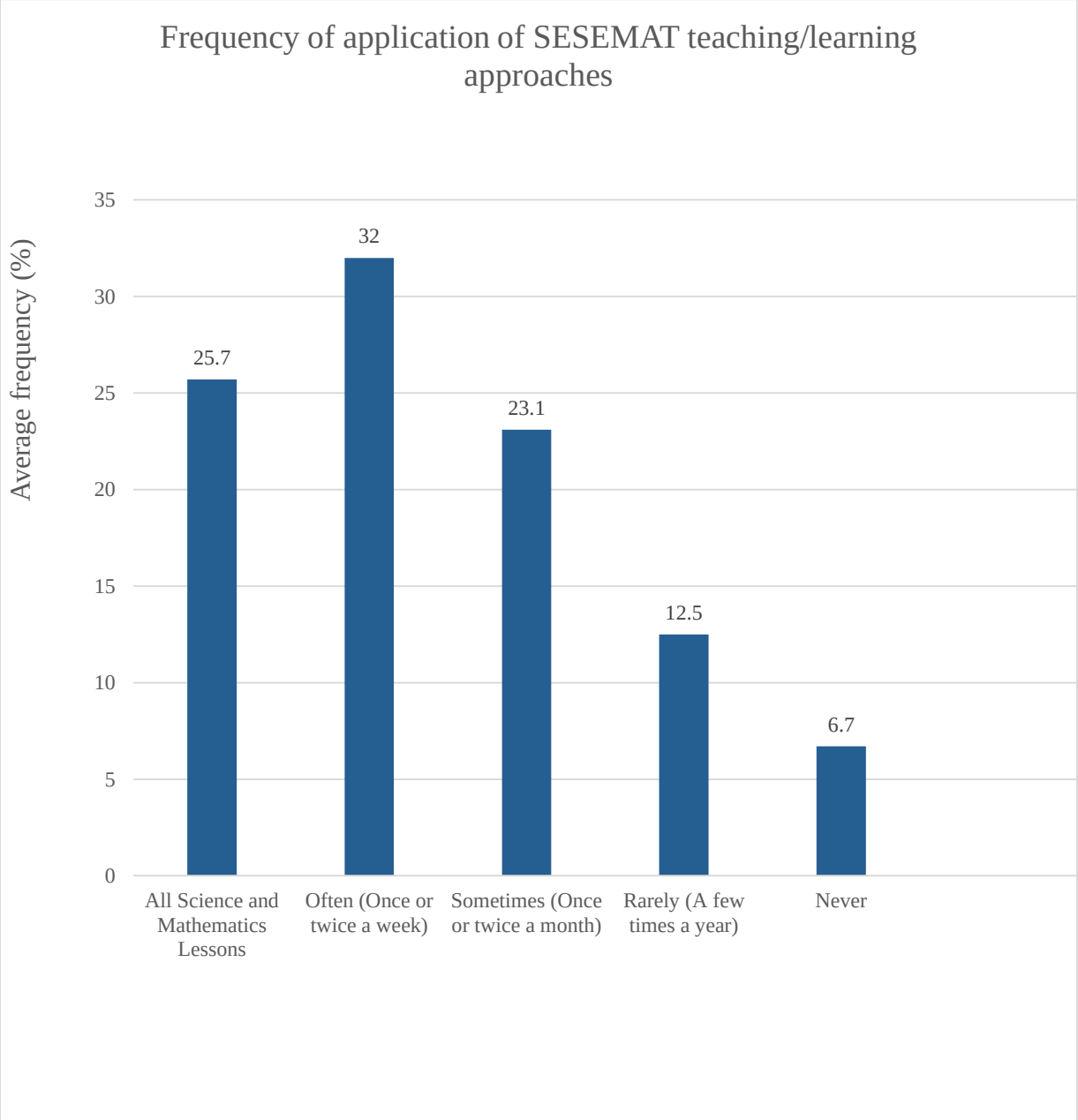

Figure (i) Source: Field Data, June 2018

4.1.2 Objective 2: Trend in academic performance
4.1.2.1 U.C.E. Examinations results of Lango region by grade category

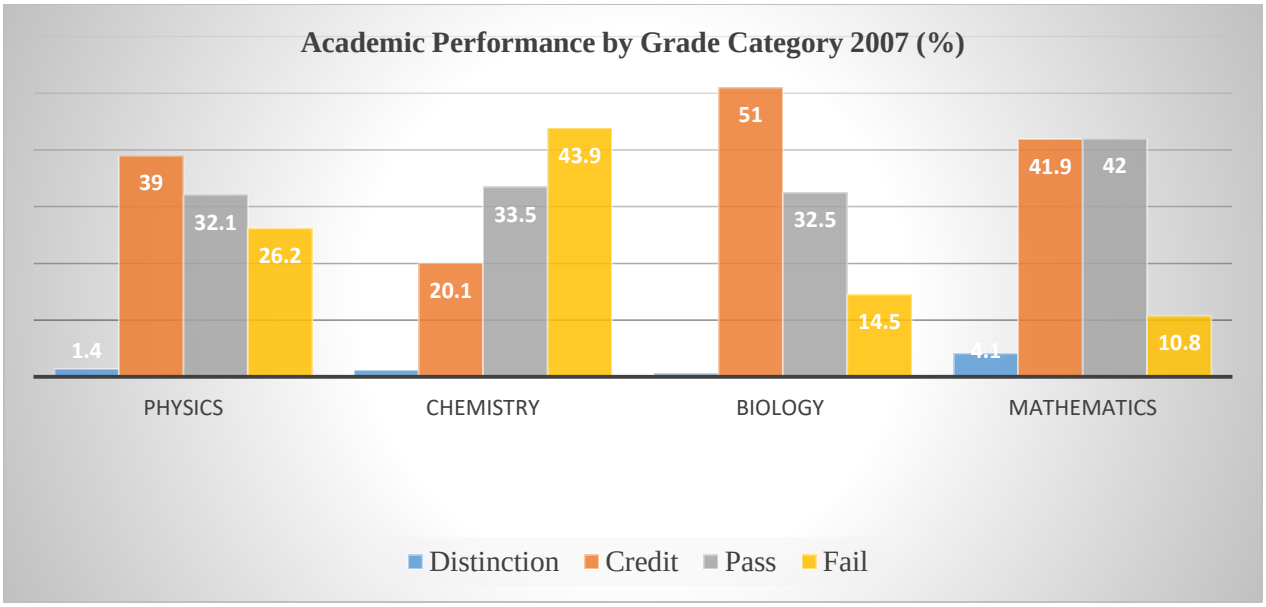

Figure (ii) **Source:** UNEB U.C.E. 2007

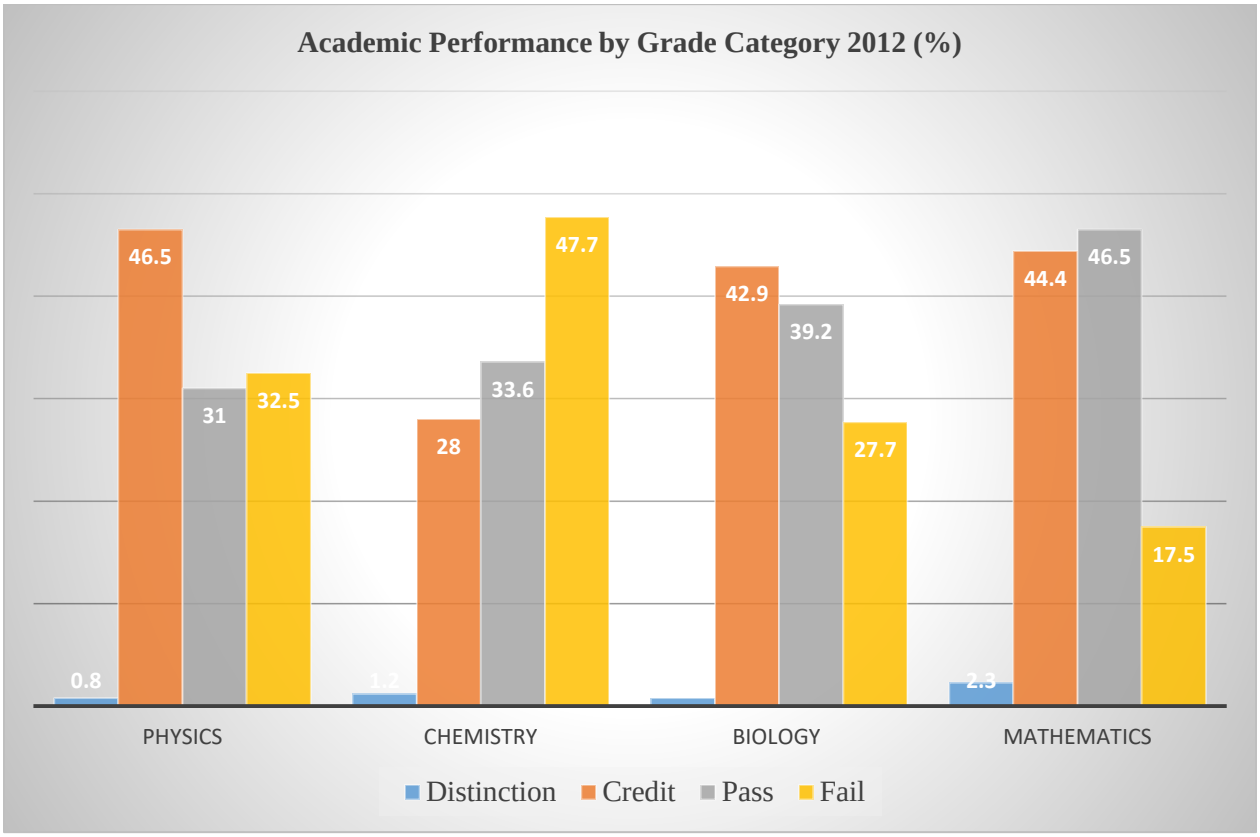

Figure (iii) **Source:** UNEB U.C.E. 2012

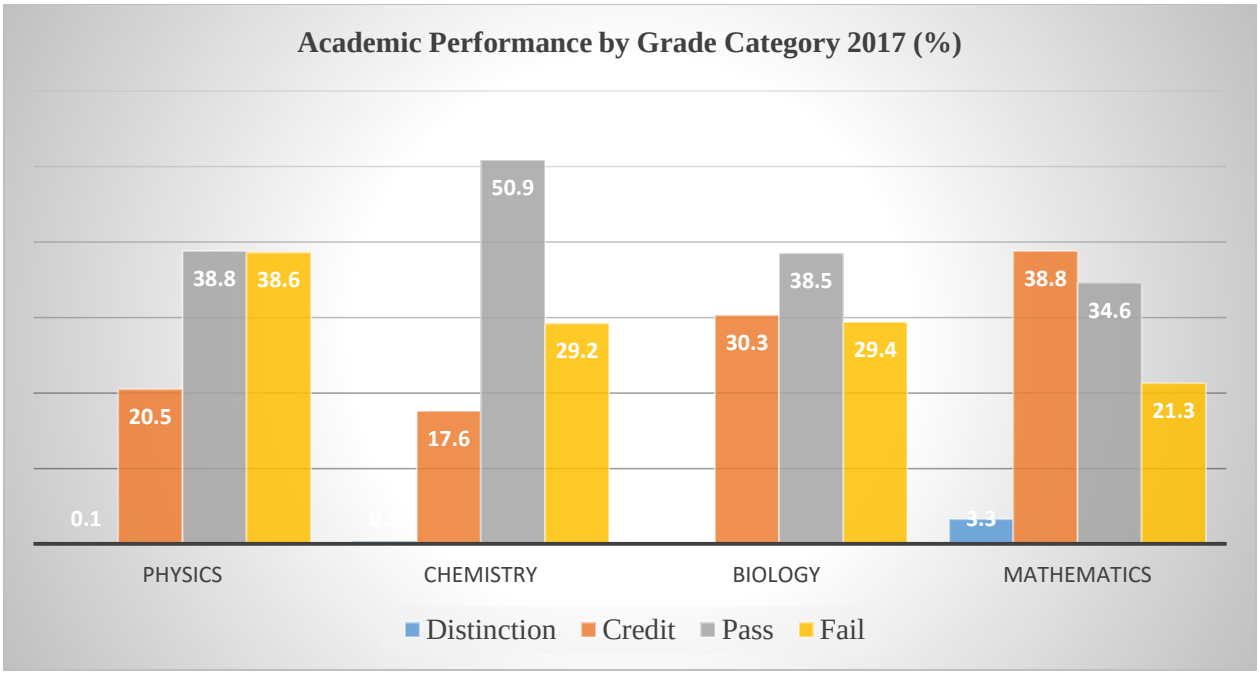

Figure (iv) **Source:** UNEB U.C.E. 2017

4.1.2.2 Interviews with school administrators

Interviews with School Administrators revealed that one of the challenges is that much as SESEMAT Programme emphasizes team-teaching, it is difficult to bring all the teachers of a particular Science subject together to team up in conducting a lesson since they have different personal problems and different commitments. It was also generally reported that Science and Mathematics teachers are very few and so most of them move about teaching in other schools in what is always referred to as part-timing. Negative attitudes of the Science and Mathematics teachers towards implementing SESEMAT Programme is yet another big challenge as most of them complain of "lack of time" because SESEMAT teaching/learning approaches require adequate preparation for lesson delivery. "As most headteachers are not Science-oriented, teachers of Science and Mathematics are not being properly supervised during lesson studies as required by SESEMAT Programme," remarked one school administrator.

When asked about the "lack of time" for completing the syllabus always raised by teachers of Science and Mathematics when SESEMAT teaching/learning approaches are used, most of the school administrators intimated that Science and Mathematics teachers simply want to have their time so as to go and do part-time teaching in other schools and most of them have negative attitudes towards the programme. One school administrator had this to say, "Teachers are lazy in implementing SESEMAT Programme, they simply want to have time for their personal businesses." Regarding strategies put in place for improving the teaching/learning of Science and Mathematics in secondary schools in the region, most school administrators reported that they have done the following things: allocated weekends for teaching practical lessons, enabled teachers to give end-of-topic assessments, allocated budget for SESEMAT activities, encouraged teachers of Arts

subjects to incorporate SESEMAT teaching/learning approaches in their lessons, always invited senior examiners from other schools to guide students on question-answer techniques and awarding best performing subject teachers.

4.1.2.3 Focus group discussions with learners

On the comparison between SESEMAT teaching/learning approaches and the traditional methods of teaching, it was unanimously agreed by the students that SESEMAT pedagogy supersedes the traditional teaching methods in that SESEMAT Programme encourages creativity as a result of the minds-on, hands-on activities done during the lesson.

Students reported that SESEMAT Programme has enabled them have positive attitudes towards learning Science and Mathematics by actively participating in lessons and freely interacting with teachers during and after lessons. They are highly motivated by the encouragements given to them by the teachers during lessons and this has promoted critical thinking. "Because SESEMAT Programme emphasizes the applicability of the skills learnt in Science and Mathematics to daily life, students are now able to prepare cough syrups and soap," said one of the students during one of the focus group discussions. Most of the students said they foresee a big improvement in their grades in Science and Mathematics because of the SESEMAT Programme.

The learners revealed that when they join Secondary Education in year one, those that are ahead of them always tell them that they cannot study Mathematics and Science because they are very difficult! It is a form of teasing thereby letting them lose interest in studying Mathematics and Science.

5.0 Findings

5.1 Objective 1

Going by the frequency of application of SESEMAT teaching/learning strategies in the classroom, only 25.7 percent of the teachers of Science and Mathematics who participated in this study reported incorporating those strategies in All Science and Mathematics lessons. This shows that the level of implementation of SESEMAT Programme in Lango region is very low.

5.2 Objective 2

The study established that the academic performance of ordinary level students in Science and Mathematics had been declining over years from 2007 through 2017. Comparing the academic performances in the three years of 2007, 2012 and 2017 on which the study was based, it was found out that there was a general decline at the distinction level from 2007 through 2017. Although academic performance at the credit level increased in 2012 compared with that of 2007, it declined drastically in 2017. At the pass level, there was no marked difference in academic performance over those years except for Chemistry which increased from 33.6 % in 2012 to 50.9 % in 2017 while Mathematics dropped from 46.5 % in 2012 to 34.6 % in 2017.

5.3 Objective 3

The free-falling academic performance of ordinary level students in Science and Mathematics in

Lango region is attributable to the poor implementation of SESEMAT Programme in the region, holding other factors that affect academic achievement.

6.0 Conclusion

It is concluded that:

The level of implementation of SESEMAT Programme in Lango region is low. The academic performance of ordinary level students in Science and Mathematics in the region is poor. The poor academic performance of ordinary level students in Science and Mathematics in Lango region is majorly a result of the low level of SESEMAT Programme implementation in the region.

7.0 Recommendations

It is recommended that: The department of Science and Technology in the Ministry of Education and Sports explore further avenues in formulating new effective policies and strategies for the continuation of SESEMAT Programme in Uganda. SESEMAT Programme National Coordination Office design programme aimed at training school administrators, especially those who are Arts biased, on how to monitor and supervise the implementation of SESEMAT Programme in their schools. School Administrators and Teachers encourage students to develop interest in studying Science and Mathematics at the earliest possible time when they join Secondary Education in order to change the mindset that those subjects are very difficult to pass.

8.0 Areas for further studies

In the process of carrying out the research, there were some areas the researcher felt could have been included in the study but was limited by the scope of the study. In this respect, therefore, these areas were excluded but could form an important part of another study on the academic performance of students in Science and Mathematics. These areas include: level of qualification of teachers and academic performance of students, experience of teachers and academic performance of students and number of years spent by a teacher in one workplace and academic performance of students.

9.0 Acknowledgment

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Article 15

Report of Students in Transition Secondary/University to Knowledge Relating to Preliminary Concepts on Functions

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Abstract

This article resulting from the observations made during the diagnostic evaluations within the framework of the courses of Analysis 1 and Discrete Mathematics with the transition secondary/university, is interested in the report/ratio of the students of first license with the knowledge relating to the generalities on the functions, particularly to the domain of definition and the parity of a function. The institutional constraint which presents the domain of definition of any real function as a union of intervals rules out any other alternative. Similarly, the definition of parity is partially exploited. The analysis of the programs and two textbooks most used in secondary school shows that the teaching of functions only uses the set register and the graphic register, without passing from one towards the other. Separating these registers, and also others, does not promote the understanding of this object of knowledge and has repercussions on the conceptions of the learners. A posteriori analysis that we made confirms all that has just been said and was noted in the a priori analysis of the questionnaire submitted to the students. The study here is prospective. We therefore propose to begin the teaching of functions with phenomena of everyday life where one perceives the notion of dependence, then its definition with all the notions attached to it by highlighting the different tasks and types of tasks.

Keywords: *Function, domain of definition, parity, tasks, task types, representation register, priori analysis, posteriori analysis*.

1.0 Introduction

Over three successive academic years (2019-2022), we have provided the Mathematical Analysis 1 course in First Graduate[7] Computer Science at the Protestant University in Congo (UCC) and the Discrete Mathematics course in First License (LMD) of Computer Science and Technology at the Department of Sciences of the Higher Pedagogical Institute of Gombe (ISP/G).During the sessions of tutorials, practical work and various assessments, we found that students return to the same errors in relation to the basic notions they saw in secondary education, regardless of the section or the level option followed. These errors are related to the basic notions of functions, in particular the notion of domain of definition and the parity of a function. We asked ourselves

[7] This level corresponds to the first License in the LMD system.

questions about the origin and causes of these difficulties. An a priori analysis of a questionnaire submitted to the students was made. An analysis of curricula and textbooks was carried out. We have found that one type of task is neglected, particularly on the way the function is defined and that relating to the geometric framework. Knowing that in the analysis of knowledge relating to the object function the literature reveals three modes of apprehension, which mode is privileged in the teaching of functions in the DRC? An analysis of the programs and functions was carried out with the aim of raising it and above all of determining the relationship of the students to the notions of the domain of definition of a function and of parity.

2.0 Methodology

We carried out various evaluations with around a hundred students. We wrote a questionnaire based on an a priori analysis and submitted to the students. We conducted an analysis of programs and textbooks. Finally, we analyzed the questionnaire and drew up statistical tables showing the various errors. A posterior analysis was also performed.

2.1 Theoretical framework and state of the question

The concept of didactic transposition introduced by Chevallard in 1975 aims to point out the gap between scholarly knowledge and knowledge to be taught, and between knowledge to be taught and knowledge taught. The anthropological theory of didactics that he will develop later will encompass and generalize the concept of didactic transposition. This theory is based on the notion of object. Chevallard considers that everything is an object (denoted O). Knowledge, and particularly mathematical knowledge, is one of them. Two other types of objects are essential in this theory, people (denoted X) and institutions (denoted I). An object O exists when a person or an institution recognizes this object as existing for them, or more precisely if there is a personal relationship from X to O (denoted R (X, O)) or institutional from I to O (denoted R (I, O)). Thus, an object only exists because it is known to a person (or an institution), it only exists as an object of knowledge.

Knowledge is objects that can be learned or taught, and cannot be known (therefore cannot be objects of knowledge) without having been learned. The term learning refers to the term institution in the sense that learning can only take place within an institution (taken here in the broad sense).

The concept of didactic transposition of a knowledge, in particular that of the function in the classes of First Graduate in Computer science at the UPC and first License (LMD) at the ISP/Gombe allows us to debate about the meaning that takes on the concept of function for the aforementioned students, and more precisely on the domain of definition and the parity of a function. Mathematical knowledge is part of human activities. It is designed in the scholarly sphere, redesigned for the school sphere, taught (by teachers) and learned (by students). All these parts of mathematical knowledge are all human activities which mean that it must be analyzed on the basis of its praxeology (Amra, 2014).

A praxeology, and therefore a mathematical praxeology, is determined by the tasks or types of

tasks, the techniques, the technologies and the theories which constitute it. As part of this study, it will be a question of determining the domain of definition of a given function, of studying its parity, etc. Any praxeology relating to the task t specifies a technique relating to t and therefore contains a practical-technical block, commonly called know-how. Amra notes that a technique only succeeds on part of the tasks of the type T to which it is related, this part is called the range of the technique. She also notes that a technique is not necessarily algorithmic despite "a fairly general trend towards algorithmization" (Chevallard, 1999, p.93).

In addition to the theoretical framework presented above, we will also use the notions relating to the registers of representations and the frameset. Amra (2014) based on the work of Gutzman-Retamal distinguishes in addition to five registers of representation that the latter identified by studying the concept of function, six others. These representation registers are the following: the algebraic register, the graphic register, the programming register, the table of values register, the verbal register, the arrow diagram register, the set of coordinate pairs, the symbolic register, the set register (R = $\{(x,y)t.q.y = x^2 \; et \; x \in N\}$ the register of the variation table and the register of geometric figures (for functional situations).

These registers are relativized to the frames in which they most often appear. The main frameworks that emerge are the numerical framework, the algebraic framework, the functional framework and the geometric framework. The latter appears in situations of modeling by a function of geometric problems. But equivalently, we can speak of the framework of physics, economics, everyday life, etc. This framework also appears in connection with the graphical representation of functions. These are (…), on the other hand, the geometric properties of functions such as parity, periodicity (…) (Amra, 2014, pp. 70-71).

Guedet G. and Vandebrouck F. (2019) present a synthesis of works that deal with the "secondary-higher transition". These authors note in the Anglo-Saxon world several reports published in the late 1990s or early 2020s aimed at drawing attention to the insufficient prerequisites of students entering the University. The lack of prerequisites is not the only reason explaining the difficulties encountered by beginning students. Research since 2000 has largely shown that different types of factors are at the root of these difficulties. These authors were interested in the first part of their work in the analysis of the causes of the difficulties.

As for functions, these authors say that they are "complex objects and their understanding by students is far from complete by the end of high school." […]. A number of concepts or global properties of functions may also not have been studied enough in high school to anchor the idea of covariation, continuum and global: domain of definition, set image, parity, periodicity, or even sign of a function on a domain for example". They find that high school math curricula are nationally defined and high school teachers are generally not involved in writing them.

As far as we are concerned, we are interested in the relationship to knowledge of First Graduate students in computer science at the Protestant University in Congo (UPC) and relating to the

fundamental notions of functions, in particular the domain of definition and parity.

3.0 Analysis of programs and textbooks

3.1 Program analysis

In this section, we analyze the 2005 program and the educational program of the Domain of Science Learning (DAS) in force since the 2020-2021 school year.

Placing ourselves in the anthropological approach, we propose here to:

- Highlight the preferred mode of apprehension in Congolese education to introduce the concept of function;
- Determine the types of tasks that emerge as well as their technical and technological environment, especially on the domain of definition and the parity of a function.

2005 program

It emerges from the reading of the methodological directives that the mode of apprehension of the concept of function is the set law. By this mode, the domain of definition of a function is defined as being the set of elements of the starting set which have an image in the arrival set, or for a numerical function of real variable, the set of real numbers x for which the image f(x) exists. The indication in the program regarding the writing of the domain of definition forces the teacher to consider that any numerical function has the set $\mathbb{R}$ as its starting set.

With regard to parity, no methodological guidelines are given.

Education program of the DAS (Third year of scientific secondary school)

The structure of this program is as follows:

- A list of essential knowledge
- A bank of situations Skills
- An example of situations
- A table of specifications
- An evaluation.

The essential knowledge relating to our study are:

- Usual numerical functions with real variables;
- Domain of definition of a numerical function;
- Operations on numerical functions.

From our analysis of this program, we can retain that the institutional relationship relating to the domain of definition consists in considering as a numerical function a function whose starting set is the set $\mathbb{R}$ of real numbers, even if the starting set is a proper part of this set. And the directive presenting this domain as a union of intervals compels teachers to this consideration. And many phenomena of everyday life modeled do not abide by this rule. Example: A mango costs 100 FC each. We designate by p the function which associates to a number x the price p(x) of x mangoes. Which gives p(x) = 100x. The domain of definition of p is $\mathbb{N}$ or a part of it, because we only sell whole mangoes.

This program introduces, from the graphic register, the geometric properties which translate a property of the graphic representation involving the geometric transformations unknown to the pupils. The proposed situation considers the time variable (in seconds) and the positions occupied by the bird 1, 2 and 3 seconds before and after having missed its prey. This variable is likely to pose a difficulty linked to the fact that t and –t belongs to the same starting or definition set.

3.2 Analysis of textbooks

We analyze two textbooks that are most used for teaching functions in the City of Kinshasa for 3rd year classes of scientific humanities and 6th year, sections: literary, commercial, pedagogical, artistic, social and cut-sewing.

The first is titled: *Study of Functions. Real functions of a real variable*. *Theory and exercises*. It was published for the third time at the Center "Recherches Pédagogiques de Kinshasa" in 2006. This manual has six chapters and the chapter that interests us is entitled: General information on the functions and includes the following points:

Introduction

1. Definitions
2. Domain of definition
   2.1. Definitions
   2.2. General rule for determining the domain of definition
   2.3. Polynomial functions
   2.4. Rational functions
   2.5. Irrational functions
   2.6. Sum, difference and product of several functions
   2.7. Quotient of two rational functions
3. Even functions
   3.1. Definition
   3.2. Property
4. Odd functions
   4.1. Definition
   4.2. Property

In the introduction, the manual insists on the variational aspect of a function by recalling this: *"Given a variable x, we say that the variable y is a function of x if the values to be assigned to y depend on the values assigned to x. This dependence between the values of x and y can be translated by the expression y = f(x), making it possible to calculate y knowing x"* (Makiadi, 2006, p.10). The manual defines without transition, without any situation for example, the definition of a function as a set law.

After the definition of the domain of definition, the manual states the general rule for determining the domain of definition of a function. The following is marked by a categorization of "usual" functions for which an algorithmizing is given in each case.

With regard to parity, the manual gives the definition and then the corresponding geometric property without reference to the given function. The graphs presented place two symmetrical points respectively with respect to the y-axis and the origin of the axes, M' (-a, b) and M(a,b). It is not easy to derive from this the definition or the parity property of a function f.
In the exercises, the only task is to determine the domain of definition for functions whose starting set is assumed be set $\mathbb{R}$.

The second textbook is titled "Maîtriser les Maths 5". It is published by Editions Loyola in Kinshasa in 2010. It includes twenty-two chapters and the one that interests us is chapter XI entitled: General information on the functions. It covers the following points:

1. Definitions,
2. Domain of definition and domain of values,
3. Comparison of functions,
4. Absolute value of a function,
5. Injective, surjective function, bijective function,
6. Reciprocal of a function,
7. Parity of a function

This textbook defines a numerical function as a set law. Like the first, it categorizes the functions and indicates each time how to find the domain of definition. Apart from the algebraic register, no other is considered.

The only task taken up in the exercises is to determine the domain of definition for "explicit"[8] functions defined in the form y = f(x), the starting set being assumed to be the set $\mathbb{R}$.
With regard to the parity, the textbook gives the definition and makes no allusion to the geometric aspect of this property.

It emerges from the analysis of these textbooks that the institutional constraint is present in both textbooks: **to write the domain of definition as a union of intervals**. And to do so, it is necessary to fix the modus operandi to determine the domain of definition for each category of functions (polynomial, rational, irrational functions, etc.). None of the textbooks presents any life situation for which the domain of definition can be determined. Neither of these two manuals makes it possible to pass from the graphic register to the algebraic register to determine the domain of definition of a function nor its parity.

4.0 Analysis
4.1 A priori analysis of the questionnaire submitted to the students
Question 1
Question asked to ISP/Gombe students
Consider the following functions:

[8] The term is from the authors of the textbook.

A. f: $\mathbb{R} \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 - x + 3$
B. f: $R^+ \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 - x + 3$
C. f: $[-5,5] \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 - x + 3$.

Determine the domain of definition of each of them.

Question asked to UPC students

Same question with the following functions:

A. f: $[-3,3] \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 + 2x + 3$
B. f: $R^+ \longrightarrow \mathbb{R}$: $x \mapsto f(x) = \sqrt{x-1}$
C. f: $]-1,1[\longrightarrow \mathbb{R}$: $x \mapsto f(x) = \frac{1}{x^2-1}$

A first variable is the algebraic expression of the three given functions f. Is the student able to find the definition of a function and to give its characteristics: starting set, arrival set and the link allowing to establish a relationship between elements of these sets? A second variable is that linked to the starting sets which are diversified. Can the student rely on this difference to determine the domain of definition of these three functions when their algebraic expression is the same? Will he be able to take into account the starting set given in the exercise or the one that is already fixed, namely $\mathbb{R}$?

To determine the domain of definition, he will use the **operational identification lexemization[9].** The official knowledge that the teacher taught him in high school tells him how to write a domain of definition of a function and how to find it. Thus, he will be able to consider the set $\mathbb{R}$ as a definition set for any given function whether the function is taken up with all its characteristics or only by its algebraic expression.

Concretely, to find the domain of definition of a function, it will be based on the operating mode that was taught to them. The latter consists of this

1) If the given function is polynomial, the domain of definition is the set $\mathbb{R}$.
2) If the given function is rational, we seek the value(s) which cancel(s) the denominator and exclude it from the set $\mathbb{R}$.
3) If the given function is irrational (of even index), we look for the values that make the radicand positive and we exclude them from the set $\mathbb{R}$.

Question 2

Question asked to ISP/Gombe students

Study the parity of each of the following functions:

A. f: $R^+ \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 + 1$
B. f: $\mathbb{R} \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 + 1$

[9] In his article entitled "Some reflections on the place of definitions in teaching", ENGOMBE WEDI SHAMBA (1989) points out that linguists distinguish the act of defining, called lexemization, from the result of this act, which they call definition. He gives the example of the definition of a set: "A set is made up of elements. A set is well determined if we can recognize all the elements that constitute it. The student is not told what a set is, but he is told how to write it and how (later) to manipulate it.

C. f: $[-5,5] \longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2 + 1$.

Question asked to UPC students

Study the parity of each of the following functions:

A. f: $[0, +\infty[\longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2$

B. f: $]-\infty, +\infty[\longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^2$

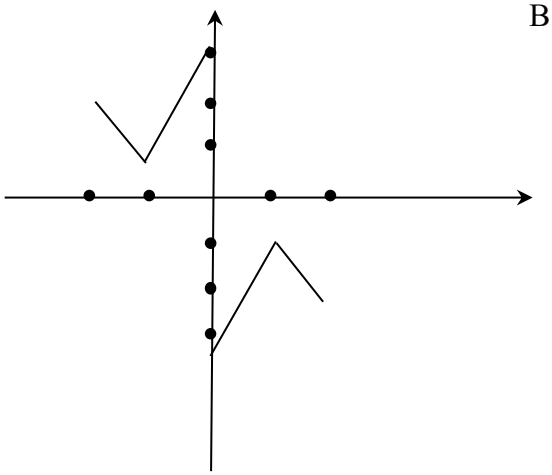
C. f: $]-3,3[\longrightarrow \mathbb{R}$: $x \mapsto f(x) = x^3 + x$.

The fact that all these functions have the same algebraic expression may push the student to find the same answer, because he will start from this expression to decide on the parity of the function. The student will find f(-x) and then compare it to f(x) or to –f(x) to conclude that the function is even or odd. It is not concerned with the existence of the opposite of x in the definition set of the function, therefore with the first condition to be fulfilled for a function to be even or odd.

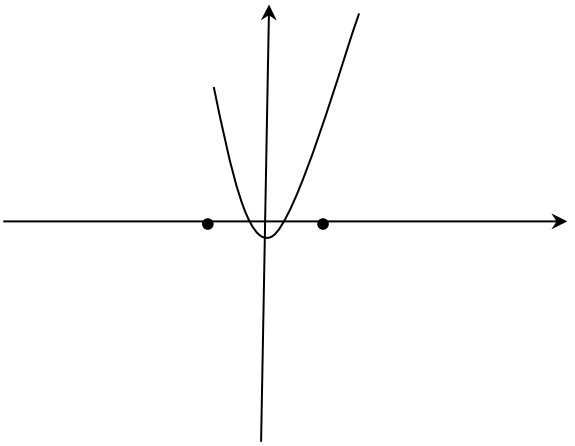
Question 3

Which of the curves given below represent an even function? An odd function? Justify the answer each time.

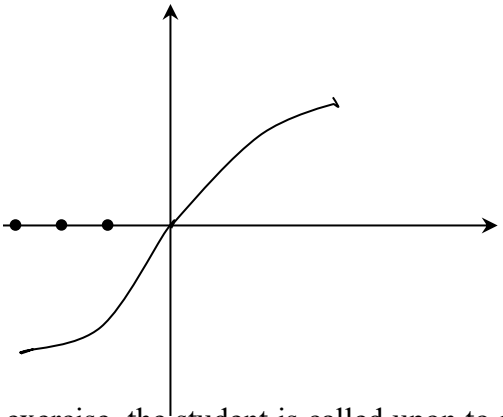
A.



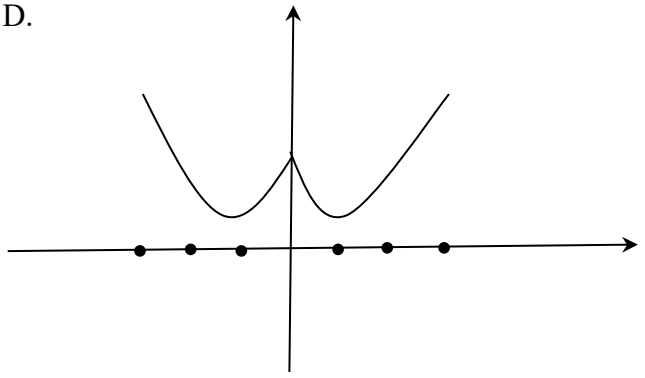
B.



C.



D.



In this exercise, the student is called upon to resort to the geometric meaning of the parity or the oddness of a function. He must use the notion of axial symmetry (in relation to the ordinate axis)

and symmetry in relation to a point. The student must choose points for which he will seek the symmetry in either case. In this exercise, the student will not rely on the characterization of an even or odd function by comparing the images of x and -x, but by looking only if the curve has an axial or central symmetry. Thus, sub-question B where there is apparently a symmetry.

Question 4

In each case of question 3, determine the domain of definition of the function. There are several ways of defining a function: as an algebraic expression, a graphical representation, a table of values, etc. This is to check whether the student knows how to move from one register to another. The passage from the analytical expression to the graphic representation is the one that the student usually uses. Does it develop the same skill to read the graphical representation and then write the definition domain?

To do this, he must project the graphic representation orthogonally on the abscissa axis.

Presentation of results

We present the results of students from two institutions.

Table 1: *Results on the domain of definition (UPC)*

Question	Answers		Number of students (in %)	
	Right	Wrong	For right answers	For wrong answers
A	[-3,3]	R	5	90
B	[1, +∞[	R^+	50	50
C	]-1,1[	$R \setminus \{-1,1\}$	15	85

Table 2: *Results on the domain of definition (ISP/G)*

Question	Answers		Number of students (in %)	
	Right	Wrong	For right answers	For wrong answers
A	$\mathbb{R}$	R	42	58
B	R^+	$\mathbb{R}$	42	58
C	$[-5,5]$	R	50	50

Table 3: *Parity results (UPC)*

Question	Answers	Number of students (in %)

	Right	Wrong	For right answers	For wrong answers
A	Neither even nor odd	Even	10	90
B	Even	-	70	30
C	Odd	Neither even nor odd	50	50

Table 4: *Parity results (ISP)*

Question	Answers		Number of students (in %)	
	Right	Wrong	For right answers	For wrong answers
A	Neither even nor odd	Even	66	34
B	Even	-	100	00
C	Odd	Neither even nor odd	00	100

Table 5: *Recognition of a graphical representation of an even or odd function.*

Question	Answers		Number of students (in %)	
	Right	Wrong	For right answers	For wrong answers
A	Even, because the graph presents a symmetrical curve with respect to the x-axis.	Odd, without any justification	90	10
B	Neither even nor odd, because the graph presents a curve which is neither symmetrical to the ordinate axis, nor symmetrical to the origin of the axes.	Even, without any justification	100	00
C	Odd, because the graph presents a symmetrical curve with respect to the origin of the axes.	Neither even nor odd	80	20
D	Even, because the graph presents a symmetrical curve with respect to the ordinate axis	Even, without any justification	90	10

Table 6: *Determination of the domain of definition from a graphical representation of a function*

Question	Answers		Number of students (in %)	
	Right	Wrong	For right answers	For wrong answers
A	$[-2,2]$	$\mathbb{R}$	8	92
B	$[-1,+\infty[$	$\mathbb{R}$	0	100
C	$[-1,1]$	$\mathbb{R}$	58	42
D	$[-3,3]$	$\mathbb{R}$	50	50

4.2 Post-hoc analysis

The students' answers confirm the institutional relationship relating to the notions of domain of definition and parity noted above in the programs.

The programs indicate a general rule for determining the domain of definition of a function, and this rule is repeated in the two textbooks that we have analyzed. Interviews with students during assessments confirm this. Although the function is defined in the form of a set law, whatever the starting set, the students start from the rule which considers that any function defined in explicit form has $\mathbb{R}$ as its starting set. This is an obstacle for the transfer of this definition to the phenomena of everyday life or to functional situations. The passage from the graphic register to the algebraic register being absent in the programs and in the textbooks, it is also absent in the relationship of the students to this knowledge. The students are surprised that they are asked to find the domain of definition from the graphical representation of a function.

As far as parity is concerned, the definition is of no use to them and they only use it in part. They are limited to checking the equalities f(-x) = f(x) and f(-x) = -f(x) without worrying about whether x and –x belongs to the starting set or to the definition field.

5.0 Conclusion

The questions asked during our ongoing evaluations have allowed us to see certain gaps in the teaching of the functions, to make a diagnosis and push us to carry out a more in-depth study on all the generalities on the functions. For the learner to acquire the meaning of the notion of domain of definition and parity of a function, we propose taking into account all the registers involved in these notions. Start with the definition of the function as a set law by insisting on the conditions of existence of the image f(x), i.e., of membership of f(x) in the starting set. If the latter is a part of $\mathbb{R}$, recall that if a and b are two elements of $\mathbb{R}$, their sum, their product, their difference are also elements of $\mathbb{R}$; their quotient, their root of even index are respectively elements of $\mathbb{R}$ provided that the denominator is non-zero, the radicant is positive. Then consider everyday life phenomena, model them and find their domain of definition. Then start from the graphic register to find the domain of definition. For parity, insist on the definition as the tendency noted among students is to check whether f(-x) = f(x) or –f(x). And for that, consider cases where the starting set does not

contain x and –x by performing the transition from the algebraic register to the graphic register and vice versa.

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Article 16

School Environment and Physics Teacher Effectiveness in Kigezi Sub-Region, Uganda

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Abstract

This study investigated the relationship between school environment and physics teacher effectiveness in secondary schools in Kigezi Sub region, Uganda. The focus of the study was to find out the relationship between school environment and physics teacher effectiveness in Kigezi-sub-Region. This study employed both quantitative and qualitative techniques where both types of data were collected and analyzed sequentially. The study adopted a mixed research design. Data was collected from 234 Physics teachers, Fourteen (14) head teachers and Six (06) education officials. The gathered data was analyzed through the statistical software programs SPSS to see if correlations between the variables existed. Descriptive analysis showed that physics teacher effectiveness is highly correlated with school environment in all aspects. Regression analysis revealed that school environment that is administrative support, collegiality and professional development had a positive significant relationship (sig 0.000, P=0.01) with physics teacher effectiveness. Findings showed that the school environment had a strong positive relationship with teacher effectiveness. From the findings, it was concluded that school environment plays a crucial role in improving teacher effectiveness. Teachers should create appropriate environment to present new thoughts by creating standards of administrative support, exercise companionship and cooperation between colleagues. Finally, develop professionally by participating in activities like educational seminars, workshops and conferences

Keywords: *School environment, collegiality, administrative support, professional development and physics teacher effectiveness.*

1.0 Introduction

Exceptionally effective teachers in the system are important because they significantly improve skills, values, attitudes and the students' academic knowledge relevant to the desired content (Laraib, 2014; Muijs & Renold, 2011). Therefore, effective teachers are required for science subjects because the quality of science, mathematics and technological education is highly needed for the development goals of industrialization and globalization to be realized (Snider, 2003; MOES, 2006). National development goals in the context of industrialization, self-reliance and globalization require quality science, mathematics and technological education (MOES, 2006). Physics is a core subject that generates knowledge in scientific discoveries and also knowledge needed in advancement in technology and hence a focus of economic development of any country (Abubakar, 2012). According to a report by Uganda National commission for United Nations Educational, Scientific and cultural Organization (UNESCO) (2017), indicate that, general performance in physics like other science subjects is dismal in developing countries. Uganda

National Examinations Board (UNEB) reports for Uganda Certificate of Education (UCE) (2016, 2017 and 2018) link this to teachers' ineffectiveness because of theoretical handling of science subjects. Accordingly, science teachers handle sciences theoretically with no hands-on approaches for students (Fauth et al., 2019). Therefore, this study sought to examine if school environment relates to physics teacher effectiveness at the Uganda Certificate of Education level, in Kigezi Sub-region.

In Western World countries, the concern has been about teacher ineffectiveness. For instance, around 1960 in USA, the issue of teacher ineffectiveness became a major concern and there were increased demands from the publican accountability from teacher about the performance of students and to clear the problem about ineffective teachers that was a challenge to the education department for some time and a hot debate in many states. To improve, the policy makers thought of designing suitable evaluation system that caters for student assessment data as well (Mathesz, 2014). In sub- Saharan Secondary schools, teacher ineffectiveness has also been a common problem. According to secondary schools in Nigeria, a number of setbacks that affect teachers' effectiveness and these reduce the achievement levels expected of an average learner. Some of the examples of setbacks that challenge teacher education in Nigeria include; teachers' professionalism, social-economic and political environments, quality and quantity of personnel (staff), instructional and infrastructural resources (Bada, Ariffin & Nordin, 2020).

In Uganda, besides the challenges of the SESEMAT programmes, another challenge that has been pin pointed as affecting performance of students in science subjects including physics, is school environment. Due to the challenges surrounding school environment, a number of scholars (e.g Nabaseruka 2010; Wasswa, 2021; Nakanwangi, 2016 & Kigongo, 2018) have investigated factors related to it. For instance, Nabaseruka (2010) found out that, poor feeding, poor sanitation and school accommodation negatively affected students' academic performance. Wasswa (2021) scrutinized results at Uganda Certificate of Education (UCE) for those students who had grade one in primary leaving (PLE) in Lyantonde, it was concluded that school physical facilities and quality discipline management measures contributed to the students' performance. Furthermore, Kigongo (2018) made a survey on the academic achievement of a girl child and found out that adequate physical facilities, presence of human resources and scholastic materials significantly influenced the academic performance.

Nakanwangi (2016) carried out a study and results indicated that essential dimensions of school culture significantly influence students' academic performance. However, gaps were highlighted from the above studies. For instance, all the studies were conducted outside schools in Kigezi sub-region context under different conditions. Still, Kigenyi, Kakuru and Ziwa (2017) looked at effects of school environment on teacher performance in public primary schools. In addition, school environment has made improvements of what makes a school that positively influences teacher efficiency and student learning as a priority, which has been a major concern over time (Hoy & Hannum, 2000; Klem & Connell, 2004). Theoretical foundation of the concept of school

environment was drawn from Lewin's field theory. The theory stipulates that human behaviour is a function of both the person and the environment (Lewin, 1936). This underlines the direct link between the school environment and teacher effectiveness. However, the extent to which this kind of environment impacts on teacher effectiveness in secondary schools was not known.

The Social Ecological Systems Theory propounded by Bronfenbrenner's in 1977 provided the theoretical underpinnings for this study on school environment. Bronfenbrenner's Social ecological systems theory focuses on the quality and context of the student's environment. The context of the students' environment in this case includes school and work place. The Bronfenbrenner's (1977) Social Ecological Systems Theory calls it a complex environment system where people dwell and work. Bronfenbrenner (1977) looks at the environment where teachers work and is able to help learners learn and regulate their behaviour. Bronfenbrenner's ecological systems theory is relevant simply due to composite arrangement in which institutions exist. In addition, the theory is important simply because it looks at actions and reactions of a child to other people in the microsystem that will affect how they treat the child in return. This theory helped to explain how school environment influenced physics teacher effectiveness in Kigezi Sub-region, Uganda.

1.1 Purpose

The aim of the study was to investigate the relationship between school environment and physics teacher effectiveness in Kigezi Sub-Region.

1.2 Objective

The study was guided by the following objective:
To find out the relationship between school environment and physics teacher effectiveness in Kigezi Sub-Region.

1.3 Research Hypotheses

The researcher sought to test the following hypotheses:

- **H_0** There is no statistically significant relationship between school environment and physics teacher effectiveness.
- **H_1** There is a statistically significant relationship between school environment and physics teacher effectiveness.

2.0 Literature Review

School environment is defined as a set of relationships that take place among members of a school community that are purposefully formed by structural, personal, and functional components of the educational institution, which provide special quality to schools (Aldridge and McChesne, 2018). With school environment, several factors can affect teaching / learning ability, including infrastructure, seating, light, noise, and even colour. Teachers who teach in a positive teaching environment have shown to be more motivated, engaged, and have a higher overall teaching ability

and more effective.

Several studies were conducted on variables of school environment and teacher effectiveness. For instance, Kigenyi, Kakuru and Ziwa (2017), conducted a study on Primary school teachers in Uganda about the effects of school environment on teachers' performance. Results from regression analysis indicated a statistically significant effect on teachers' efficacy. However, much as the study was conducted on primary teachers, this was outside the secondary schools' environment. The school environment as a basis for teaching and learning has been a focus of research interest for decades and developing school settings that positively influence student learning has been a subject of policy and practice that has grown in intensity over time (Sackney, 2007). The concept of school environment has been defined in various ways. Bascia and Rottmann (2011) conceptualize school environment in terms of the school amenities, enough rooms, healthy facilities (sickbays), and disciplinary guidelines. This conceptualization delineates between a positive school environment measured in terms of a school having appropriate facilities**,** well-managed classrooms, available school-based health supports, and a clear, fair disciplinary policy (Tutu et al. 2014). Benchmarks of a poor school environment among many include ineffectiveness of staff, a lot of teacher absenteeism, low student's achievement levels, and chaotic or unsafe physical environment (Omolo et al., 2020). Studies revealed that a poor learning environment is greatly connected to low teacher effectiveness as presented by poor student test scores; low attendance rates, and student engagement (Mup & Chinooneka, 2015).

Mick (2011) on the other hand, perceives the school environment as the degree to which the arrangements facilitate students' wellbeing, which may include topics like academic environment and psychosocial support systems and services, and the fairness plus enough disciplinary procedures (Arul, 2012). The learning environment brings on board a number of disciplines, from the purely educational to psychology, environmental and building design and not excluding ergonomics. Existing empirical research on the environmental impacts on teaching and learning tends to rely mainly on some elements of noise and fail to come up with understandings (Gilavand, 2016). Aspects of Cultural and geographical differences, as part of the school environment, also highlight the importance of sensitivity to context (Cazden, 2001; Rogers et al., 2005). For this reason, it is very difficult to make judgments about which of the school environment are 'worth' focusing on.

Omodan, Kolawole and Fakunle (2016), carried out an investigation on school climate as correlates of teaching effectiveness in secondary school teachers. A sample of nine (09) secondary schools and 480 teachers took up the study. Findings showed that, there is a significant relationship between school climate and teaching effectiveness of teachers in secondary schools in Nigeria. The school climate includes leadership styles, other equipment and other educational facilities. The study clearly showed a positive correlation between school climate and teacher effectiveness, however according to the study the context is about secondary schools in Nigeria, which is different from the context of this study, Kigezi Sub-region, hence, a gap.

According to a review carried out by Martinez and McAbee (2020), focusing on the relationship between school administration and teacher effectiveness at school, results indicate that, certain administrative efforts, used independently or in combination, are effective in supporting teachers. The support include induction, mentoring, staffing support, resource and professional development enhancement, meaningful and constructive evaluations, discipline/rule enforcement. Madiha (2012), carried out a study on the importance and benefits of teacher collegiality in schools. The study reveals that teacher collegiality plays an important role in increasing teacher professional growth and development, job satisfaction, organizational and professional commitment as well as school quality and student achievement. Studies carried out by Klassen and Tze (2014), on teachers' self-efficacy, personality and teaching effectiveness, it is noted that self- efficacy correlates with stronger teaching performance and this translates to higher academic achievement. In addition, it is found out that the physical learning environment affects teachers' sense of efficacy

There is clear evidence that proves extremes of environmental elements like poor ventilation or excessive noise, have negative effects on both teachers and students and by improving these elements have a number of benefits (Berry, 2002). Likewise, existence of supportive or unsupportive people within the school represents the social environment. Research reports show that, existence of a strong link between effective engagement with staff, students and other users of school buildings and the success of teacher behavior brings about well-being or attainment (Bosch, 2003; Fisher, 2001; Gifford, 2002). OECD's, and Teaching and Learning International Survey (TALIS) reports about the comparison of perspectives on conditions of teaching and learning, OECD countries and other partner countries, teachers and school principal, were the major focus. Random sampling was used and 200 schools and 20 teachers were selected to participate. Many areas were looked at among them include how well teachers feel prepared, quality of classroom climate, professional developments of teachers, teacher appraisal and the effective feedback. The findings correlated positively according to the study because teachers who attended professional developments are better equipped and hence effective in teaching. This agrees with what SESEMAT through Ministry of Education and Sports agitate for refresher courses for science and mathematics teachers in secondary schools in Uganda. Such professional developments and other interventions need to be for targeted teachers of physics, chemistry, biology and mathematics as the case is for SESEMAT programme. The current study looks at school environment in terms of administrative support, collegiality, professional development) whether they have a significant effect on teacher effectiveness, in the context of Kigezi Sub-Region, and which no one has ever attempted.

3.0 Methodology

3.1 Research Approach

This study employed both quantitative and qualitative techniques where both types of data was collected and analyzed sequentially. Combining qualitative and quantitative research approaches was desirable because the qualitative approach enables an in-depth analysis of phenomena and provides the means whereby data on multiple realities could be examined (Patton 2000). The quantitative approach, on the other hand, yields data that not only supplements and confirms

findings from the qualitative approach but also helps to establish whether they could be generalized to the whole group.

3.2 Research Design

This study adopted a mixed research design to provide answers to different research questions and hypothesis (Creswell, 2014). This was because the objective and hypothesis required a combination of quantitative and qualitative research approaches where no single approach could manage the study.

3.3 Participants

Participants in the study were as follows:

Table 1: Sampling frame

Category of respondents	Population	Sample	Sampling techniques
District Education Officials	06	06	Purposive sampling
Head Teachers	185	14	Purposive sampling
Physics Teachers	555	234	Simple random sampling
Total	746	**254**	

Source: *Primary data (2020)*

3.4 Instruments

The study used Self-Administered Questionnaire (SAQ) for Teachers. The teachers responded by writing or putting 1, 2, 3 ,4, 5 on the relevant response out of five alternatives provided. A 5 point Likert scale was to be answered as follows ;1 for strongly disagree (SD), 2 for Disagree (D), 3 for Not Sure (NS), 4 for Agree(A) and 5 for strongly agree (SA). Choice of questionnaires were based on the fact that they give standard questions, uniform answers, easy to distribute, can be filled at ease, are time saving, eliminate interview bias and create greater anonymity (Creswell, 2014). Other tools used included:

Interview Guide

An interview guide was used by the researcher in order to get respondents' opinions about the issues under study.

Focus Group Discussion (FGD)

The researcher conducted a focus group discussion (FGD) in order to establish the attitudes, beliefs, opinion or ideas about the study. A focus group discussion involves gathering people from similar backgrounds or experiences together to discuss a specific topic of interest (Creswell, 2014).

Classroom environment Checklist:

The Classroom Environment Checklist was a set to guide the researcher on what happens in a real classroom environment. The instrument checked 12 schools both government and private. Through the checklist, the researcher seeks to obtain first-hand information about the positive learning environment, whether clearly communicated expectations related to instruction and

behaviour are there in the class. The researcher opted for this tool because it provides additional information and instant feedback. Validity and reliability results are presented in section of results.

4.0 Data Analysis

4.1 Quantitative and Qualitative Data Analysis

Quantitative analysis involved descriptive and inferential analyses. Descriptive analysis for the relationship between school environment and teacher effectiveness involved calculation of frequencies, percentages, Kurtosis and means using SPSS. Data from interviews, observations, FGD were analyzed in themes and from each item, responses were grouped into key themes and later interpretations were done. Creswell (2018) essentially guided the method of analysis. Verbatim quotations were also used where necessary.

4.2 Results

4.3 Relationship between the school environment and physics teacher effectiveness in Kigezi Sub-Region

Three indicators were studied that is Professional Development, Collegiality and Administrative Support. Preliminary analysis was done using descriptive statistics as presented in the Table 3;

Table 3: *Summary Descriptive Statistics*

	N	Mean	S.D	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Administrative Support							
I feel I have supportive administration	194	4.34	0.62	-1.55	0.18	7.38	0.35
I value principal communication	194	4.21	0.74	-1.86	0.18	6.61	0.35
I feel like the whole staff is recognized	194	4.28	0.66	-1.45	0.18	5.71	0.35
I feel generally satisfied with the situation	194	4.14	0.66	-1.37	0.18	5.45	0.35
I see that the school is well run	194	4.24	0.55	-1.44	0.18	10.50	0.35

Mean		**4.24**	**0.65**	**-1.53**	**0.18**	**7.13**	**0.35**
Collegiality							
I really feel staff shares beliefs	194	4.01	0.80	-1.58	0.18	4.09	0.35
I feel that I am valued in the Physics department	194	4.26	0.62	-1.44	0.18	7.23	0.35
I feel I do see Physics teachers working together	194	4.22	0.81	-1.92	0.18	5.66	0.35
I see planning together in a department a waste of time	194	4.15	0.84	-1.74	0.18	4.43	0.35
I feel a head of physics department advising colleagues about school goals encouraging	194	4.34	0.62	-1.55	0.18	7.38	0.35
I find teachers respecting one another encouraging	194	4.21	0.74	-1.86	0.18	6.61	0.35
Mean		**4.20**	**0.74**	**-1.68**	**0.18**	**5.90**	**0.35**
Professional Development,							
I see enough opportunities for professional development	194	4.14	0.66	-1.37	0.18	5.45	0.35
I feel I am given a chance to get training for work related activities	194	4.24	0.55	-1.44	0.18	10.50	0.35
I see myself on the list of staff going for a	194	4.41	0.62	-1.62	0.18	7.73	0.35

workshop									
I feel the department usually organizes in house trainings	194	4.27	0.70	-1.71	0.18	6.54	0.35		
I feel encouraged when I see my department with enough sources to enable me work up to optimum level of my abilities	194	4.15	0.64	-1.34	0.18	5.88	0.35		
Mean		**4.24**	**0.63**	**-1.50**	**0.18**	**7.22**	**0.35**		
Grand Mean			**4.23**		**0.67**	**-1.57**		**0.18**	**6.75**	**0.35**

Source: *Primary Data*

The analysis from the three indicators as shown in Table 3 revealed that the status of school environment in Kigezi Sub-region scored a very high mean average of (4.23) in which administrative support was at (4.14), collegiality (4.20) and professional development at (4.24) respectively. The analysis also revealed an average standard deviation of 0.67 (67%) in which administrative support was at (0.65), collegiality (0.74) and professional development at (0.63) respectively. Collegiality exhibited a relatively higher distribution as compared to administrative support and professional development. Well as the SD shows that there is a slightly higher spread from the common view of the respondents (< 0), it also suggests that some respondents' views were slightly scattered away from the mean of the data.

The analysis also revealed that the responses were highly skewed (> -1 and < 1). The distribution has a heavy tail on one end, an indication that data was not evenly distributed. This can be explained by the fact that the indicators were not having the same level of influence on teacher effectiveness.

4.4 Correlation School Environment and Physics Teacher Effectiveness

To get a better understanding of the relationship between School Environment and Physics Teacher Effectiveness a correlation statistic was done using the data collected as shown in Table 4;

Table 4: *Correlation School Environment and Physics Teacher Effectiveness*

		Teacher Effectiveness	School Environment
Teacher	Pearson	1	.719**

Effectiveness	Correlation		
	Sig. (2-tailed)		.000
	N	194	194
School Environment	Pearson Correlation	.719**	0.01
	Sig. (2-tailed)	.000	
	N		1 194
			9
			4

Source: *Primary Data*

The analysis indicates that there is a statistically significant correlation (r= 0.719; Sig (2-tailed) = 0.000) between the two variables, that is, school environment and teacher effectiveness. This indicates that with r value closer to 1 (0.719) the correlation between the school environment and teacher effectiveness is strong and a Sig (2tailed) = 0.000 with value that is less than 0.5 implies that there is a statistically significant correlation. Hence, the alternative hypothesis, H_1: There is a statistically significant relationship school environment and physics teacher effectiveness was accepted. The r value explains the relationship between the two variables that a unit change in school environment as a variable could lead to a (0.519) 51.9% improvement in teacher effectiveness.

4.5 Findings from the Head teacher interviews on the relationship between School Environment and Physics Teacher Effectiveness.

The results from both the descriptive statistics and correlation analysis continued to show that there was a significant relationship between School Environment and Physics Teacher Effectiveness. Interviews from key informants and the findings revealed that;

Theme 1: Administrative Support

In theme one, data that reflected on the administrative conditions that exist in the school system that may be affecting the effectiveness of physics teachers were considered. The key issues that came out strongly are presented as follows;

The head teacher's responses showed that the school administration was not in position to regularly support the teachers through provision of equipment due to limitations in finances.

Secondly most school head teachers showed that the schools didn't have an established reward and recognition system in place. Without such systems the administrative function of motivating teachers to perform can never be operationalized.

Interview responses from the head teachers showed that apart from general examination materials that usually come in UNEB, majority of the head teachers did not support the teachers by way of providing regular materials to be used in the physics lessons. With only 2 head teachers out of 14

supporting their teachers regularly, it's clear why the students in Kigezi
Sub – Region continue to perform physics poorly despite the SESEMAT teacher training that most of the teachers have gone through.
When asked about the head teacher communication with the physics teachers, majority of the teachers expressed that there was no need to meet specific teachers when there is a regular staff meeting. This negative response shows that teachers don't often meet the head teacher to express their challenges and to find ways to overcome them. This explains why the physics teacher in Kigezi Sub-Region still fails to produce grades as expected because the fundamental pillars of the SESEMAT approach are not adhered too.
In addition to communication, the head teachers expressed that most of the physics teachers put a lot of time into part time teaching in other schools. This means that the teachers often have a lot of work which compromises the quality of work they do at school.

Theme 2: Collegiality
Under theme two, all the data that explained factors that are related to collegiality were placed and presented as follows;
Majority of the head teachers expressed that their staff did not share similar beliefs on performance of physics. With differing beliefs, it makes it hard to focus on the same goal. This explains as to why physics performance in Kigezi Sub-Region is still low despite the SESEMAT training the teachers have obtained over the years.
From the interviews, the head teachers expressed that teachers never plan together. This affects the collegiality principle on which the SESEMAT model is built. This means that the teachers cannot effectively implement the model and thus explain why students in Kigezi Sub-Region have continued to perform poorly in physics despite the teacher training.
In the interviews, the head teachers showed that in most cases the school has one physics teacher at a time. Yet the collegiality principle is built on teachers working collectively in teams which strengthens what they are doing. So in the case of Kigezi Sub-Region teachers mostly work alone even when they are more than one at school. Bleaching this principle of collegiality explains why students in Kigezi Sub-Region continue to perform poorly irrespective of the SESEMAT training that the teachers have undergone.

Theme 3: Professional Development;
Under the third theme, all the data that arise that was focusing on professional development was put together and these are some of the major factors that came out the interviews with the head teachers. Majority of the head teachers that were interviewed expressed that the schools did not have adequate funds to support teachers when opportunities for professional development arise. With little continuous training the teachers usually lose the quality of skills they possess. This defeats the very premise on which the SESEMAT model is built and gives the explanation as to why the physics teachers in Kigezi Sub-Region continue to underperform in physics.

In schools where the school was willing to finance teachers to go for training, many teachers were

not in full attendance of the training due to having many other commitments. Because the teachers miss the training or partially attend they do not acquire or develop the necessary skills to help them perform better in physics. This have backed way of SESEMAT training explains why the SESEMAT model is not effective and physics teachers continue to underperform in Kigezi Sub-Region.

Many head teachers revealed that the schools do not organize in-house refresher training for the teachers. Because of this the teachers depreciate in terms of originally acquired skills over time. This lack of continuous strengthening of the teacher defeats the assumptions on which the SESEMAT model is built and hence explains why physics teachers in Kigezi Sub-Region continue to have students perform under expectations.

The head teachers who were interviewed revealed that they lack enough resources and because of this the training they organize are usually of low quality which affects the results grossly. These bleaches the building blocks of the SESEMAT approach and hence explains as to why teachers of physics in Kigezi Sub-Region are not effective.

Findings in Table 5 indicate that the Cronbach Alpha value was ranging from 0.7 – 0.85 which is in the range of 0.70 - 0.95 that is recommended for instrument validity (Cronbach, 1951). This level of validity was supplemented and complemented by use of triangulation of research designs, paradigms, data collection methods, techniques, data sources and data types. This approach is expected to increase the validity and reliability of both quantitative and qualitative findings.

5.0 Discussion, conclusions and recommendations

5.1 Summary of the findings

Schools where there is a strong support from the administration in form of provision of study materials, open ground to air out issues affecting the teachers are seen to have a high teacher effectiveness as compared to those schools or teachers with limited support from the administration.

5.2 Discussion

Relationship between the school environment and physics teacher effectiveness in Kigezi Sub-Region. Sixteen questionnaire items were used to measure the three indicators administrative support, collegiality and professional development. According to descriptive statistics, it is revealed that the status of school environment in Kigezi sub region scored a high mean of 4.23 in which administrative support was at (4.14), collegiality (4.20) and professional development at (4.24). This implies that the responses were highly skewed (>-1 and < 1). The analysis also showed an average standard deviation (SD) of 0.67 (67%) where administrative support was at (0.65), collegiality (0.74) and professional development (0.63). This SD shows that there is a slightly higher spread from the common view of the respondents (< 0). Further, it implies that some respondents' views were slightly scattered away from the mean of the data. The study established that there is a statistically significant correlation (r = 0.719; sig (2-tailed = 0.000) between school environment and teacher effectiveness. It is therefore apparent that the school environment

determined the teacher effectiveness. The existence of these indicators i.e. administrative support, collegiality and professional development, according to the current study in a school environment have therefore influenced effectiveness of a physics teacher.

The findings of this study are supported by Kigenyi, Kakuru and Ziwa (2017), who found out that school environment in terms of enough classrooms, infrastructure, teachers working table to mention, significantly affect teacher's efficacy. This improvement in school environment leads to a greater improvement in teacher performance. Teacher effectiveness depended on how regularly the administrators support teachers by providing them with equipment, establishment of proper reward and recognition system. The results for the hypothesis (H1) to the relationship between the school environment and teacher effectiveness indicated that there was a strong positive, significant correlation. This indicated that an improvement in the school environment would increase the effectiveness of the teachers. This finding was consistent with the findings of previous scholars. For example, Mick (2011) established a school environment as the degree that facilitates student's wellbeing.

Similarly, Bascia and Rottmann (2011) reported that the teaching conditions/ working conditions significantly correlates with teacher satisfaction and efficiency hence an improvement in students' achievement. Also Tutu etal., (2014) reported that availability of residential facilities in schools and instructional materials have a positive influence on learners' academic performance. Additionally, based on Gilvand (2016), the study revealed observed that mean outdoor and indoor noise levels, which are beyond the standards (according to world healthy Organizations standards), affect the academic attainment. The findings of the study are in agreement with the observation made by Hartnah etal, (2020), who hypothesized that leadership of the principal, work environment and motivation influence directly teachers' performance. In conclusion, therefore school environment conceptualized as administrative support, collegiality and professional development, significantly influence physics teacher effectiveness.

5.3 Discussion of qualitative data

Head teachers who were interviewed revealed that teachers of science and in particular physics no longer help each other, plan together. This is simply because majority of science teachers have more than one school which cannot allow them to have enough time to rest in one school.

5.4 Conclusions

Considering results that the indicators (collegiality, administrative support and professional development) were not having the same level of influence on teacher effectiveness. This was indicated that a change in collegiality, administrative support and professional development as indicators of a school environment cause a change in improvement in teacher effectiveness. Therefore, it is concluded that school environment plays a crucial role in improving physics teacher effectiveness.

5.5 Recommendation

Based on the findings, the study has the following recommendation to be effected by the different stakeholders in secondary schools in order to improve the teaching and learning of physics. The study recommends that for physics teacher improvement, school environment should be improved first. District education office should revive inspections and publish guidelines that will compel administrators at school level to support their teachers.

In order to improve school environment, teachers should create appropriate environment to present new thoughts, in this case create standards of administrative support, exercise collegiality and professionally develop skills, values in activities like seminars, workshops and conferences.

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Article 17

Determination By The Analytical-Graphic Method Of The Center And The Radius Of The Circle Inscribed In A Triangle Where Projections Are Known

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Abstract

This paper is as a result of observations made during descriptive geometry assessments in secondary fifth and sixth grade. Given that the various cases of descriptive geometry, the study focused on the determination of the center and the radius of a circle inscribed in a triangle where the projections of the summits are known. The study showed that the proposed Analytical-graphic method is easy to understand and apply in solving different geometry problems which also achieves the same result as the analytical approach provided by the National educational programme. It is utilizes both algebra and geometric constructions with the steps followed for this research being: Translation of a given problem of Descriptive Geometry into a problem of plane analytical geometry; Solving the problem in plane analytical geometry; Translation of the solution obtained into a solution of Descriptive Geometry; Translation of the given problem of descriptive geometry into a problem of three-dimensional analytical geometry; Solving of the translated problem analytically; Comparison of both solutions which confirmed both methods achieved the same result.

Key words: *Analytical method, graphical method, analytical-graphical method, bisector of an angle, circle inscribed in a triangle, horizontal projection of a point, frontal projection of a point, vector product of two vectors.*

1.0 Introduction

Over fifteen successive years, (2008-2023) the descriptive geometry course was offered at the Bukasa Nsenda College in Mbujimayi and at the Isp/Mbujimayi application school in secondary fifth and sixth grade. The educational programme uses the Monge method for descriptive geometry which highlights the techniques of folding, rotation, and right triangle to find true greatness (Programme National de Mathématiques 2005). After several trials, it was found that only 10 percent of students performed well because the techniques employed were complicated. The analytical-graphic method was proposed as it saved time and allowed students to use the formulas of analytical geometry, to transpose them onto graphs which confirmed the same result as those obtained by the DRC educational program.

2.0 Methodology

The paper made a comparison where problems were solved using both the analytically and analytical-graphic methods to compare and confirm the same results.

3.0 Theoretical framework and state of the question

The analytical-graphic concept was introduced in 2019 by Mr. Faustin NGOYI at European University Editions where he approached descriptive geometry using the analytical method (Ngoyi F. 2019). In 2020, Mr. Kafuta also solved a specific problem using the analytical method to determine the center and the radius of the circle inscribed on a sphere (Kafuta 2020).
According to KUYUNSA BIDUM and S. SHOMBA K. (Kuyunsa et Shomba, 1995), the problem designates a set of ideas which specify the position of the problem by the subject of study.
So, constructing a triangle knowing the lengths of its sides, constructing the bisectors of a triangle, determining the center and the radius of the circle inscribed in a triangle are problems of elementary geometry whose solutions are easy to find in the plane.

On the other hand, solving these same problems in descriptive geometry presents some difficulties. What can be done to overcome these difficulties? This is answered in this study

1. Illustration

a) Problem of descriptive geometry

Determine the center O and the radius r of the inscribed circle of triangle ABC.
Drawing space 280x280

$$A\begin{Bmatrix} A^f(50{,}240) \\ A^h(50{,}80) \end{Bmatrix} \qquad B\begin{Bmatrix} B^f(90{,}200) \\ B^h(90{,}40) \end{Bmatrix} \qquad C\begin{Bmatrix} C^f(130{,}160) \\ C^h(130{,}60) \end{Bmatrix}$$

b) Analytical solution

3.1 Conversion of Descriptive Geometry data into of Analytical Geometry data

In the problem posed, the horizontal and frontal projections of points A, B and C are given. So the abscissa of each point represents the$x$ (x_1, x_2, x_3), while the ordinates for the horizontal projections of each point will be denoted by y (y_1, y_2, y_3) and finally the ordinates for each point in frontal projection will be denoted by$z$ (z_1, z_2, z_3), (P.Florent, G.Lauton, M.Lauton; 1981):

x_1	y_1	z_1
$= 50$	$= 80$	$= 240$
$x_2 = 90$	$y_2 = 40$	$z_2 = 200$
$x_3 = 130$	$y_3 = 60$	$z_3 = 160$

So: $A(50{,}80{,}240)$; $B(90{,}40{,}200)$; $C(130{,}60{,}160)$

3.2 To find the center O and the radius r of the triangle one should follow the steps below:

Calculate the lengths L_1, L_2, L_3 of sides of triangle ABC; L_1 is the length of side BC, L_2 is the length of side AC, L_3 is the length of side AB:

$$L_1 = \sqrt{(x_3 - x_2)^2 + (y_3 - y_2)^2 + (z_3 - z_2)^2}$$

$$L_2 = \sqrt{(x_3 - x_1)^2 + (y_3 - y_1)^2 + (z_3 - z_1)^2}$$

$$L_3 = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

So:

$$L_1 = \sqrt{(130 - 90)^2 + (60 - 40)^2 + (160 - 200)^2} = 60$$

$$L_2 = \sqrt{(130 - 50)^2 + (60 - 80)^2 + (160 - 240)^2} = 114.89125$$

$$L_3 = \sqrt{(90 - 50)^2 + (40 - 80)^2 + (200 - 240)^2} = 69.28203$$

Find the sum L of lengths L_1, L_2, L_3 :

$$L = 60 + 114.89125 + 69.28203 = 244.17328$$

Find the coordinate x_4, the coordinate y_4 and the coordinate z_4 of the center O of the circle included in the triangle ABC (Ngoyi F., 2019) :

$$x_4 = \frac{L_1 x_1 + L_2 x_2 + L_3 x_3}{L}$$

$$y_4 = \frac{L_1 y_1 + L_2 y_2 + L_3 y_3}{L}$$

$$z_4 = \frac{L_1 z_1 + L_2 z_2 + L_3 z_3}{L}$$

So :

$$x_4 = \frac{60 \times 50 + 114.89125 \times 90 + 69.28203 \times 130}{244.17328} = 91.52056 \approx 92$$

$$y_4 = \frac{60 \times 80 + 114.89125 \times 40 + 69.28203 \times 60}{244.17328} = 55.50391 \approx 56$$

$$z_4 = \frac{60 \times 240 + 114.89125 \times 200 + 69.28203 \times 160}{244.17328} = 198.47944 \approx 198$$

Coordinates of the projections of the center O of the inscribed circle of triangle ABC are as follows:

$$O \begin{cases} O^f(92,198) \\ O^h(92,56) \end{cases}$$

The radius r of the inscribed circle of triangle ABC is:

$$r = \frac{\left\| \overrightarrow{AO} \wedge \overrightarrow{AB} \right\|}{\left\| \overrightarrow{AB} \right\|}$$

Where $\overrightarrow{AO} \wedge \overrightarrow{AB}$ is the vector product of vectors $\overrightarrow{AO}$ *and* $\overrightarrow{AB}$.

And :

$$\overrightarrow{AB} = (x_2 - x_1)\vec{\imath} + (y_2 - y_1)\vec{\jmath} + (z_2 - z_1)\vec{k}$$

$$\overrightarrow{AC} = (x_3 - x_1)\vec{\imath} + (y_3 - y_1)\vec{\jmath} + (z_3 - z_1)\vec{k}$$

So :

$$\overrightarrow{AO} = 41.520564\vec{\imath} - 24.49609\vec{\jmath} - 41.52057\vec{k}$$

$$\overrightarrow{AO} \wedge \overrightarrow{AB} = \begin{vmatrix} \vec{\imath} & \vec{\jmath} & \vec{k} \\ 41.520564 & -24.49609 & -41.52057 \\ 40 & -40 & -40 \end{vmatrix} = -680.9792\vec{\imath} - 680.9792\vec{k}$$

Magnitude of vector $\overrightarrow{AO} \wedge \overrightarrow{AB}$ is $\left\|\overrightarrow{AO} \wedge \overrightarrow{AB}\right\|$ =963.04985

$$r = \frac{\left\|\overrightarrow{AO} \wedge \overrightarrow{AB}\right\|}{\left\|\overrightarrow{AB}\right\|} = \frac{963.04985}{69.28203} = 13.90043$$

c) Analytical-graphic Method

3.3 Find lengths of sides AB, AC and BC

Below the length of triangle ABC:

$$AB = \sqrt{(90-50)^2 + (40-80)^2 + (200-240)^2} = 69.28203$$

$$AC = \sqrt{(130-50)^2 + (60-80)^2 + (160-240)^2} = 114.89125$$

$$BC = \sqrt{(130-90)^2 + (60-40)^2 + (160-200)^2} = 60.$$

3.4 Draw the inscribed circle of triangle ABC with the above lengths.

3.5 Construct triangle ABC given sides AB, AC and BC ;

3.6 Construct bisector Γ_1 of angle $\widehat{B}$ and bisector Γ_2 of angle $\widehat{C}$ of triangle ABC;

- Find the point O where bisectors Γ_1 and Γ_2 of triangle ABC;
- Find point L where bisector Γ_1 meets side AC of triangle ABC;
- Find point K where bisector Γ_2 meets side AB of triangle ABC:

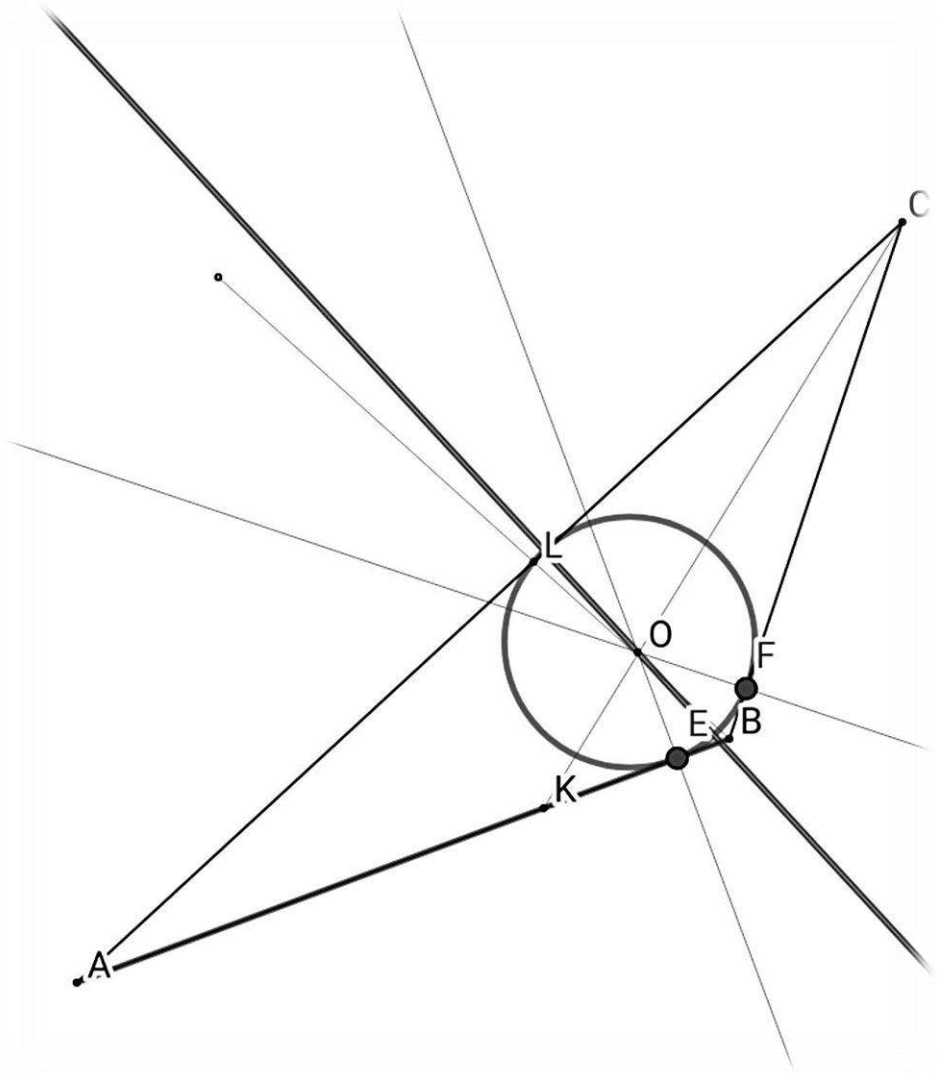

Fig. 1: *By measuring using a ruler, it is found that the distance from point O to any of the sides AB, AC and BC equals 14 mm, that is the radius of the inscribed circle in triangle ABC.*

3.7 After drawing the circle included in the triangle ABC, we are going to draw up the triangle ABC with the measurement given in the example illustration:

- Find projections K^h and K^f of point K :
- Make coincide points A and A^h ;
- Duplicate side AB and place point K on it ;
- Draw the line segment BB^h ;
- Find the point K^h where the parallel drawn from point K to BB^h meets A^hB^h, this implies K^f on A^fB^f(Makiadi., 1987)
- Find projections L^h and L^f of point L :
- Make coincide points C and C^h ;

- Duplicate side AC and place point L on it ;
- Draw the line segment AA^h ;
- Find the point L^h where the parallel drawn from point L to AA^h meets A^hC^h, this implies L^f on A^fC^f.

➢ Find the point O^h where lines C^hK^h *and* B^hL^h meet and the point O^f where lines C^fK^f *and* B^fL^f meet [Arthur Guion 1967, Belgique].

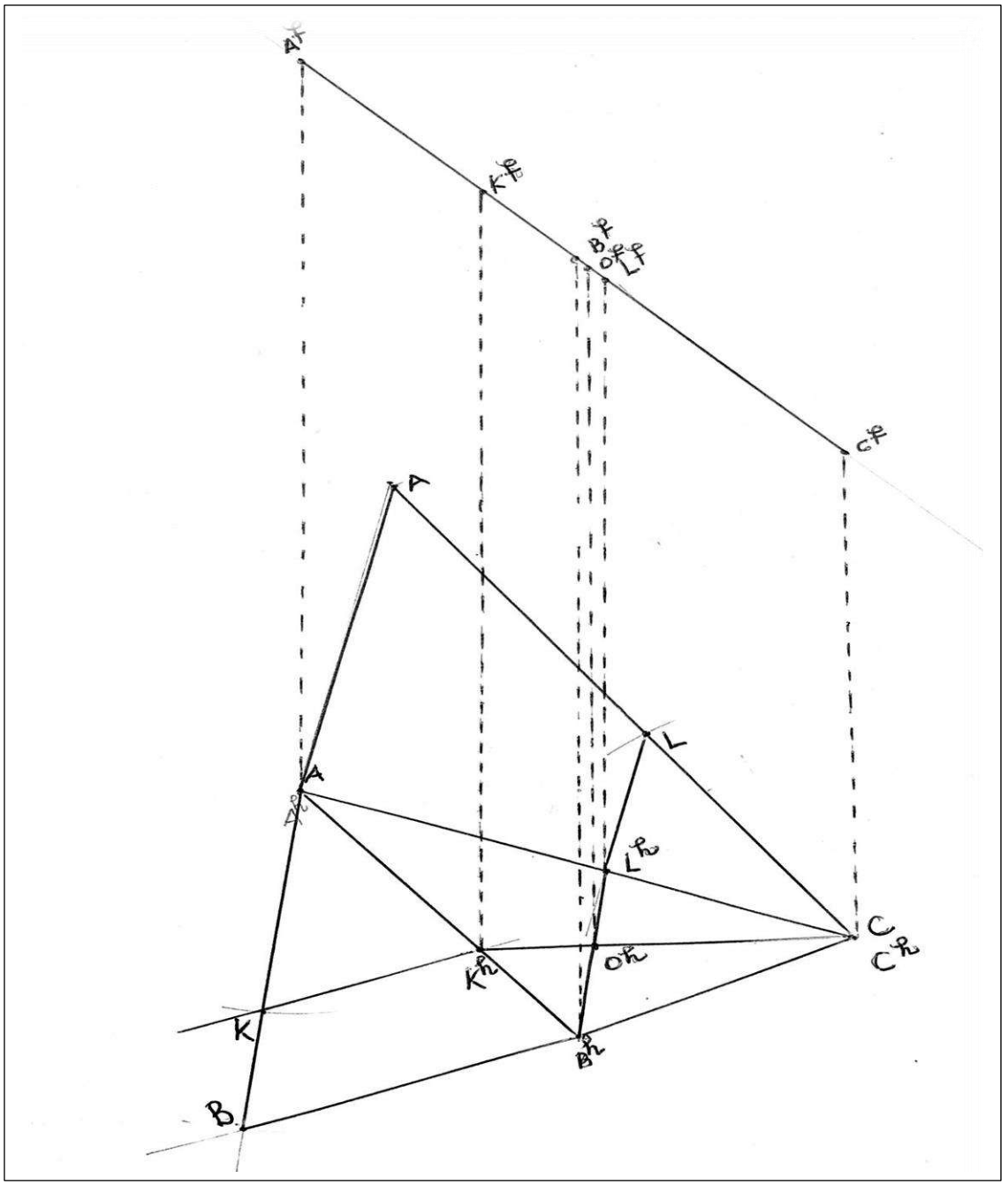

Fig. 2 : By measuring by a ruler coordinates of points O^h *and* O^f *, we arrive to*

$$O\begin{cases} O^f(92{,}198) \\ O^h(92{,}57) \end{cases}$$

The radius of the inscribed circle of triangle ABC is r = 13.90043

In conclusion, the study confirms the same result from both approaches.

4.0 Conclusion

The research question posed was answered in this study. Comparison of the results obtained via the analytical method to those obtained via the analytical-graphical method show arrival at the same result; with the latter proving to be simpler and quicker to understand and apply.

These assertions allow us to conclude that the analytical-graphic method is an initiative which will allow fifth and sixth secondary students to properly assimilate the notion of true magnitude in descriptive geometry.

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STRAND FOUR
ICT Integration in STEM Education
1. Resources and Solutions for STEM Learning
2.Fun Learning STEM through Games and Robotics
3.Link School and Industry on STEM Education

Article 18

Wavumbuzi Entrepreneurship Challenge: A Gamified Approach to Entrepreneurial Mindset Development

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Abstract
Research shows that the gamified approach is an effective way of learning in the classroom, especially for learners who have difficulty learning using contemporary methods. Wavumbuzi adopts this method of learning in its model for the Wavumbuzi Entrepreneurship Challenge – a free online 6-weeks Challenge offered to learners in secondary/high schools throughout Kenya. As a result, knowledge transfer is more fun and a self-discovery journey for learners who participate in the Challenge. To test this model, Wavumbuzi Knowledge and Research Unit conducted a Pre- and Post-survey during the Wavumbuzi Entrepreneurship Challenge. The objective was to assess the change in learners' level of entrepreneurial competencies before and after participating in the Challenge. Hence, measurements were taken before administering the intervention (learners engaging in the Challenge), followed by a post-test measurement on the same study participants. A total of 447 learners completed both surveys. Findings from this study indicated that several entrepreneurial competencies improved. Entrepreneurial competencies with positive average differences between baseline (Pre) and end line (Post) were: Entrepreneurial experience; Intend to start up (Entrepreneurial intention – EI 2); Future business planning (Entrepreneurial intention – EI 3); Structured tasks and following others' rules (Entrepreneurial mindset – EM 2); Positive entrepreneurial mindset (Entrepreneurial mindset – EM 1); and Taking action and initiative.
The results confirm that the gamified approach applied by Wavumbuzi is effective in stimulating entrepreneurial competencies amongst learners.

Keywords*: Gamified approach, Entrepreneurship Mindset Development; Secondary/ High School Learners, Kenya, Entrepreneurial Competencies, Learning, Entrepreneurship Challenge*

1.0 Introduction

Education is undergoing a significant transformation in the modern world which is primarily

marked by the integration of technology and the implementation of innovative teaching approaches. As traditional methods show limitations in addressing the individual needs of students, educators and policymakers are exploring alternative models to foster skills that are crucial for the 21st century. Among these skills, entrepreneurial competencies stand out as vital in preparing learners for both career and life challenges. The Wavumbuzi Entrepreneurship Challenge is an educational initiative that embodies this new wave of learning by focusing on the development of entrepreneurial skills among secondary and high school learners in Kenya (Kareithi, R. M. & Mangira, S., 2021; Kareithi, R. et al 2019; Wavumbuzi, 2022). By using a gamified learning platform, the Challenge provides an interactive and engaging environment where learners are exposed to real-world scenarios and problem-solving tasks. This paper aims to offer a comprehensive evaluation of the Wavumbuzi Entrepreneurship Challenge by examining its impact on the entrepreneurial competencies of the participating learners. Specifically, it will assess the effectiveness of the program's gamified learning approach and analyze how it contributes to skill development and knowledge acquisition. The findings of this paper aspire to inform educators, policymakers, and stakeholders about the potential benefits and limitations of implementing gamified learning experiences in educational settings.

1.1 Background

Traditional educational methods often focus on textbook-based learning (BECF, 2017), which may not cater to the diverse needs of learners. The current classroom scenario in Kenya often sees a single teacher responsible for up to 50 students, further complicating personalized learning. Traditional methods do not adequately prepare learners for the real-world challenges they will face, such as the need for entrepreneurial skills and critical thinking. Since its inception in 2019, the Wavumbuzi Entrepreneurship Challenge has adopted a gamified approach to learning, aimed at bridging this gap. This program provides a free six-week online course that exposes learners to various entrepreneurial topics divided into specific challenges, known as "Quests" such as "Hospital," "Farming," and "Water" (Wavumbuzi, 2022).

With the support of a teacher or up to two teachers per school, learners register on the platform and engage in the challenges at their own pace, outside of normal school hours. Through partnerships with organizations like CEMASTEA, the reach of the Wavumbuzi Entrepreneurship Challenge has expanded year-over-year. For example, the number of participants rose from 815 learners in 2019 to 2,541 learners in 2021. The upcoming 2023 edition aims to engage 7,500 learners, backed by the training of approximately 730 teachers to facilitate the program.

1.2 Problem statement

While the Wavumbuzi Entrepreneurship Challenge has shown tremendous promise in increasing learner engagement and expanding its reach, there is a need to scientifically evaluate its impact. The gamified approach (R. Mee, T. Shahdan & M. R. Ismai, 2020), although popular among learners, requires empirical validation to determine its effectiveness in fostering entrepreneurial competencies. Furthermore, there is a lack of data on the comparative performance between first-

time and repeat participants in the Challenge. This paper will, therefore, seek to assess the efficacy of the Wavumbuzi Entrepreneurship Challenge in enhancing entrepreneurial skills and competencies among Kenyan secondary / high school students.

2.0 Methodology

Guided by Wavumbuzi's Knowledge and Research Unit (KRU) and under the expert supervision of Prof. Melodi Botha from the University of Pretoria, the principal objective of this research was to quantitatively evaluate the impact of the Wavumbuzi Entrepreneurship Challenge on learners' entrepreneurial competencies (ECs). To adhere to ethical standards, consent was obtained from all participants, and confidentiality was ensured through data anonymization. Ethical approval for the study was granted by the University of Pretoria.

2.1 Design of the study

The study used a Pretest–Posttest experimental design. Measurements were captured prior to introducing the educational intervention—namely, the Wavumbuzi Entrepreneurship Challenge—followed by identical measurements after the challenge concluded.

2.2 Sampling method

The study sample was composed of high school learners attending over 200 schools spread across 42 of the 47 counties in Kenya. Stratified random sampling was utilized to secure a representative sample. The baseline (pre-test) involved 1,504 usable surveys, and the endline (post-test) garnered 637 usable responses. 447 respondents completed both the pre-test and post-test, making them eligible for inclusion in the final inferential analysis.

2.3 Data collection

Data was amassed over a period of six weeks, from August 16, 2021, to October 20, 2021. The schedule deliberately excluded examination periods and school holidays. Data collection was facilitated through an online, self-administered survey hosted on Wavumbuzi's AWS platform. The survey instrument was developed by Wavumbuzi's KRU under the oversight of Prof. Melodi Botha. Prior to the main study, a pilot test was conducted to validate the reliability and validity of the survey questions.

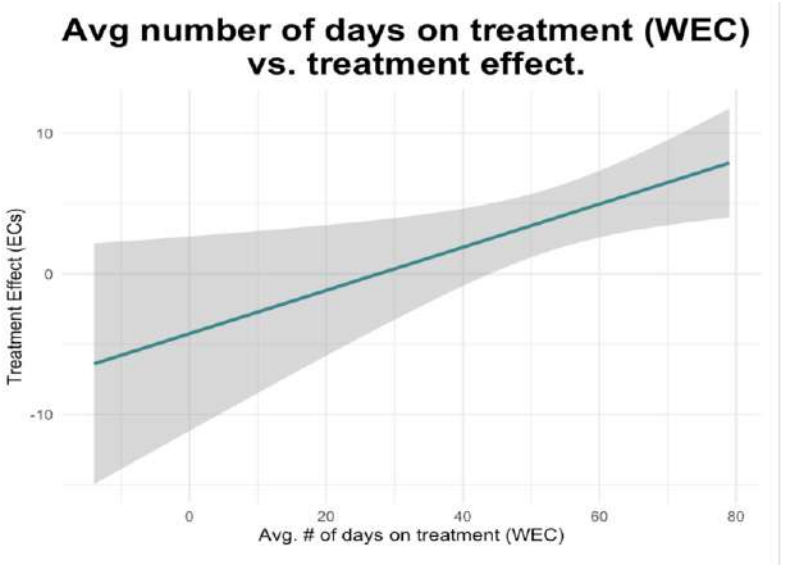
2.4 Data analysis

Statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS). Paired-sample t-tests were the primary statistical tests utilized to contrast the pre-test and post-test scores in Entrepreneurial Competencies (ECs). The average difference between the post-test (endline) and pre-test (baseline) scores in entrepreneurial competencies was calculated to assess improvement.

3.0 Results

Findings from this study indicated that there were six main entrepreneurial competencies (ECs) that improved. Entrepreneurial competencies with positive average differences between baseline

(Pre) and end line (Post) were: Entrepreneurial experience, intend to start up (Entrepreneurial intention – EI 2), Future business planning (Entrepreneurial intention – EI 3), Structured tasks, and following others' rules (Entrepreneurial mindset – EM 2), Positive entrepreneurial mindset (Entrepreneurial mindset – EM 1) and Taking action and initiative. A similar study conducted in Rwanda also indicated similar entrepreneurial competencies improvements. Improvement in ECs (treatment effect) increased significantly when learners started to engage early on during the first few weeks of the challenge versus playing during the last few weeks as depicted on the Figure below.



Please note that the figure illustrates negative days and negative treatment effects. This is primarily due to its generation using a statistical regression model, which often includes negative or positive intercepts (Kutner, 2005). The Figure above has wide confidence intervals between 0 and 20 mainly because of low number of students who did not engage > 20 days

4.0 Discussion

The study substantiates the efficacy of using a gamified approach in educational settings, particularly for stimulating entrepreneurial competencies among learners. This aligns with existing literature that suggests game-based learning can be highly effective for various types of learners (BECF, 2017).

One of the notable impacts of implementing this approach is the shift in teaching roles. Traditionally, the teacher stands as the central figure in the educational setting; however, the gamified approach allows for the learner to take a more active role, transforming the teacher into a facilitator. This transition not only redefines the classroom dynamics but also allows for a more learner-centric model, which can be particularly beneficial for engagement and deeper understanding of the subject matter.

The Wavumbuzi Entrepreneurship Challenge also goes beyond basic educational objectives and

aims to prepare learners for real-world entrepreneurial and technological challenges. This preparation is vital for addressing larger societal issues such as unemployment (Hall, S. 2017). The curriculum, designed around "quests" related to various industries like healthcare and agriculture, provides learners with an interdisciplinary perspective that is likely advantageous in their future endeavors.

The increased interest from educators who have been part of the Wavumbuzi Entrepreneurship Challenge indicates potential for scalability and broader impact. Educators expressing a desire for their learners to participate in future iterations of the challenge can be seen as a testament to the program's effectiveness.

5.0 Conclusion and recommendation

The study shows promising results reinstating Jasiri's commitment of building on the foundations of the existing competence-based curriculum in the entrepreneurship space and developing the five pervasive entrepreneurial mindsets of drive, resilience, self-efficacy, initiative and innovative thinking to set up learners for success. By conducting and reporting on this study, Jasiri further acknowledges the need for further research which would benefit from incorporating more rigorous statistical methods to affirm the improvement in entrepreneurial competencies. Also, given that the current study is limited to a Kenyan context, it would be valuable to see if the results can be generalized to other cultural or educational settings. Expanding the scope to include a more diverse range of participants and implementing a longitudinal study could provide deeper insights into the long-term impact of the gamified approach on entrepreneurial competencies.

6.0 Acknowledgement

Our profound gratitude goes to Wavumbuzi Partners without whom this work would not have been a success. Thank you to the Ministry of Education (MoE), Kenya Institute of Curriculum Development (KICD), Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA), Teachers Service Commission (TSC), Kenya Private Schools Association (KPSA), Kenya Association of International Schools (KAIS), Compassion and Family Group Foundation (FGF). This work was supported by AGGP. Our deepest appreciation goes to the Gray Family for their long-term commitment to motivating and supporting individuals in Africa to become high-impact, responsible entrepreneurs. Further we thank Anthony Farr, CEO AGGP Africa, as well as all members of the Wavumbuzi team namely Aline, Phumlani, Ruti, Katharina, Njoki, Noel and Rafiki among others for their dedicated efforts. Finally, we thank the anonymous reviewers. Your useful suggestions have contributed to improving the quality of this paper.

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Article 19

SMART Table: Virtual Environment for Teaching Mathematical Concepts - Continuum

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Abstract

Technology performs a vital role in enhancing our daily activities. It is therefore necessary to develop engaging and enjoyable technological pedagogical methods through games. In order to impart knowledge and skills through what attracts the learners' maximum attention there is need to leverage technology. Research reveals that people spend an average of 2.5 hours on social media and technological games daily. Therefore, the replication of a classroom lecture on a technological surface to teach scientific concepts can be a better option; however, its viability as a suitable pedagogical method has not been investigated fully. In order to determine the viability of a multi-platform environment as a teaching tool, this paper reports competency-based learning skills acquired through a practicum virtual game-based research findings. The research experiment was conducted on an educational software game created on smart technology, the Smart Table and teachers and student's usability experience from K-12. The study objective was to increase student motivation for learning mathematics concepts. A 4.5 self-reported score based on a 5.0-point Likert on computer literacy was highly favourable with a significant population agreeing that students learn better through interactive hands-on activities than traditional methods. On usability, a 4.0 easy to use and learn score on a 5.0 Likert scale with 69% of users were likely to use if availed as a teaching tool was significant. In conclusion, a SMART Table is a creative way of promoting learning through fun and is recommended to impart knowledge and promote understanding of mathematical concepts in the classroom.

Keywords: *multi-touch, K-12, SMART, technology, teaching, educational software, game.*

1.0 Introduction

The introduction of pedagogical multi-touch tools such as the SMART Table is meant to encourage collaboration instead of competition. SMART table can be used to teach ideas that are easily explained through hands on exercise than traditional lectures. This is significant because it exhibits how the use of a SMART Table is likely to aid users develop more friendships leading to good social skills through teamwork. Thus, emphasizing on co-operation is key since, it is a skill more desirable for working in the real world. This research presumes that the SMART table technology will be accepted by users and that it can improve students' motivation to learn new concepts presented as content materials using the platform i.e. mathematical lessons.

Figure 1: *SMART Table [12]*

Human computer interaction is defined as a process when the user and the system (computer) work in harmony to successfully accomplish out a task. Thus, in the human computer interaction process, a system is considered fully functional once the developer ensures that the system responses are promptly presented to the users and that the system never becomes intrusive nor problematical (Wikipedia Foundation, Inc, 2009) in the usability process. For example, in the past few years there has been a growing interest in virtual reality which is described as a simulation of a world where the user is interacting with the world (Wikipedia Foundation, Inc, 2009) while immersed in it. The virtual reality technology, has necessitated for an improved user interaction interfaces to deliver a satisfying interaction experience to the users.

Owing to the improved virtual reality experience technology, scientists are captivated with virtualization and they desire to achieve a clear-cut understanding of their findings, resorting to the use of 3D technology in these circumstances which is an essential tool for visualizing scientific data given that a user's standard tasks entail continuous variables (i.e., temperature, density, pressure, velocity) and volumes and surfaces. Pertaining to information visualization, a user's normal task entails forthright variables and the detection of patterns, trends, and gaps. There is a high percentage of success with 3D in games particularly in the first-person shooter games, such as Doom and Quake and our goal is to replicate the same in teaching mathematical lessons. Furthermore, certain use of the games allows a user to select 3D avatars as a substitute for themselves (Shneiderman, November 2003) e.g. second Life with the various actions that a user can perform in a virtual environment. Therefore, a virtual environment like second Life allows users to navigate around the environment, do distance estimation and also manipulate objects. In Section 2 of this research paper discusses the objectives of the research in relation to the review on virtual environments and different input devices that can be used to interact with a virtual environment. Section 3 discusses the methodology of the research in relation to learning in a virtual environment while Section 4 outlines the project's main idea SMART Technologies. Section 5 discusses the research's Multi-Touch Table Mathematics Game Development, Section 6 discusses data and results while Section 7 presents a conclusion and future work of the research.

2.0 Objectives

The motivation of this project came into view from browsing the SMART Technologies website. From viewing the SMART Technologies website, we noticed that they were hosting a contest. In this contest the developer or developers who design the best lesson will receive a SMART Table for their academic institution or organization (SMART, 2010). So, we decided to enter the contest and in order to complete this project we had to download the SMART Table SDK.

Initially, we had a challenge of coming up with an educational game. After a few brainstorm sessions, we decided to create a lesson and a game to teach an educational concept to students. We decided that a mathematical game in the area of geometry would be educational and entertaining. The goal of our game is to teach children the ability to calculate area and find the perimeter of a figure. A picture of our game is displayed in Figure 2.

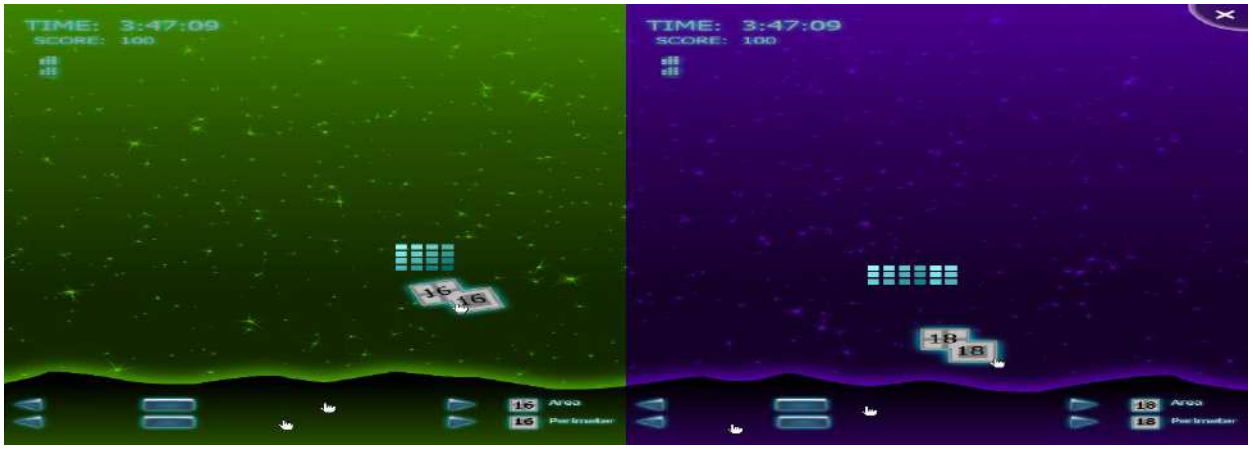

Figure 2: *Area and Perimeter Game*

Our main objective was to create a game that is entertaining and educational to teach math skills; so we decided that the Area and Perimeter game would have random shapes of difficulty. In this figure there are real shapes falling down similar to a Tetris game environment.

3.0 Methodology

Until recently computer users and designers had only a keyboard and lines of text to accomplish their task. However, with the improvement of technology, a mouse was developed and it provided support to a very well developed and significantly improved system design in harmony with a two-dimensional surface of a user interface. In the last few years, user interfaces have changed immensely with touchscreen user interfaces going an immense popularity against other pointing devices. Thus, three SMART technology utilizes touchscreens user interfaces with a little alternative to collaborating indirectly with a cursor controlled by a computer device.

3.1 Multi-Touch

Nowadays, the computer/technology industry has numerous interactive displays with the Multi-touch feature becoming popular. At the same time, the multi-touch technology is being

supplemented with the gestural interfaces, whereas the Multi-touch technology is classified as a virtual environment since the user interact with the system by manipulating objects through the surface. Thus, displays that allow direct manipulation of objects associated with SMART Technologies have become a common computing interface leading to its adoption in development of the SMART Table. The SMART Table is shown in Figure 1 (Table, 2009).

The SMART Table uses Multitouch technology based on Digital Vision Touch technology and this technology takes advantage of a digital camera capable of locating 120 touch points by children working all together (Donlyres, R., 2009), (Multitouch, 2010)].

3.2 Learning

Learning can take place in many forms, however in the information age, it frequently can take place through having conversation with an enlightened individual, by searching for information on the Internet, or other social interactions. Traditionally a formal education process can enhance learning through a classroom method of teaching and evaluation of students on a set of course materials to students. This method is sometimes ineffective because, in some schools, inexperienced teachers do not stress on active learning because of lack of proper training, teaching tools and the motivation to incorporate a more active learning style. The active style of instruction could need a lot of time for the teacher to adapt lessons to support this methodology. Nonetheless, literature states a classroom that encourages cooperative and collaborative problem-solving teaching approach in addition to discussions and reflections achieves better learning results with students comprehending information unlike vice-versa (Niemi, 2008).

Besides the data that supports collaboration as a better method of imparting knowledge unlike the traditional passive method, a significant number of learning institutions use the passive traditional method of learning nevertheless. Passive learning emphasizes memorization of information, with less emphasis on the students do practically discover the knowledge and skills independently. The lack of independence means less interaction and discussion in the classroom which leads to some of the learners not paying as much attention to educational material occasionally, thus leading to no learning and comprehension of the learning material. Due lack of attention, students lack of engagement leading to boredom and loss of morale in being in the classroom (McKeachie, 2009)
To promote of active learning, research is moving in the following directions: student communicating more with faculty, students collaborating more among other students, student attaining superior grades, students are able to convey their points better with others, students analyze a subject in greater detail, and students gain motivation towards wanting to learn something new (McKeachie, 2009).

4.0 Technology Description

4.1 Virtual Environment

Some may wonder what virtual reality actually is and the justification behind utilizing virtual environments. As introduced previously, virtual reality can be used in many different areas.

4.2 CAVE

The concept of the Automatic Virtual Environment (CAVE) was first thought of at the University of Illinois at Chicago. Thomas A. DeFanti, Daniel J. Sandin, and Carolina Cruz-Neira are known as the inventors of the CAVE (Wikipedia Foundation, Inc, 2009). The CAVE is very useful because it can be used to explore 3D environments represented as places that cannot be visited, such as historical cities. According to John Hedberg & Barry Harper "outer space or the ocean floor, is probably the most often discussed application of such environments in learning (J. Hedberg, 2002)" A benefit of a virtual environment is that a virtual environment is immersive, traditional user interfaces do not have this characteristic. Currently the virtual environment area is becoming extremely critical in research to the desirable use of this technology. In order to improve user interfaces to virtual environments, one has to evaluate the users' performance and satisfaction. Improvement is needed to concentrate on usability becoming a common normal process in the development of virtual environments (Abrams, 2008).

Most engineers and scientist use the CAVE to evaluate their data. It helps them identify patterns and sometimes form the main set of tools for the data analysis and sometimes it is the beginning point for going into further detail investigation of the data. A great benefit of the CAVE is that it is interactive. When a person enters the CAVE they are instantly introduced to sharp and finely detailed stereo images projected in real time on the CAVES walls and floor. When viewed through Liquid Crystal Display (LCD) shutter glasses, the left and right stereo images are presented distinctly to the left and right eyes displaying to the user the illusion of 3D objects visible both within and farther along the walls of the CAVE. The images are constantly updated with perspective to the position where the person is located (S. Miller, 2005).

4.3 Input Devices

There are many input devices that can be used to interact within a virtual environment. The goals of these input devices are to show a different output on the screen that the user is requesting from a CAVE like system (i.e., the user might want to manipulate an object or move in a different direction in a world). When a user views a world they can use a wand, joystick, mouse or keyboard to interact with the world (S. Barrera, 2003). A wand is a device similar to a mouse and it consists of a few buttons. The wand is one of the most popular input devices for interacting in a virtual environment. These are some of the most common input devices, however one can interact with a virtual environment by utilizing many other hand input devices or non-hand input devices (S. Barrera, 2003).

5.0 Multi-Touch Table Mathematics Game Development

The SMART Table is a great tool for active learning. According to The Cone of Learning, we remember 70% of what we say when we communicate our thoughts to others around us. In addition, we also remember 90% of what we say and do when we get engaged in that particular activity. Hence, the SMART Table achieves the incredible task of maintaining the attention of younger children (McKeachie, 2009). The aim for multi-touch technologies such as the SMART

Table is placing focus on teamwork rather than competition. SMART Tech is specifically focused on teaching educational concepts to children. The price of a SMART Table can range from $7,000 to $8,000 dollars. Through use of a SMART Table, some of the skills that a student may possibly improve upon could "involve areas like reading, counting, problem solving and visual spatial awareness (Biggs, 2010)."

Currently SMART Technologies products have become well-liked in a large number of classrooms. The authors of this paper have participated in outreach in the local community, and we have observed that in several classrooms the teacher utilize a SMART Whiteboard. There have been more than 1 million SMART Board interactive whiteboards used around the world and these days over 25 million students learn with products made by SMART. SMART products are not only being used in every US state, they are additionally being utilized in more than 170 countries (Smarttech, 2009), (Research, 2010). The SMART Table is capable of 2-6 students cooperating with each other in learning a new skill. In the future the SMART Table may perhaps become even more popular than the whiteboard.

Since SMART technologies provides the support and learning opportunities needed to make the most of the SMART Table, were motivated to see how the SMART Table and other SMART products can help you enhance whole-class, small-group and individual learning, through educational games. We entered into a SMART contest which required that a developer or developers who design the best lesson will receive a SMART Table for their academic institution or organization [10]. We downloaded a downloaded the SMART Table SDK to actively engage and created a smart table game to teach math skills.

In this project we found out that the developers of the SMART Table SDK did not test for Multi-Touch capability on the Windows 7 Operating System prior to the contest. When a developer runs a game on a Windows 7 machine they would discover that only one mouse is capable of interacting with the interface. We did our testing on the Windows XP Operating System. The Windows XP Operating System provided us with actually seeing multiple mice displayed on the screen. Initially, we had a challenge of coming up with an educational game. After a few brainstorm sessions, we decided to create a lesson and a game to teach an educational concept to students. We decided that a mathematical game in the area of geometry would be educational and entertaining. The goal of our game is to teach children the ability to calculate area and find the perimeter of a figure. A picture of our game is displayed in Figure 2.

Figure 2: *Area and Perimeter Game*

We wanted our game to be entertaining and educational so we decided that our Area and Perimeter game would have random shapes of difficulty. In this figure there are teal shapes falling down similar to a Tetris game environment. In order to solve the area and perimeter of the random shape it is necessary for the student to use the scrollbar to move to the correct area and perimeter. After they have decided on the correct values for area and perimeter they then should drag their answers to the shape. If the student response is correct, the shape will disappear and the student will acquire points and a different shape will start falling down but if the student's answers are incorrect they are permitted to try again and solve this question before the shape exits the screen. In order for a player to win our game, the other player must not have any more lives remaining. When the game ends a scoreboard will be displayed on the interface. A user can view which shapes that they got correct and which shapes they got incorrect. A scoreboard is shown in Figure 3.

Figure 3: *Game Scoreboard*

6.0 Data Analysis and Results

When we finished our mathematical application, we tested it out with users by giving them pre-questionnaires before they played the game. After the users completed the pre-questionnaires, they then utilized the software game and then after testing the application, the users completed post-questionnaires. In the pre-questionnaire, we asked questions such as "are you computer literate?" and "do you like playing educational games?" In our post questionnaire, we wanted to

ascertain whether educational games promoted user satisfaction based on Ben Shneiderman's criteria of presenting a great user experience to the user. So we asked questions such as do you like the appearance of the game and does this game make it easier for an instructor to provide materials to reinforce student learning. With regard to our testing, we presented the questionnaire on a three and five-point scale. The users gave us helpful analysis of the educational game. We had a total of 17 users give us feedback of our game. Most of our users were computer literate scoring over a 4.5 on a 5.0 scale. Our analysis revealed that approximately 69% of our users were informed about new developments in computer technology. We found that during the pre-questionnaire all of our users agreed that they understood how to calculate area and perimeter but we observed during the actual playing of the game some of our users had difficulty in remembering how to calculate area and some had difficulty in calculating perimeter. Our tool was a great refresher to teach these concepts. Furthermore, we discovered that 96% of our users agreed that K-12 students can learn better by doing more interactive hands on activities than traditional learning and we also found that many of our users enjoyed playing educational games.

When users completed the post questionnaire, we expected that the results would be greater than 3.0 for all questions related to user experience. Through gathering this data, we observed that our hypothesis was correct as shown in Figure 4. The graph shows that users enjoyed playing the educational game. The study results reveal that the game was not terrible, frustrating, or boring, in fact the users gave it a rating greater than 4.0 in regard to the game being wonderful, satisfying, and fun. In addition, the users' critique of the game was that it was not too easy nor too difficult. They gave it a rating greater than 3.5 and this was a significant result because a game that is extremely difficult or too easy can cause a player to lose interest.

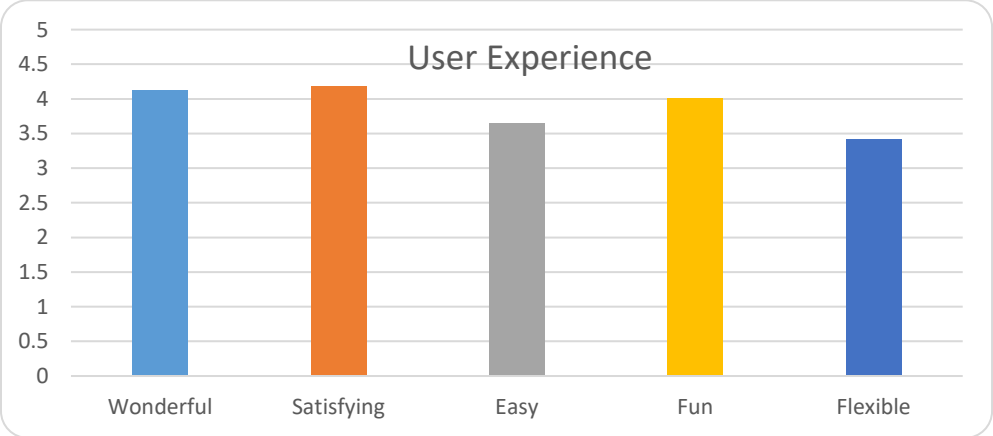

Figure 4: *The Post-Questionnaire User Experience with Game a 5-point scale*

When users completed the post-questionnaire, we expected our results to be greater than 1.5 on a 3-point scale for all question related to the educational game that will be utilized on the SMART Table. Moreover, our users gave the game a rating higher than 2.5 with regard to the games

appearance and it being easier to enforce lecture review concepts to students as shown in Figure 5.

The lowest rated variable for user acceptance was user understanding of the game without assistance. This means our user acceptance lower bound for the experiment of being greater than 50% approval, but indicates that users may have encountered some difficulty with the game. This leads us to consider that in future iteration of the prototype, the developers need to include a tutorial or improve the usability of the game.

We also found another variable that was above lower bound for acceptance with greater than 60% approval. Users indicated that the educational game may be more of a challenge for individuals who rarely use computers, which gives the designers information to improve the next version of the prototype, but we should validate this result through further testing with novice users to validate whether this is an actual concern. For the final variable about the viability of this project, we found that 98% of our users agreed that the SMART Table should be used in more classrooms.

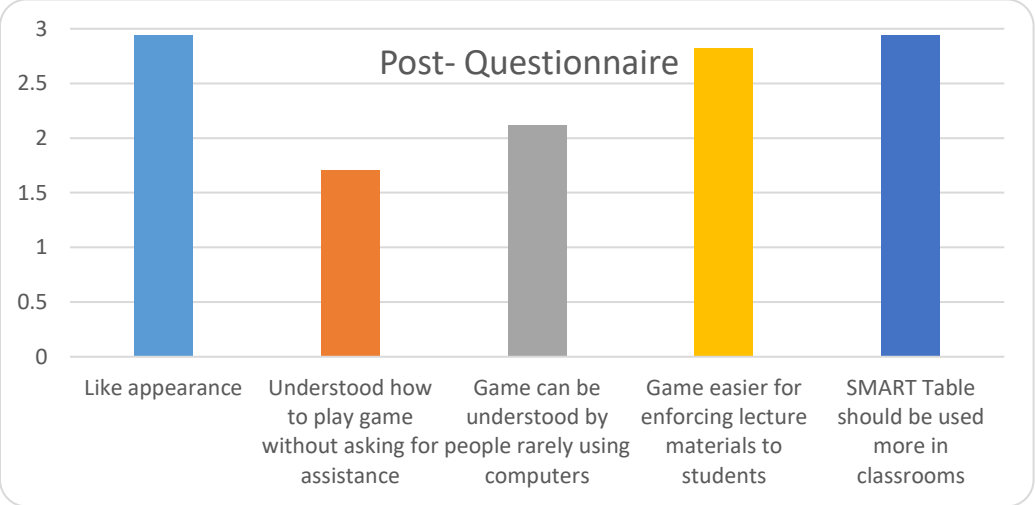

Figure 5: *Post-Questionnaire Virtual Environment for Teaching Math Lessons a 3-point scale*

7.0 Conclusions and Recommendations

The research results are in support of the idea that a Multi-Touch environment considered or classified as a virtual environment in this case offers the user a total control to accomplish a well-defined task to completion through manipulation of objects. A SMART Table is considered a type of a SMART technology and is a novel technique of supporting fun activities for pleasure but can also enable a student to acquire educational knowledge at the same time.

SMART table can a great teaching tool for strengthening the mathematical and science skills of children at an early age which can impart children with buoyancy to focus in mathematical oriented courses like advanced placement courses while in high school. The new technology can influence

students willing to pursue careers in teaching to have a passion toward mathematical education necessary for the success of future generations in engineering and maths that have low enrolment in most institutions of higher learning. The fun way of delivering math concepts can be very beneficial and is likely to be of help because not all students are capable of grasping concepts in the same fashion in a normal classroom setup. The SMART Table therefore is a creative way of promoting fun in the classroom while imparting knowledge as well promoting understanding of educations concepts.

Therefore, a tutor can enrich the teaching experience and promote learning in a classroom using a SMART Table lesson that place emphasis on promoting learning activities that are entertaining to the students. The research paper uses the perimeter and area concepts results outlined in the experiment and data sections as a proof of concept and affirms that SMART Table features can be used to teach mathematical concepts successfully. In the future works the research will include more mathematical concepts like geometry and polynomials. On the other hand, we have already other research section focusing on creating games related to chemistry or biology that can be implemented on the SMART Table. Consequently, the research project results show that the SMART Table as a high chance to become a stimulating and authoritative tool to increase enthusiasm for learning mathematical concepts among a group of users because is a fun, easy to use and learn technology.

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Article 20

Use of Geogebra and Pre-Service Teachers' Performance in Geometry in Colleges of Education in Ghana

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Abstract

Studies have indicated pre-service teachers' difficulty in learning geometry. Geometry is one of the courses in the mathematics curriculum for college students in Ghana. GeoGebra is a technology tool that is used in stimulating geometry through algebraic modeling. This study investigated the first-year pre-service teachers' performance in geometry using GeoGebra in colleges of education in the Eastern Region of Ghana. The objective of this investigation was to establish the difference in geometry performance between pre-service teachers' who are taught using GeoGebra and those who are taught without using GeoGebra. The study used a quasi-experimental design with a nonequivalent (pre-test and post-test) control group design. The study targeted 3062 participants in the seven colleges in the Region. Out of the seven colleges in the region, two (colleges A and B) were randomly selected for the study. From these two colleges, one intact class from each of colleges A and B were randomly selected as the sample. College A was assigned an experimental group and College B, a control group. The experimental and control groups had 74 and 100 participants respectively. The study gathered the data using a geometry achievement test. Data were analyzed using independent samples t-test and paired samples t-test. The study found a significant difference in geometry performance between the experimental and control groups. Based on the findings, it is concluded that GeoGebra can improve achievement in geometry. The study recommends that GeoGebra should be used in teaching and learning geometry in colleges of education in Ghana.

Keywords: *Technology, Geometry, GeoGebra, Experimental group, control group*

1.0 Introduction

1.1 Background to the Study

This section discusses the impact of technology, more specifically, GeoGebra on the teaching and learning of mathematics. Technology provides additional opportunities for learners to visualize and interact with concepts in mathematics. It promotes a deeper understanding of mathematical concepts and rules. Learners can explore and make discoveries with technological software. According to Emaikwu et al. (2015), technology can play a role in improving students' academic performance in mathematics. Furthermore, teaching with technology can change the classroom environment and facilitates meaningful and result-based learning. Research indicates that teaching mathematics with technology increases students' engagement and understanding of mathematics (Zutaah et al., 2023). Some of the widely used technologies in the mathematics classroom include

computers and software such as Derive 6, Geometers Sketchpad, Maple, GeoGebra, and many more. Due to time constrain, this study investigated the use of GeoGebra in mathematics classrooms among Pre-service Mathematics Teachers (PMT) in the Colleges of Education (CoE) in Ghana.

GeoGebra is computer software that enhances students' academic achievement in mathematics. It is a software that has algebra, calculus, geometry, probability, and statistics views. As a result, the software is capable of teaching and learning concepts in these strands of mathematics. The software was developed by Markus Hohenwater in 2001 for teaching and learning mathematics. Research indicates that GeoGebra software is effective in teaching and learning geometry concepts among secondary school students in Nigeria (Akanmu, 2015). However, the present study focused on PMT in colleges of education in Ghana. GeoGebra allows learners to access mathematical concepts that move beyond straightforward pencil and paper computations. In a nutshell, the use of GeoGebra in the teaching and learning of geometry in particular, and mathematics in general, can promote students' engagement and interaction in the mathematics classroom. Hence, enhances students' understanding and academic performance in geometry concepts to be specific and mathematics in general. This study focused on GeoGebra software because it is user-friendly and free to download from the internet. GeoGebra is effective in teaching and learning all strands of mathematics such as algebra, calculus, geometry, and many more. This study was limited to using GeoGebra in the teaching and learning of geometry concepts among PMT in the colleges of education in Ghana due to time constrain.

Geometry is a strand of mathematics that deals with shapes, relationships between shapes, and their properties. According to Heilbron (2023), geometry is a branch of mathematics that deals with the relationship between the length, area, and volume of physical objects. Geometry was derived from Greek words meaning ‘‘Earth Measurement’’. Geometry is not only limited to the study of two-dimensional objects (plane geometry) and rigid three-dimensional objects (solid geometry) but it also includes the study of abstract thoughts and images. Geometry helps students to respond to their practical problems such as abstract visualization and generalization. It prepares the mind of PMT to visualize abstract objects. Sunzuma et al. (2013) opined that geometry develops students' spatial awareness, visualization, and critical thinking, and increases students' problem-solving skills.

Nevertheless, PMT seems to have difficulty learning the subject. This is justified by Zutaah et al. (2022) who investigated PMT performance in colleges of education in Ghana and reported that participants have difficulty solving geometric concepts. Perhaps one of the reasons for PMT low academic achievement in geometry in the CoE could be attributed to the absence of teaching mathematics with technological software. This software helps mathematics teachers capture the minds of the learners in the mathematics classroom. However, the study of Zutaah et al. (2022) did not use software such as GeoGebra in the teaching and learning of geometry. To bridge this gap, the present study investigated if the use of GeoGebra could improve PMT performance in

geometry in the CoE in Ghana. The following paragraphs present studies on GeoGebra and its impact on learners.

Globally, Shadaan and Eu (2013) looked at how GeoGebra affected Malaysian high school student's understanding of learning circles. Findings revealed a significant difference in mean scores between these two groups, with experimental group students outperforming control group students. Similarly, Guven (2012) conducted a study in Turkey on the use of GeoGebra software to improve secondary school students' geometry performance. Participants who learned geometry using GeoGebra outperformed their counterparts who learned geometry using traditional methods, according to the results. GeoGebra software may have helped by making geometry concepts clearer and easier to understand. GeoGebra software is an active tool that encourages students to actively participate in the lesson, resulting in better understanding and performance in geometry. GeoGebra is an enabler that aids learners in understanding geometric concepts during the teaching and learning process. These findings are encouraging, and they have motivated the current study to conduct a similar study among PMT at the college level of education in Ghana. This group was chosen because college pre-service teachers have received professional teacher training. If this issue is addressed among college students within the next ten years, we will have good mathematics teachers who can effectively teach geometry to learners for them to grasp geometry concepts.

In Africa, Adelabu et al. (2019) investigated the importance of learning geometry using GeoGebra software among South African secondary students. The study discovered a significant difference in students' academic achievement in geometry between the experimental and control groups, favoring students in the experimental group. Furthermore, Princess and Uzor (2021) investigated how to improve secondary school students' geometry achievement in Nigeria. The results show that students who learned geometry using the GeoGebra software outperformed their counterparts who learned geometry using traditional teaching methods on the post-test. This demonstrates that GeoGebra software improves learners' geometry performance. The software appears to enable students in the experimental group to learn geometry more effectively than students in the control group. It is reasonable to assert that GeoGebra is an enabler that assists students in grasping geometric concepts, resulting in higher academic achievement in the subject. This encouraging result has prompted the current study to concentrate on PMT in Ghana because the training they received on integrating GeoGebra software into geometry teaching and learning will enable them to effectively teach geometry using the software after graduation. The implication is that within the next ten years, we will have good mathematics teachers who will be able to effectively integrate GeoGebra into the teaching and learning of geometry, in particular, and mathematics in general.

In Ghana, Salifu (2020) investigated the impact of GeoGebra on PMT academic achievement in circle theorem and found that students who were taught circle theorem using the software had higher mean scores than their counterparts who were taught circle theorem using the traditional method. In a roundabout way, the software helped experimental group participants understand

geometric concepts better than their counterparts who learned the circle theorem the traditional way. The implication is that GeoGebra software is useful for teaching and learning mathematics in general, and geometry in particular. Salifu (2020) studied at the Evangelical Presbyterian College of Education in Bimbilla, Ghana's northern region. This encouraging result has prompted the current study to conduct a similar study in Ghana's eastern region, as Zutaah et al. (2022) report that PMT students in the region have difficulty solving geometry concepts. The use of GeoGebra software can help improve PMT performance in geometry. Based on the reviewed literature, there is sufficient evidence to conclude that GeoGebra has a significant effect on learner performance in mathematics in general, and geometry in particular.

Several studies, including Shadaan and Eu (2013) were conducted among secondary school students, leaving out PMT at the college level of education. Secondary school graduates are not expected to teach after graduation, whereas college students are expected to teach after graduation. The knowledge gained by college students in the GeoGebra application is assumed to have a greater impact on learners' performance in geometry specifically and mathematics generally in this study. To bridge this gap, the current study investigated whether the use of GeoGebra could improve PMT academic achievement in geometry in Ghana's CoE. As a result, the goal of this study was to look into the effect of using GeoGebra on PMT academic achievement in geometry at the college level in Ghana.

1.2 Statement of the Problem

Geometry serves as a foundation for PMT to learn more advanced mathematics. Furthermore, it plays a role in helping students understand complex phenomena in the future. Again, studying geometry creates many foundational skills and enables students to develop deductive reasoning skills, logical reasoning skills, and analytical reasoning skills. On the other hand, inadequate knowledge of students in geometry could make them unable to develop spatial sense and geometric thinking. As a result, students would not be able to explore different representations such as virtual manipulatives and mathematical formulas. Also, students' lack of geometry knowledge could make them unable to measure accurately and cannot understand abstract concepts in mathematics.

However, in the teaching and learning of geometry, it is observed that PMT have challenges grasping geometric concepts leading to low academic achievement in the subject. Although the teacher delivers the appropriate content knowledge to enable students to comprehend geometric concepts, learners appear to show a lack of knowledge in applying the knowledge to a given mathematics problem. This could be due to the absence of teaching geometry with technological manipulatives. This study assumes something more is needed to enable PMT to comprehend concepts in geometry and visualize abstract geometric concepts. Most of the studies were conducted on secondary school students and were conducted abroad.

This study attempted to fill this gap by investigating if the use of GeoGebra software could improve PMT academic achievement in geometry at the college level of education in Ghana. The software might play a role by enabling PMT to understand concepts in geometry through the exploration

and visualization of abstract geometric concepts. Additionally, a review of the literature shows that GeoGebra software is effective computer software for enhancing students' academic achievement in geometry. Therefore, the purpose of this study was to investigate the use of GeoGebra and its impact on PMT academic performance in geometry in CoE in Ghana.

1.3 Objective

The study investigated the following objective:

1) To establish the difference in geometry performance between pre-service teachers' who are taught using GeoGebra and those who are taught without using GeoGebra.

1.4 Hypothesis

This study tested the following null hypothesis:

H0: There is no statistically significant difference in geometry performance between pre-service teachers' who are taught using GeoGebra and those who are taught without using GeoGebra.

2.1 Methodology

Here, we discuss the methodologies used in the study. This study used a quasi-experimental design. More specifically, the study used a nonequivalent pre-test and post-test control-group design. Participants in the experimental group learned geometry for eight (8) weeks using GeoGebra while their colleagues in the control group learned the same content for eight (8) weeks using the traditional method. In this study, the use of GeoGebra in teaching and learning geometry is the independent variable while pre-service teachers' performance in geometry is the dependent variable. The study was conducted in selected CoEs in the Eastern Region of Ghana because of academic affordances such as the availability of functional computers and internet connectivity. The target population for this study was 3062 first-year students in the seven (7) CoEs in the region. The composition of the target population is outlined in Table 1 below.

Table 7: *Population Sample Frame*

Serial Number	College	Enrollment
1	A	488
2	B	402
3	C	315
4	D	713
5	E	364
6	F	350
7	G	430
Total	7	3062

A look at Table 1 above shows that this study targeted 3062 participants from seven (7) colleges in the region.

2.2 Sampling Procedures

To begin with, this study used the purposive sampling technique to select two (colleges A and B) from the seven (7) in the region based on the availability of functional computers and internet connectivity. The study used two different CoEs in the region to avoid data pollution. Second, the study used a simple random sampling technique to select the experimental and control colleges. From the academic perspective, a simple random sampling technique is defined as a sampling procedure that allows each member of the target population to have an equal chance of being selected for a study (Lauren, 2023). College A was randomly selected as the experimental college and B as the control college. Third, this investigation randomly selected one (1) intact class (74 PMT) in college A to represent the experimental group. Fourth, one (1) intact class (100 PMT) in college B was randomly chosen as the control group.

2.3 Study Sample

The sample for this study consisted of 174 PMT where 74 students were in the experimental group (treatment was given) while 100 students were in the control group (no treatment was given). The sample size for this study is representative since Gall et al. (2003) indicate that the experimental study should have at least 15 participants in each of the experimental and control groups. The composition of the sample is summarized in Figure 1 below.

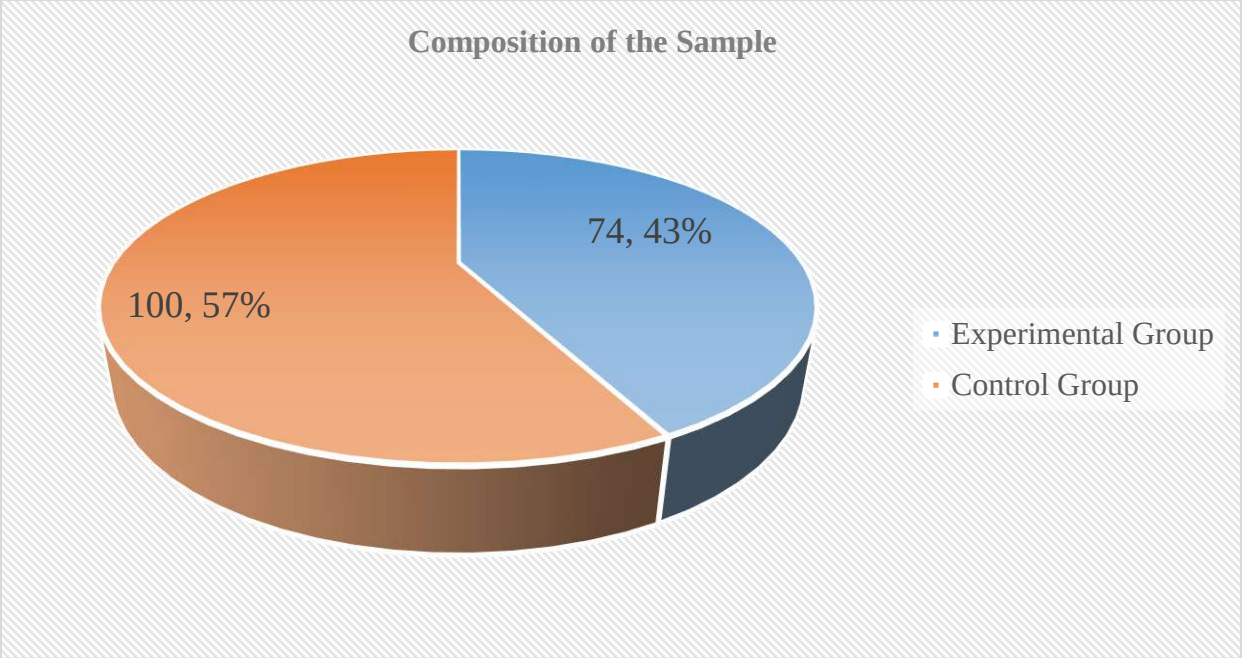

Figure 1: *Composition of the Sample*

A look at Figure 1 above shows that this study included 74 (43%) and 100 (57%) participants in the experimental and control groups respectively giving a total of 174 PMT. Furthermore, the study used a geometry achievement test as a tool for data collection. At the beginning of the study, both the control and the experimental groups took a pre-test to establish their abilities in geometric concepts. The control group learned geometry concepts using the traditional learning method not involving GeoGebra for eight weeks while their counterparts in the experimental group underwent

an intervention where they learned geometry using GeoGebra for eight weeks. At the end of the intervention, a post-test was administered to both groups. The pre-test and post-test contained similar items. Both tests consist of 11 questions each of which 10 were multiple-choice items and one subjective question. The researchers sought permission from the principals of the selected CoEs through the Ghana Tertiary Education Commission to enable them to conduct the study in these institutions.

More so, this research conducted a pilot study on PMT in a different college who were not part of the main study to refine the instruments. The split-half technique was used to estimate the reliability of the instruments. The instruments were found to have an alpha value of 0.76 and 0.81 for the pre-test and post-test respectively using the Spearman-Brown formula revealing that the instruments have internal consistency. This is justified by Creswell (2014) who indicates that a reliability coefficient of 0.70 or more is acceptable and can be used in the main study. On the other hand, the researchers checked for the validity of the instruments using the content and face validities. The content validity was checked using the table of specifications while the face validity was validated by two research experts in the Department of Educational Communication and Technology at Kenyatta University.

Finally, the data was analyzed using Statistical Package for Social Sciences (SPSS) version 25. The investigators used independent samples t-tests and paired samples t-tests to analyze the research objective. The data was presented using Tables. The t-test was used to test for statistical significance differences between the experimental and control groups. The t-value was estimated at a significance level (p-value) of $p \leq 0.05$ (2 – tailed) at a confidence interval of 95% with a margin of ±5.

3 Results

This section discussed the results of this study based on the research objective:

3.1 Difference in Performance between PMT who are taught using GeoGebra and those who are taught without using GeoGebra

This study investigated if there is any significant difference in geometry performance between PMT in the experimental group and the control group. Furthermore, this investigation tested the following null hypothesis; **H0:** There is no statistically significant difference in geometry performance between PMT who are taught using GeoGebra and those who are taught without using GeoGebra. This was determined by conducting independent samples t-test to compare the mean scores in the pre-test and post-test between participants in the two groups. First and foremost, the study compared the mean scores in the pre-test between both groups. The result is shown in Table 2 below.

Table 2: *Results of Independent Samples T-Test on the Pre-Test for both Groups*

	Gr ou	N 10	M 13	M 0a	St d.	t- va	Si g		
Exp eri me ntal	on tr ol	0 74	.0 8 13.93	85 2 en ce	0.85 0 n	852 d)	2.97 2	1.586	0.114

t-value significant at $p < 0.05$

Table 2 above indicates that PMT in the experimental group had a mean score of 13.93 while their counterparts in the control group obtained a mean score of 13.03. There is a slight difference in a mean score of 0.852 favoring participants in the experimental group with a t-value of 1.586. However, the p-value was high at 0.114 ($p > 0.05$) indicating that there is no significant difference in PMT performance in geometry before the treatment between the two groups. This result indicates that learners in both the experimental and control groups have similar characteristics (such as abilities in learning) before the intervention was administered.

Additionally, PMT in the experimental group received treatment for eight weeks by learning geometry using GeoGebra software while their counterparts in the control group learned geometry using traditional methods. At the end of the eight weeks' intervention, a post-test was conducted for participants in both groups and their results were analyzed using an independent samples t-test. This was done to establish whether there existed any significant difference in geometry performance between learners in the experimental and control groups. PMT performance in geometry in the post-test is summarized in Table 3 below.

Table 3 Results of Independent Samples T-Test on the Post-Test for both Groups

C on tr ol	10 0 Gro up	12 .6 9 N	3. 72 9 Mean	2. 19 1 Mean Differen ce	Std. Devi atio n	t-value	Sig (2- tailed)
				3.729	2.49 4	10.461	0.000

t-value significant at $p < 0.05$

Table 3 above shows that PMT in the control group obtained a mean score of 12.69 while their counterparts in the experimental group obtained a mean score of 16.42. There was a mean score difference of 3.729 in favor of students in the experimental group with a t-value of 10.461. Nonetheless, the p-value was low ($p < 0.05$) revealing that there is a significant difference in PMT performance in geometry between participants in the experimental and control groups. This

outcome shows that participants who learned geometry using GeoGebra scored higher marks than their counterparts who learned geometry without using GeoGebra. During the posttest, participants in the experimental group outperformed their counterparts in the control group. The GeoGebra software might have helped PMT in the experimental group to understand geometry concepts better than their counterparts in the control group leading to better performance. Based on the finding of this study, it has been established that there is a statistically significant difference in geometry performance between PMT who are taught geometry using GeoGebra (M = 16.42, SD = 2.494) and those who are taught without using GeoGebra (M = .12.69, SD = 2.191); [t (172) = 10.461, p = 0.000 < 0.05] at the 2-tailed level of significance.

Furthermore, the study looked at participants in the two groups concerning which group gained more mean scores. This was done using the paired samples t-test. The result of paired samples t-test is summarized in Table 4 below.

Table 4 Results of Paired Samples T-Test for both Groups

t-value significant at $p < 0.05$

		Mean Difference	Std. Deviation	t	Sig. (2-tailed)
Pair 1	Posttest score – Pretest score (Experimental Group)	2.486	3.772	5.671	0.000
Pair 2	Posttest score – Pretest (Control Group)	.390	4.647	0.839	0.403

The study used paired samples t-test to compare the pre-test and post-test for both the experimental and control groups. Results in Table 4 above indicate that there is a mean score difference of 2.486 between the post-test and pre-test for the experimental group as compared to a mean score difference of 0.390 for the control group. The experimental group obtained a t-value of 5.671 and the p-value was low ($p < 0.05$) indicating that there is a significant difference between the pretest and the post-test for participants in the experimental group. On the other hand, the t-value for the control group was 0.839 and the p-value was high ($p > 0.05$) indicating that the differences between the pre-test and post-test scores were not significant. This result shows that there was a significant improvement in the scores of participants in the experimental group. On the other hand, there was an improvement in scores in the control group but not significant. It makes sense to state that PMT gained from both approaches but students in the experimental group gained more compared to students in the control group.

The findings of this study revealed that teaching and learning geometry using GeoGebra provided PMT with new learning experiences such as helping them to think, analyze, and visualize abstract geometric concepts, and relate them to real life. Furthermore, the software-enabled future teachers to work in groups, interact among themselves, manipulate the software, and shared ideas. The software helped participants to learn geometry in a conducive environment which led to active participation in the mathematics classroom. Hence, students have high academic achievement in

geometry.

Also, results from the independent samples t-test revealed that there was a statistically significant difference in geometry achievement between PMT who were taught geometry utilizing GeoGebra and those who were taught using the traditional methods favoring students who learned geometry using the software. The outcome indicates that using GeoGebra in the teaching and learning of geometry is more effective than using traditional methods. The software might have played a role by helping learners in the experimental group to understand geometry concepts more than their counterparts in the control group. Based on the findings of the paired samples t-test, it is established that though participants gained from learning geometry using GeoGebra and the traditional method, participants gained more utilizing the GeoGebra software.

In summary, the results of the independent t-test show that the experimental and control groups performed similarly on the pre-test (Table 2). However, the statistical difference in both groups' post-test results revealed that the difference was statistically significant, with the experimental group outperforming the control group (Table 3). As shown in Table 4, sample t-tests for post-test and pre-test results were significant when paired, and both groups performed better at the end of the lessons, with the GeoGebra treatment group outperforming the traditional teaching group. This suggests that learners learned more effectively when GeoGebra was used as a learning tool in this study and for this population of participants. These findings are consistent with Salifu's (2020) findings, who investigated the effect of GeoGebra on Ghanaian PMT academic achievement in circle theorem and reported that students who were taught circle theorem using the software achieved higher mean scores than their counterparts who were taught circle theorem using the traditional method. Similarly, the current study findings agree with those of (Adelabu et al., 2019; Princess & Uzor, 2021) in South Africa and Nigeria respectively regarding the efficacy of incorporating GeoGebra into geometry teaching and learning. Furthermore, the current study findings are supported by those of Guven (2012) in Turkey, who found that GeoGebra had a significant effect on students' geometry achievement when compared to traditional instruction. The implication is that GeoGebra software is useful for teaching and learning mathematics in general, and geometry in particular. Based on the findings of this study, there is enough evidence to conclude that there is a statistically significant difference in geometry performance between PMT who use GeoGebra and those who do not use GeoGebra in favor of the GeoGebra users.

Finally, the null hypothesis was tested in this study: **H0**: There is no statistically significant difference in geometry performance between PMT taught with GeoGebra and those who are not. GeoGebra users outperformed non-GeoGebra users in terms of geometry performance, according to this study. This study's findings provide enough evidence to refute the claim that there is no statistically significant difference in geometry achievement between participants who learned geometry using GeoGebra and those who did not. The findings of this study corroborate those of Shadaan and Eu (2013), who investigated the effects of GeoGebra on high school student's understanding of Malaysian learning circles. The study's findings revealed a significant difference

in mean scores between these two groups, with experimental group students outperforming control group students.

4.0 Conclusion

The findings of this study indicate that GeoGebra is an effective software for enhancing students' academic achievement in geometric concepts. PMTs were able to explore and visualize abstract geometric concepts. Also, students interacted among themselves and shared ideas. The teacher's role was as a facilitator. This enabled PMT to grasp geometry concepts better rather than being passive learners which led to students' high academic achievement in geometry. In a nutshell, GeoGebra software is an effective software for improving PMT academic performance in geometry. This study projects that if mathematics teachers integrate GeoGebra software into the teaching and learning of mathematics in general and geometry specifically in ten years to come, learners' difficulty in learning geometry will be a thing of the past.

5.0 Recommendation

Based on the findings of the present study, it is recommended that the Ministry of Education should enforce the integration of GeoGebra into colleges of education mathematics curriculum. More so, this study focused on basic PMT academic performance in geometry leaving other strands in mathematics. Therefore, further studies should be carried out on other strands of mathematics.

6.0 Acknowledgment

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