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Strengthening Mathematics and Science Education in Africa

SMASE-AFRICA

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

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PREFACE

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

The first virtual 18th Conference for Mathematics, Science and Technology Education in Africa [COMSTEDA 18] was held on 23rd-25th, November 2021. 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 not only widens the scope of understanding the context of STEM education, but also deepens knowledge and skills that respond to the needs of the 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 4th edition of the journal will continue to further trigger research in this crucial area of STEM education from early learning to tertiary levels of education. This edition contains sixteen (16) research papers that were presented during the forum.

We thank the leadership of the Universidade Rovuma, Mozambique for hosting the conference in partnership with SMASE-Africa. Gratitude to the conference organizing committees with membership drawn from various stakeholders including the country focal point persons for teamwork during the planning and implementation of the conference.
Gratitude to all the SMASE-Africa partners for the provision of material and human resources that immensely contributed to a rich event. We value your contribution and hope to work together in the future. To SMASE Africa delegates, participants, and paper presenters, we are grateful that you chose to be part of this great millstone and for the valuable inputs during the virtual conference.

We hope that COMSTEDA 18 was an enjoyable learning experience and look forward to seeing more research papers in COMSTEDA 19.

COMSTEDA 18 Organizing Committee

ABOUT SMASE-AFRICA AND COMSTEDA FORUMS

SMASE-Africa Association: The desire to develop mathematics and science education in African countries informed the creation of the SMASE-Africa network in 2001. The Association brings together African countries and STEM-based organizations to dialogue about STEM education in Africa. The members share innovative ideas and practices that are relevant to respective countries through conferences, technical workshops and exchange visits. The regional secretariat is located in Kenya, hosted by CEMASTEA with offices inside the University of Nairobi - Kenya Science Campus. SMASE-Africa is a member of the African Union Continental Strategy for Africa's teacher development and STEM education clusters.

Vision: *"A leading organization in promoting effective classroom practices for quality STEM education in Africa"*

Mission: "*To promote effective classroom practices in Science, Technology, Engineering and Mathematics education through research, fostering relevant policies, networking, collaboration, advocacy and capacity building in Africa*".

COMSTEDA International Forums: SMASE-Africa designed an international forum known as the Conference on Mathematics, Science and Technology Education in Africa (COMSTEDA) which 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 organizations aim at building synergy in strengthening the 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. The conference is held annually in African countries. 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) and a virtual COMSTEDA 18 hosted by Mozambique (2021).

The objectives of COMSTEDA 18 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 the continent

EDITORIAL

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

Article 1

The paper on the, **Influence of the head teachers' practices in curbing drug and substance abuse among students in public secondary schools in Mukurweini sub-county, Kenya** *by Edna Nyakambi Bosire* established that the curriculum contained little content on drug and substance abuse, guidance and counselling were not being exploited fully to address drug and substance abuse and school rules were not being fully enforced. The study recommends; that the Ministry of Education should organize national workshops aimed at training guidance and counselling teachers; the Teachers Service Commission should identify and deploy qualified guidance and counselling teachers to schools. Head teachers should establish drug and substance abuse routine checking programs in their schools; provide secluded rooms for counselling to enhance privacy; involve students in the formulation of school rules and firmly enforce school rules on students. The study further recommended that the Kenya Institute of Curriculum Development should design a curriculum to contain content addressing drug abuse.

Article 2

Joseph Haufila conducted a study on **Lesson Study as a New Approach to Improve Continuous Professional Development (CPD): Case of Biology Teachers and School Principals, Khomas Region, Namibia** which aimed to find out whether LS improves CPD in Khomas region. The findings revealed that there was lack of in-service training on CPD in Khomas region and participants need training in their subject areas and pedagogies. The study recommends that the Ministry of Education should strengthen in-service training on CPD in schools. Furthermore, school-based LS should be implemented in schools to add value to the current CPD.

Article 3

The paper on **'Cheerful incidents' An opportunity for learning through reflective practice: A case of Kenyan chemistry teacher trainers** by *Dr. Mercy W. Macharia & Njeri Mburu S* explored teacher learning through reflective practice. The study involved four chemistry teacher trainers and lasted for one year. During and after the study, the teacher trainers 'cheerfully' reported learning experiences, from critical incidents they isolated and reflected on from their lessons. The research findings showed that the teacher trainers enhanced their pedagogical knowledge, content knowledge and knowledge of how students learn. Regarding knowledge of teaching methods, the teacher trainers learned that they: rarely involved students in class demonstrations and were doing most of the work; sometimes they assumed students were following what they were doing. The findings also reviewed that students can learn better when teachers: involve them in practical experiences; use their ideas, use guided practice, address misconceptions; use their prior knowledge, and attend to the language used in providing explanations. Further research is recommended to determine whether the four teacher trainers have

improved their practices of teaching chemistry, after this study. Similar research is also recommended with a large number of teachers to allow generalization of the research findings to a wider population.

Article 4

Teacher professional development of mathematics professors at Rovuma University: Past, Present and Future by *Gabriel Mulalia, GMM, Maulana; Claudecir, CP, Paton; Sergio de Mello, SMA, Arruda* discusses the past, present and future of four Mathematics professors working at Rovuma University – Cabo Delgado Extension, with the aim of characterizing their Teacher Professional Development in an African context. The research found that teachers were insecure in terms of knowledge, skills and teaching values at the beginning of the profession. However, over time they learned in practice through teaching, reading, reflection, research, and interaction with others. From a past of insecurities about teaching, teachers today feel capable of satisfying professional demands, but clamour to continue learning to improve their professional performance. For this, they aim for academic training, technology learning and research.

Article 5

The Effect of School-Based Professional Development (SBPD) Model on Teachers' Pedagogical Content Knowledge and Pupils Achievement in Basic Science at the Middle Basic Education Level in Nigeria *by Dr. Zainab Muhammad Shuaibu, & Armiya'u Malami Yabo,* found out that teachers' exposure to SBPD model significantly improved lesson delivery and learners' achievement. It is recommended that SBPD model should be used in schools as one of the major constituents for improving teachers' pedagogical content knowledge for teaching science at the basic and post-basic school level through school supervision and inspection.

Strand 2 # School Culture and Learning in STEM

Article 6

Gender difference in the influence of role model and gender stereotype on science performance among secondary school students in Migori county, Kenya by *Polycarp, O. Gor, Lucas O. A. Othuon & Quinter A. Migunde* found out that gender stereotype negatively predicts students' performance in science. The study recommends that stereotypes should be reduced particularly so for girls.

Article 7

The relationship between self-efficacy and academic achievement in secondary schools in Kenya *by Leonard Kipkirui & Pascal Kiplangat.* The study also sought to establish the level of self-efficacy of the students and if differences in self-efficacy exist between male and female students. The results of the study revealed a moderate level of self-efficacy among the students. Moreover, a significant relationship between the students' self-efficacy and academic achievement was found. However, no statistically significant difference between males and females in self-efficacy was found. From the findings, it was recommended that teachers should improve self-efficacy beliefs of the students by using peer models, using moderately difficult tasks, encouraging

the students to set goals, altering the emotional states of learners, and using performance-contingent.

Article 8

Inclusive STEM education for learners with special needs: A case study for Itekeng Junior Secondary School mixed ability Integrated Science results in Gantsi Botswana by *Mogwase, S.S. & Abotseng, M.M Gaborone* focused on the academic performance of students with special needs in Integrated Science. The study found out that some of the factors of particular concern which affect students' performance inter alia are teaching methods, learning styles, curriculum, syllabus coverage, students' assessment patterns and student feedback timeliness. This paper recommends that there be a review of the curriculum to cater to students with learning disabilities, teaching of integrated science to be separated into different subjects just like in senior secondary school where chemistry, biology and physics are taught separately, and teachers who are principal policy implementers should be trained to teach slow learners.

Article 9

Number of household members, caretakers' family income and science academic performance of orphaned secondary school learners in the central district of Botswana by *O. G. Mokgethi & E. B. Fetogang* focused on the extent to which orphaned learners receive support and care from the community and at home as key towards academic performance. The study revealed that in the perception of orphaned learners, the number of household members significantly influences involvement of caretakers in their education. In addition, the results showed that orphaned learners are of the perception that, family income significantly influences caretaker involvement and expected academic performance in Science Double Award (SDA). The study recommended that the Ministry of Basic Education should establish a training program for orphaned leaners' caretakers on how best they can engage in the upbringing that contributes to good academic performance. The other recommendation was; the Government of Botswana through the Ministry of Local Government and Rural Development should review support programs for orphans and consider providing incentives to caretakers who are of low family income to boost their morale. It was also recommended that more research could be carried out to determine other factors which influence Science academic performance among orphaned and non-orphaned learners.

Strand 3 # STEM Curriculum Development, Implementation and Assessment

Article 10

Application of the UNESCO ICT framework in web design by Limkokwing University of Creative Technology students in Botswana by *E. B. Fetogang & B. Monyamane.* The study was done to determine the extent to which UNESCO ICT framework aspects have been imparted during teaching among Limkokwing University students in Botswana. The results indicated that the perception of the Limkokwing University students, learning of the knowledge, deepening and

creation aspects were not learnt equally significant. Generally, understanding ICT policy in education, application of digital skills, organization and administration were significantly less emphasized during teaching. The study recommended that the university needs to integrate the UNESCO ICT Competency Framework into its curriculum and plans so as to produce graduates ready for the job market in today's economy.

Article 11

The contribution of argumentation in the emergence of the reflective teacher in science teaching by *Belém Júrcia Violeta Macie & Sergio de Mello Arruda* sought to understand how the teacher manages argumentation in the classroom, based on pro-argumentation actions, correlated to the reflective teacher. Results pointed out that the teacher can implement actions in the interest of building evidence for scientific explanations. This study reinforces the need for argumentation in science classes, by collaborating in the indication of pro-argumentation actions and revealing that it is impossible for the teacher to apply argumentation in classes without being reflective.

Article 12

Effect of Reciprocal Constructivist Instructional approach on Students' Achievement in Basic Science in Rigachikun Education Zone Kaduna State Nigeria *by Ibrahim Sani & Yahaya Sani Rigachikun.* Findings from the study revealed that Basic Science students exposed to reciprocal constructivist instructional approach performed significantly better than those taught using lecture method. It was also discovered that students taught Basic Science using lecture method were not actively engage in the teaching and learning of Basic Science. It is recommended among others that Basic Science teachers plan and implement lessons using reciprocal constructivist instructional approach which is activity-based teaching strategy that create a conducive atmosphere for effective teaching and learning to enhance students' critical thinking skills, creativity, innovation and achievement.

Article 13

Effect of Evidence-Based Teaching Strategy on Students' Academic Performance in Biology Concepts in Kaduna Education Zone, Kaduna State-Nigeria *by Ahmed Muideen & Yashim Jagaba Mathias***.** The findings indicated that Biology students taught using evidence-based strategy performed significantly better than those taught using lecture-based method. The result further showed that students' engagement/participation in the evidence-based lesson is better than those taught using lecture-based method. This study recommended that Biology teachers should plan and implement their lessons using evidence-based teaching strategies in order to encourage and promote active learners' participation and meaningful learning of biological concepts.

Strand 4 # ICT Integration in STEM Education

Article 14

District instructional management system for STEM learning by *Dr Muavia Gallie (PhD) & Dr Corvell Cranfield (PhD*) sought to find out how to maintain undisrupted learning during a

global pandemic. This paper focuses on the District Instructional Management System for schools (DIMS) which is an online learning tool that provides access to students with high-quality teaching, facilitation of learning and assessments functionalities beyond their face-to-face school experiences. This paper argues that the DIMS as a methodology of monitoring and evaluation, allows district officials to manage student learning in all schools at the same time, 24/7.

Article 15

School to industry linkage platforms and STEM education in Mozambique: The case of Instituto Industrial e Comercial de Nampula, by *Saíde Issufo Momade, PhD & Tomás Castelo Armando, MA* investigated studied norms and conditions created by Instituto Industrial e Comercial de Nampula (IICN), to enable female students successfully embrace STEM education. The study found out that there is a serious gender imbalance in STEM education. The study recommends hiring female trainers.

Article 16

Attitude of teachers towards the application of information and communication technology (ICT) in teaching and learning of STEM in Rigachikun Education Zone, Kaduna State, Nigeria, by *Dr. Zainab Muhammad Shuaibu, Misbahu Adamu Sani & Nyam Yakubu Yusufu.* The result of the study revealed that majority of teachers had a very poor attitude towards application of ICT in teaching and learning process. It was observed that female teachers had a negative attitude towards ICT applications, while male teachers showed a positive attitude. This paper recommends in-service ICT training for teachers in Rigachikun Education Zone of Kaduna State to enhance their capacities in applying ICT in teaching and learning process.

DR. BENSON BANDA
EDITOR - IN- CHIEF

Strand 1# 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

Influence of the head teachers' practices in curbing drug and substance abuse among students in public secondary schools in Mukurweini sub-county, Kenya

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Abstract

Drug and substance abuse (DSA) has continued to ruin school going children and subsequently education despite various measures to stop it. This study aimed at establishing the influence of head teachers' practices to curb drug and substance abuse among students. The objectives were: to assess the influence of the head teachers' use of curriculum in curbing drug and substance abuse, to determine the influence of the head teachers' use of Guidance and Counseling in curbing drug and substance abuse and to assess the use of school rules and regulations in curbing drug and substance abuse in public secondary schools in Mukurwe-ini Sub-County, Kenya. The study employed descriptive research design. Data was collected by use of questionnaires and interviews. The study established that the curriculum contained little content on drug and substance abuse, guidance and counseling was not being exploited fully to address drug and substance abuse and school rules were not being fully enforced since they contravened Ministry of Education policies and guidelines. The study recommends; that the Ministry of Education should organize national workshops aimed at training guidance and counseling teachers; the Teachers Service Commission should identify and deploy qualified guidance and counseling teachers to schools. Head teachers should; establish drug and substance abuse routine checking programs in their schools; provide secluded rooms for counseling to enhance privacy; involve students in formulation of school rules and firmly enforce school rules on students. Kenya Institute of Curriculum and Development should design curriculum to contain content addressing drug abuse.

***Keywords**: Influence, Head teacher, practice, curbing, drug, drug and substance abuse, student, Public, Secondary schools.*

1.0 Introduction

Drug and substance abuse among the youth has become a major challenge facing the Kenya education sector. A report by United Nations Drug Control Program (UNDCP) shows that 60% of students abuse drugs and substances. A drug has been defined as any substance which when introduced into the body by way of ingestion, smoking, inhalation, injected, dissolved under the tongue or absorbed through a patch on the skin, will alter the normal biological and psychological functioning of the body especially the Central Nervous System (Myers, 2006). Studies and statistics show that globally more preadolescents and teenage children are using drugs and alcohol (Australian Drug Foundation, 2000).

Current evidence reveals a continuing upward trend in Drug and Substance Abuse worldwide (World Drug, 2004). The report by WHO (2004), estimates that 1.1 thousand million people representing a third of the world population above age 15 years use tobacco in form of cigarette. The National Centre on Addiction and Substance Abuse (CASA) at Colombia University, found out that college students had higher rates of drug addiction compared to the general public. The study revealed that 22.9% of students met the medical definition of drug abuse or dependence which is a compulsive use of substances in spite of the consequences. Alcohol is the most widely abused substance according to a NACADA (2008) report. According to Amayo (1994), drug use, in particular heroin is becoming a serious threat in Egypt, where around 6 percent of a sample of secondary school students admitted to having experimented with drugs. According to Mpaata (2008), substance abuse is the leading cause of school dropout by students in Uganda. The Global School Based Students Health Survey carried out in Tanzania revealed that alcohol was the most abused drug among students (Gelinas, 2006).

Republic of Kenya (2008) indicates that head teachers and teachers are involved in the prevention, control and mitigation of drug and substance abuse through formal and non-formal curriculum. The head teachers' practices through the school curriculum, staff personnel, student personnel, school finance, school plant and the school community foster effective management of schools (Okumbe, 1999; and Obiero, 2006). In the USA, the Safe and Drug- Free School Program is a comprehensive federal initiative funded by the U.S.A Department of Education, which is designed to strengthen programs that prevent the use of drugs and violence in and around the nation's schools (Martinez, 2004). The general objective of teaching the DSA topics is to create awareness and deter the use of drugs by students (KIE, 2008). Informal curriculum is also used in the fight against drug and substance through the use of sports and games, plays and music, drama, club and societies, public lectures as well as debates as observed by Matzingulu (2006) and Muraguri (2004).

School guidance and counseling is necessary as it reduces anxiety, decreases classroom disturbances and that preventive counseling occurring before students are in a crisis can reduce risks of school dropout (Mullis & Otwell, 1997). According to Chand (2008) school guidance and counseling teachers are effective in teaching life and social skills. Research done in the USA by Baker and Gerler (2001) shows those students who participate in school counseling programs have significantly less inappropriate behaviors and have more positive attitudes toward school and life.

In South Africa, the Norms and Standards of Educators (NSE), places the demands of pastoral care on all teachers (Department of Education, 2000: 18). According to Kirangari (2010), Chand (2008) and Mungai (2007), effective guidance and counseling programs in schools have contributed significantly in reducing drug and substance abuse among students.

Schools need to enforce rules in order to discipline students abusing drugs. A survey by NACADA (2006) and Kimori (2010) hinted that most drugs enter schools at the opening of a new term as students carry them hidden in their personal effects. Jeruto and Kiprop (2011) conducted a research on the extent of student participation in decision making in secondary schools in Kenya and they reported students' minimal participation.

Sisungo, Buhere and Sang (2011) found that headship of secondary school requires knowledge and experience in managerial skills. Okumbe (1999) noted the importance of qualification and experience in enhancing the head teachers expertise, credibility, confidence and decisiveness in management practice. Ouru (2008) and Oside (2003) concur that head teachers with many years of experience in handling students had a better understanding of their students and their practices as principals.

1.1 Statement of the Problem

Kenyan secondary schools have continued to experience several problems associated with drug abuse including examination poor performance, school dropout, suicides, unplanned pregnancy, arson, violence, school unrest and truancy (Orifa, 2004: NACADA, 2006: GOK, 2001). Due to this, the GOK is currently implementing several measures aimed at curbing various cases of drug and substance abuse in secondary schools. Other strategies include the National strategy on prevention, control and mitigation of drug and substance abuse in Kenya 2008-2013 (Republic of Kenya, 2008) and an inclusive curriculum. Schools in Mukurwe-ini Sub County have continued to witness drug abuse among students hence this study sought to establish the influence of principals' practices in curbing drug and substance abuse.

The study employed descriptive research design. This is a method where data is collected by interviewing or administering a questionnaire to a sample of individuals. The method is used to collect data on attitudes, opinions, habits or any of the variety of education or social issues (Orodho, 2005). The study hence collected attitudes and opinions from various respondents based on the study objectives. Therefore, the study has described the practices used by head teachers to curb drug and substance abuse since it is a social problem which students are potentially exposed to. Data was collected by use of questionnaires for head teachers and an interview guide for heads of guidance and counseling departments.

The target population comprised of 33 public secondary schools, consisting of 33 head teachers, 33 heads of guidance and counseling departments. Since the study could not cover all the 33 schools, stratified random sampling was used to sample 15 secondary schools out of which 10 were mixed, 3 were boys and 2 were girl schools to take part in the study. A sample of 15 Head teachers and 15 G&C heads of department which constitutes 49.5% was selected by census; all from the schools sampled.

This study aimed at establishing the influence of head teachers' practices to curb drug and substance abuse among students. The objectives were: to assess the influence of the head teachers' use of curriculum in curbing drug and substance abuse, to determine the influence of the head teachers' use of Guidance and Counseling in curbing drug and substance abuse and to assess the use of school rules and regulations in curbing drug and substance abuse in public secondary schools in Mukurwe-ini Sub-County, Kenya.

2.0 Findings and Discussion

2.1 Use of Curriculum to curb drug and substance abuse

Curriculum is the sum total of learning opportunities presented to a learner by the environment especially planned, organized and constructed for that purpose (Education Act, Cap. 211, 2013). Curriculum is therefore as a plan for providing learning opportunities and experiences to learners in order to achieve educational goals and specific objectives which wholesomely and adequately addresses drug and substance abuse challenges. The Kenyan education curriculum is broadly classified into formal curriculum, comprising of subjects taught in class; informal which is comprises co-curricular activities and the non-formal curriculum that comprises those learning experiences that occur as a result of interacting with role players in the school environment.

Head teachers agreed that the school curriculum adequately addresses the problem of drug abuse in schools this post a mean of 4.8. They also agreed that students are aware that there are topics in the curriculum that address drug and substance abuse with a mean of 4.4. The head teachers further agreed that co-curricular activities such as drama, music and sports adequately create DSA awareness among students as this posted 4.4 mean score response. The findings concur with Muraguri (2004) and Matzingulu (2009) that co-curricular activities such as drama, music and sports are used to provide opportunities for educating students about dangers of DSA in a more social and informal way by use of well-choreographed themes. On school syllabus, the head teachers agreed that it is taught effectively to enhance curbing DSA as this recorded 4.1 response mean. When asked to indicate whether teachers were competent in handling DSA among students, the respondents agreed; as the statement returned a mean score of 3.5 from head teachers. This shows that teachers have adequate knowledge about drugs hence able to handle related issues with competence. It was noted that life skill programme was not taught adequately in most schools since head teachers disagreed posting a mean of 2.4. This concurs with a study carried out by Mutsotso (2004) which revealed that most school head teachers preferred to concentrate on examinable subjects to obtain high grades in national examination since the subject is not examinable. The responses are presented in table 1 below.

Table 1

Head Teachers Responses on Areas of Curriculum Used to Curb DSA

	1		2		3		4		5		Mean Score
Statement	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	

The school curriculum addresses DSA among students	0	0	0	0	0	0	2	13	13	87	4.8
Students are aware of topics in the curriculum that address DSA	0	0	0	0	0	0	8	53	7	47	4.4
Teachers are competent in handling DSA among students	0	0	4	27	2	13	6	40	3	20	3.5
Co-curricular activities such as drama, music and sports are used to create awareness on DSA	0	0	0	0	2	13	5	33	8	53	4.4
School syllabus is effectively taught to enhance curbing of DSA	0	0	1	7	3	20	4	27	7	47	4.1
Life skills is taught in your school	2	13	7	47	4	27	1	7	1	7	2.4

Key: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

The majority of heads of guidance and counseling department indicated that curriculum addresses DSA through subject topics on drugs in Biology, life skills, Christian religious education and chemistry though adding that the content covering DSA was inadequate in addressing drug and substance abuse awareness. It was however noted by the heads of guidance and counseling departments that co-curricular activities such as drama, music and sports were not adequately designed to create DSA awareness among the students. Majority of heads of G&C departments also indicated that some schools were using videos, posters and booklets and documentaries with DSA topics showing dangers of DSA among youths to further create awareness among the students. Most of them noted that the curriculum should be designed into a subject that fully addresses DSA. Life skill lesson was not frequently taught as stated by a majority of the guidance and counseling heads of departments citing that it was not on the school timetable in majority of the schools sampled.

The study established that curriculum contains information on drug and substance abuse but it is not adequate as observed by majority of guidance and counseling departmental heads. The content is too scanty and does not sufficiently tackle in depth issues on drug and substance abuse. There is no proper emphasis given to topics that touch on drug and substance abuse issues and some subjects that address it are elective.

2.2 Use of Guidance and Counseling

School head teachers agreed that G&C is effective in addressing DSA among students which had a mean score of 4.6. This is in agreement with Ouru (2008) who points that drug and substance abuse is tackled through G&C by providing developmental skills. Head teachers further agreed that they were directly involved in handling DSA cases among students with a mean score of 4.3, this was in agreement with the students' mean of 4.4 which rated principals competent in handling

DSA issues; they however were neutral on how often drug abuse counseling seminars were conducted in schools with a mean score of 3.3. Heads teachers however disagreed on having a G&C counseling units in the schools as indicated by a mean score of 2.5; this implies that counseling services are provided rather in the open as opposed to a secluded place. When asked whether the heads of G&C department were competent in handling DSA cases they were neutral posting a mean of 3.2 as presented in table 2 below.

Table 2

Head Teachers' Responses on the Influence of G&C in Curbing DSA

	1		2		3		4		5		Mean Score
Statement	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	
You are directly involved in G&C of DSA cases among students	0	0	0	0	0	0	10	67	5	33	4.3
You often conduct DSA counseling seminars in school	0	0	4	27	4	27	5	33	2	13	3.3
There is a G&C unit in school	0	0	8	54	0	0	3	20	2	13	2.5
G&C influences curbing of DSA among students	0	0	0	0	0	0	5	33	10	67	4.6
The head of G&C is competent in dealing with DSA cases	0	0	4	27	3	20	3	20	4	27	3.2

Key: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

Interviews conducted with heads of G&C department indicated that guidance and counseling seminars were not conducted often in schools as noted by majority of them, this finding disagreed with the responses given by the head teachers in which the head teachers agreed that counseling seminars were conducted posting a mean of 3.3. On the other hand, majority of heads of G&C further observed that school s didn't have a counseling unit to facilitate private counseling sessions. The findings corresponded with those posted by head teachers where they disagreed on having counseling units posting a mean of 2.5.

Study findings by Chand (2008) and Mungai (2007) revealed that G&C has been instrumental in the mitigation of DSA in schools. Mungai (2007) further noted that individual counseling, group counseling, peer counseling, mentorship programs and role modeling helps students to overcome drug abuse. From the study, majority of the heads of guidance and counseling reported that DSA counseling experts were not frequently invited to talk to students due to cost implications; however, some observed that when need arose; an expert was usually invited though once after a long time.

2.3 Use of Rules and Regulations

Most school heads agreed that there are a set of school rules and regulations that address DSA in their schools as this response recorded a mean score of 4.9. Head teachers further agreed that

school rules and regulations were enforced on students involved in DSA with a mean score of 4.7. They however disagreed on student participation in formulation of school rules and regulations as this recorded a mean of 1.4 as shown in table 3 below.

Table 3
Head Teachers' Responses on the Influence of School Rules in Curbing DSA

	1		2		3		4		5		Mean Score
Statement	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	
The school has a set of rules and regulations that address DSA	0	0	0	0	0	0	1	6.7	14	93.3	4.9
The students participate in formulation of school rules and regulations	8	53	2	13	3	20	0	0	0	0	1.4
School rules are enforced on drug and substance abusing students	0	0	0	0	0	0	4	27	11	73	4.7

Key: 1-Strongly Disagree 2- Disagree 3 -Neutral 4-Agree 5-Strongly Agree

The results of the findings concur with Jeruto and Kiprop (2011) that though there were attempts but mainly tokenistic. This shows that student participation was still wanting. However, the head teachers suggested that students should be involved in formulation of school rules and regulations. Interviews conducted on heads of guidance and counseling departments revealed that school rules were essential in curbing DSA among students as they outlined the penalties imposed on any students caught abusing drugs, peddling or smuggling them to the school compound. Majority however indicated that some of the rules were not enforced on students caught with drugs. On the same note, they pointed out that sometimes their hands were tied by the Basic Education Act (2013) under which the MOE prohibits expelling students from school; and the International Convention on the Rights of the Child (CRC) where Kenya is a signatory therefore limiting execution of school rules. These policies contravene some of the school rules hence left them on the losing side. They further observed that the school administration did not engage students in formulation of school rules and regulations hence rules were basically imposed on students.

2.4 Other strategies to curb drug and substance abuse

Use of persons who had been affected by drugs to talk to students on the dangers of abusing drugs as highlighted by head teachers as a strategy used to curb drug and substance abuse. The involvement of the church in giving spiritual guidance to the students through organized pastoral programs was another strategy.

A majority of head teachers indicated that impromptu searching of students' belongings helped to nab any drugs hidden and instilled fear in the learners so they would not hide drugs or keep them within the school compound. It was also indicated that use of local administration like the chief's

office helped to arrest students caught with drugs and carrying out further investigations. Another strategy was sending students who were suspected to be abusing drugs for drug testing.

3.0 Conclusions and Recommendations

The curriculum does not contain adequate content on drug and substance abuse that could equip learners with sufficient knowledge and skills to help them resist drug and substance abuse. On the other hand, guidance and counseling teachers and heads of guidance and counseling lack specialized skills and knowledge to deal with drug and substance abuse. Guidance and counseling were not being exploited to address drug and substance abuse. On the other hand, school rules and regulations were noted to contravene Ministry of Education policies and guidelines hence school policy makers should adhere to these policies and guidelines while formulating rules and regulations. The students should be involved in the formulation process in consideration of their views and inclusiveness.

The study therefore recommends that;

1. Ministry of Education (MOE)

Guidance and counseling teachers could be trained on relevant skills and knowledge related to DSA. It could organize national workshops and seminars annually to facilitate capacity building on control of drug and substance abuse.

2. Teachers Service Commission

To deploy guidance and counseling teachers specially trained from colleges to various schools and reduce their teaching work load.

3. Head Teachers to;

i) Establish routine checking programs in their schools carried out once in a week and all members of staff should be committed to the success of such programs since findings revealed that guidance and counseling sessions didn't address much on Drug and Substance Abuse issues.
ii) Provide secluded and conducive rooms for counseling to enhance privacy. Findings from the study showed that most schools did not have a guidance and counseling units.
iii) Invite Drug and Substance Abuse expert counselors once in a term to tackle students' concerns on Drug and Substance Abuse (DSA).
iv) Involve the students in formulation of school rules and regulations at the beginning of each year this will foster co-operation and uniformity in enforcement.

4. Kenya Institute of Curriculum Development to provide adequate content in the syllabus that addresses drug and substance abuse.

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ARTICLE 2

Lesson Study as a New Approach to Improve Continuous Professional Development (CPD): Case of Biology Teachers and School Principals, Khomas Region, Namibia

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Abstract

Namibia's Ministry of Education's reports on Grade 12 NSSCO results of Biology examination showed that learners' performances in Khomas region have been very poor over the years; although 90% of the teachers are qualified. These poor results might affect learners in pursuing their studies at tertiary institutions. Learners' poor performances normally attributed to lack of teachers' in-service training on CPD. Therefore, this paper aimed to find out whether LS improves CPD in Khomas region. A mixed-method approach employed a case study design was used. 49 Biology teachers and 22 secondary school principals were purposefully sampled. Document analysis, google form questionnaire and semi-structured interviews were used. Data were analysed using SPSS and thematic data analysis. The findings revealed that there was lack of in-service training on CPD in Khomas region and participants need training in their subject areas and pedagogies. LS found to be a solution to support participants and encourage them discuss their unique challenges they were faced with. LS also save participants' time training elsewhere. Many participants didn't attend available CPD's activities due to workload and time. And there were no induction programs in place for novice teachers. The study recommends that the Ministry of Education should strengthen in-service training on CPD in schools. Furthermore, school-based LS should be implemented in schools to add value to the current CPD for the teachers to be more proactive in solving problems that affect their teaching and learning and update their knowledge at the convenience of their school environments.

Keywords: *Lesson Study (LS), Continuous Professional Development (CPD), novice teachers, in-service training, participants (school principals and teachers), learners' poor performance.*

1.0 Introduction and Background

Namibia's Vision 2030, outlines the significance of science subjects, and as such Science and Technology are now widely considered by many nations as pillars of development. Namibia envisages advancement in Science and Technology, however, learners' performances in the Namibia Senior Secondary Certificate Ordinary (NSSCO) level Biology examination (Grade 12) has been very low over the years including in Khomas Region. For instance, Khomas Region Grade 12 candidates pass rate in Biology National Examinations was 41% in 2016, 34% in 2017, and 36% in 2018 based on the quality symbols (grades) %, A-D (100 - 50%) (Hanse-Himarwa, 2018). Although 90% of the teachers are qualified, the performance of learners at the national examination in the Khomas region has been low almost in every subject for the past years. The learners'

performance, especially in Biology, is worrisome because the pass rate is usually below average (50%) for several years now, and this means many learners who are thinking of pursuing Biology courses, their dreams are cut short. The poor performance in Biology needs some changes for improvements. This seems to be a national issue but not only in the Khomas Region, because based on the performance of the 2015 Grade 12 candidates it's almost certain that only 6 056 (29.8%) candidates qualified for admission to tertiary institutions compared to 7 536 (38.9%) candidates in 2014, thisis based on a minimum of 25 points in five subjects a candidate have obtained (Hanse-Himarwa, 2018). This on its own is already calling for interventions especially in terms of improving teachers' quality by providing sufficient Continuous Professional Development activities.

Table 1 shows the academic performance at grade D and above in Mathematics, English, Agriculture, Biology, and Physical Science nationwide in the year 2015 as compared to 2014.

Table 1: Result analysis of 2015

Subject	2014	2015	Target	Difference
Mathematics	40%	42%	42%	Target achieved
English	31%	30%	33%	-3.0%
Agriculture	56%	56%	58%	-2.0%
Biology	30%	33%	32%	+1.0%
Physical Science	43%	46%	45%	+1.0%

Source: Ministry of Education (2015)

Table 1 shows that learners obtained better grades in Science, English, and Mathematics are below average, with the exemption of Agriculture which is slightly above average. This is more than enough evidence to indicate that the teachers' CPD system is not doing well and there is a need for reform. The teacher standard can never be overemphasized, so a new approach to improve continuous professional development is required for teachers to enhance their knowledge.

Table 2: Biology academic performance for 2016 and 2017, in Khomas Region, Namibia

2016 VS 2017

SYMBOL	A*	A	B	C	D	E	F	G	U
2016	2	5	55	181	173	190	169	135	100
2017	1	7	71	185	215	237	238	211	139

Source: Analysed and compiled by the author

Table 2 indicates that learners were struggled to obtain better symbols (A* - C) in Biology for both 2016 and 2017 and more candidates obtained lower quality symbols between E and U. This is worrisome and calls for of how Biology teachers can be supported to develop different teaching methodologies to enhance the teaching and learning. According to United Nations Educational,

Scientific, and Cultural Organisation (UNESCO) (2014), some scholars have given theories about the causes of low performance and one of the key reasons is the lack of regular Professional Development Programmes to improve the pedagogical skills of teachers As with other professions, teachers are responsible for enhancing their expertise, developing their technical skills, keeping themselves up to date on major developments impacting their field and being able to adapt their teaching methods to cope with the digital era agenda. It is against this background that this study is aimed at gathering the views of secondary Biology teachers and school principals in the Khomas Region regarding the proposed School-Based Professional Development – Lesson Study (SBCD-LS) as a new approach to improve the current CPD. The study attempts to find out whether SBCD-LS will improve the pedagogical knowledge of Biology teachers in the Khomas region. The results of the research will be used to facilitate the introduction of school-based LS in Namibian schools to provide the platform for teachers to do mini research on how they can make the learners learn better. The key research questions were: (a) what are the views of Biology teachers and school principals on the current situation of teachers' Continuous Professional Development in the Khomas Region and (b) what are the views of Biology teachers and school principals on LS as a new approach to Continuous Professional Development?

2.0 Literature Review

2.1 Policy Setting for a Decentralized CPD Model in Namibia

CPD's approach to decentralization that gives national and local bodies more power, obligations, and responsibility continues to overwhelm the writing. In Namibia, the concept paper for the Namibian CPD consortium firmly focuses on the requirement for a decentralized framework to compose local levels of CPD activities (University of Namibia, 2012). The method has been rolling out to all 13 regional directorates where committees are formed. The aim was for teachers to take ownership in the preparation and execution of their own on-going professional development activities with the support from circuit and regional officials. It is noteworthy from the writing that decentralization isn't liberating focal authority from its national job of providing direction, backing, coordination, and cooperation, however, it ought to be seen as a joint effort including all parties. The Ministry of Basic Education, Sports, and Culture (2003) and the CPD Consortium Concept Paper (2010) concurred on the requirement for CPD coordination through a focal body, for example, UNAM's CPD Unit, which deals with the arrangement of CPD and offers help and direction to CPD accomplice associations, systems, and experts. The Ministry of Basic Education, Sports, and Culture (2003, p. 5) sees in a rather more extreme manner, "no framework will work appropriately without a command centre guide to characterize the best approach to go". The possibility of a national critical body is implanted in the CPD Consortium concept paper through the advancement at the University of Namibia of an organizing CPD Unit. Though much has been done according to the literature, there is a gap in the Namibian Ministry of Education's practical nature of doing things. The CPD booklets produced by the University of Namibia have been distributed to stakeholders, including schools, but a great lack of implementation has been found. It seems to me that CPD's decentralization was a very positive idea but it lacks concrete programs that could guide the teachers about what they should do. Therefore, the unified CPD program in

schools and national directorates is still not enforced to date. This is because there is no evidence-based mechanism for tracking and assessing the policy's progress.

2.2 Continuous Professional Development (CPD) from Other Countries' Perspectives

Worldwide, countries strive to improve their education systems by investing heavily in teacher professional development (Darling-Hammond, Wei, & Andree, 2010). The quality of school education can never go beyond the quality of teachers and the school principals. All high performing systems have developed policies to improve the quality of teachers (UNESCO, 2014). For Shanghai, it was the school-based teaching research that played a role to ensure the professional growth of teachers (Zhang & Kong, 2012). Shanghai Teaching and Learning International Survey (TALIS) results and CPD System in Shanghai - China has a long tradition of "respecting teachers" and persisted in "boosting and protecting teachers' enthusiasm" in various ways; "an efficient interrelated triangle teacher policy system" for teachers' lifelong development with governmental financial and time support-main reasons.

Shanghai's education framework has pulled in universal consideration since its students developed top in perusing, arithmetic, and science on the Program for International Students Assessment (PISA) tests in 2009. One significant explanation for these accomplishments is the diligent promise to building up a great teaching power, with solid help for teachers' professional advancement by governments and schools (Zhang & Kong, 2012). The Shanghai Municipal Education Commission requires every novice teacher to pass the assessment directed by the various districts before being utilized as educators to fulfil the guideline of the framework (Shanghai TALIS, 2012). The normalized preparing for new educators in a primary and secondary school in Shanghai includes four significant territories of inclusion: proficient morals, management of classrooms, and individual experience, teaching research, and expertise improvement.

In Sweden, 104 hours or 15 days every year (roughly 6 percent of teachers' absolute working time) are distributed for educators' in-service preparation, and in 2007, the national government appropriated a huge award to build up professional advancement program called Lärarlyftet ("Lifting the Teachers"). There is no formal in-service teacher education framework at the national level in Finland, other than a couple of long stretches of compulsory yearly training. Instead of mandatory, conventional in-service trainings are services focused on schools or communities, and continuing and long-term career development opportunities. These initiatives concentrate on improving teacher competence and improving their capacity to resolve challenges inside their school settings by incorporating proof-based approaches and measuring the effect of their measures (Darling-Hammond et al., 2010). The report required the schools and local government to set up inflexible evaluation frameworks for educators and prize teachers exhibiting greatness so as to manufacture a profoundly qualified educating power (Chu-Chang & Paine, 2009).

2.3 Lesson Study in Singapore

According to McKinsey and Company's global report, Singapore's education framework is one of the world's most noteworthy performing instruction frameworks (Barber & Mourshed, 2007). Inferring that the efficiency of an education system cannot outperform the productivity of its

teachers (Stigler & Hiebert, 1999). Singapore Ministry of Education decided to use Japan's model of LS as a tool or platform to embrace Continuous Professional Development (CPD) for teachers. The Japanese model is highlighted because of the high level of achievement of Japanese students and is based on the notion that teaching is a dynamic, cultural practice (Stigler & Hiebert, 1999). LS is viewed as a move from a customary method for instructing as telling to a cutting-edge method of instructing for comprehension (Lewis, 2002), esteemed by teachers in Japan. The thought is basic: teachers meet up to work in a gathering all through the procedure of LS, cooperating to design, watch, and think about lessons.

2.4 Lesson Study in China (Teacher Research Group (TRG)

Chinese also conduct a form of LS called Teaching Research Group (TRG) activity. Each TRG's obligation is to study and improve the method for teaching (Ministry of Education, 1952). During the past 60 years, the Chinese have established a specific pedagogical structure for thinking about the planning, evaluation and reflection of lessons called Three Points: (1) the main theme of the lesson; (2) the challenging idea of the lesson; and (3) the crucial point of the lesson (Yang, 2009). During TRG activities, the Three Points and the learning effect influence teachers' collaborative work and teachers' thinking through such questions as: What are the main instructional objectives? What is hindering students' learning? How should the instructional steps be designed in the teaching process? What impact did it have on the learning performance of the students? A coordinated effort among Chinese teachers is a normal and basic piece of Chinese teaching work during TRG exercises.

3.0 Methodology

A mixed-method approach study employed a case study design was used to explore the views of Biology teachers and school principals on the LS, a means to improve CPD. The case study research is a contextual investigation that happens in real life (Creswell, 2014). The questionnaires were used to help in the construction of the principals and teacher`s views. The major emphasis was on determining how to improve continuous professional development for Biology teachers by using LS as a new approach which will eventually increase learners' performance. Document analysis like the examination performance records in Biology for the past few years for Khomas region schools was done to assess the level of pedagogical content of the teachers. The google form questionnaire was used to collect the data from the respondents and the form link was shared through WhatsApp and Emails. This survey questionnaire aimed to identify the views of teachers and principals on the current CPD situation and the proposed LS as a new approach to improve CPD. The items in the survey questionnaire explored the extent of the continuous professional development needs of teachers using a four-point scale. To have a holistic picture of CPD in the Khomas region, 49 Biology Teachers and 22 secondary school principals participated in this study. The purposive sample was used to select Biology teachers because this is one of the subjects in which the learners performed poorly over the years in the Khomas region. The close and open-ended questions were used to gather data on the opinions of teachers and principals on the improvement of CPD using LS.

3.1 Data Analysis

The study used descriptive, quantitative, and explanatory statistics to analyse the data collected using the questionnaires. The study quoted some of the explanation from the respondents especially the principals where there was the provision of giving general comments on LS approach. The thematic investigation was utilized to dissect qualitative information developed through semi- organized interviews to distinguish forms, thoughts, and subjects that rise up out of the information. Tables, figures, and charts were utilized to decipher quantitative reactions. At the initial stage, I interpreted the recorded information.

The analysis of data was done using the Statistical Package for Social Sciences (SPSS) (Version 25) to break down the information utilizing pre-decided subjects created from the examination questions and afterward deciphered the information in point-by-point conversations. Information gathered from the surveys were statistically figured utilizing SPSS. The frequencies of the teachers and principals' reactions on every ability were changed over into percentages. The figures illustrated in percentages showed the extent to which teachers and principals strongly disagreed, disagreed, agreed, and strongly agreed on whether or not there need to improve the current continuous professional development in the Khomas region. The quantitative and qualitative responses from the respondents were used as supportive evidence and direct comments were incorporated to triangulate the data.

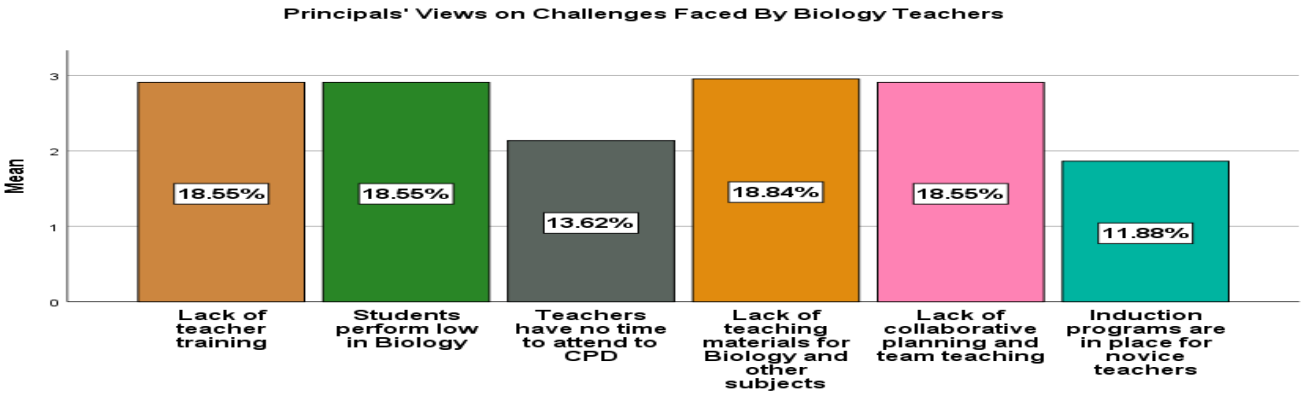
4.0 Findings

4.1 Teachers' views on CPD

Teachers indicated that they would like to attend continuous professional development activities, but most of the time this type of activity is not available. This area of the study asks the teachers on what prevented them from participating in more professional development activities. *The majority of the teachers indicated that there was no suitable professional development offered*. Many at times the regions, through the Senior education officer only train teachers for a few days in a year or even no training at all in some years. A few teachers also indicated that some *professional development activities conflicted with their work schedule*. Biology is one of the subjects which has overloaded content to be covered. Most teachers struggle to finish the syllabi on time for the learners to be ready for the examination. That is why the teachers do not find time to attend CPD if they could be available sometimes. A few others, also say that they *could not meet the requirements for the selection because of experience or seniority*, this happens usually when only one teacher is requested to attend the workshop and most of the time the principal selected the experienced teachers only.

4.2 Principals' views on Teachers' CPD needs

The principals usually may know their teachers' needs through school teachers' self-evaluation forms that every school fills in every year. Also, school principals may know their teacher's



continuous professional needs through classroom observation tools. Therefore, this area of the study probe the principals on what are the CPD needs of their teachers. Figure 1 below shows the training needs for the teachers as voted by the principals.

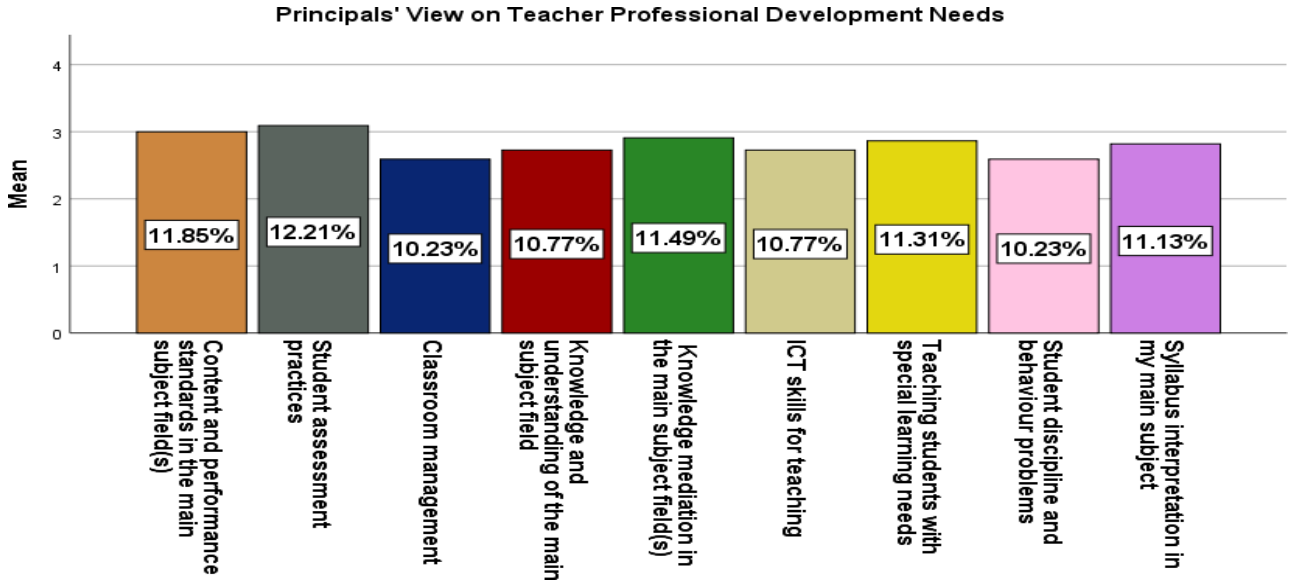


Figure 1: Principals' views on Teachers' CPD needs

The majority of the principals stated that teachers need more training on the students' assessment practice. It is not by surprise that the principals figured out this need because it has been a concern that there is a gap between what the teachers assess at school level and what is assessed at the national level. Teachers tend to teach the textbooks instead of teaching what is prescribed by the syllabus. Thus, training on content subjects and syllabus interpretation was also mostly voted by the majority of the principals. It was also quite surprising that the Information and Communication Technology (ICT) skills could not earn the majority because with the ICT skills teaching and learning skills will be much easier.

4.3 Principals' views on the Challenges face by Biology Teachers

Even though teachers may tend to work hard, there could always be some challenges that will affect the progress of the teaching and learning process and then affect the learners' achievements.

Some of the challenges needed to be addressed only when there are good CPD platforms in the place where teachers can collaboratively discuss these challenges and see how they can solve them amicably. This part of the study looks at the principals' views on the challenges faced by the teachers based on school self-evaluations and classroom observations. Figure 2 below summarise the views of the principals on the challenges faced by the teachers.

Figure 2: Challenges face by Biology Teachers

The majority of principals indicated a lack of teaching materials for Biology as the most challenge for teachers with 18.84%. This was also followed by a lack of in-service training, learners' performance, and lack of collaborative planning and team teaching among teachers with the percentage around 18%. Some principals also indicated that there is no time for teachers to attend to continuous professional development activities because of the workload. Some principals indicated that there were no induction programs of novice teachers and some also indicate induction for novice teachers is in place.

4.4 Lesson Study a New Approach to Improve CPD

4.4.1 Lesson Study Benefits by Principals

LS is a tool used by many high performing countries where teachers study and research the learning gaps of their learners. During the LS, subject teachers come together and plan, research, teach, and observe each other's lessons to evaluate and identify learning gaps and fill them right away at the school level. In this area of the study, the principals were asked to figure out the most important benefits of LS to the teachers.

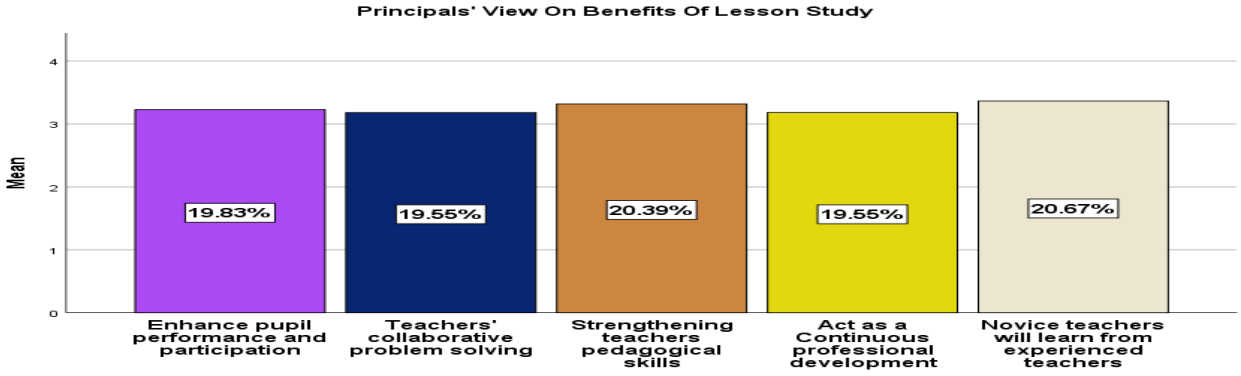


Figure 3: Principals' view on Benefits of Lesson Study

Generally, the benefits of LS were almost rated equally by the principals. However, novice teachers learning from experienced teachers was the most favourite of the choices with 20.67% followed by strengthening teachers' pedagogical skills. Enhancing pupil performance and participation, teacher's collaborative problem solving, and act as a continuous professional development platform were all at about 19%.

4.1.2 Principals' views on the Lesson Study and CPD

Secondary school principals were asked to give their general comments on continuous professional development for teachers and LS. Some of the principals revealed that LS will be a solution to lack of CPD support they receive from the region, they pointed out that it will save the time of attending training elsewhere and make teachers discuss their unique challenges they are facing at the school level. This is what Principal A said: "*I personally strongly believe that LS will be very beneficial to the teachers for the reasons that: it helps teachers to improve their teaching approaches together, teachers realize their weaknesses and work on them during LS, build confidence in teachers, encourage collaboration, teachers become experts in their subjects, learners are assessed equally with the same standard, and then eventually the performance of learners in Biology will be improved. Most teachers do not enjoy the profession anymore because of lack of support through CPD".*

Hollingsworth (1999) says that poor teacher professional development activities are caused by a lack of coordination and leadership, little collegial activity, and no obvious commitment. The respondents also felt that CPD in Namibia is not taken seriously and this is the reason why the learners are failing because of the teacher quality. This finding is in line with UNESCO (2014) idea that the education system of a country can only be as good as its teachers. *"CPD is not taken seriously in Namibia that is why learners are not performing. CPD supposed to be contextualised depending on the need analysis of the school because every school has its own unique needs. It is a pity that there are policies in Namibia but lack of implementation is a problem. There is a booklet about CPD structure but there is no term of reference for how it should operate because even the members of CPD committees are themselves are not trained and have no ideas where to start. Senior Education Officers (SEOs) supposed to give subject content on CPD and Inspectors of Education supposed to give general professional developments especially on policy implementations and work ethics, but this is not the case".*

4.1.3 Teachers' and Principals' Views on Current CPD in Namibia

Lack of CPD activities contributed to the poor teacher quality and the high failure rate of learners in the Khomas region. This study revealed that most of the teachers and principals agreed that there has been a lack of in-service training on CPD in the Khomas region. Both teachers and principals have indicated some needs for training in their subject and pedagogy. The principals on the other hand also indicated that not all teachers are invited to the regional training and this resulted in not all teachers being trained and thus poor performance of learners. It became clear that the teachers and principals are aware that there is a lack of teacher quality. According to UNESCO (2014), the standard of the education system cannot be greater than that of its teachers. This also shows that lack of CPD activities and in-service training contributes to low-quality teachers which eventually resulted in poor academic performance of learners. The goal of the Teacher Professional Development (TPD) is to enhance the teachers' efficiency so that this positive effect can be maximized. Therefore, Namibia needs to take a stand in investing in teachers by making sure that they receive enough training both pre- and in-service. Principals feel that teachers need more training in learner assessment practice while the teachers feel they need more training in teaching learners with special needs. However, both principals and teachers could not make ICT

skills a major training need which could mostly help the teachers to overcome the other training needs. Although the government of the Republic of Namibia emphasize on the issue of ICT skills promotion, many teachers and principals do not value the need for ICT training as a major.

4.1.4 Teachers' and Principals' Views on Lesson Study as a New Approach to Improve CPD

During the research process, it became clear that participants understood that embracing LS as a new approach to continuous professional development will result in high learners' achievements. The participants brought attention to the benefits of LS toward the teaching and learning process, novice teachers learning from experienced teachers were among the most rated benefit of LS by the participants. Teacher collaboration and improvement of learners' performance were also among the benefits of LS highlighted by the participants. Both principals (81.82%) and teachers (83.67%) were in favour of the LS to be implemented in schools by a mean percentage of 80%. School-based professional development activities make teachers be more proactive in solving problems that affect their teaching and learning. Teachers learn more when they are actively engaged with activities that are school-based and integrated into the daily work of teachers (Greeno, 1994).

5.0 Conclusion

From the findings, the majority of the teachers and principals strongly agreed that the current continuous professional development activities in the Khomas region are not sound and need improvement. Finally, they also strongly believe that LS could improve the current CPD if implemented in schools to improve the teaching quality. There is no much difference between the views of the teachers and those of the principals. It was surprising that the teachers did not choose ICT skills as one of the most important training needs. It seems the teachers are still stuck with the traditional way of teaching and are not looking into ICT as a way to improve teaching and learning. Both teachers and principals were supporting the idea of LS as a new approach to CPD. Both principals and teachers suggested that the teachers required training in the following areas: ICT skills, problem-solving and conflict resolution, counselling skills, interpretation of official documents, reflective and logical investigation skills, analytical and assessment skills, knowledge of pedagogy and subject matter, contact with different stakeholders and lesson planning and presentation skills. The principals should see to it that the teachers are provided with enough platforms at the school level for them to learn from each other.

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ARTICLE 3

'Cheerful incidents' An opportunity for learning through reflective practice: A case of Kenyan chemistry teacher trainers

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Abstract

The study reported in this paper explored teacher learning through reflective practice. How and what teachers learn from their teaching experiences were investigated. Qualitative case study method was employed, adapting a constructivist view of learning to provide a lens through which the teacher trainers' learning was explored.

The study involved four chemistry teacher trainers and lasted for one year. During and after the study, the teacher trainers *'cheerfully'* reported learning experiences, from *critical incidents* they isolated and reflected on from their lessons. Data were gathered using group reflection discussions and interviews and were analysed thematically using a coding scheme developed by the researcher from the research questions. The research findings showed that the teacher trainers enhanced their pedagogical knowledge, content knowledge and knowledge of how student learn.

Regarding knowledge of teaching methods, the teacher trainers learned that they: rarely involved students in class demonstrations and were doing most of the work; sometimes they assumed students were following what they were doing, when they may not have been during demonstrations and sometimes they introduced misconceptions when teaching. The findings also reviewed that students can learn better when teachers: involve them in practical experiences; use their ideas, use guided practice, address misconceptions; use their prior-knowledge, and attend to the language used in providing explanations.

The findings of the present study have significant implications for educational practice. They propose and confirms that teachers can, improve their practice and enhance student's learning if they reflect individually and as a group on their teaching experiences. Further research is recommended to determine whether the four teacher trainers have improved their practices of *teaching chemistry*, following this study. A similar research is also recommended with a large number of teachers to allow generalisation of the research findings to a wider population.

Keywords: *Reflective practice; Critical incidents; Teacher professional learning; Teacher Trainers.*

1.0 Introduction

Teaching, and learning how to teach, are very, complex, and challenging processes, demanding teachers to have a wide range of knowledge and skills (Loughran, 2013; Macharia, 2020). Continuous professional leaning can address the complexity of teaching and learning to teach, by

ensuring that teachers become lifelong learners (Körkkö, Kotilainen, Toljamo, & Turunen, 2020; Macharia & Kilonzo, 2020). Through continuous professional learning teachers improve their professional knowledge and skills (Ambler, 2016; OECD, 2014). There are a variety of professional development models that can help teachers build their professional expertise (Macharia, 2020; Vangrieken, Meredith, Packer, & Kyndt. 2017). The study reported in this paper adopted a model through which the teacher trainers were given an opportunity to learn from their teaching experiences by reflecting on critical incidents isolated from their chemistry lessons (Farrell, & Macapinlac, 2021; Macharia & Kilonzo, 2020).

1.1 Reflective practice in teaching

Building on the scholarly work of Schön (1983), research shows that reflective practice is important to continuous teacher professional learning and development (e.g., Kyndt, Gijbels, Grosemans, & Donche, 2016; Loughran, 2013). It allows teachers to consider prior teaching experiences that could facilitate their learning (Bruster, & Peterson, 2013; Tripp, 2012). Reflective practice was adopted in the study reported in this paper to promote chemistry teacher trainers' learning (Macharia, 2020).

The skill of reflecting on practice is considered a necessity for effective teaching. Van Manen (1991) in his early scholarly work described unreflective types of pedagogy as a contradiction to effective instruction. Harrison and Lee (2011) observed that, teachers who are unreflective about their teaching tend to be more accepting of the everyday reality in their teaching. They considered this to be a restricted way of thinking that limits framing problems in different ways.

In this study, teachers made sense of their teaching experiences by asking searching questions about an experience that occurred in their chemistry lessons. Questions such as: what happened, why it happened and what else could have been done were used to assist the teachers construct meaning of their teaching experiences (Nilsson & Karlson, 2019).

1.3 Model guiding reflection

A structured model of reflection developed by the researcher illustrated in Figure 1 guided the teacher trainers in the reflection process. The model involves four stages: Describing (D), Reconstructing 1 (RI) Reconstructing (R 2) and Informing [I] (DRRI). It borrows ideas from other models in literature such as Brookfield's (1995) four complementary lenses model, Johns's (1995) structured model, Kolb's (1984) experiential learning cycle and Korthagen's (1985) ALACT model.

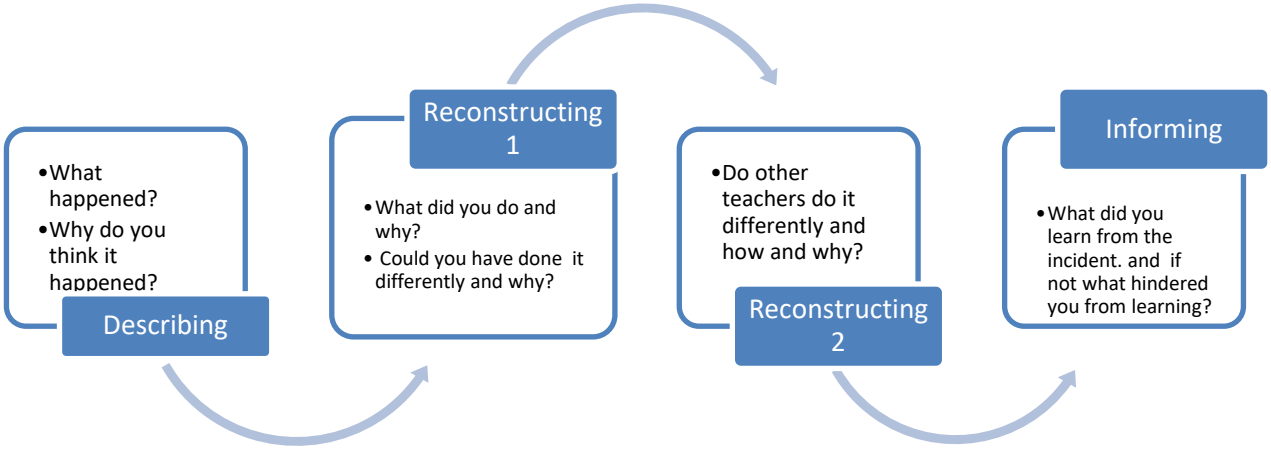

Figure 1: A model of critical reflection on classroom practice (DRRI)

Individually, participants reflected on a critical incident they isolated from their Chemistry lessons. They constructed meaning of their teaching experiences and considered alternative ways of teaching better. Collaboratively they shared those experiences with colleagues to get perception of their experiences and also learn from them if they had handled such issues differently. Finally, participants reflected on what they could have learnt from their own and their colleagues' experiences and challenges hindering teaching and learning processes in their classrooms.

Critical incident reflection has assisted educators elicit ways of improving the teaching and learning process (Nilsson & Karlsson, 2019). They provide teachers a platform to express themselves, because the voice used when describing a critical incident is that of one practitioner to another on the subject of their practice (Tripp, 2012).

1.4 Research problem defined

There are relatively few studies in Africa, Kenya included, explaining why teachers teach as they do (Macharia, 2020; Schiefelbein & McGinn, 2013). Many studies in Kenya, particularly in Chemistry focus on introducing new methods of teaching through expert-facilitation cascade models without considering what teachers already do, and what they could learn from what they do (e.g., Mihindo, Wachanga & Anditi, 2017; Subagia & Wiratma, 2020; Thumbi, Gatumu & Muriithi). This study attempted to address this gap by exploring teacher learning from their own teaching experiences utilising reflective practice.

1.5 Research question

The learning experiences of the teacher trainers were captured with the overarching question, *"What do Kenyan Chemistry County teacher trainers learn from participating in a study in which they reflect on their secondary school teaching experiences?*

2.0 Methods

The study adopted an interpretivist paradigm approach to research and was based on a social constructivist view of learning. Two methods of data collection were employed: group reflection and individual interviews. Thematic coding technique was used to analyse data.

2.1 Theoretical and philosophical underpinning

In an interpretivist paradigm approach to research, individuals focus on understanding and interpreting the world around them (Creswell, 2013). Participants of this study reflected, interpreted, made meaning of their teaching experiences and discussed on how they could improve their practice based on those experiences.

According to social constructivist view of learning, knowledge is constructed through experiences, reflection on one's own ideas, and interactions among learners (Vavrus, Bartlett, & Salema, 2013). Teacher trainers who participated in the study were provided an opportunity to examine their own teaching experiences. They used those personal experiences to construct meanings of what occurred in their lessons and suggested change to address concerns and improvements in future. In group meetings they shared their critical incidents that facilitated social interactions and in the process developed a common understanding of the process of teaching and learning chemistry. Loughran, Berry, and Mulhal (2012) observed that a common understanding of teaching and learning among science teachers is critical to the learning and development of a refined knowledge of practice.

2.2 Sample

Participants were four Kenyan Chemistry County teacher trainers with a teaching and training experience of more than five years. The trainers are also classroom teachers in their respective Counties. They were selected because they can easily share lessons learnt from this study with a large number of chemistry teachers during In-Service Education training (INSET). This kind of sharing potentially widens the scope of impact the study might have. The composition of the sample was two male and two female and their characteristics are shown Table 1

Table 1

Participants' characteristics

Teacher	Teaching subjects	Responsibility	Years of experience	
			Classroom teacher	Teacher trainer
Dott[x]	Chemistry Mathematics	Deputy principal	22	17
Rett[x]	Chemistry Biology	Deputy principal	18	15
Ritt[x]	Chemistry Biology	Chemistry subject head	15	5
Kytt[x]	Chemistry Mathematics	School principal	25	15

Note. x indicates pseudo names of the participants

2.3 Data collection methods

Two methods were used to generate the qualitative data, group reflection discussions and semi-structured individual interviews. Prior to the study an orientation workshop was conducted to induct participants into the data collection process. In the workshop, the teacher trainers agreed to meet monthly, during weekends, in one of the participant's schools for group reflection

discussions. A total of six group reflection discussions (GRD) were conducted and were audio recorded.

Prior to the group reflection meeting, teacher trainers were asked to write self-reports in which they described and reflected on a critical incident that occurred in one of their weekly chemistry lessons. The written protocols were used as prompts in the group reflection discussion meetings. Individual interviews were conducted at the end of the study. The interviews were conducted over a mobile phone and audio recorded using Another Caller Recorder (ACR) recording application. Group reflection discussions and interviews were then transcribed for analysis.

2.4 Data analysis

Thematic analysis guided data analysis generated from group reflection discussions and interviews (Braun & Clarke, 2012) using a coding scheme constructed by the researcher. Themes were identified theoretically/deductively (Stuckey, 2015) since the researcher was interested in *how* and *what* teacher trainers learn from their teaching experiences a quite specific research question. Braun and Clarke posit that a theoretical approach is appropriate to identify themes from research data for specific research questions. However, during data analysis coding was kept open to guard against narrowing the field of analysis associated with a theoretical to data analysis.

The process of development and refinement of the coding scheme followed several steps including: (a) identification of focus areas from the research questions, (b) categories and sub-categories from related literature, (c) development of theoretical codes and (d) constructing anchor items for the theoretical codes. Applicability and reliability of the coding scheme was tested before it was used to code of all data collected. To facilitate coding, Microsoft Excel was used (Ose, 2016). Emerging patterns arising from ideas expressed by participants about teaching and learning processes were interoperated and discussed.

3.0 Findings

Several *potential professional learning activities and outcomes* were identified from the teachers' responses. This paper discusses two potential learning outcomes that are related to teachers' professional knowledge of practice. These are: *knowledge of teaching methods and knowledge of how student learn.*

3.1 Development of knowledge of teaching methods

Potential change in teacher trainers' teaching methods was identified as a potential professional learning outcome. The study reviewed that the teacher trainers increased their professional knowledge concerning teaching methods particularly towards more student-centred approaches. Findings identified three forms of knowledge that the teacher trainers used to "change" *their teaching methods*. These are: knowledge-in-practice, knowledge-of-practice and knowledge-for-practice.

3.1.1 Knowledge in practice

This type of knowledge is acquired as practitioners carry out their duties and in this study teaching. Teacher trainers' responses demonstrated how they learnt from this kind of knowledge. One

participant reviewed a likely weakness in her teaching when conducting demonstrations in class. She became aware of this weakness when demonstrating presence of chloride ions from her students' behavior. She recounted: *"What surprised me is that, as I was doing all this, my students were just looking at me, some were not even interested with what I was doing".* She isolated this incident and reflected on it after the lesson. She found that she rarely allowed students to participate in demonstrations and sometimes assumed that they were following what she was doing, when they may not have been.

Another participant isolated an incident where he was teaching ionic equations, and realized that he did most of the work on the chalkboard. He stated that he learnt the following: (a) for students to understand how to write ionic equations, they must understand how to write formulae and oxidation states of ions correctly in their previous lessons, (b) the topic on structure of the atom as well as that of the periodic table is very significant in all chemistry topics and considered handing it well in future lessons (c) the topic should also be allocated more teaching hours (d) teachers should make connections of every topic taught for students to have a deeper understanding, and proposed involving students in constructing concept maps, which probably would assist them to connect topics.

3.1.2 Knowledge-for-practice

Findings also showed that the participants used *knowledge-for-practice* which they acquired during group reflection discussions to learn about teaching methods. One of the participants named Ritt said that he learnt a method of teaching electronic configuration when they discussed Dott's critical incident during the fifth group refection meeting. He stated:

> I have been giving a theory approach… I did not have any other way of teaching and I think that is why I have been having the same problem my colleagues have been having, but today *I have gotten a new idea*. From what [Dott] has described, the way she has been doing it. *I think I will adopt her method*, and see whether it can change my students (r. 16)

Findings from individual interview corroborated group reflection discussion data in relation to teacher trainers learning about alternative methods of teaching from their colleagues. Kytt, for example, stated the following:

> In the group reflection, I experienced a lot of learning. This is where I realized that we have different approaches of teaching the same content. The same content can be approached using different methods depending on the students one is handling. I also learnt others have the same challenges I have with my students but they approach the problem differently from the way I approach. I thought it is the way I have been teaching certain concepts but I realized there are other ways of doing it. (Kytt interview, r. 27)

3.1.3 Knowledge-of-practice

Teacher trainers also confirmed to having learned alternative methods of teaching from knowledge they constructed from their own teaching experiences (*Knowledge-of-practice*). Ritt, narrated an experience of trying a different teaching method to cover a back-log of Form Two work that had

he not taught in the stipulated time frame. He set up an activity and guided students in groups to carry out research on that work. Students were also guided to present their work to other group members (micro-teaching) before presenting in the actual lesson. In this critical incident, Ritt stated that he "learnt that students can learn on their own if they are organized and are given direction and necessary resources" (r. 77). He initially thought that the students would not do the work, but to his surprise, the students enjoyed and that the lesson was interesting. Ritt, following this experience stated:

> What I would do in future lessons, when I have a topic that I want to cover in a short time, rather than going step by step the way we have been doing. I will be dividing the work among students and give them some time to go and do some research and present their findings to the class. (r. 76)

3.2 Development of knowledge of student learning

Finding showed that teacher trainers enhanced their knowledge of student learning from knowledge of, in and for practice acquired from their group and individual reflections on their teaching experiences. Aspects of this learning included an increased awareness that students can learn better when teachers (a) use their ideas, (b) attend to the language they use in providing explanations (c) involve them in practical experiences, (d) use their prior-knowledge, (e) address misconceptions and (f) use guided practice. Data supporting the identification of these areas of teacher learning are discussed in the following sections.

3.2.1 Practical experiences

The teacher trainers learned that they were not involving their students fully in practical experiences, which is an important component in learning both knowledge and skills in Chemistry (e.g., DottGRD3; RettGRD2; RittGRD6). Many concepts in Chemistry are explored experimentally (DottGR1). As illustrated in data, practical experiences were used to model abstract concepts and stimulate students' interest in topics that they often found difficult in Chemistry (Ritt GRD2). Data also reviewed that engaging students more in practical experiences learning enhances their learning and retention (DottGRD5).

3.2.2 Student ideas

The importance of using students' ideas was another way teacher trainers learned regarding development of their knowledge of student learning from their group reflection discussions. For instance, Kytt (GRD1) said that he learnt that "many a time, [they] assume the teacher is always right. [He said that] it is also important that [they] recognize that the students also know a lot" (r. 329). Teacher trainers noted that student learning was more fruitful when they used students' ideas in their lessons.

3.2.3 Guided practice

In numerous instances, teacher trainers found that use of guided practice in their lessons was either lacking or ineffective. Dott for example realized that guided practice was important for students to

acquire skills of making a cone by folding a filter paper. She said that teachers need to identify the steps in which students experience difficulties in the folding process. She resolved that

> in future lessons; instead of giving students the whole procedure, [she] will be doing it step by step until [she is] sure they are able to do the right thing; for example, folding filter papers to make cones. (r. 9)

She said that teachers should not assume that students understand what they are shown when they are not actively involved in the learning process.

3.2.4 Student misconceptions

Research has shown that some students' chemistry misconceptions stem from many factors, such as abstractness of the subject, students' difficulties in understanding some scientific concepts and teachers using inappropriate teaching methods. Such findings were no exception in this study. In one of the group reflection discussions, Kytt proposed the following: "I think the way we are teaching our students, they do not seem to understand" (GRD3, r. 34). If his sentiment is correct, it is likely that students are developing many misconceptions from the way sometimes they are taught (DottGRD4, r. 58). Indeed, several critical incidents confirmed that teacher trainers learned that their students held misconceptions in some topics of which they had not been previously aware (e.g., RettGRD6; DottGRD1).

An example suggesting teachers' responsibility for introducing misconceptions is seen in GRD5. In this discussion, Dott described typical methods to teaching about electron configuration. She said teachers "sometimes bring misconceptions and also [they] do not give [their] students opportunities to internalize those concepts" (r. 31). This provoked the teacher trainers to recognise a need for a change in teaching strategies.

3.2.5 Prior-knowledge and pre-requisite knowledge

Teachers' knowledge of students' prior-knowledge makes it easy for them to sequence instruction according to their needs (KyttGRDR3). This is a critical area of concern as students require considerable pre-requisite knowledge to understand subsequent and interrelated concepts in chemistry (RittGRD3). Findings of this study showed that both individual and group reflection assisted the teacher trainers to realize the importance of considering students' prior knowledge before planning their lessons. In GRD3 for example, Ritt described a critical incident in which he failed to achieve his lesson objectives as his students had limited prior knowledge of what he intended to teach. He admitted that the lesson outcomes were compromised due to his learners' limited knowledge on writing ionic equations; an area of pre-requisite knowledge of what he intended to teach. He commented:

At the end of the day, the lesson ended when we had not achieved the objective of writing ionic equation because there were some knowledge students did not have. *I* discovered that, for this topic, the students required to have understood very well *prior knowledge* on how to write correct formulae, how to write oxidation states of some ions, for them to able to handle this content (r. 74).

4.0 Conclusion

The present study aimed at increasing our understanding of teacher learning. The findings of the present study have significant implications for educational practice. It is proposed that teachers can, improve their practice and enhance student's learning if they look back at what they taught, what they want to teach, what they are teaching, and what they intend to teach in future—i.e., reflecting. The study confirmed that through individual and group reflection teachers can increase their knowledge of teaching methods, content and how students learn better.

5.0 Recommendations

The study recommends for research directed at *further* scrutiny of the four teacher trainers to determine how, over time, they have changed (if at all) their practices of *teaching chemistry*, after this study**.** A repeat of a similar study is also recommended using larger number of teachers that could be beneficial to generalise the findings to a wider population.

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ARTICLE 4

Teacher professional development of mathematics professors at Rovuma University: Past, Present and Future

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Abstract

This article presents and discusses the past, present and future of four Mathematics professors working at Rovuma University – Cabo Delgado Extension, with the aim of characterizing their Teacher Professional Development in an African context. Data collection was carried out through a reflective interview applied using the Zoom virtual platform application, after an invitation and clarification of the terms of participation in a WhatsApp group of teachers from the mathematics course. The information obtained was qualitatively analyzed in light of Content Analysis procedures and indicated that teachers were insecure in terms of knowledge, skills and teaching values at the beginning of the profession. However, over time they learned in practice through teaching, reading, reflection, research, interaction with others and/or teacher education and regulated themselves. From a past of insecurities about teaching, the teachers today feel capable of satisfying professional demands, but clamor to continue learning to improve their professional performance. For this, they aim for academic training, technology learning (Mathematics Education software) and research.

Keywords: *Mathematics Education. Professional development. Technology. Education. Research.*

1.0 Introduction

Teaching is a profession normally exercised after at least one teacher education course, which prepares the teacher for the exercise of this profession. It happens, however, that "a significant number of teachers throughout the world are under-prepared for their profession" (Villegas-Reimers, 2003, p. 19), which means that training has not been sufficient for a full exercise of this profession. In Higher Education Institutions (HEIs) in Mozambique, this insufficiency is aggravated by the recruitment of the teaching staff with a Bachelor's degree to teach at undergraduate level. Frige *et al*. (2021) estimate that over 60% of the teaching staff of Mozambican HEIs has only one degree. Furthermore, this is a "fertile" scenario for the occurrence of Teacher

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Professional Development (TPD) at work, as it suggests the need for teachers to adapt, as quickly as possible, to the demands of teaching and of a HEI. For the *Universidade Pedagógica*[4], Duarte and Bastos (2018) suggest enhancing academic education and regular training of teachers to respond with quality to the demands of the government and of the teaching, research and extension processes.

Based on this scenario and the scarcity of studies on Google Scholar that investigated TPD in Mozambican HEIs, as only Frige *et al*. (2021) was found who investigated this theme and in a restricted way to promote teacher professional learning through a reflective community of practice, this research was carried out at Rovuma University (UniRovuma), a Mozambican Public HEI. The idea is, then, to understand and create a reference of how TPD works, in general, in Mozambican HEIs.

Thus, in this article we analyze the professional trajectory of Mathematics professors[5] at UniRovuma – Extension of Cabo Delgado, with the aim of characterizing the TPD of these professionals throughout their careers at work. The characterization involves identifying and describing the past, present and future of their teaching practice and the activities involved in their professional regulations. This information is later interpreted taking into account that the trades and professions that deal with the other, certainly do not always have well-defined peculiarities (Tardif, Lessard, 2014). We carried out the research by asking: which activities and peculiarities characterize the trajectory and TPD of Mathematics teachers at UniRovuma – Cabo Delgado throughout their career at work?

The research was guided by the EDUCIM[6], a research group that investigates what happens in educational practice and not just in teaching prescriptions or duties (Arruda, Passos, Broietti, 2021). The group understands that analyzing what is done in education allows for criticism and appropriate interventions on teaching practice. Based on this, it was thought that investigating the professional trajectory of Mathematics professors at UniRovuma – Cabo Delgado, from the point of view of TPD, allows us to understand the peculiarities and challenges of these professors' TPD, from which proper interventions for a proactive and quality teaching practice could be made.

2.0 Teacher Professional Development (TPD)

All over the world, the practice of teaching requires psycho-pedagogical training (pre-service and/or in-service teacher education) and learning throughout the exercise of this profession. This learning, which begins in education and continues in practice, configures TPD (Marcelo, 2009), as "the natural process of professional growth in which a teacher gradually acquires confidence, gains new perspectives, increases in knowledge, discovers new methods and takes on new roles" (Eraut, 1977, p. 10). It is a process in which the teacher naturally and intentionally acquires and

[4] At that time, this HEI was throughout the country (Mozambique) represented by Delegations. Today it is only in the Maputo province and is called the Pedagogical University of Maputo (UPM).

[5] In this article, we use the term "professor" whenever a reference or direct comment is made to the research participants, since they teach in Higher Education. On the other hand, we use the term "teacher" in the Introduction and Theoretical Background sections when presenting discussions about teacher professional development, as the theoretical discussions most commonly employ the term "teacher" in the international literature.

[6] Science and Mathematics Education Research Group. http://educim.com.br/

increases the professional knowledge and skills of teachers that regulate teaching practice in order to improve student learning outcomes (Darling-Hammond, Hyler, Gardner, 2017; Day, 2001; Eraut, 1977; Fiorentini; Crecci, 2013; Villegas-Reimers, 2003). According to Day (2001, p. 21, our translation), TPD is a process through which teachers, as agents of change, review, renew and expand individually or collectively, their commitment to the moral purposes of teaching, acquire and critically develop, together with children, young people and colleagues, the knowledge, the skills and the emotional intelligence, essential for reflection, planning and effective professional practice, in each of the phases of their professional lives.

In this definition, it is possible to understand that TPD is a process in which the developing teacher becomes an active subject, who critically explores the situations and possibilities internal and external to the work that allow them to learn professionally. Other characteristics of TPD are presented by Marcelo (2009, p. 7), who defines it as "[…] an individual and collective process that must be implemented in the teacher's workplace: the school; and which contributes to the development of their professional skills, through different types of experiences, both formal and informal". From this point of view, TPD can occur through its own or through collective effort and is triggered by practice, which generates interest on the part of the teacher in learning in different learning contexts to serve the teaching and students.

Under these conditions, the TPD movement is from the inside out (Ponte, 1998), part of the interest and commitment of the teacher who learns professionally by seeking and acting, since it is "about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth" (Avalos, 2011, p. 10). Furthermore, Eraut (1997) describes TPD as a spontaneous and slow process. Based on experience, lack and need, motivation or professional commitment, from which the teacher defines goals and paths and gets involved in activities that promote the desired professional learning.

Professional learning is the "product of both externally provided and job-embedded activities that increase teachers' knowledge and help them change their instructional practice in ways that support student learning" (Darling-Hammond, Hyler, Gardner, 2017, p. 2). Avalos (2011, p. 10) describes it as "a complex process, which requires cognitive and emotional involvement of teachers individually and collectively, the capacity and willingness to examine where each one stands in terms of convictions and beliefs and the perusal and enactment of appropriate alternatives for improvement or change".

As we understand, there are basic characteristics to consider in teacher professional learning as a TPD process: active process (learning is through the critique of experiences and searches inside and outside work) and it is driven by the commitment to the quality of education (teacher learning is aimed at improving teaching and, above all, student learning in the classroom). These aspects lead the teacher to focus on knowledge of teaching content and procedures (Darling-Hammond, Hyler, Gardner, 2017), knowledge and skills that can be acquired through various activities.

In relation to activities promoting TPD, Eraut *et al. apud* Day (2001, p. 19, our translation) list the "combination of reflection, experimentation and dialogue with other people". Passos *et al*. (2006) point to the practices of reflection, collaboration and investigation and admit the existence of other

aspects: investigation and reflection on the practice itself, use of reflective diaries, participation in in-service education and/or curriculum innovation projects (as a student or teacher) and teaching in different contexts from the current ones.

In a review of the international literature, (Avalos, 2011) identified several themes published around TPD, one of which is professional learning – which deals with learning and regulation processes, developing or applying theory to the discussion of teacher learning. In this theme, the author found specific processes: of reflection (analysis of needs, problems, change processes and feelings of effectiveness), tools such as learning instruments (use of technology) and learning of new teachers (beginnings of teaching practice, mentoring, induction and comparisons between new and experienced teachers).

A study on TPD in public HEIs in Brazil identified three TPD strategies: lectures, seminars and workshops (Selbach, Luce, 2018). These sets of activities/strategies constitute a broad set of activities that promote TPD which, as they are not expressed by the same names, can be synthesized and rewritten as follows: teaching (exercise of teaching), reflection, education, interaction and research.

Teaching (the exercise of teaching) refers to the experience of teaching, entering the classroom and acting with students in order to lead them to learn. Since students are human beings capable of resisting the teaching action (Tardif, Lessard, 2014), the classroom becomes a space that normally provides situations (issues or tensions) that lead the teacher to reflect - analyze their knowledge and procedures of teaching seeking to overcome situations and guide students to learning. “Reflection presents itself as the essential element of professional development because it enables teachers, based on their experiences, to build new knowledge and transform personal perspectives” (Fringe *et al.*, 2021, p. 6, our translation). According to Avalos (2011, p. 11), “the analysis of needs, problems, processes of change, feelings of effectiveness, beliefs are all factors that contribute to the professional development of the teacher, whether through improved cognitions or new or improved practices”.

As they become aware of problems that need solutions, teachers can develop interests and actively engage in search activities through reading, education – attending courses, training that meets their needs (Ponte, 1998), research – collecting and systematically analyzing data from their own practice (or not) in order to improve scientific and pedagogical knowledge that will promote reflection on their practice (Mesquita-Pires, 2010; Passos *et al.*, 2006) and they may resort to interaction with others - sharing of ideas, materials and experiences, followed by discussions with others.

Teaching and the dialogues derived from these experiences provide opportunities for mutual learning and are characteristic of teaching-learning processes in the classroom, as a social work, because “working is not exclusively transforming an object into something else, into another object, but it is getting involved at the same time in a fundamental praxis in which the worker is also transformed by their work” (Tardif, Lessard, 2014, p. 28, our translation). This means that the teacher learns while teaching and/or dialoguing, sharing ideas and experiences (Avalos, 2011).

3.0 Research design

As indicated in the introduction, we carried out this research aiming to characterize the TPD of Mathematics professors at Rovuma University – Cabo Delgado Extension in their practice. We classified the research as qualitative, based on the "[…] classification and interpretation of linguistic (or visual) material to make statements about implicit and explicit dimensions and structures of meaning-making in the material and what is represented in it" (Flick, 2014, p. 5). In this study, we identify, describe and interpret the activities that make up the TPD of the professors who participated in this study.

3.1 Participants

The research involved four Mathematics professors who joined the invitation made through *WhatsApp* by a group of Mathematics professors at UniRovuma - Cabo Delgado and who provided information about the peculiarities of their professional trajectories. The professors had between 4 and 6 years of experience at the University and all started teaching with a Bachelor's degree and currently one is a master and two are attending the master's degree. For ethical reasons, these teachers are identified as P_1, P_2, P_3 and P_4.

3.2 Data collection

Data collection was carried out using reflective interviews conducted through the *Zoom* virtual platform, given the limitations caused by the Covid-19 pandemic, aggravated by the location of the interviewer (in Brazil) and interviewees (in Mozambique).

A reflective interview is "a human interaction, in which the perceptions of the other and of oneself, expectations, feelings, prejudices and interpretations for the protagonists are at stake: interviewee and interviewer" (Szymanski, 2018, p. 12, our translation). This interview is based on a triggering question, followed by more in-depth, clarifying and focusing questions based on the answers given by the respondent. It is also possible to issue understandings or make follow-up questions in order to improve the information and understandings obtained (Szymanski, 2018). In this research, each teacher was asked if they felt they were the same professional as when they started teaching. As a result of the answer, other questions and discussions were made in order to gather more information or clarify the trajectory of professional growth. The interviews were video and audio recorded and later transcribed.

3.3 Data analysis

Data analysis followed Content Analysis (CA) procedures, an analysis procedure aimed at the message issued by the informant (Franco, 2018, Bardin, 2016). According to Bardin (2016, p. 44, our translation), CA is "[…] a set of communication analysis techniques that use systematic and objective procedures to describe the content of messages". In this research, the systematic procedures consisted of proceeding, successively, with pre-analysis (pre-reading of the transcribed information and identification of excerpts containing activities and challenges that promote the professional growth of teachers), analysis (collecting information based on the similarity of the registered activities) and inference (elaborating conclusive interpretations confronting categories,

theoretical frameworks, objectives and research question). The information provided by the teachers is presented in italics, size 10.

4.0 Results

After analyzing the information obtained through the reflective interview, it was found that the teachers learned and regulated themselves throughout their careers through involvement in some activities. Still, there are demands to be met in order to improve professional performance and achieve satisfaction.

Regarding learning and regulation, the four professors reported that they made changes in their knowledge and professional skills over the time they worked at the university, as attested by the following statements:

I don't feel like the same person professionally. I feel that changes have occurred. In the first years I was insecure, I didn't know if what I was doing was what I was supposed to do, but I had to do something (P_1).

I don't feel like the same person (professionally) in relation to years, months or days ago, that is, with each passing day I feel like a different person in terms of learning, knowledge because every day, every time I learn something, I become another person in terms of knowledge and in academic terms (P_2).

During the period of my professional experience, there were changes in the way of facing knowledge and teaching for me and how to transmit knowledge (P_3).

Before, I used to enter [the classroom] as if I were an individual who didn't know what was going on (P_4)

In these statements, it is clear that teachers have a different past from the present. For some teachers, the beginning of teaching was characterized by insecurity in relation to teaching knowledge, practices and values, as is evident in P_1 and P_4.

Teachers' improvements stem from their involvement in some activities carried out during their teaching time, namely: teaching, reflection, reading, interaction, education and research. The designation of these activities is based on the discussion between the data and the theoretical framework. As there are differences in names between similar activities, for example dialogue (Day, 2001) and collaboration (Passos *et al*., 2006), this article uses names that approach the specifics of the context studied. For a better understanding, the descriptions of the TPD-inducing activities found are presented in Table 1.

Table 1: Activities inducing professional learning in teaching work

Activity	Description
Teaching	It refers to the act of teaching in the classroom, taking into account the interaction with students and student reactions. Teachers point out situations in the classroom that lead them to develop or seek knowledge that aim to zealously fulfill their duty to help the student to learn.

Reflection	Based on classroom situations, the teacher seeks or elaborates solutions through the cognitive activity of thinking and evaluating their work. This activity takes place in the classroom or outside, before, during or after class.
Reading	It is based on a theoretical framework search. It usually takes place before class (preparation) or after class through situations that happened in the class for which the teacher needs to clarify and/or find explanations.
Interaction with others	Reciprocal sharing of knowledge with colleagues (teachers) and other actors inside and outside the institution. It takes place in formal meetings and informal or non-formal conversations through debates or discussions. Includes sharing of material (theoretical frameworks) and assistance with classmates.
Education	Improvement: short courses, training, conferences, …, aiming at learning or improving scientific, technological and pedagogical knowledge.
	Academic: degree courses (Masters or Doctorates)
Research	Inquiry, systematic collection and analysis of information from the practice itself, aiming to improve scientific, technological and pedagogical knowledge that will have an impact on their practice.

Source: Research data

Following this description, table 2 below shows some representative signs of these activities.

Table 2: Some TPD-inducing activities per teacher

Teacher	Registration units	TPD Inducing Activities
P_1	*There are classes where contributions were weak and then I got worried about trying to understand what was happening to those who were not willing to contribute. So I realized that it was necessary for me to make a little more effort.*	**Teaching** – weak class contributions **Reflection** – trying to understand what was happening that culminates in the perception of needs
P_2	*First is reading, second is interaction with staff* [colleagues], *conversations with other people… Through interaction* [with students] *we learn something because we don't go to the classroom to unload what we know as teachers, but we also learn some things from them… As a teacher, I can't make the classroom and the student ask a question and I simply not give the answers they probably expect.*	**Reading –** explicitly points to reading **Interaction –** sharing knowledge with staff and others **Teaching –** interacting with students, answering student questions
P_3	*I have already mentioned normative documents. But there is also training, short courses, qualifications, students… Students already contribute by coming to class. Just*	**Reading –** be guided by normative documents,

	knowing that I'm going to teach some content, I prepare myself. In this preparation, I end up learning things that I didn't understand before… Besides, even when preparing the class, there are times that students ask questions that I didn't foresee. When I have no idea of the answer, I prefer to be humble and say that I will get more information to answer their question. When I do this, I learn not only that what the student asked, but also other things while reading.	preparation for class and clarification **Education –** indication of education, training **Teaching** – the presence of the student in the classroom and the asking of questions are potential promoters of professional learning.
P_4	*There are students who, sometimes, ask about a problem that I didn't expect, on the other hand, I didn't take into account that there could be a problem similar to this one. Many times, I look for ways to see, if possible, if I can solve* [the problem], *I look for a way out, to have a basis, be it a problem or something from our research, sometimes working in parallel.*	**Teaching** – posing unexpected problems **Reflection and Research** – search for solutions and inquiry

Source: Research data

Table 2 shows how the activities influenced the teachers' TPD, making them able to meet professional demands after a past of insecurities. Despite the professional learning achieved, teachers reveal that they are not satisfied with their knowledge and skills and, therefore, these activities have not sufficiently improved their performance. As a result, professors crave to learn more and aim to improve scientific knowledge, technological tools, improve time management and relationship with students, they especially want to attend a master's and/or doctorate that favors academic, technological and research training. The following reports attest to this desideratum:

I feel that I need more training in my area of expertise, namely, courses, training such as a short course, a master's and a doctorate... Being in a geometry class you need to have basic training in the use of, for example, technological tools, so that the knowledge is transmitted easily (P_3).

The thing that I think I need right now, which is a challenge, is research. It's something I need to embrace, I think that in the field of teaching, if you don't master research, you will hardly be able to continue successfully (P_4).

5.0 Discussion

The results presented in the previous section are consistent with the characteristics of Teacher Professional Development and consolidate the naturalness and intentionality of professional learning in this process (Darling-Hammond, Hyler, Gardner, 2017; Day, 2001; Eraut, 1977; Fiorentini; Crecci, 2013; Villegas-Reimers, 2003).

The insecurities at the beginning of their careers confirm the poor preparation of some teachers (Villegas-Reimers, 2003), confirm the contribution of the tensions provided by students who resist the teacher's action (Tardif, Lessard, 2014) and represent a favorable scenario to trigger TPD (Avalos, 2011). Furthermore, insecurity is an emotional value that, together with the satisfaction that teachers seek, is linked to the psychosocial values involved in TPD. In the statements of the teachers, it is possible to perceive that they all describe themselves as committed to students' learning. This teaching interest is the nature of TPD, which is directed from the inside out (Eraut, 1997; Ponte, 1998; Day, 2001).

The effectiveness of teachers' TPD stems from the involvement of these teachers in activities listed in table 1, which lead to professional learning and regulation (Darling-Hammond, Hyler, Gadner, 2107), as shown in table 2. These activities have already been implemented. indicated as inducers of TPD, but in this case the list surpasses three activities that several theorists usually present (Passos *et al.*, 2006; Avalos, 2011; Ponte, 1998; Selbach, Luce, 2018; Eraut *et al. apud* Day, 2001). In the researched context, these activities were not fully evidenced by each teacher, which means that each one has their own TPD process. The absence of evidence, however, does not mean that the teacher is not involved in the undisclosed activity, as this may be related to forgetfulness, as P_3 admitted: *I didn't mention it because I didn't remember* [to mention] (chuckles), *it's hard to think of everything*.

It should be noted that, although some of these activities are taking place, some continue to be projections for the future, namely, improving scientific knowledge, time management and student relations, master's and doctoral training and the improvement of research. These needs indicate the intention of teachers to continue learning professionally and expose the need for institutions to promote academic training and regular training (Duarte, Bastos, 2018).

The activities presented reveal that the trajectory taken by teachers from the past to the present follows a "broken line", as professional learning takes place through differentiated and challenging situations that require specific and adequate feedback. Based on this trajectory, it can be said that TPD, despite being a continuous process, is not linear and this explains why Eraut (1997) describes it as slow.

6.0 Final considerations

This article presents and analyzes the Teacher Professional Development of four Mathematics professors at Rovuma University - Cabo Delgado Extension, aiming to characterize it through the trajectory (past, present and future) and professional activities that shape the professional learning of these professors in the workplace.

The first conclusion is that the professors learned in practice since the moment they started to exercise their teaching duties at UniRovuma – Cabo Delgado and everything indicates that this will continue throughout their careers. Professional learning, as it turned out, is generally triggered by the teaching experience and, above all, by the passive or active nature of students that demand appropriate feedback. This scenario led the professors, spontaneously or intentionally, to engage in activities that induce learning and TPD, namely: teaching, reading, reflection, interaction with

others, education (improvement or academic) and research. These activities suggest that the professional learning of an in-service teacher is natural. (Avalos, 2011; Eraut, 1977).

Although the six activities are not exactly new, as they can be found between the lines of the activities listed by Eraut *et al. apud* Day (2001), Passos *et al.* (2006) and Avalos (2011), it was understood that, to characterize, say if, "truthfully" the TPD of the Mathematics professors at UniRovuma – Cabo Delgado who participated in this study, it was necessary to re-elaborate the list of inducing activities of the TPD. These activities do not follow a linear path, due to interference from challenging practice situations. With this, it can be said, by analogy, that the TPD, in general, and of these professors in particular, follows a trajectory similar to the "broken line".

Another conclusion is related to psychosocial aspects involved in TPD processes and activities. It was found that despite being natural, the TPD of these professors is also intentional, 'from the inside out' (Ponte, 1998). The involvement in acts of reading, consulting others, innovating, desiring training, becoming interested in technology and research are triggered by the feeling of not being complete for the full exercise of teaching at the University. When mentioning concern with student learning, these professors reveal a commitment to student learning, to the quality of education and, therefore, their professional learning seeks to improve scientific, technological and pedagogical knowledge to improve student learning and also the teachers' own learning, thus demonstrating that the TPD must be continuous and transforming from the past to the present and from there to a future that prides itself on being promising. This, from what we understand, suggests that UniRovuma should invest in academic education (promote Masters and Doctorates in mathematics, provide scholarships, create partnerships or strengthen and foster inter-university academic exchanges within and outside the country, etc.), in regular education/training of its faculty in matters of technology management (mathematics education software) and scientific research.

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ARTICLE 5

Exploring the Effect of School-Based Professional Development Model on Teachers' Pedagogical Content Knowledge and Pupils Achievement in Basic Science at the Middle Basic Education Level in Nigeria

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Abstract

This study was designed to explore the effect of School-Based Professional Development (SBPD) model on teachers' pedagogical content knowledge and pupils' achievement in basic science at the middle basic education level in Nigeria. Studies indicates that a lot needs to done in order to improve the quality of lesson delivery and pupils' understanding of science concepts. A quasi-experimental design was employed for the study involving 14 teachers and 219 pupils. Three instruments were used for data collection these are Teacher Pedagogical Content Knowledge Assessment Test (TPCKAT), Basic Science Assessment Test (BSAT) and Classroom Lesson Observation Checklist (CLOC). These instruments were validated; pilot tested and the reliability coefficients established were 0.9, 0.86 and 0.76 respectively. Two research questions were answered using mean, standard deviation and standard error and two research hypotheses were tested with two sample t-test, ANCOVA and Kruskal-Wallis one-way analysis of variance at 0.05 level of significance. Data collected were analyzed with the Statistical Package for Social Sciences (SPSS), IBM version 20. The results obtained revealed that, there was a significant gain of knowledge and skills for the experimental group compared to the control group. Specifically, the study showed no significant difference between male and female teachers in the experimental group and pupils' achievement in Basic Science in the experimental group is independent of gender. It was concluded that teachers' exposure to SBPD model significantly improved lesson delivery and learners' achievement. It is recommended that SBPD model should be use in schools as one of the major constituents for improving teachers' pedagogical content knowledge for teaching of basic science at the basic and post basic school level through school supervision and inspection.

Keywords: *School-Based Professional Development, Pedagogical Content Knowledge, Pupils' Achievement.*

1.0 Introduction

Basic Science is taught at basic education level in Nigeria to help build a solid foundation for productive employment or for secondary and post-secondary education (FME, 2008). Basic science plays an important role in the economic and social development of the world in general and Nigeria in particular. However, it is on record (Adeyemi, 2011) that in spite of the large money

invested in science and technology sector over the years, performance of students is not commensurate with huge amount of government spending.

SMASE (2006) Baseline survey in Kaduna, Niger and Plateau also showed poor performance of pupils in Basic Science, the result indicates that most teachers use the teacher-centred content-based approach and do not relate what they teach to the immediate environment of the pupils. However, the finding of studies from some researchers (Okebukola, 2009, Danjuma & Shuaibu, 2015) tends to suggest that a lot need to be done in order to improve the quality of lesson delivery and pupils understanding of science concepts. These studies indicate that there is a gap between lesson delivery and pupils understanding of science concepts, hence the need for intervention strategy that could fill that gap by having access to sustainable, high quality professional development in order to improve teaching and student learning.

2.0 Literature Review

2.1 School-Based Professional Development Model on Teachers'

School-Based Training (SBT): This is an in-house training run by the school itself; it is training for the teachers by the teachers in their own schools for Continuous Professional Development (CPD). It is one of the easiest modalities of disseminating information or skills acquired during workshops or seminar.

The current cascade (train the trainer) training may not be able to cover every school teacher in Nigeria as a whole due to the fact that: -

1. Recruitment of teachers is continuously done;
2. Those that missed training may not be able to have another chance;
3. Sustainable practice is needed (CPD) (SMASE, 2011).

To build a common ground for teaching method regardless of teacher and teaching style. School-Based Professional Development is being advocated in Nigeria. It is training for the teachers by the teachers in their own schools for Continuous Professional Development (CPD) (Eneji, 2012). It is usually coordinated and run by teachers themselves and it takes the forms of collaborative lesson planning.

Purpose of School-Based Professional Development in Schools are to: -

1. share newly attained teaching techniques, skills etc;
2. create opportunities for teachers to learn from one another;
3. create the culture of continuous professional development among all teachers;
4. assure that the level and styles of teaching are on the same path regardless of teachers.

School-Based Professional Development has been proofed to be effective according to researchers (Lewis 2002; Isoda, Stephens, Ohara & Miyakawa 2007, SMASE, 2013) and it has long been practiced in Zambia, Uganda and Kenya with positive impact on both teachers and students. In this study, it is the interest of the researcher to explore the effect of School-Based Professional Development model on teachers Pedagogical Content Knowledge, and Pupils' Achievement in Basic Science at Middle Basic Level in Nigeria.

Teachers who teach Basic Science need to be confident with what they are teaching, they need to have appropriated teaching techniques, different strategies for motivating the pupils; that really

means having a good professional development system in place (Brain, 2008). Stigler and Hiebert (1999) suggest that teachers must be the driving force behind improvements in the education system as they are in the best position to understand and propose solutions to problems faced by students. Teachers must have access to sustainable, high quality professional development in order to improve teaching and student learning.

A key aim of professional development in recent years internationally has been to develop sustainable networks of teachers who engage in developing effective pedagogy (Dana, & Yendol-Silva, 2003).

3.0 Statement of the Problem

The training of skilled manpower in basic science which has to integrate with the society for the different aspects of national development, is considered a priority which ought to receive special attention in the light of local, national needs and realities (Muhammad, 2012). However, there is still a gap between the things outlined in the course curriculum and planning at the highest level with the things that are shared and practiced in the classroom (Awang, Jindal-Snape & Barber, 2013).

An impact survey on Strengthening Mathematics and Science Education (SMASE) programme conducted in 2018 by the National Teachers' Institute and SMASE stakeholders revealed the prevailing factors in mathematics and science classrooms among others are knowledge-based teaching and teacher-centred lessons.

The impact survey concluded that Nigerian teachers need to acquire more skills on how to plan and deliver a learner-centred activity-based lessons in mathematics and science, through exposure to activities that enhances understanding of concepts and production of improvised materials. They also stated that teachers' attention needs to be drawn for them to re-examine their instructional approach for the benefit of their learners. Therefore, a strong need exists for teachers to experience sustainable high-quality professional development in order to improve student learning and teacher instruction (SMASE Baseline Survey, 2006; SMASE impact survey, 2018; Danjuma and Shuaibu, 2015).

3.1 Research Question

1. What are the differences in the observed classroom lesson delivery skills among basic science teachers exposed to School-Based Professional model?
2. What is the effect of teachers' exposure to School-Based Professional model on pupils' achievement in Basic Science?

3.2 Research Hypotheses

$Ho_{1:}$ There is no significant difference in the rating of observed Classroom Lesson delivery skills among teachers exposed to School-Based Professional Development model.

$Ho_{2:}$ There is no significant difference in pupils' achievement in Basic Science taught by teachers exposed to School-Based Professional model and those teachers not exposed to School-Based Professional model.

4.0 Methodology

4.1 Research Design

The mixed method design employed was an explanatory approach with a quasi-experimental design. The quantitative method was quasi-experimental between-subjects approach utilizing a pre- and posttest group design. Qualitative data was collected at two time points post intervention.

4.2 Sample and Sampling Technique

Two schools were selected at random using the simple random sampling technique involving balloting with replacement in Bauchi state, it was also used to select the experimental and control groups. For the teacher's selection, the middle basic (Primary 5 teachers) of the schools were sampled purposively for the study the pupils in the teacher's class were used for the study.

4.3 Instruments for Data Collection

For the purpose of this study, the following instruments were used for data collection:

1. Basic Science Achievement Test (BSAT) for to the pupils developed by the researcher.
2. Classroom Lesson Observation Checklist (CLOC) was adapted from SMASE, (2013).

The two instruments were subjected to content and face validation by experts.

4.4 Methods of Data Collection

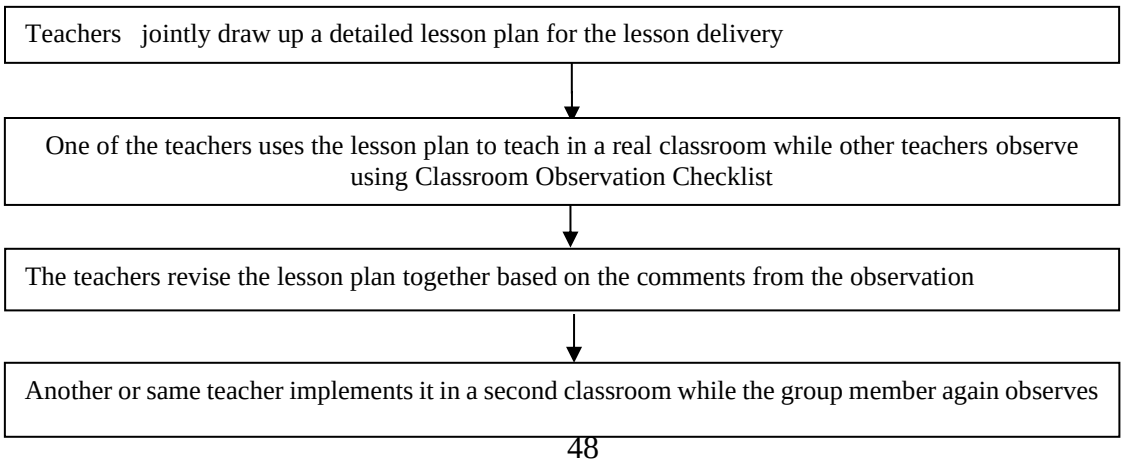
The Basic Science Achievement Test (BSAT) for the pupils were administered to both experimental and control groups before the commencement of the treatment. The raw scores of the pretest were analyzed to determine if there is any difference in pupil's achievement between the experimental and control. The result of the two groups showed that the pupils are equivalent in their achievement in Basic Science concepts.

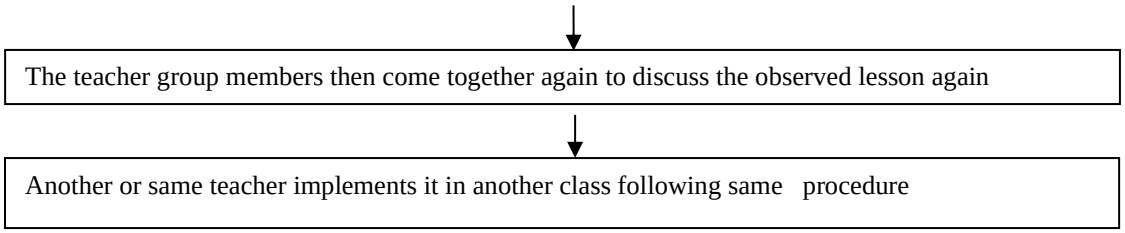
4.4.1 Experimental Group

The pupils of the experimental group were taught with Learner-centred lesson plans developed by teachers exposed to School-Based Professional Development Model for Seventy-two (72) periods of thirty-five (35) minutes lessons for 12 weeks.

The teachers undergo the stages and procedure of professional development model as presented below:

Fig. 1 School-Based Professional Development Model





The Classroom Lesson Observation Checklist (CLOC) was used to assess the aspect of lesson delivery with rating scale 1-5 with following response types: - Poor (1), Fair (2), Good (3), Very Good (4) and Excellent (5).

4.4.2 Control group

The control group teachers were not exposed to School-Based Professional Development and they taught the same topics used in the experimental to teach their pupils using the conventional lecture method alone.

Immediately after the twelve (12) weeks period of treatment, a posttest was administered to both experimental and control groups with BSAT and data collected was subjected to analysis.

4.5 Method for Data Analysis

Descriptive statistics in form of mean and standard deviation and graphically illustrations using bar charts and line graphs was used to answer research questions. Kruskal-Wallis one way analysis of variance was used to test hypothesis one and analysis of Covariance (ANCOVA) was used to test the other hypothesis.

4.5.1 Results and Discussion

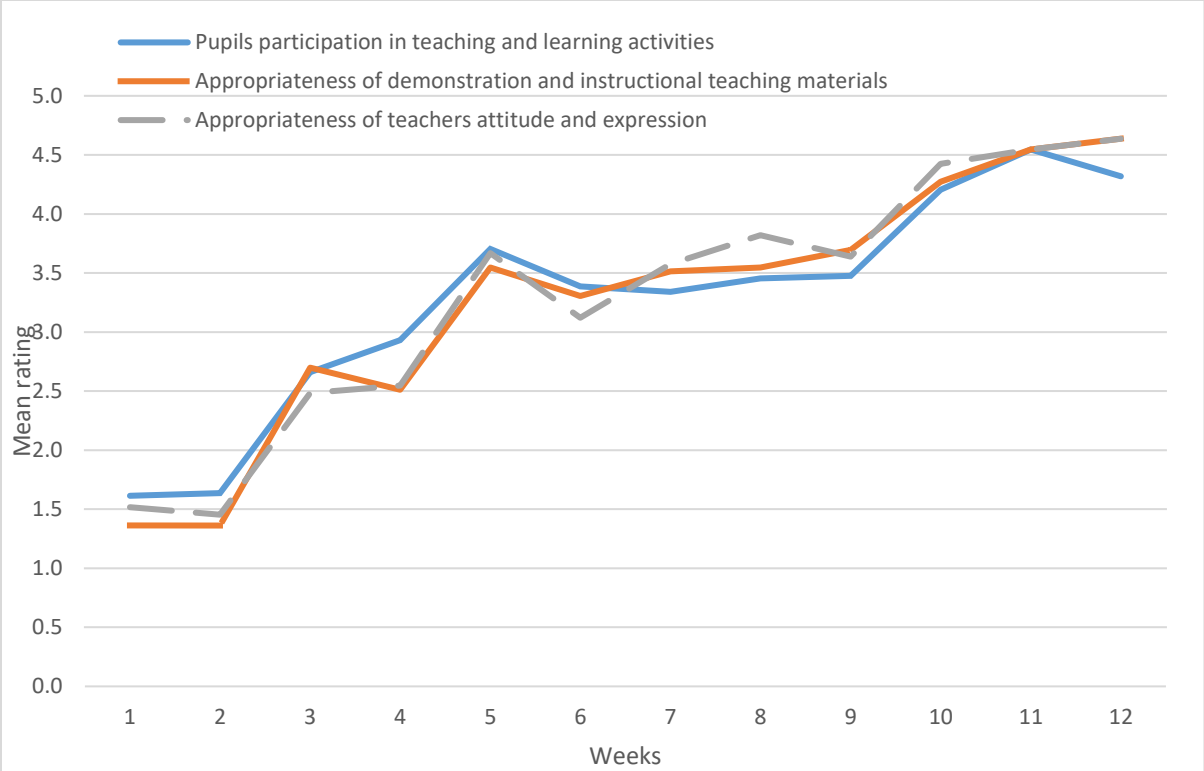
Three major variables were assessed in the observation by raters during the experiment. These were Teaching Procedure, Fundamental Techniques/methodology and Class Management. The mean scores are graphically illustrated for the 12-week period in bar charts for the rated means of the components of teaching procedure while line graph was used for the rated Fundamental techniques/methodology and bar chart was used for the Class management and their respective components.

Figure 2: Observed teaching procedure and appropriateness of lesson over 12 weeks' period

Fig. 2 : Oberved teaching procedure and appropriateness of lesson over the 12week period

The mean rating in Figure 2 shows that the teachers had a progressive increase in their effectiveness of the various teaching procedures from the first week till the 12th week of the experiment. This was the case for Clarity /feasibility of lesson objectives, appropriateness of lesson introduction, emphasis on main concept and achievement of set objectives. For appropriateness of lesson content, innovation, language used and lesson summary, optimum effectiveness was achieved in the eleventh week of the experiment. There were observed difference in the mean rating between the first four weeks, and the subsequent weeks but mean rating increased to 'very good' based on the five-point scale at the 9th week of the experiment and remain till the 12th week for the teaching procedures used by the teacher participants.

Figure. 3 Observed rated fundamental techniques/methodology used by the teachers over the 12-week period.



Observed rated fundamental techniques/methodology used by the teachers over the 12week period

The data in figure 3 shows use of fundamental techniques/methodology by the teacher participants rose in the second week of the experiments. All the three components of the variable were observed to follow this trend of progress among the teacher participants. The observation revealed that effective usage achieved in the 5th week was dramatic because a slight decline was observed in the 6th week. But progress was again accelerated in the 7th week till the 11th week when optimum effective usage of the methodologies (pupils' participation in teaching and learning activities, appropriateness of demonstration and instructional teaching materials and appropriateness of teachers' attitude and expression) were achieved. The ratings of the methodologies are generally very low in the first three weeks and attained highest rating in the 11th week. Though continuous increase was observed for appropriateness of demonstration and instructional teaching materials and appropriateness of teachers' attitude and expression but the observation for pupils' participation in teaching and learning activities did not increase proportionately.

Figure. 4 Observed rated classroom management/control by the teachers over the 12weeks period

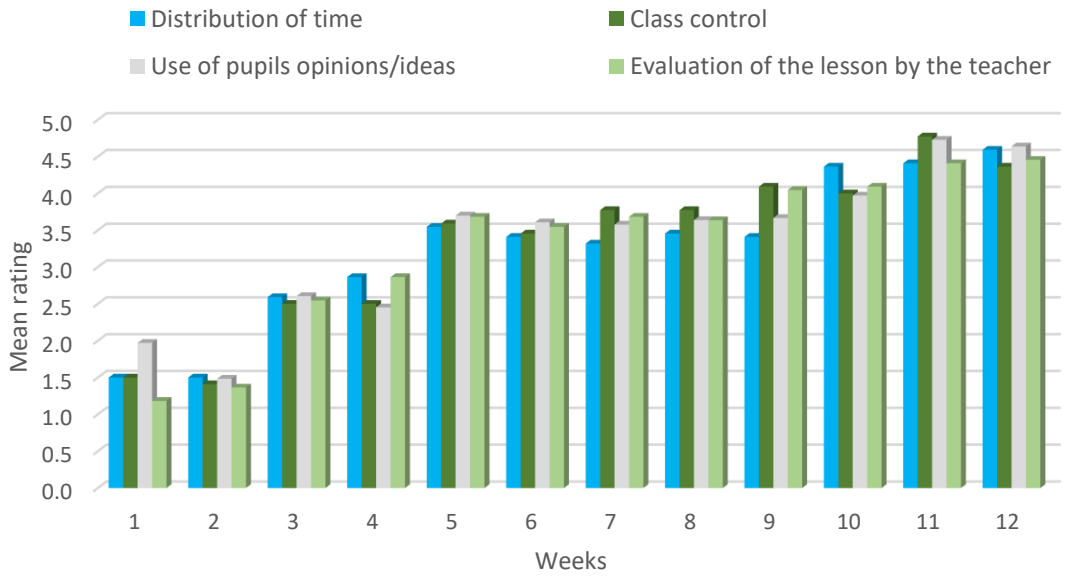


Fig. 4 : Observed rated classroom management/control by the teachers over the 12weeks period

The observed ratings of the class management by the teacher participants were generally low in the first two weeks. Though there was better rating of the use of pupils' opinions/ideas, it could be said to be a random development since it was not replicated in the subsequent weeks. Like all the improvements, optimum class control was achieved by the teacher participants in the 11th week for the distribution of time, class control, use of pupils' opinions/ideas and evaluation of the lesson by the teacher participants. From the observations, it could be concluded that there were differences in the ratings of observed classroom lesson delivery skills among Basic Science teachers exposed to School-Based Professional Development model at the middle basic education level over the 12week period.

Table 1: Mean achievement of pupils before and after their teachers' exposure to School-Based Professional Development model

Level	Type	N	Mean	Std. Deviation	Std. Error	Mean difference
Pre-test	Control	205	13.45	3.081	0.215	
	Experimental	219	13.12	2.639	0.178	-0.33
Post-test	Control	205	13.87	2.431	0.170	
	Experimental	219	33.00	5.133	0.347	19.13

The mean scores of pupils who were taught by the teachers in the two groups before the experiment were basically the same. The score of pupils taught by teachers in the control group was 13.45±3.081 while that of those in the experimental group was 13.12±2.639. The mean difference was -0.33 against pupils taught by teachers in the experimental group. After the teachers in the experimental group were exposed to school-based professional development model, their pupils' performance rose from 13.12±2.639 to 33.00±5.133 while the scores of pupils taught by teachers

in the control group only improved from 13.45±3.081 to 13.87±2.431 with a mean difference of 19.13.

4.6 Test of hypotheses

The tests were carried out at a probability level of 0.05 as follows:

Table 2: Kruskal-Wallis one-way analysis of variance on classroom lesson delivery skills among teachers exposed to school-based professional development model.

Ratters	N	Teaching procedure Mean Rank	Methodology Mean Rank	Class management Mean Rank
1	12	76.58	71.79	71.96
2	12	68.00	69.38	70.92
3	12	68.04	63.50	63.21
4	12	64.83	70.67	68.88
5	12	65.58	70.75	70.46
6	12	60.96	57.50	63.25
7	12	67.83	65.96	62.25
8	12	63.75	67.08	64.88
9	12	63.67	58.75	60.75
10	12	67.33	64.42	65.08
11	12	64.92	71.71	69.88
Chi-square		1.323	2.085	1.308
DF		10	10	10
P-value		0.999	0.996	0.999

The result for Ho1 in the table showed that the ratters or observers did not differ significantly in their rating of the effectiveness of teachers in their usage of the classroom lesson delivery skills when exposed school-based professional development model.

For Ho2, the test was conducted with the Covariance analysis (ANCOVA) procedure with the type of group as the independent variable and their pre-test score as the covariate factor.

The result revealed that the observed variability in achievement of the pupils taught by teachers in the experimental and control groups is statistically significant (F-value of 2798.671, df 1, 42, P <.05). Though the covariate factor was significant which indicated the role played by the pre-test in the experiment as it transcends all the variables but the observed difference could also be associated with the previous knowledge of the pupils in the pre-test. By these observations, there is sufficient evidence to reject the null hypothesis that there is no significant difference in pupils' achievement in basic science taught by teachers exposed to School-Based Professional Development model and those teachers not exposed to School-Based Professional Development model is therefore rejected.

A post hoc test was conducted on the mean examined using the Least Significant difference procedure as summarized in Table 7. The result showed the achievement of pupils taught by teachers who were exposed to school-based professional development model was significantly higher than that of pupils who were taught by teachers in the control group.

Table 3: Analysis of covariance on Pupils' Achievement in Basic Science and Technology taught by teachers exposed to School-Based Professional Development Model and those taught by teachers not exposed to it.

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	39785.889	2	19892.944	1414.777	.000
Intercept	4896.815	1	4896.815	348.259	.000
Pretest	1029.833	1	1029.833	73.241	.000
Type	39351.645	1	39351.645	2798.671	.000
Error	5919.611	421	14.061		
Total	284868.000	424			

(F-critical at 1, 421 df = 3.84 at 0.05)

Table 4: Pairwise Comparisons of Pupils' Achievement in Basic Science taught by teachers exposed School-Based Professional Development Model and those taught by teachers not exposed to it

(I) TYPE	(J) TYPE	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
Experimental	Control	19.309(*)	.365	.000	18.592	20.027

* The mean difference is significant at the .05 level.

4.7 Discussion on Findings

It was found out that there is great improvement in teacher's classroom performance and pupils' participation during exposure to the intervention, the raters of the classroom observation checklist did not differ in their rating and there was great improvement in teaching procedure, innovation, and classroom management by teachers over the period of the intervention.

There was also great improvement in pupils' achievement due to their teacher's exposure to School Based Professional Development model. The result shows that School-based Professional Development model positively impacted teaching ability of teachers which revealed the great improvement in pupils' achievement. This result agrees with the findings of (Danjuma & Shuaibu 2015) that students' performances in subjects depends on their teachers' ability to deliver.

The result of the test revealed that achievement of pupils taught by teachers who were exposed to the model was significantly higher than the achievement of pupils taught by teachers who were not exposed to the model.

5.0 Conclusion

Based on the findings, the researcher wishes to conclude that teacher's exposure to School-Based Professional Development Model has a significant effect on teachers' classroom lesson delivery skills which in turn improves pupils' achievement in basic science in Nigeria

5.1 Contribution to Knowledge

The study was able to establish the fact that school-based professional development model was an effective professional development package for teachers because it is very reliable and provide consistent retraining of teachers in lesson delivery and planning and could serve as a means of improving the performance of learners at all education levels in Nigeria.

5.2 Recommendation

Based on the findings of this study, school-based professional development model was suggested to be adopted by school head teachers and principals to improve teaching, learning and learners' achievement across subjects. The Universal Basic Education Commission (UBEC) should recommend the use of School-Based Professional Development Model as one of the major constituents for improving teachers' pedagogical content knowledge for teaching of basic science at the basic and post basic school level through school supervision and inspection. There is a need for the inclusion of School-Based Professional Development Model for teachers through seminars and workshops for improved teaching of basic science at all school levels which will lead to enhanced achievement of the pupils.

However, the study was limited to Bauchi state of Nigeria due to financial constraints. The study is suggested to be replicated covering more than one geographical zone of the state, and to be conducted over a longer time duration to investigate other effects including retention and attitudes of pupils to basic science concepts when their teachers are exposed to school-based professional development model. To find out the long-term impact and effectiveness of the study, a return to the subjects is recommended in 6 to 12 months.

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Strand 2 # School Culture and Learning in STEM

1. Leadership for learning & role of professional associations
2. Creating space for in / out of school STEM learning
3. Equity & access in STEM education
4. Gender-based STEM education
5. Inclusive STEM education for learners with special needs
6. Increasing STEM learning outcomes for vulnerable children

ARTICLE 6

Gender difference in the influence of role model and gender stereotype on science performance among secondary school students in Migori county, Kenya

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Abstract

The purpose of this study was to establish the gender difference in the influence of role model and gender stereotype on science performance. A sample of 327 Form Four students in Migori County was used. Questionnaires, focus group discussion guide and interview schedules were used for data collection. Quantitative data were analyzed using descriptive statistics correlation and regression analysis. Qualitative data were organized into themes and interpreted. Overall, boys had higher levels of performance in science (Mean=39.21) than girls (Mean=30.80) and the mean difference was statistically significant *(t=3.89, p=.00)*. Boys had higher levels of role model (Mean=2.99) than girls (Mean=2.71) and the mean difference was statistically significant *(t (173) = 3.452, p = .001)*. However, girls had a higher level of gender stereotype (Mean=1.66) than boys (Mean=1.67) but the difference was not statistically significant *(t (173) = -.187, p = .852)*. Further, the correlation between role model and performance in science for both boys and girls were found not to be statistically significant with boys having *r=.069 (p=.446, n=200)* while girls having a *r=.053 (p=.717, n=127)*. For boys, gender stereotype significantly correlated with performance in science *r=-.211 (p=.018, n=200)* while for girls there was no significant correlation *r=-.089 (p=.540, n=127)*. Gender stereotype predicted performance in science *b* = -4.917 (p=.013, 327). It is concluded that gender stereotype negatively predict performance in science and therefore to reduce the gender gap in science performance, gender stereotype should be reduced for students but more particularly so for girls.

Key words: *Role model, Gender stereotype, Kenya, Science performance, Moderation*

1.0 Introduction

Gender bias in Mathematics and science classrooms has been and still continues to be a problem (Diane, 2003). Despite improvements in the past two decades, girls are still less likely than boys to take physics and higher-level Mathematics and science courses in high school. As a consequence, fewer female students may study Mathematics and science at the college level. The types of courses taken in high school and how students perform in these courses can impact acceptance into college, choice of college major, and subsequent career choice (Diane, 2003).

A growing demand for professionals in Science, Technology, Mathematics and Engineering (STEM) is met with a significant labour shortage in these fields as women account for just 28 percent of global researchers but the figure masks wide variations between countries and regions (UNESCO, 2016). Women are often underrepresented in STEM, and their low levels of participation can be traced back all the way to their school years, where a number of influences from society and culture, education and the labour market are all at play (UNESCO, 2016).

Statistics Canada (2007) reports that as of 2006 only 22% of professionals in natural sciences, Engineering, and Mathematics are women, an increase of a mere 2% from 1987; and since women continue to account for a small sector of the student population in these fields, there will probably be little change to this statistic in the near future (Fried & MacCleave, 2009; Statistics Canada, 2007). Similar situations are visible in the United States and Europe. In the United States, women comprise 50% of the workforce but only 15% of scientists are female (Weinburgh, 2000). While more women are receiving PhDs in science nowadays there still is no equity as far as their career is concerned (Burrelli, 2008; UNESCO, 2007 & Ochwa-Echel, 2011).

Data from the Kenya National Bureau of Statistics (2019) indicate that in general, in Kenya, the number of females in STEM profession is 21,400 in comparison with males who make up 52,400. At the university, females constitute just 30% of STEM students. This weak representation of females in science is again reflected in the performance of sciences down the ladder. The KCSE performance for instance attest to this worrying trend as boys have outshone girls in all Science related subjects from the year 2017 to 2019. The STEM performance has not been any better in Migori county as well. Although the average national result for all sciences in the 2018 KCSE stood at an average mark of 27.78% for boys and 24.98% for girls giving a gender disparity of 2.8% in science performance, Migori county had girls scoring an average mark for all sciences of 22.63% against the boys' 26.65% indicating a gender disparity of 4.02%. This goes against the Millennium Development Goals which advocates for gender parity in STEM performance and promotion of STEM subjects for attainment of Vision 2030.

While some studies indicate a male advantage in mathematics and science, other studies show that female students perform equally well or even better than male students at mathematics and science. Based on these conflicting findings, one cannot authoritatively assert that females perform poorly in sciences than males. It is for this that the current study sought to establish the gender disparity in performance of sciences by subjecting students in Migori county to a science achievement test with a view to examining how the selected factors influence the science performance.

One possible explanation of gender disparity in performance in sciences is that girls and young women are not exposed to many female STEM role models, and as a result degrees and occupations in STEM do not occur to them as attainable or realistic choices that may influence their performance (Truscott, 2017). Consequently, Science is largely still considered a masculine discipline (Fox et al., 2006; Hill et al., 2010) based on binary opposites; valuing norms more frequently associated with men, such as rationality, control, logic, over more feminine attributes, such as emotions, or intuition (Blickenstaff, 2005; Francis & Skelton, 2005; Murphy & Whitelegg, 2006). Students define themselves within these parameters and determine what is of relevance to them. Murphy and Whitelegg (2006) suggest that girls may go so far as to avoid tasks if the content is masculine even though they are fully capable of completing the tasks. Society has created stereotypes for girls in science (Belkin, 2008; Hill et al., 2010). As such these gender barriers have seen girls register a weaker performance in science than boys (UNESCO, 2016; Else-Quest et al., 2010; Francis & Skelton, 2005; Hill et al., 2010; FAWE, 2003a; Ayoo, 2002 & Chepchieng & Kiboss, 2004)

However, the afore-cited studies were either based in the Western countries whose cultural connotation on gender cannot be assumed to be similar to African values attached to gender or looked at academic performance in general. The studies thus failed to address performance in sciences in particular and it is therefore for this and the afore-cited gaps that the current study sought to fill these knowledge gaps.

1.1 Objectives of the Study

The study was guided by the following objectives;

1. To establish the level of science performance across gender.
2. To establish the level of role model across gender.
3. To establish the level of gender stereotype across gender.
4. To examine the influence of role model on science performance.
5. To examine the influence of gender stereotype on science performance.

2.0 Research methodology

2.1 Research design

A mixed methods research design which includes both quantitative and qualitative paradigms was adopted in the study. More specifically, the convergent parallel mixed methods approach was used.

2.2 Sample size and sampling technique

The study used Fisher et al. (1991) formula to arrive at a sample size of 327 form four students of the year 2020 in Migori county who took all the 4 science subjects of Mathematics, Biology, Chemistry and Physics. The study used cluster sampling method and simple random sampling technique to sample the students for study from a study population of approximately 2,200, i.e., 1550 boys and 650 girls spread out in the 240 public secondary schools in the county.

2.3 Research instruments

Five tools were used for data collection; Science Role Model Scale (SRMS), Gender Stereotype Scale (GSS), Science Achievement Test (SAT), Focus Group Discussion Guide and Head of Science Interview Schedule (HOSIS).

2.4 Methods of data analysis

Descriptive statistics, correlation analysis and simple linear regression were used to analyze quantitative data. The software used for quantitative data analysis was the Statistical Package for the Social Sciences (Version 24). Qualitative data was analyzed thematically.

2.5 Ethical considerations

All the protocols for conducting research in psychology were observed. The study was approved by Maseno University Ethics Review Committee prior to data collection.

3.0 Results and discussion

3.1 Reliability analysis

A Test-re-test was conducted on the different instruments using a sample of 33 participants and yielded the following results.

Table 1 Cronbach's alpha for each variable

Variables	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items
Science Performance	0.782	0.781
Role Model	0.786	0.787
Gender Stereotype	0.792	0.795

Tables 1 shows the reliability measurement for each variable, with Cronbach's Alpha and Cronbach's Alpha based on standardized items. The α Coefficients are all above the standardized point of .70. Since each variable attained the set minimum standard of .70, all the instruments were deemed fit and were therefore used for the study.

3.2 Science performance across gender

Table 2 contains mean scores in the Science Achievement Test sub-scales as well as the overall mean score across gender. The overall mean score for boys (Mean=39.21) was higher than for girls (Mean=30.80). Boys consistently outperformed girls in all the four science subjects. The best-done subject Mathematics followed by Biology and then Physics. The worst performance was in Chemistry.

Table 2 Level of Performance in science across gender

	Mean Score by Gender	
	Boys	**Girls**
Physics	9.90	7.02
Chemistry	7.39	5.78

Mathematics	11.25	9.08
Biology	10.66	8.92
Overall Mean	**39.21**	**30.80**
Valid N (listwise)	200	127

The highest gender disparity was recorded in Physics followed by Mathematics. Biology had the third highest gender disparity in performance while Chemistry had the lowest gender disparity. The fact that boys did better than girls is consistent with the findings of Eriba and Sesugh (2006) and KNEC (2019).

In order to establish if the mean difference in science performance between the mean for boys and that for girls is statistically significant or not, the independent samples t-test was used at α=.05 (two-tailed). Table 3 shows the outcome of the analysis which indicates that the fundamental assumption for t-test regarding the equality of variances was satisfied at α=.05 (*F*=.83, *p*=.37). With equal variances, the difference in science performance between boys and girls was statistically significant at α=.05 (*t*=3.89, *p*=.000). Therefore, the mean difference in science performance between boys and girls was a true difference in the population from which the sample was drawn and not a result of chance or sampling error.

Table 3: Test of significance for gender difference in science performance

		Levene's Test for Equality of Variances		**t-test for Equality of Means**		
		F	**Sig.**	***t***	***df***	**Sig. (2-tailed)**
Performance in Science	Equal variances assumed	.83	.37	3.89	173	.000
	Equal variances not assumed			4.08	100.60	.000

This observation further confirms that girls tend to perform at a lower level than boys in science. It is in agreement with the findings of Eriba and Sesugh (2006) in Nigeria which found that boys outperformed girls in integrated science and mathematics achievements. Similarly, the finding corresponds with that of Ochwa-Echel (2011) in Uganda in a project, dubbed Female Education in Mathematics and Science in Africa. The study found that girls's performance in science subjects (which is the gateway to computer science studies) in the Uganda Certificate Examinations is very low compared to that of boys.

Likewise, the finding is a true reflection of the situation in Kenya as recent literature show that there has been a big problem of poor performance in STEM subjects in Kenya as a whole with girls performing even worse in comparison with the boys (Forum for African Women Educationalists, 2008). The same position is held by Wambua (2007) in his study as he found that boys performed better than girls in STEM subjects. With the Science Achievement Test being developed from science questions in the KCSE exams, the study finding mirrors the true performance scenario on the ground as recent national KCSE results of 2017, 2018 and 2019 have all shown that boys continue to perform better than girls in all the science subjects.

The current finding also corroborates other studies done in the local environment. According to the records at the Migori County Office, boys have continued to perform better than girls in the sciences. For instance, in the 2018 KCSE results, Migori County had girls scoring an average mark for all sciences of 22.63% against the boys' 26.65%, giving a gender disparity of 4.02%. (Migori County Education Office Records, 2019).

3.3 Level of role model across gender

Table 4 presents mean scores for role model across gender derived from an independent-samples t-test. The overall mean score for boys is 2.99 and the overall mean for girls is 2.71. This implies that the level of self-efficacy for boys was higher than that for girls.

Table 4 Level of role model

	G	N	Mean	Std. Deviation	Std. Error Mean
Role Model	Male	200	2.9880	.49012	.04384
	Female	127	2.7133	.43649	.06173

In order to establish if the mean difference in role model between the mean for boys and that for girls is statistically significant or not, results from the independent samples t-test was used at $\alpha = .05$ (two-tailed). Table 5 shows the outcome of the analysis which indicates that the fundamental assumption for t-test regarding the equality of variances was satisfied. There was a significant difference in the scores for Males (M=2.99, SD=.49) and Females (M=2.71, SD=.44); at $\alpha = .05$ $t(173) = 3.452$, $p = .001$.

Table 5 Test of significance for gender difference in level of role model

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Role Model	Equal variances assumed	.029	.865	3.452	173	.001	.27467	.07957	.11761	.43173
	Equal variances not assumed			3.628	100.762	.000	.27467	.07571	.12447	.42486

The results above suggest that there is a significant difference in the level of role model across gender. Specifically, male students have a higher level of interest in science than female students. This finding concurs with the findings of UNESCO (2016,) Statistics Canada (2007), Weinburgh (2000), Dewandre (2002), Eriba and Sesugh (2006) and Ochwa-Echel (2011) who all found that boys have a higher number of role models in Science, Technology Engineering and Mathematics than their female counterparts.

3.4 Level of gender stereotype across gender

Table 6 presents mean scores for gender stereotype across gender derived from an independent-samples t-test. The overall mean score for boys is 1.66 and the overall mean for girls is 1.67. This implies that the level of gender stereotype for girls was higher than that for boys.

Table 6 Level of gender stereotype

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Gender Stereotype	MALE	200	1.6587	.50484	.04515
	FEMALE	127	1.6740	.45222	.06395

In order to establish if the mean difference in role model between the mean for boys and that for girls is statistically significant or not, results from the independent samples t-test was used at $\alpha = .05$ (two-tailed). Table 7 shows the outcome of the analysis which indicates that the fundamental assumption for t-test regarding the equality of variances was not satisfied. There was a no significant difference in the scores for Males (M=1.66, SD=.50) and Females (M=1.67, SD=.45); at $\alpha = .05$ t (173) = -.187, p = .852.

Table 7 Test of significance for gender difference in the level of gender stereotype

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Gender Stereotype	Equal variances assumed	3.850	.051	-.187	173	.852	-.01533	.08208	-.17734	.14667
	Equal variances not assumed			-.196	100.19	.845	-.01533	.07829	-.17065	.13998

This finding corroborates the findings of Onyeizugbo (2003) and Ayoo (2002) which asserted that gender stereotypes are mainly in favour of boys and the girl-child is left to battle it out alone in a male dominated field of academics. As such, the girl-child ends up getting much affected than the boys.

3.5 Relationship between role model and performance in science

The overall correlation between role model and performance in science was found not to be statistically significant at $\alpha=.05$ with $r=.109$ ($p=.152$, $n=327$). Thus, an increase in role model is not associated with an increase in science performance. When data were disaggregated by gender, the correlation between role model and performance in science for both boys and girls was also found not to be statistically significant at $\alpha=.05$ with boys having a $r=.069$ ($p=.446$, $n=200$) while

girls having a *r*=.053 (*p*=.717, *n*=127). Put differently, the correlation between the two variables was positive weaker and non-significant for both boys and girls. On checking the predictive power of role model on performance of science, regression analysis was done to establish the level of relationship. Table 8 displays the result of the analysis.

Table 8 Prediction of performance in science from role model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.374	8.784		1.636	.104
	Role Model	.579	2.164	.021	.267	.789

The Table indicates that the regression coefficient is B= .579, (*p*=.789). Therefore, the slope of the regression line for predicting students' performance in science from their role model scores is not significantly different from zero at α=.05. When data was disaggregated by gender, the regression coefficient for boys is b=*1.869, (p= .446)* while that of girls is b= -1.432, (p=.717) showing that role model does not significantly predict science performance among both the gender. This means that a change of 7.823 units for boys and -1.432 units for girls in science performance is associated with a corresponding change of one unit in science performance. This change is however not significant at α=.05.

This finding concurs with the qualitative data got from heads of science department who a majority (21 out of 30) affirmed that roles models do not influence science performance of students. One female head of department reported that:

For the years I have served as a head of science department I have tried to enlighten the students particularly on various successful individuals in the field of science. I in particular was made a head of science department to inspire girls' performance in science and indeed many girls and even boys recognize me and even others as their role models in science but this has not translated to good performance in science. What normally happens is that the learners see the success of such role models as coming as a result of the exemplary qualities of the role models that they themselves lack.

This therefore points out that role model in itself is not able to inspire good performance in science. For a role model to inspire this positive result, the student must be able to be made believe that what the role model achieved is actually achievable. This was alluded to during the focus group discussion by one student who said that:

My role model is my Mathematics teacher, he teaches us Mathematics so well but I keep on getting D's in Mathematics. I know I cannot get better than that because he is so clever and Maths is running in his blood but as for me however much I try I don't think I can get anything better. I long to be like him but his success is due to intelligence which I lack.

This finding concurs with those of Carrington, Tymms and Merrell (2005, 2008), Martin and Marsh (2005), Elstad and Turmo (2009), Zirkel (2003) and Weinburgh (2000) who found no significant relationship between the role model and student science performance.

This finding however contradicts the findings of Wood (2000), Downing, Crosby and Blake (2005), Gilmartin et al. (2007), Dentith (2008), Rosser (2004), Warrington and Younger (2000), Schmid (2010), Scott and Mallinckrodt (2005), Mueller (2004), Bloor et al. (2007), Osborne and Collins (2001), Gilmartin et al. (2007), Britner and Pajares (2006) and Kashu (2014) who found a significant relationship between role model and science performance. Consequently, the afore-cited studies indicate support given by role models to the students and therefore their findings cannot be used to reflect the scenario in the current study where there was no indication of support from the role models.

3.6 Relationship between gender stereotype and performance in science

The overall correlation between gender stereotype and performance in science was found to be statistically significant at α=.05 with r= -.178 (p=.019, n=327). Thus, an increase in gender stereotype is associated with a decrease in science performance. When data were disaggregated by gender, the correlation between gender stereotype and performance in science for boys was also found to be statistically significant at α=.05 with boys having a r=-.211 (p=.018, n=200) while the correlation between gender stereotype and performance in science for girls was found to be statistically insignificant at a r=-.089 (p=.540, n=127). Put differently, the correlation between the two variables was positive, significant and stronger for boys but positive, weaker and non-significant for girls. On checking the predictive power of role model on performance of science, regression analysis was done to establish the level of relationship. Table 9 displays the result of the analysis.

Table 9 Prediction of performance in science from gender stereotype

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.374	8.784		1.636	.104
	Gender Stereotype	-4.917	1.967	-.179	-2.499	.013

The table shows that Gender Stereotype has a B weight of -4.917, a Beta weight of -.179 and a t-value of -2.499. This implies that gender stereotype negatively predicts -4.917 of changes in science performance and has a negative impact of -.179 on science performance. With a p-value of .013, this relationship is significant at a p-value <.05. The null hypothesis is therefore rejected. The study therefore finds that gender stereotype influences science performance among secondary school students in Migori county. This implies that an increase in the level of gender stereotype leads to a decrease in the level of performance in science and therefore, the more one becomes gender stereotyped the weaker the performance in science.

The current finding echoes those of previous studies by Spelke (2005), Murphy and Whitelegg (2006), Else-Quest et al. (2010), Raviv et al. (2003), Gilbert (2001) and Brickhouse et al. (2000), who found a direct link between negative gender stereotype comments and poor girl performance in science. Such comments were also blamed for the low numbers of girls in science classes as the

comments made the girls feel as though science was a 'male field'. Similarly, Huguet and Regner (2007), Halpern, 2004), Blickenstaff (2005) concurs with these findings as their studies also noticed that stereotype threat significantly impacted girls' performance negatively.

In concurrence with these findings are studies by Wigfield et.al. (2000) and Learch (2003), Onyeizugbo (2003) and Kakonge (2000) who go further to explain how negative gender stereotype beliefs impact science performance negatively. The studies opine that socio-cultural factors may influence girls' attitudes toward mathematics and science. For example, parents tend to view mathematics as more important for sons and language, arts and social studies as more important for daughters. Parents are more likely to encourage their sons to take advanced high school courses in chemistry, mathematics, and physics and have higher expectations for their success.

4.0 Conclusion and recommendation

In light of the findings of the study, it is concluded that male students in Migori county perform better than female students in all the science subjects. In addition, an increase in the level of role model does not translate to an increase in the level of science performance among students whereas gender stereotype negatively influences the level of science performance. The higher the level of a student's belief in gender stereotype notions, the lower the level of science performance and vice versa. It is therefore recommended that there needs to be meaningful intervention by the government and teachers to initiate public awareness campaigns to demystify existing negative stereotype beliefs that depict science as a preserve of the males through motivational talks, public barazas, official media platforms and social media as these beliefs have shown to negatively impact on girls' science performance.

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ARTICLE 7

The relationship between self-efficacy and academic achievement in secondary schools in Kenya

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Abstract

This study examined the relationship between self-efficacy and academic achievement among Kenyan secondary school students. It also sought to establish the level of self-efficacy of the students and if differences in self-efficacy exist between male and female students. The data was collected from 281 students (136 females and 145 males) selected from four secondary schools. The Children Perceived Self-Efficacy Scale (CPSE) questionnaire consisting of two subscales that measure self-efficacy for academic achievement was used to gather data on self-efficacy with express permission by the author_ Albert Bandura. Academic achievement data was also used and obtained from students' classroom academic performance records. The data was analyzed using descriptive and inferential statistics. Pearson correlation analysis was used to examine the relationship between self-efficacy and achievement while independent samples t-test was used to examine the difference in the level of self-efficacy between male and female students. The results of the study revealed a moderate level of self-efficacy among the students. Moreover, a significant relationship between the students' self-efficacy and academic achievement was found. However, no statistically significant difference between males and females in self-efficacy was found. This may mean that there are challenges reaching worthwhile learning goals. Further they may not be able to control their anxiety and stress as well when goals are not reached. From the findings, it was recommended that teachers should improve self-efficacy beliefs of the students by (i) using peer models, (ii) using moderately difficult tasks, (iii) encouraging the students to set goals, (iv) altering emotional states of learners, and (v) using performance-contingent

Key words: *Self-efficacy; Academic achievement*

1.0 Introduction

Academic achievement is essential in placement and upward mobility and the academic world is looking at ways in which it can be facilitated into the learning process. One of the areas of interest is "self-efficacy" which the study is based. According to Schunk (1991), self-efficacy is concerned with an individual's judgments of his or her capabilities to perform given actions. Unlike other self-constructs, such as self-concept, self-efficacy is not about personal characteristics such as physical and psychological traits. As such, students judge their capabilities to accomplish tasks and not their traits. These beliefs are multidimensional and thus linked to different domains of functioning. Consequently, efficacy beliefs for biology may differ from those of chemistry. Efficacy beliefs are also context-dependent. For instance, students may exhibit a higher sense of

self-efficacy to learn in high-performing schools than in low-performing schools. Measures of self-efficacy depend on a mastery criterion of performance rather than normative or other criteria (Bandura, 1997). Therefore, students can rate their certainty in solving academic problems of varying difficulty, not how well they expect to perform in comparison to others. Self-efficacy is usually assessed before an activity is performed. This provides a temporal ordering for assessing self-efficacy beliefs in causal structures

Students with high levels of self-efficacy believe that: success is forthcoming, that they have abilities to reach worthwhile goals, that they can control their anxiety and stress when goals are not reached, and that they are in control of their environment (Bandura, 1997). When highly efficacious students encounter challenging tasks, they expend high effort. They also persist longer when goals are not initially reached. When it comes to strategy use, they discard strategies that seem unproductive. These characteristics enable them to be having higher academic achievement than students with low self-efficacy.

Conversely, low efficacious students believe that future success is not forthcoming and that they cannot control their environment. They also experience and depression and easily give up when goals are not initially reached (Bandura, 1997). In strategy use, students with low self-efficacy continue to use the same strategies even when they seem to be unproductive (Wiseman & Hunt, 2013). Moreover, they avoid challenging tasks, and when they encounter such tasks, they expend low effort. These attributes make low efficacious students perform poorly in academic tasks than high efficacious students of the same ability.

According to Bandura (1997), self-efficacy is not the only factor that influences behaviour. Factors such as requisite skills, students' values, and outcome expectations do have an influence on behaviour. Students with low skills and high sense of self-efficacy cannot produce competent performance (Schunk, 1995). It, therefore, implies that it takes more than high self-efficacy levels to produce high achievements. The role of self-efficacy in performance is to enable an individual to strive harder and become motivated to acquire the necessary skills and to make the best use of the skills in performance (Jane, 2014). Similarly, highly efficacious students might not perform well if they lack the values to pursue a particular task (Wigfield, Tonks, & Eccles, 2004). Also, outcome expectations affect behaviour. Students participate in activities that they think will yield positive results and avoid those that they believe may produce negative outcomes (Zimmerman & Schunk, 2001).

It has been found that efficacy beliefs influence self-regulation (Zimmerman, 1995). Self-regulation involves regulation of one's learning process through processes such as goal setting, self-evaluation, strategy use and planning. Through the use of such self-regulatory processes, self-efficacy beliefs provide students with a sense of agency to motivate their learning (Zimmerman, 2000). Social cognitive theory posits that self-regulated learners direct their learning processes and attainments by setting challenging goals for themselves, by using effective strategies to reach their goals, and by enlisting self-regulative influences that motivate and guide their efforts (Zimmerman, Bandura, & Martinez-Pons, 1992). Students with higher efficacy beliefs about their learning ought to be more apt to employ self-regulation and create effective environments for

learning (Zimmerman & Schunk, 2001). Self-efficacy, along with self-regulation, have also been found to have an impact on academic achievement (Schunk & Zimmerman, 2007).

Efficacy beliefs have also been reported to influence career-related choices. Lent, Brown, and Larkin (1986) investigating self-efficacy and its prediction of academic performance and perceived career options found out that efficacy beliefs were highly correlated with career choice, academic grades, and perseverance. Moreover, efficacy beliefs predicted grades and career choices in scientific fields. Positive correlation and statistically significant associations have also been reported between self-efficacy beliefs, academic achievement and persistence (Lent, Brown, & Larkin, 1984; Multon, Brown, & Lent, 1991).

The purpose of this study was to determine the relationship between self-efficacy and academic achievement among secondary school students in Kenya. Specifically, the study aimed to:

i. Determine the level of self-efficacy

ii. Determine the relationship between students' self-efficacy and academic achievement among secondary school students.

iii. Determine if gender is a factor in self-efficacy.

2.0 Methodology

2.1 Research design

The study employed quantitative research methods applying descriptive research design in order to address research objectives. Descriptive research is designed to provide a precise and valid representation of the variables that are relevant to the research question. According to Taylor, Kermode, and Roberts (2006), this type of research describes phenomena in order to answer research questions.

2.2 Sample and sampling procedure

The sample for this study was derived from students in Kenyan secondary schools. The study targeted form three students. The schools used in the study were sampled purposively. Purposive sampling involves selecting individuals as samples based on some specific characteristics of interest (Johnson & Christensen, 2012). For this study, the schools were purposively selected based on the mean score in Kenya Certificate of Secondary Education (KCSE) in the year 2013. Two low-performing schools (a boys' and a girls' schools with mean scores of 4.5 and 4.97 respectively) and two high-performing schools (a boys' and a girls' school with mean scores of 11.2 and 9.83 respectively) were selected for the study (see table below). From each of the four schools, eighty (80) students were recruited to participate in the study. Therefore, the final sample for the study consisted of 320 participants.

Table 1. 1: Category of schools by KCSE mean scores

Category of school	2013 KCSE Mean Scores
High-performing males	11.20
High-performing females	9.83
Low-performing males	4.50

Low-performing females	4.97

Source: County Director of Education office, Kiambu

2.3 Data Collection Instrument

A questionnaire was used in gathering information from students to collect data on efficacy scales. It comprised of 37 items, which represent seven domains of functioning- self-efficacy for academic achievement, self-efficacy for self-regulated learning, self-efficacy for leisure and extracurricular activities, self-regulatory efficacy, perceived social self-efficacy, self-assertive efficacy, and perceived self-efficacy to meet others' expectations (Pastorelli et al., 2001). Two subscales from the CPSE were selected to be used in the study: self-efficacy for academic achievement and self-efficacy for self-regulated learning domains of CPSE because they measure perceived academic self-efficacy. Furthermore, questionnaires were used to collect classroom assessment scores at the end of term two (2014), end of term three (2014), and end of term one (2015) in nine key subjects: Mathematics, Geography, Biology, Chemistry, Physics, English grammar, English Literature, History, and Foreign Languages.

3.0 Findings

3.1 Objective 1: To determine the level of self-efficacy

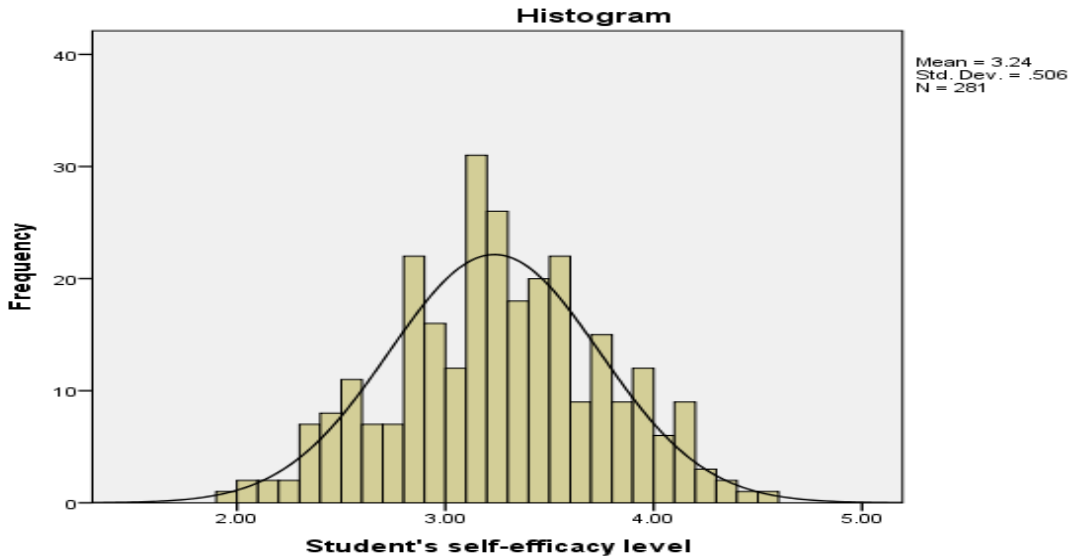
To address the objective, descriptive analysis (frequencies) was conducted in SPSS. The results show that the minimum self-efficacy score of the students is 1.95 and the maximum 4.55. On the other hand, the students' self-efficacy mean score is 3.24 and standard deviation .51. Also, a histogram produced to test normality of self-efficacy scores showed that the scores were approximately normally distributed.

Table 1. 2: Descriptive statistics of students' overall self-efficacy scores

Descriptive Statistics

	Mean	Std. Deviation	N	Minimum	Maximum
Student's self-efficacy level	3.24	.51	281		
				1.95	4.55

Figure 4. 1: Distribution of students' self- efficacy scores

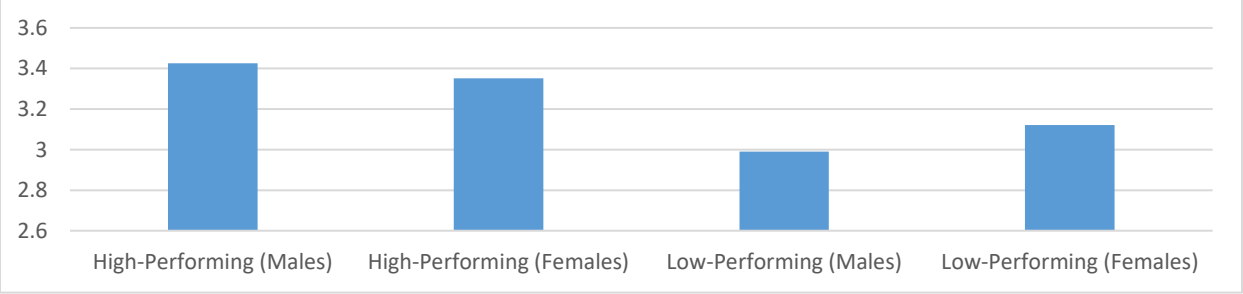


Descriptive analysis was also conducted to determine the level of self-efficacy in each of the four categories of schools. High-performing male students reported the highest self-efficacy mean scores, (M = 3.42, SD = .47), followed by high-performing female students (M = 3.35, SD = .38), then low-performing female students (M = 3.12, SD = .0.53), and lastly low-performing male students (M = 2.99, SD = .53).

Table 1.3: Descriptive statistics for self-efficacy scores by school category

	N	Mean	Standard dev.
High-performing (Males)	75	3.42	0.47
High-performing (Females)	80	3.35	0.38
Low-performing (Males)	70	2.99	0.53
Low-performing (Females)	56	3.12	0.53
Total	281	3.24	0.51

Figure 1.4: Students' self-efficacy mean scores by school category



3.2 Objective Two: To determine the relationship between students' self-efficacy and academic achievement among secondary school students.

To address this objective, both descriptive and inferential analysis were utilized. Results of descriptive analysis showed that the students' self-efficacy mean score was 3.24 while the standard deviation was 0.51. The minimum and maximum self-efficacy scores were 1.95 and 4.55 respectively. On the other hand, students' academic performance mean score was 51. The standard deviation, minimum self-efficacy scores, and maximum academic performance scores were 14.04, 17.08, and 86.33 respectively.

Table 1.5: Descriptive statistics of Students' self-efficacy and academic performance scores

Descriptive Statistics

	Mean	Std. Deviation	N	Minimum	Maximum
Students' self-efficacy level	3.24	.51	281	1.95	4.55
Students' academic performance	51	14.04	281	17.08	86.33

Pearson's product-moment correlation procedure was also conducted to determine the relationship between students' self-efficacy and academic achievement. Before the analysis was conducted, the data were screened for outliers. To detect outliers, participant's self-efficacy scores and academic achievement scores were converted to standard score equivalents. Outliers were those cases associated with large standard z-score values, smaller than -3.0 and greater than +3.0. This process did not reveal any outliers in the data. Next, normality assumption was tested using histograms. The distributions of student's self-efficacy scores and academic achievement scores are displayed in Figures 4.6 and 4.7, respectively. Both histograms revealed that the sample self-efficacy scores and academic achievement scores were approximately normally distributed. The two variables had a linear relationship as examined by scatter plot.

Figure 4. 2: Distribution of students' self- efficacy scores

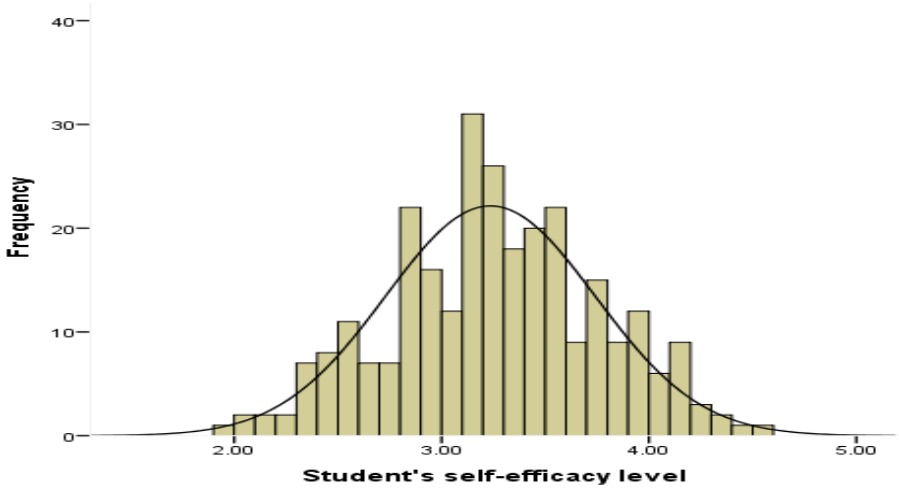


Figure 4. 3: Distribution of students' academic achievement scores

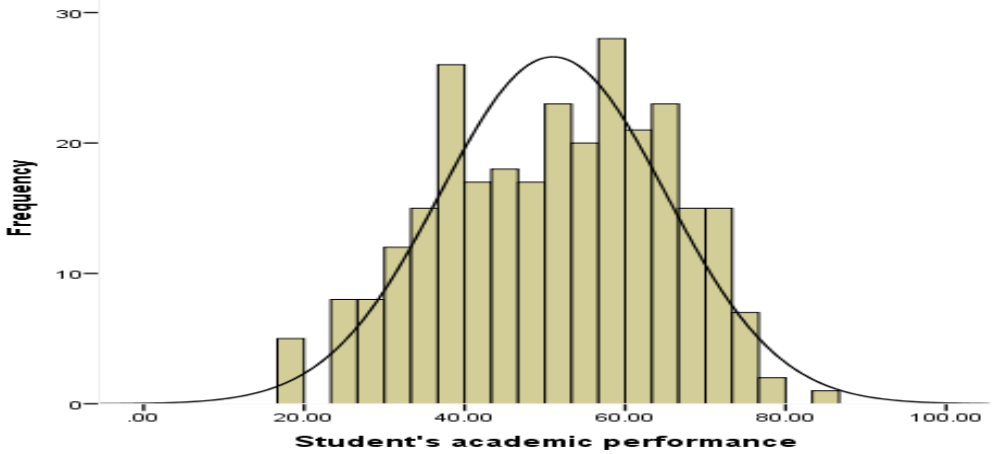
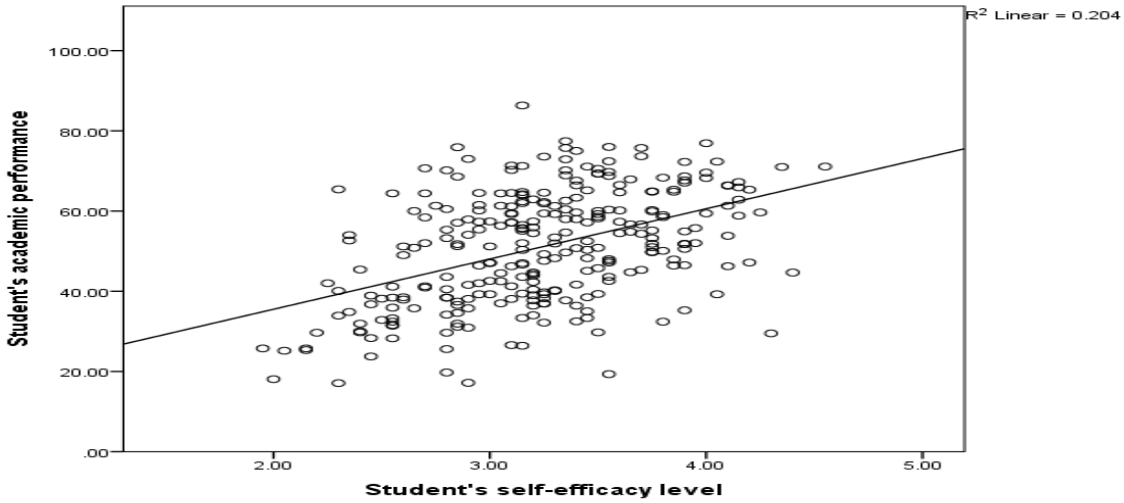


Figure 4. 4: Scatter plot showing the relationship between students' SE and AP



The results of Pearson product-moment correlation analysis established a significant correlation coefficient between student's self-efficacy and students' academic achievement was found, r (279) = 0.45, p< .05. The relationship is positive since the Pearson product-moment correlation coefficient, r, is .45 and, therefore, it can be observed that students with higher self-efficacy tend to have higher academic achievement.

Table 1.6: Pearson Correlation coefficient on students' self-efficacy and academic achievement

		Students' self-efficacy level	Students' academic performance
Student's self-efficacy level	Pearson Correlation	1	.45**
	Sig. (2-tailed)		.00

	N	281	281
Student's academic performance	Pearson Correlation	.45**	1
	Sig. (2-tailed)	.00	
	N	281	281

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

3.3 Objective Three: To determine if gender is a factor in self-efficacy

To address this objective, an independent-samples t-test was conducted to evaluate whether males and females differed significantly on self-efficacy scores. The data were screened for outliers. To detect outliers, participant's self-efficacy scores were converted to standard score equivalents. Outliers were those cases associated with large standard z-score values, smaller than -3.0 and greater than +3.0. This process did not reveal any outliers in the data. Next, normality assumption was tested using histograms. The distributions of student self-efficacy, for male and female students, are displayed in Figures 4.9 and 4.10, respectively. Both histograms revealed that the sample self-efficacy scores were approximately normally distributed. Levene's test was not significant, an indication that the groups had equal error variances.

Figure 1.7: Distribution of male students' self- efficacy scares

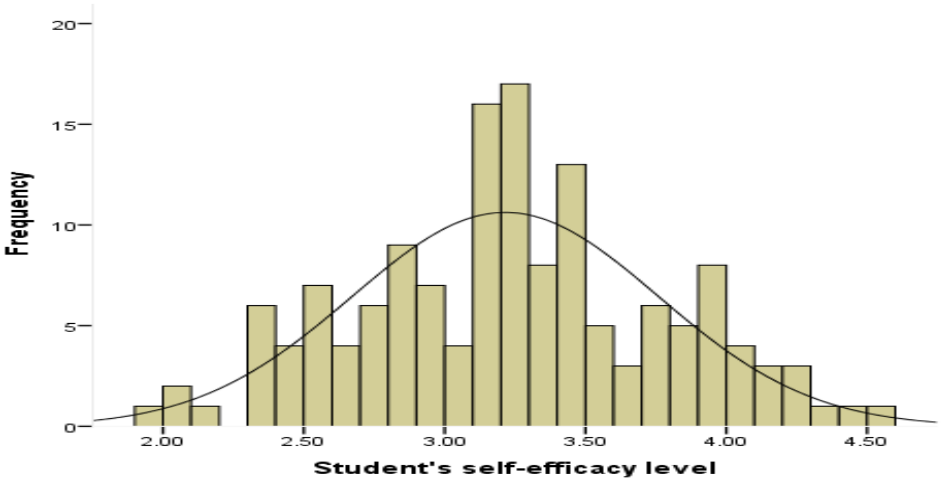
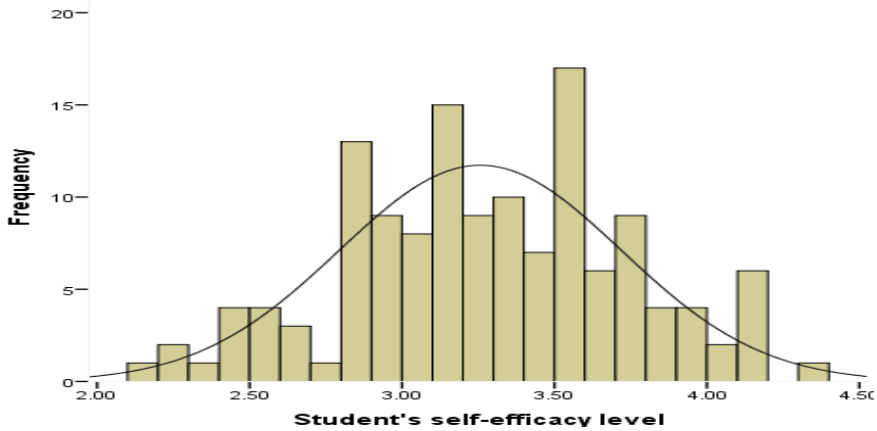


Figure 1.8: Distribution of female students' self- efficacy scores



The t-test procedure (see Table 2.0) revealed no significant difference between male and female students self-efficacy (t (279) = -.69, p = .49). An examination of the group means shows that female students (M = 3.23, SD = .53), had a slightly higher self-efficacy scores than male students (M = 3.21, SD = .54) though the difference was not significant (p = .49). These results are shown in Table 1.9 below.

Table 1.9: Student's Self-efficacy level by Gender

	Student's gender	N	Mean	Std. Deviation	Std. Error Mean
Student's self-efficacy level	Male	145	3.21	.54	.05
	Female	136	3.23	.53	.05

Table 2.1: Independent T-test Results

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig	t	df	Sig. (2 tailed)	Mean difference	Std error difference	95% Confidence interval of the difference	
									Lower	Upper
Students Self-efficacy level	Equal variances assumed	2.07	.15	-.69	279	.49	.041	.061	-.16	.08

4.0 Discussion

4.1 Objective One: To determine the level of self-efficacy

Descriptive analysis was conducted to obtain the overall students' self-efficacy level and also to get the students' self-efficacy level in each of the four schools. Analysis results showed that the overall students' self-efficacy mean score is 3.23. This is a moderate level of self-efficacy given that the CPSE scale used in the study was a Likert scale with 1 as the lowest on the self-efficacy scale and 5 as the highest rating on the self-efficacy scale.

On the other hand, descriptive analysis of students' self-efficacy per each school showed that high-performing male students had the highest self-efficacy mean scores, (M = 3.42, SD = .47), followed by high-performing female students (M = 3.35, SD = .38), then low-performing female students (M = 3.12, SD = .0.53), and lastly low-performing male students (M = 2.99, SD = .53).

From the analysis, it can be seen that high-performing male and female students had higher self-efficacy mean scores than their low-performing counterparts. These results are supported by Bandura's Social Cognitive theory that asserts that vicarious experience is one of the sources of self-efficacy (Bandura, 1997). Vicarious experiences involve observing other individuals, similar

to oneself, perform a task successfully (Bandura, 1997). This enhances observer's belief that he or she also can succeed in the same activity. On the other hand, seeing others fail in particular task lowers an observer's judgment of his or her capability to accomplish the same task. It is believed that the high levels of self-efficacy mean scores in high-performing boys and girls can be attributed to both vicarious experience since they came from high-performing schools. Similarly, low levels of self-efficacy seen in low-performing boys and girls can be attributed to vicarious experience since they were drawn from low-performing schools.

4.2 Objective Two: To determine the relationship between students' self-efficacy and academic achievement among secondary school students

To address this research objective, Pearson correlation analysis was conducted in SPSS 20. The independent variable was student's self-efficacy scores, and the academic achievement was the dependent variable. Preliminary analysis revealed that the data had no outliers, had a linear relationship, and did not violate normality assumptions.

Correlational analysis revealed a significant relationship between students' self-efficacy and academic achievement, r (279) = .45 $p < .05$). This indicates that students with higher levels of self-efficacy tend to have higher academic achievement while those with lower levels of self-efficacy tend to have lower academic achievement. Other researchers (Akram & Ghazanfar, 2014; De Fátima Goulão, 2014; Shkullaku, 2013) have also found positive correlations between self-efficacy and academic achievement.

Even though a positive correlation between self-efficacy and academic achievement was found, the relationship was moderate as indicated by Pearson's correlation coefficient, r = .45. A possible explanation for the moderate relationship is that academic achievement is affected by other factors other than self-efficacy. According to Ary and Ary (2014), "when an independent variable cannot be controlled in a study, alternative explanations such as the presence of other independent variables must be considered". Other factors which may have an effect on students' academic achievement include teacher and classroom context (Sanders, Wright, & Horn, 1997), motivation, interest, and academic engagement (Singh, Granville, & Dika, 2002).

Another possible explanation for the moderate correlation between self-efficacy and academic achievement is reverse causality. That is, it is not known whether higher academic achievement leads to higher self-efficacy or if higher self-efficacy causes higher academic achievement. In this case, reverse causation has to be considered. It could be that, if a student performs well in academics, this could make the student to develop a higher sense of self-efficacy.

4.3 Objective Three: To determine if gender is a factor in self-efficacy

To address the third objective of the study, a t-test procedure was conducted. The *t*-test procedure revealed no significant difference between male and female students' self-efficacy (t (279) = -.69, p = .49). Similar findings have been reported by other researchers (De Fátima Goulão, 2014). Contrary to this, other studies have shown statistically significant differences between gender and self-efficacy (Akram & Ghazanfar, 2014; Momanyi, Ogoma, & Misigo, 2011; Shkullaku, 2013). Moreover, gender differences in self-efficacy have been reported in different academic subjects.

For instance, females have shown higher self-efficacy levels in languages and arts than males while their male counterparts have exhibited higher self-efficacy levels in mathematics and sciences (Huang, 2013).

Even though there was no significant difference in self-efficacy scores of both groups of students, the female students (M = 3.23, SD = .54), had a slightly higher self-efficacy scores than the male students (M = 3.21, SD =.54). This was a moderate level of self-efficacy given that the CPSE scale used in the study was a Likert scale with 1 as the lowest on the self-efficacy scale and 5 as the highest rating on the self-efficacy scale.

5.0 Conclusion

The study concludes that a significant relationship exists between self-efficacy and academic achievement since highly efficacious students are more likely to have higher academic achievement as compared to their inefficacious counterparts. Based on the results of the study that show that self-efficacy is important in academic achievement, educational stakeholders should create an environment that fosters students' self-efficacy. Enhancing of self-efficacy beliefs will hopefully lead to higher academic achievement. Also, it was established a moderate students' self-efficacy hence a need to enhance these beliefs. In addition, the study findings indicate that female and male students did not significantly differ in self-efficacy.

6.0 Recommendations

Based on the findings of this study, it is important for teachers to help the students to develop a good sense of self-efficacy, as high efficacy beliefs are key to academic achievement. Thus, the study recommends:

a) The use of peer models by teachers to enhance students' efficacy beliefs by watching a peer successfully complete a task.
b) The use of moderately-difficult tasks by teachers because tasks that are too difficult for students lowers their efficacy beliefs while those that are too may not enhance efficacy beliefs since they do not provide new information on student's competence.
c) The setting of goals by the students as they provide students with criteria against which they can compare their academic achievement. When a student fails to achieve set goals, they become more motivated to increase efforts towards achieving the goals.
d) The enhancement of students' efficacy beliefs through the use of performance-contingent rewards that match the quality and level of academic performance of the student inform the student of his or her improvement as well as his or her progress towards attaining goals.

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ARTICLE 8

Inclusive STEM education for learners with special needs: A case study for Itekeng Junior Secondary School mixed ability Integrated Science results in Gantsi Botswana

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Abstract

The educators, researchers and policy makers in education world-wide in the recent years have been advocating for inclusive education. Consequently, the teaching and learning of Science Technology Engineering and Mathematical (STEM) was not an exception in this paradigm shift. Countries across the globe have immensely invested in Science, Mathematics and Engineering subjects, this has helped countries such as United States of America and Japan to experience significant grow in their economies. This is because STEM education creates critical thinkers, innovators and problem solvers. The government of Botswana through the ministry of Tertiary Education, Research, Science and Technology have put measures in place to enhance teaching and learning of STEM subjects in schools. The Botswana Revised National Policy on Education (RNPE, 1994) and Vision 2016 emphasized on the need to provide equal access to education for all children. This study focused on the academic performance of students with special needs in Integrated Science. Students' performance in Integrated Science is very low despite the good strategies in place aiming at encouraging good performance. If students are performing way below average, it automatically disadvantages them to do a Science related career. Both qualitative and quantity approach research methods were used on the collected secondary data from Botswana Examination Council (BEC). Data analysis was done using Statistic Package for Social Sciences (SPSS) software. The results in the study recorded a great drop from 18.6% -10.9% between the years 2018 - 2019. Most students in Integrated Science got grade D and E followed by grade U (ungraded) ranging from 20.77% to 28% for the years 2014 to 2017. This suggested that method used in teaching mixed classes of STEM need reconsideration.

Keywords: *Mixed learning abilities, Integrated Science, special needs, teaching methodology, Science Technology Engineering and Mathematics, Botswana Examination Council.*

1. Introduction

In Botswana teaching and learning of Science and Mathematics is regarded as one of the critical aspects of national development goal. The country has taken a stance in investing in human resource development moving from mineral resource-based economy. The critical subjects are in areas of Science and Technology. The results from secondary school leavers show low performance in Science and Mathematics subjects. This study evaluated the performance of learners in an inclusive STEM education of learners with special needs.

2. Background

Over the recent years the educational theorists have advocated for inclusive education across the globe. According to UNESCO (2008), inclusive education is defined as transformations in schools and other centres of learning implemented to cater for learners from different backgrounds including ethnic minorities, rural populations, those affected by HIV/AIDS and those with learning disabilities/ difficulties (UNESCO, 2008). In Botswana, inclusive education is adopted as a way of ensuring that all citizens have equal access to education. This willingness is demonstrated by the government through ministries of Basic Education and Local Government and Rural Development providing for basic needs of orphans, venerable and needy students. Furthermore, according to Botswana Revised National Policy on Education (RNPE, 1994), all students are provided with the equal access, same curriculum and materials under same teaching and learning environment.

Under inclusive education, students are mixed in the learning environment and the teacher has the duty to teach the students with different learning styles, backgrounds and health. Therefore, the role of the teacher to ensure that all students understand the concepts of different subjects taught in each day. This put the teachers under mammoth challenge to vary teaching methods in a mixed class to meet the needs of every student. Nugroch and Prasetyo (2019), stated that the process of teaching learners in a mixed class involves various elements which are influenced by the environment. However, Liberman (2017), argued that a universal design is recommended for use in delivering content to students with learning difficulties. The authors alluded that the design is best designed as a scientific framework that guides learning practices which provides the flexibility of presenting information, giving students greater freedom to respond and demonstrate their knowledge and skills (Nugroch & Prasetyo, 2019). In a mixed class, students are exposed to similar education experiences in learning science, which may affect their performances. In an inclusive class set-up, there are students with various abilities such as gifted, moderate and severe intellectual disabilities and all these students require intensive support that is individually planned and coordinated for their individual needs (Collins, 2007). It is therefore against this backdrop that students in science need intrinsic attention to ensure that relevant teaching methodology, which will address each learner's expectation.

Teachers play a crucial role in ensuring that the policy of inclusive education is realised, therefore, they need to have expertise and understanding of the teaching technique which works best in classrooms (Mangope, 2017). According to Iloanya (2014), some instructional teaching materials used by teachers sometimes do not cater for the abilities of all the students to meet the students intended learning outcomes. There is a possibility that this might be so because the training institutions in Botswana train teachers mostly for above average students. This may end up creating a skills gap on teaching students with varying educational needs (Iloanya, 2014). According to White (1996), Virtanen *et. al.,* (1999), Aspegran *et. al.,* (1998) learning of science should be done in an environment that will activate prior knowledge, encouraging and facilitating new learning in which this knowledge will be required in real world situation. The methodology of instruction is such that the students of science should construct their own understand and knowledge through

experiencing things and reflecting on those experiences (Akcay, 2009). The current teaching methodologies which are used in teaching in case on Itekeng Junior Secondary School, personal oral interview, *inter alia* though not limited to discussion, research, expository, group work and lecturing need reconsideration with a view to improve students' performance. The teaching methodologies used as seen in lesson plans and scheme books are not ideal for slow learners and therefore need reconsideration for a possible change that will favour slow learners as well.

3. Materials and Methods

The study was done in Itekeng Junior Secondary School located in Gantsi township, North West Educational Region, Gantsi District, Botswana.

3.1 Methodology and data collection

Students were assigned to classes, 40 students *per* class in a mixed ability (below and above average). Teaching methods were the same throughout the teaching time and students were examined by Botswana Examination Council following quality assurance measures. Data was collected within a six-year period beginning 2014 to 2019 and tabulated in **figures 1** and **2** shown below. Data from BEC is presented in excel sheets in national regions, schools and individual students. The collected data was analysed quantitatively.

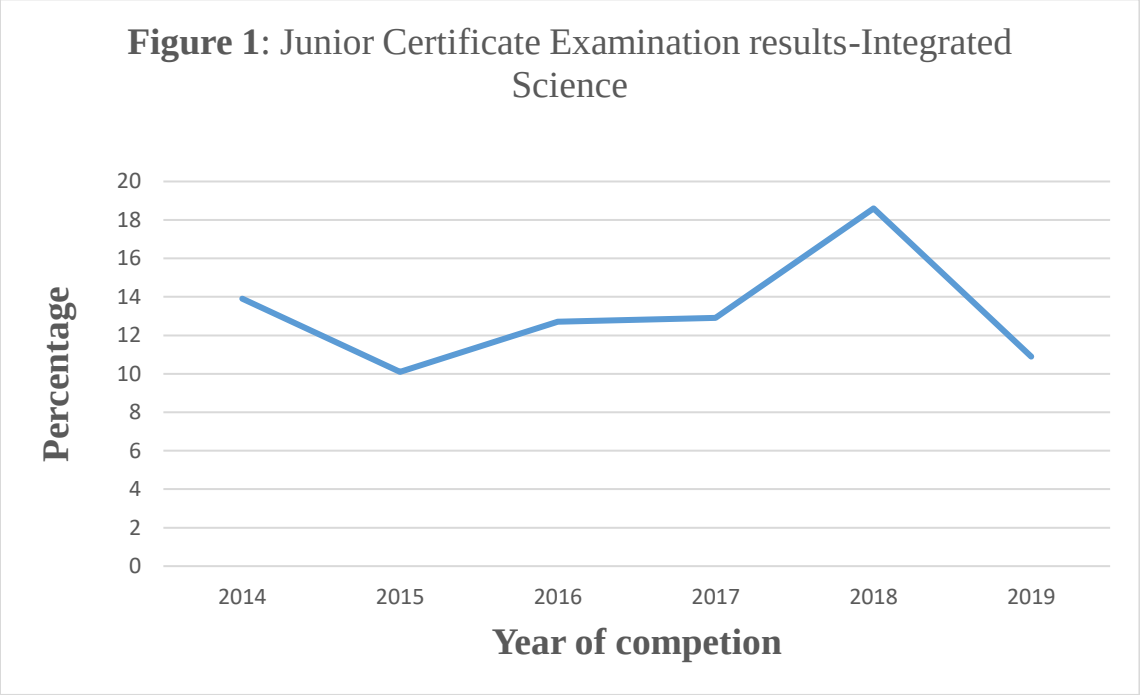


Figure 1: Junior Certificate Examination results-Integrated Science

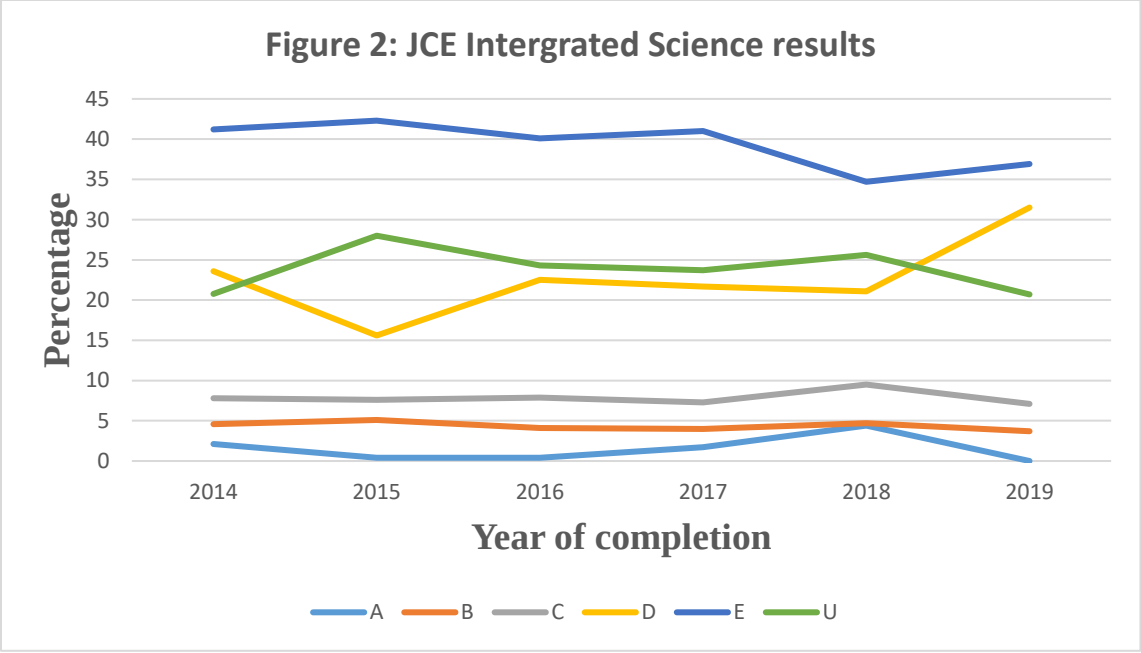
4. Results

The results depicted in figure 1 indicates significantly (<0.05) low performance by students in the year 2014 to 2019. Baseline set for students *per* subject including integrated science was 60% and the outcome in figure 1 is a clear indication that there is a problem that needs intervention. Some of the factors of particular concern which affect students' performance *inter alia* are teaching methods,

learning styles, curriculum, syllabus coverage, students' assessment patterns and student feedback timeliness. Other factors of concern that might have a vast contribution to low performance are shortage of resource learning materials, shortage of laboratories, sudden massive transfers of teachers, teacher student ratio, demotivated teachers, lack of student motivation, students' indiscipline and bulky integrated science syllabus. Failure to complete the syllabus by students before final examination was a contributory factor as well.

There was a sharp drop in the year 2019 (figure 1) and this was affected by the increase by students who attained grade D (figure 2). The poor performance by students might have been the fact that the students were not assessed internally before they wrote Junior Certificate Examinations (JCE). The reason advanced for not writing tests and end of term examinations was that there was a problem of the duplication machine, and it did not only affect the completing classes but the whole school. Massive transfers of science teachers which took some time to get a replacement also played some part in the performance of students.

Teachers desire to have all their learners perform well and integrated science is not an exception. They spend quality time delivering packed syllabus to students with mixed abilities and the teaching methodologies unfortunately seemed not to work for students with LD. Mostly methods used are lecture methods, discussion, expository and research most of these methods disadvantage the learners. figure 2 below shows some of the grades attained by students and are very low and academically disturbing. Most students attained grades D, E and U and is shown below.



5. Discussion

The results recorded a great drop from 18.6% -10.9% between the years 2018 - 2019. Most students in Integrated Science got grade D and E followed by grade U (ungraded) ranging from 20.77% to 28% for the years 2014 to 2017 as indicated in figure 1 and 2 above. Teaching and learning of science are supposed to help with the cognitive development of students since it

engages problem solving, critical thinking and analytic skills. Currently science curricula in middle/junior schools are failing because teachers and students have limited time to cater for innovation, explorations, and experimentations (Candrasekaran *et al* 2014). The question therefore arises whether integrated science is taught in the manner that students get actively involved during lessons and can they apply the learned concepts during examinations. High classroom student–teacher ratio and resources are directly affecting integrated science learning, the shortage of resourced laboratories, limited internet, and shortage of textbooks might be a cause to low or poor performance. Students learn better when they do experiments since they recall what they did practically. In case of Itekeng Junior Secondary School, most of the teaching delivery methods are discussion by teacher with students and teacher demonstrations which are teacher-centred methods.

The student's poor performance can also be attributed by perceptual and motor problems which they have (Abosi and Kandjii-Murai, 1995), so this calls for teachers to be equipped to cater for various students learning abilities. Furthermore, the authors argued that the background of some of the students may predispose them to school failure because the children have not been prepared to understand or made comfortable in the classroom. Stakes and Hornby (2000) found out that most students who perform badly were found that they have dyslexia, which makes learning very difficult and exhibit low performance.

Attention getter methods are the best for slow learners. It has been found that implementation of lesson plans with real object as learning source and Big Book as media increase the interest of lower achieving students to learn science (Nugorho and Prasetyo, 2019). The authors further alluded that the curriculum design should be such that it is modified so that it fulfils the academic needs for the slow learner. According to Nugorho and Prasetyo (2019), enlarging pictures and reading text makes slow learners interested to look at the pictures and read more. Big Book also makes learning more meaningful and fun because it contains short sentences, clear and interesting pictures with clear legible vocabulary (Normalisa and Ibrahim, 2010). Most of the students perform poorly probably due to the methodology of instruction in lessons. Some students are unable to read, and their confidence is affected negatively in case of use of discussion or presentation methods. Boredom and comprehensive note taking and note reading discourages slow learners.

With virtual simulations, students visualize and interact with concepts outside the realm of a traditional science laboratory. Students can be hands-on and manipulate the microscopic cell or variables such as gravity and friction. Some simulations offer a full laboratory experience, thus allowing students to participate in laboratories that are typically reserved for teacher demonstrations (Angelo *et al* 2014). The authors further argue that when students are exposed to the simulation methods in the laboratory helps students to learn with fun which keeps students focused throughout. According to Hornby and Stakes (2000), visual aids and audio encourage students with learning difficulties, this agrees with Angelo *et al* 2014. The findings of this paper, is incongruent with the use visual aids and audio clips encourage students with learning disabilities.

Virtual laboratories on the other hand, had been introduced as the answer to the problems faced by learning institutions struggling to offer Science students the experimental learning experiences they need. Lynch and Ghergulescu (2017), argued that organizing laboratory spaces is time consuming, expensive, and requires mindfulness of health and safety regulations. Furthermore, when students are unable to attend real laboratory session, they might not get a second chance or remedial session to practice what they acquired during the lesson. According to Lynch and Ghergulescu (2017), virtual laboratories provide students with the chance to experiment repeatedly with different solutions to problems in science. Moreover, virtual laboratories can reduce the cost of running and overall maintenance of laboratory facilities, while offering students a safe environment to build up experience and enthusiasm for STEM subjects. Lynch and Ghergulescu (2017), piloted presentation of the Atomic Structure virtual lab with secondary school students that have special education needs and the results came up positive. So, this could one of the initiatives that could be taken up to check if it won't improve the results for integrated in schools. It is against this backdrop that this paper advocates for use of virtual laboratory presentation in STEM teaching. Prior to the outbreak of covid-19 pandemic, there was peer collaborated team teaching in Itekeng Junior Secondary School which was a positive initiative. It helped students through remedial teaching where teachers exchanged students and varied teaching methods. It was since halted due to various covid-19 protocols which inhibited some of the initiatives like group work and teachers exchanging students as well as restrictions on the number of students per class.

A culture of collaboration increases the viability of STEM programs (Asghar *et al*., 2012; Bruce-Davis *et al*. 2014; Herro and Quigley 2017; Lehman et al. 2014; Stohlmann *et al*. 2012; Wang *et al*. 2011). Authors further reiterated that teachers explained the importance of collaborating with other STEM teachers and university professionals to not only create an atmosphere that enhances preparation for STEM lessons, but also to model a team approach to students. STEM pedagogy required students to collaborate to solve challenges, so a teacher modelling the strength of a group approach is beneficial. One teacher noted that teachers had been siloed in the past, and an integrated team approach was necessary for STEM planning and implementation (Asghar *et al*. 2012). Other teachers attributed much of their success with STEM to partnerships with university faculty and accessing the expertise in their community (Lehman *et al*. 2014). These supports helped the teachers feel comfortable taking risks and delving deeper into STEM concepts outside their comfort areas. The state of science education today is influenced by several problems specifically the issue of inadequate instructional materials and teaching tools aligned to the learning outcomes prescribed by the department of education. Teachers find it difficult to teach some science concepts and principles due to the scarcity of relevant, responsive, and research-based learning materials. According to Jalmasco (2014), the lack of science education facilities is reflected in the poor quality of basic science and math education seen by the low achievement scores of Filipino students in various tests, and this agrees with what the findings in this paper as shown by low performance by students. Generally, in Botswana there are limited resourced science laboratories which makes it difficult to teach and do practicals with students, therefore these findings are in agreement with the Filipino study. Flores (2008) found that students with varied

learning styles clearly preferred activities that matched their learning styles. Furthermore, Rogayan and Dollete (2016) further reiterated that the use of workbooks after lesson improved marks. It is against this backdrop that this paper seeks to recommend the use of simplified workbooks to enhance good performance. The current system mostly provides textbooks that are not actually simplified for slow learners, and this creates a barrier for mixed ability class as slow learners find it difficult to use.

6. Conclusions

Teachers need quality curriculum that aligns with learners' ability and the guidelines should include formative assessment techniques teachers can use to assess their students' conceptual understandings. Integration of methodologies and technologies suitable for slow learners will improve performance as it will cultivate students' motivation. Inclusive education curriculum on the other hand needs review so that learners are allowed to do what they can according to their needs and ability. STEM is not difficult as secondary students perceive and to make it doable and encouraging good performance appropriate methods of delivery are key. Provision of resources such as laboratories, equipment and reagents for experiments to be secured so that learners can be able carry out experiments.

7. Recommendations

This paper recommends that there be a review in curriculum to cater for students with learning disabilities. The teaching of integrated science to be separated into different subjects just like in senior secondary school where chemistry, biology and physics are taught separately. Teachers who are principal policy implementers should be trained to teach slow learners. As it stands currently teachers who teach STEM are trained to teach average to above average students and this also affect STEM results negatively. A deliberate position on selecting only high achievers and those interested in STEM should be allowed to study science related subjects. Students should be allowed to choose what they like and have the ability to successfully complete it. Itekeng Secondary School should have resources and infrastructure specifically for special needs students.

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ARTICLE 9

Number of household members, caretakers' family income and science academic performance of orphaned secondary school learners in the central district of Botswana

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Abstract

The extent to which orphaned learners receive support and care from the community and at home is key towards academic performance. The purpose of this inferential-survey study was to establish how number of household members and caretakers' family income influences Botswana senior secondary schools' learners' academic performance in Science: Double Award (SDA) in the Central District. A questionnaire with closed ended items was administered to 233 form 5 orphaned learners. To test the hypotheses in the null form, a One-Way Analysis of Variance (ANOVA) was performed at .05 alpha level. Data analysis was performed using Statistical Package for Social Sciences (SPSS). The findings of the study revealed that in the perception of orphaned leaners, number of household members significantly influences involvement of caretakers in their education. In addition, the results showed that orphaned learners are of the perception that, family income significantly influences care taker involvement and expected academic performance in SDA. The study recommended that the Ministry of Basic Education should establish a training program for orphaned leaners' caretakers on how best they can engage in the upbringing that contributes to good academic performance. The other recommendation was; the Government of Botswana through the Ministry of Local Government and Rural development should review support programmes for orphans and consider providing incentives to caretakers who are of low family income to boost their morale. It was also recommended that more research could be carried out to determine other factors which influence Science academic performance among orphaned and non-orphaned learners.

Key Words: *expected academic performance. caretaker involvement, family income, household members.*

1.0 Introduction

Educational environments exist in order to provide excellent academic performance. In any school's educational environment, there are learners with different backgrounds and challenges. In the end, there are vulnerable and non-vulnerable learners. Various categories of vulnerable children exist in Botswana, which include children living in remote areas, child laborers, children on the street, children in child-headed households, children in conflict with the law, those with disabilities and orphans (UNICEF annual report, 2011). This study targeted orphaned learners.

Children who have lost parents through death are exposed to various challenges. These children are referred to as orphans. Chandler (2010) holds that orphans are categorized into the following: Paternal orphans; - this is a child whose father has died, maternal orphan: - a child whose mother has died, double orphan: - a child whose both parents have died and social orphan: – a child who has lost both parents due to abandonment. The researchers focused on all types of orphans, being paternal, maternal and double orphans.

The government of Botswana has come up with various measures to ensure that the needs of orphans are met. According to Ministry of Local Government (1999):

In 1998 the Ministry of Health commissioned a rapid assessment on the situations of orphans in Botswana. The assessment pointed to the urgent need to provide support to orphans. Preliminary findings indicated among other things that food and clothing were immoderate needs of orphans. These findings prompted the government to declare the problems of orphans a national crisis that needed immediate intervention. As a result, the government of Botswana developed a Short-Term Plan of Action (STPA) for orphans. A National Orphan Care Program exists and its mandate is to ensure provision of care and support to orphans. Despite the efforts by Botswana government to support orphans, they still experience academic challenges in SDA at school.

Mushtaq and Khan (2012) pointed out that student academic performance measurement has received considerable attention in previous research, it is a challenging aspect of academic literature, and Science students' performance is affected by social, psychological, economic, environmental and personal factors. In line with this view, Olusola and Omatande (2014) alluded that some inhibiting factors affecting Science subjects learning and students' poor performance in science subjects have been identified. Even though there are numerous underlying factors of orphan hood that influence academic performance, the researchers focused on number of household members and family income of caretakers.

Number of household members in the context of this study refers to family size. According to Ella, Odok and Ella (2015), family size refers to the total number of children in a child's family in addition to the child himself. They further share the view that, larger numbered families whether rich or poor are difficult to maintain, they are characterized with a high number of children, rowdiness and this does not create convenience for learning. Once the environment is not conducive for learning, it will be very difficult for orphaned learners to concentrate on their studies resulting in poor academic performance in SDA.

Family income may be linked to academic performance because when income level of caretakers is high or medium, they will be able to provide learners with materials required for learning. Machebe, Ezegbe and Onucha (2017) pointed out that parents have a critical role to play in improving the academic achievement of their children by providing the moral, financial and maternal support needed for their children to be encouraged to perform academically at school. Acquisition of support materials is a way of investment in education. Reduced income may lead to lower investment in education. A study carried out by Morrisey, Hutchinson and Winsler (2014) established that low family income may result in poor academic performance among children.

The current study was limited to number of household members and family income of caretakers as factors which influence expected academic performance of orphaned learners hence generalizations and conclusions were based only on those variables.

1.1 Theoretical foundation

Psychological Motivational Theory called 'Maslow's Hierarchy of Needs' is the one that guided this study. For learners to be able to express their potentials, their human needs must be met. Magampa (2014) indicated that, considering how the needs are divided, "Abram Maslow Hierarchy of Needs divides the human needs into physiological, safety, belongingness, self-esteem and self-actualization". The needs are arranged in a ranked manner as shown in figure 1:

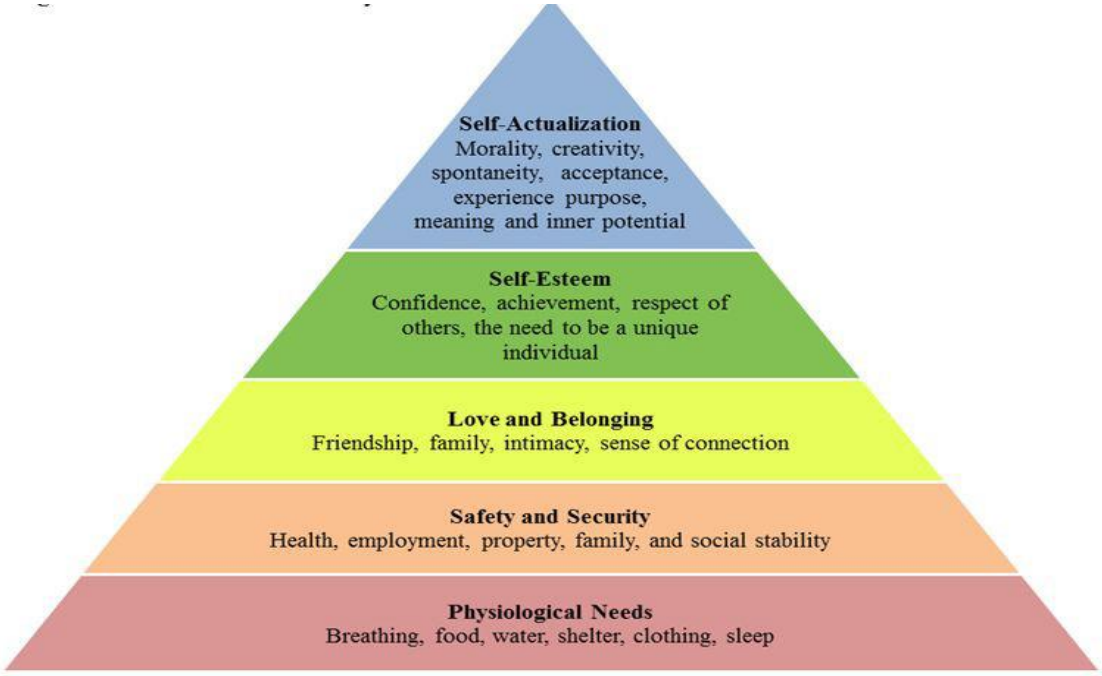

Figure1: Maslow's Hierarchy of Needs, Source: Burleson and Thoron (2014)

1.2 Problem and purpose of the study

Science is a valuable discipline in our daily life. Therefore, it is very critical that learners acquire its basic knowledge and skills. Science is valued by society because the application of scientific knowledge helps to satisfy many human basic needs and improving living standards (Rull, 2014). To support this claim, safety and security is one of the human needs proposed by Abram Maslow. According to Kaur (2013), Abram Maslow was a clinical Psychologist who introduced his theory based on personal judgment, which was generally known as the need hierarchy theory. Health is one of the aspects of safety and security needs. Fetogang (2015), asserts that the ultimate goal of education in any country is to develop human resources and build a strong manpower foundation with skills and knowledge needed for the development of such a country. For instance, health officers acquire scientific knowledge and skills which they apply when assisting patients. This

enables people to be in good health hence fulfilling the safety and security needs. Orphaned learners also have the right to have their human needs fulfilled hence the need for them to be given the opportunity to study Science and produce good results.

Owino and Nabwire (2015), assert that the increasing situation of orphan-status is incapacitating children's learning ability. Teachers extend support but there is a need for collaboration with stakeholders such as social workers so that orphaned learners could achieve excellent academic performance. Orphaned learners and non-orphaned learners are exposed to the same teaching and learning conditions but surprisingly there appears to be variation in academic performance in SDA. According to Botswana Examinations Council (BEC) 2019 Botswana General Certificate of Secondary Education (BGCSE) report, some schools declined in performance. Some of those schools formed part of this study. The researchers believe that among the learners who performed poorly, orphans were inclusive. The challenges experienced by orphaned learners affect their academic performance negatively. In the study carried out by Oyedele, Chikwature and Manyange (2016), they recommended that teachers should find a means of identifying orphaned students in class. They provide necessary support especially psychological help related to trauma of parental death. It is therefore vital for teachers to identify such learners so that they could be assisted. Even though that is the case, Mwona and Pillay (2016) proposed that the challenges deterring teachers from supporting Orphans and Vulnerable Children (OVC) include lack of time for individual attention to the OVC. In the education system of Botswana, one of the contributing factors to lack of time for individual attention for learners is large class size. The purpose of this study is an effort made to contribute a solution to orphan hood and academic performance among form 5 orphaned learners by establishing how the number of household members and family income of caretakers' influence SDA academic performance in the central district of Botswana.

1.3 Research hypotheses

H_{01}: In the perception of form 5 orphaned learners, number of household members (NHM) do not significantly influence the involvement of caretakers in their science education.

H_{02}: Family income of caretakers for form 5 secondary school orphaned learners in the central region of Botswana does not significantly influence involvement of their caretakers and their expected academic performance in sciences.

2.0 Review of related studies

Number of household members is one of the things that affect academic performance. Bysenk and Locksoh (2011) cited in (Ella, Odok & Ella, 2015), established that, most extrovert children come from smaller homes and that they adjust more easily to school environment, can express themselves easily in the classroom therefore, they achieve a greater academic performance as opposed to introverted children of larger family size. Kolk (2014), asserts that children from larger families may have lower chances of receiving adequate education, and at the same time due to interrogational transmission of fertility preferences they are likely to form large families themselves. In line with this view, Ella, Odok and Ella (2015) established that there is a significant influence of family size, family type on academic performance of secondary school students.

Contrary to this, the study conducted by Korir (2017) revealed that number of siblings had no effect on students' academic performance. Since there are different views on family size and academic performance, the researchers found it fit to establish if there is a significant relationship between number of household members and SDA academic performance of orphaned form 5 senior secondary school learners in the central region of Botswana.

Family income of caretakers is one of the factors that can affect academic performance since learners will not be able to receive adequate resources they require for learning. When caretakers are credit constrained, reduced income can result in lower investments in education. Children's ability to learn can be affected by financial hardship resulting in poor academic performance in SDA. Some published studies revealed that there is a significant relationship between family income and academic performance. For example, a study which focused on Mathematics subject conducted by Baliyan *et.al* (2015) revealed that income level has significant influence on the performance in Mathematics. Another study conducted by Kamut (2015) deduced that the higher the parents' education level, occupation status, income and their household income, the higher would be the parent's involvement in their child's education. This shows that once caretakers' income is higher, their involvement in the education will be promoted resulting in good academic performance in SDA. Even though the mentioned researchers found out that there is a significant relationship between family income and academic performance, some researchers have different views. For instance, Brembah (2013) observed that there is no significant relationship between household income and academic performance of pupils. This disparity has led to the researchers finding out if there is a significant relationship between family income and SDA academic performance of orphaned form 5 senior secondary school learners in the central region of Botswana.

3.0 Methodology

The study was inferential survey which was found to be suitable to relate family income, number of household members of the family, care taker involvement and expected performance in SDA among form 5 secondary school orphaned learners in the central district. A sample of 233 orphans completed the questionnaire where 139 (59.7%) were females while 94 (40.3%) were males and it shows that 146 (62.7%), 85 (36.5%) and 1 (.4%) of the orphans were coming from rural, semi urban and urban areas respectively.

The questionnaire made up of closed ended questions was completed by wiling orphaned participants intended to elicit their level of agreement or disagreement to each statement. There were six items that measured caretaker involvement as a dependent variable. Expected academic performance was captured by participants in form of grades for their BGCSE and was recoded as dependent variable. Number of household members was captured as a discrete variable but recoded as an independent categorical variable. Family income level was captured directly as an independent categorical variable. The tool comprised of a six Likert-scale and the Cronbach Alpha analysis of reliability of the instrument for caretaker involvement was .76. A One - Way Analysis of Variance was performed and data analysis was done using SPSS.

4.0 Data Analysis and Interpretation of Results

Table1: One-Way Analysis of Variance (ANOVA) of the Influence of Number of Household Members (NHM) and Family Income on Care Taker Involvement and Academic Performance in SDA Among Form 5 Orphaned Learners

Variable	**NHM**	**n**	$\bar{X}$	**SD**	**SE**	**Source of Variation**	**SS**	**df**	**MS**	**F**	**Sig.**
Care Taker Involvement	1 to 5	80	23.51	6.98	0.78	Between Groups	359.29	2	179.65	3.74	.025
	6 to 8	62	21.15	6.69	0.85						
	≥ 9	62	20.53	7.09	0.90	Within Groups	9649.12	201	48.01		
	Total	204	21.89	7.02	0.49	Total	10008.41	203			
Variable	Family Income	N	$\bar{X}$	SD	SE	Source of Variation	SS	Df	MS	F	Sig.
Care Taker Involvement	Low	50	19.44	7.08	1.00	Between Groups	418.95	2	209.47	4.16	.019
	Average	33	23.15	7.27	1.27						
	High	8	25.38	6.32	2.24	Within Groups	4428.44	88	50.32		
	Total	91	21.31	7.34	0.77	Total	4847.39	90			
Expected Performance in Science	Low	51	2.94	0.90	0.13	Between Group	5.30	2	2.65	3.03	.050
	Average	35	2.46	0.98	0.17						
	High	8	2.50	0.93	0.33	Within Group	79.51	91	.874		
	Total	94	2.72	0.96	0.10	Total	84.81	93			

The null hypotheses were tested by a one-way analysis of variance on whether number of household members among form 5 orphaned learners significantly influences the extent of care they receive from the caretakers in their education. Orphaned learners have indicated that number of household members significantly influences ($F(2) = F\ 3.74$, $p < .05$) involvement of caretakers in their education from the central region of Botswana and the null was rejected. In addition, results show that orphaned learners are of the perception that family income significantly influences ($F(2) = F\ 4.16$, $p < .05$) care taker involvement and expected academic performance in SDA ($F(2) = F\ 3.03$, $p < .05$). The null hypotheses were rejected (Table 1). It is then concluded that in the perception of orphaned learners, family income of their caretakers plays a role in the extent of care they receive in their education from home and their expected performance in sciences.

Table 2: Pairwise Comparism Using the Least Significance Difference (LSD) test on Number of Household Members and Family Income Influence on Caretaker Involvement and SDA Performance Among Orphaned Form 5 learners

Number of Household Members (NHM)		Mean Difference (I-J)	Std. Error	Sig.
1 to 5	6 to 8	2.367*	1.172	.045
	> 9	2.980*	1.172	.012
6 to 8	1 to 5	-2.367*	1.172	.045
	> 9	.613	1.244	.623
> 9	1 to 5	-2.980*	1.172	.012
	6 to 8	-.613	1.244	.623
Income Level		Mean Difference (I-J)	Std. Error	Sig.
Low	Average	-3.71*	1.59	.022
	High	-5.94*	2.70	.031
Average	Low	3.71*	1.59	.022
	High	-2.22	2.80	.429
High	Low	5.94*	2.70	.031
	Average	2.22	2.80	.429
Low	Average	.484*	.205	.020
	High	.441	.355	.218
Average	Low	-.484*	.205	.020
	High	-.043	.366	.907
High	Low	-.441	.355	.218
	Average	.043	.366	.907

*. The mean difference is significant at the 0.05 level.

To find out where the differences lay, a post-hoc least significant difference (LSD) test was performed in order to determine the levels or pairs of means that were significantly different and the results are presented in Table 2. The analysis shows that when the household members are 5 or less (M = 23.45) in the families of orphaned learners, care taker involvement in their education is higher than when the household members are 6 or more (M = 21.15). It is concluded that with smaller household members, orphaned learners receive more care in their education than in larger families from the caretakers at home.

Other hypotheses were tested to find out if the means are significantly different (Table 2). When family income is higher (M = 25.38), orphaned learners received more caretaker involvement than when family income is low (M = 19.44). Interestingly, when the family income is low (M = 2.94), orphaned learners expected to pass their final examination in science than when the family income is average (M = 2.46).

5.0 Discussions

The study sought to find out how the number of household members among orphaned form 5 senior secondary school learners influences SDA academic performance in the central district of Botswana. The findings revealed that smaller household members, orphaned learners receive more care in their education than in larger families from the caretakers at home. This is in agreement with the findings by Ella, Odok and Ella (2015) which states that there is a significant influence

of family size on students' academic performance. This study has contributed positively to literature since previous studies have not examined how number of household members influences academic performance rather, they focused on siblings and family size.

The study also sought to find out how family income of caretakers among orphaned form 5 senior secondary school learners influences SDA academic performance in the central district of Botswana. The data revealed that family income of caretakers plays a role in the extent of care orphaned learners receive in their education from home and their expected performance in SDA. This shows that families which are financially well-off are able to take part in the education of their children by providing the necessary resources as compared to those with low family income. For lower- income families, parents are bustle around for life and expect little from their kids, and moreover they may put subsistence before children's learning (Lin & Lv, 2017). As per the findings of this study, income level of caretakers significantly influences expected academic performance in SDA. Given that prior studies had typically considered family income and academic performance, this study focused on family income and expected academic performance. The findings of the studies that focused on family income and academic performance yielded different findings. For example, the study that was carried out by Fayegh et al, (2010) revealed that family income significantly affects academic achievement. This is contrary to Brembah (2013), who claims that there is no significant relationship between household economic status and academic performance of pupils.

The study implies that if caretakers could strengthen their involvement, then perhaps their performance would improve. Similarly, if the government could enhance support services in terms of housing probably their performance would improve.

5.1 Recommendations

The study recommends that the Ministry of Basic Education should establish a training program for orphaned leaners' caretakers on how best they can engage in the upbringing that contributes to good academic performance.

The other recommendation is; the Government of Botswana through the Ministry of Local Government and Rural development should review support programmes for orphans and consider providing incentives to caretakers who are of low family income in order to boost their morale. It is also recommended that more research should be carried out to determine other factors which influence Science academic performance among orphaned and non-orphaned learners.

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Strand 3 # *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 10

Application of the UNESCO ICT framework in web design by Limkokwing University of Creative Technology students in Botswana

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Abstract

ICT integration in learning is important for growth and development in any society and classroom teaching practices are key towards this realization. If the curriculum and other international tools are not aligned to industry skills needs, the competency of the graduates in modern day becomes questionable. The study was done to determine the extent to which UNESCO ICT framework aspects have been imparted during teaching among Limkokwing University students in Botswana. The quantitative data was collected using a questionnaire survey with a sample of 204 respondents enrolled in different programmes but taking Web Design module. The test performed was mainly a Single - Factor Repeated Measures ANOVA and given a significant F-value, Post Hoc Test Least Significant Difference (LSD) was executed to identify significant means in a pair of the aspects. The results indicated that in the perception of the Limkokwing University students, learning of the knowledge, deepening and creation aspects were significantly not leant equally. Generally, understanding ICT policy in education, application of digital skills, organisation and administration where significantly less emphasized during teaching. The findings inform future research and classroom practices that need to be enhanced in this era of ICT transformation. Thus, it is recommended that university to integrate the UNESCO ICT Competency Framework in their curriculum and plans so as to produce graduates ready for the job market in today economy.
Keywords: *knowledge creation, creation, deepening, ICT framework*

1.0 Introduction

Because of the exponential growth of technology in all spheres of human life, the twenty-first century presents new opportunities and challenges (UNESCO, 2018). Technological

advancements continue to have a significant impact across all industries. Without a doubt, this shift is also being felt in the academic sector, and it necessitates new dimensions to teaching and learning in order to create knowledge economies: It should also be noted that the academic sector is constantly shaken by unprecedented technological advancements in teaching and learning methods, which necessitate the development of new ICT pedagogies and robust 21st century skills relevant to contemporary human capital (UNESCO, 2011). In this context, the traditional teaching and learning methods have been tried by the impact of Information and Communication Technologies integration in schools, and this happens at a time when educational leaders, policy makers and teachers are faced with challenges which include In this context, the impact of Information and Communication Technologies integration in schools has tried traditional teaching and learning methods, and this occurs at a time when educational leaders, policymakers, and teachers are confronted with challenges such as limited ICT skills and literacy in ICT integration in the classroom, and limited ICT infrastructure to support student-centered learning and fulfillment of ICT integration standards (UNESCO, 2005).

The Botswana government has been making great efforts to support the implementation of ICTs in schools. Such efforts are seen in the National Development Plan 11 of 2017. The national development plan clearly articulates that the government continues to invest in the development of ICT infrastructure in regard to network connectivity and reduction in pricing of network access points. All these according to this section of the policy are to promote creativity and innovation among businesses and individuals (National Development Plan11, 201 7). This endeavor is also seen in ICT policies such as Maikano ICT Policy, Education and Training Sector Strategic Plan (ETSSP, 2015) as well as the United Nations Educational, Scientific and Cultural Organization (UNESCO) ICT Framework for Teachers (UNESCO, 2018). ICT infrastructure and Internet accessibility are essential aspects for human capital development and a workforce that is proficient in the use of ICT infrastructure and tools for social, economic and cultural benefits.

In this regard Botswana needs to focus its ICT efforts, and budget on teaching and learning and the development of technologically literate nation vibrant to meet the needs of the future. Curriculum and other improved international tools inform teaching and continuous alignment is important to ensure that that universities produce competent graduates.

1.1 Statement of the Problem and Purpose of the Study

Botswana educational system experiences drastic transformation following changes in pedagogical approaches that demands for new technologies, competent teachers, new ICT polices and industry relevant graduates. In this respect, the implementation of the Botswana Education and Training Sector Strategic plan was set-out to improve the quality of education and promote the use of technology in both private and government schools in preparation for relevant workforce (NDP11, 2016).

Although the Botswana government advocates for the implementation and usage of educational technologies in schools, there are still great challenges of technology being fully immersed in schools. There are many tertiary students around the country that are still without or with limited accessibility to these resources and tools, due to poor or weak network connectivity across the

nation and high costs of network data (SundayStandard, 2018). Amid all these challenges as teaching is digitized, adoption of the international tools should not be left behind so as to ensure that graduates are able to function in today world as employees and employers

Launched in 2008, it is against this background that this study was conducted to determine the extent to which the UNESCO ICT Framework for Teachers is applied during the teaching of Web Design subjects at Limkokwing University.

1.2 Research Hypotheses

The study was driven by the following hypotheses in the null form;

H_{O1}: There is no significant difference in the level of acquisition in each of knowledge aspects during learning by Limkokwing university students

H_{O2}: Limkokwing university students learnt all levels of the knowledge deepening aspects equally

H_{O3}: Limkokwing university students in web design consider each knowledge creation aspect equally learnt

2.0 Literature Review

At a global perspective, research shows that the United Nations Educational, Scientific and Cultural Organization (UNESCO) is committed to promoting the adoption of technology-based solutions that seek to expand access to education and facilitate knowledge dissemination, effective learning and the development of efficient education services (Mpoeleng, 2016). It was indicated that the United Nations Educational, Scientific and Cultural Organization (UNESCO) supports the development of new approaches to teaching and learning and the capacity of teachers to integrate ICT in their classrooms (UNESCO, 2018).

The ICT framework for teachers introduces key sets of skills and competencies that teachers ought to exhibit in their teaching so as to promote high student academic achievement. The framework presents the approach on how teachers' ICT competencies could be applied to facilitate effective teaching and learning to maximize student learning outcomes. UNESCO framework presents 18 competencies for teacher's organised in six domains, under three progressive levels that guide on how teachers should pedagogically use ICT in their classroom These levels include; knowledge acquisition (technology literacy), Knowledge deepening and Knowledge creation. The domains consist of: understanding ICT in Education policy; curriculum and assessment; pedagogy; application of digital Skills; organization and administration; and teacher professional learning (See Figure 4). These aspects are further elaborated in the following section:

Understanding ICT in education posits that teachers should be aware of how ICT is aligned to national and school policies applicable in the classroom setting. Teachers and potential teacher students have to master educational policies in their professional development through the three levels; knowledge acquisition, where teachers gain awareness of ICT in teaching and learning; knowledge deepening, where teachers and students gain the capacity to critic national policies as well as be able to make recommendations as they create knowledge under this domain (UNESCO, 2018). The Pedagogy aspect supports teachers and students need to gain ICT skills that support effective teaching and learning approaches.

Research conducted at the Brookings Institution, Washington DC in America by Anderson, Care, Kim and Vista (2018) in which they assessed education system alignment for the 21st century skills, three core challenges were identified, the first one being; lack of understanding and knowledge of the nature of the 21st century skills. Under this challenge, three sets of skills such as collaboration, critical thinking and problem solving are unclear in terms of skills development and how they should be inculcated in the new learning goals set by schools (Anderson et al, 2018). The second challenge is attributed to how students build on the mastery of skills gained from one particular domain through basic knowledge to sophisticated skills.

Learning progression of these skills are available in the traditional learning domains such as mathematics, but for subjects such as web design and development the order of precedence of the 21st century skills are hard to predict given the advancement and changes in curriculum and technology.

The European Union outlines fundamental competencies as the combination of knowledge, capacities and attitudes adapted to the current demands (Council of the European Union, 2018). Thus, being competent is associated with everything that society requires to overcoming the challenges of the time in which it develops (Almenara, Romero & Rodríguez, 2020). The realization of knowledge societies calls for digital competencies which include the safe and critical use of information technologies for work, leisure and communication (Council of the European Union, 2018). However, research indicates that 44% of Europeans have not developed basic digital abilities, despite the fact that 79% use the internet regularly, at least once per week (Eynon, Potter & Williamson, 2019). At the same time, research also reveals that majority of jobs in the future would demand for digital abilities. To achieve this, all teachers should perceive classroom teaching practices through following the curriculum/syllabus as a means of enhancing quality of education (Fetogang & Macheng, 2015).

The adoption of ICT and implementation of educational technology artifacts used in classrooms affect the roles of teachers, students, their teaching and learning methods. It is the principal's role and responsibility to ensure that good teaching and learning is practiced across board in all classrooms. Great expectations have been placed on school leaders for them to strengthen underperforming schools by utilizing ICT (Hirtz & Munoz, 2013). Research conducted in Saudi University, Africa, by Alandejani, Almadani and Basri (2018) observed that in order to deliver engaging curriculum and effective teaching methodologies, there is need to shift into paradigms that promote the utilisation of ICT to encourage student-cantered learning such that students become the central point in the learning process (Alandejani et al, 2018).

Therefore, teachers need to take note that the utilization of technology in teaching and learning also requires teacher to have an open and flexible mind, characterized by initiative, leadership, problem solving and self-reflection for the collective good of training students with the relevant skills (Ertmer & Ottenbreit-Leftwich, 2010).

In a study conducted by Butcher, Hoosen and Moore (2014) on the Guyana's ICT Professional Development Strategy for Teachers, it was found that ICT integration in education had many positive benefits. The creation of an ICT orientated curriculum in Guyana was achieved at a

relatively low cost through the adoption of the (UNESCO ICT CFT) which they used in their study. The authors cited good feedback received from stakeholders indicating satisfaction towards the implementation of ICT in Guyana. The strategy achieved its vision as it was stipulated by the Ministry of Education. It is reported that teachers improved their ICT competencies towards improving teaching strategies and promoting learner-centered learning (Butcher et al, 2014).

Studies conducted in Botswana revealed that when educational technologies are integrated into classrooms, students tended to be more interested towards their subjects because the use of technology in teaching and learning provides different opportunities which make learning more engaging and enjoyable to learners as supported by Garegae and Kamodia (2019). Using technology allows both teachers and students to develop essential skills for the 21st century as ICTs usage allows students to gain the skills they need for their personal, career and professional development endeavours. These skills amongst others include: collaboration, solving complex problems, critical thinking, and communication and leadership skills (Garegae et al, 2019; Mpoeleng, 2016).

Since ICT has been growing drastically for the past years in all sectors in Botswana, this, then means that all the affected sectors should embrace the presence and advancements brought about these new developments, which all come with new approaches and challenges that should be managed to the advantage of realizing the benefits of ICTs (Mpoeleng, 2016). These changes are heavily felt in Botswana's education system, as the government endeavors through the implementation of policies and strategies to embrace and support the technological advancements that impact on teaching and learning (Mafuraga & Moremi, 2017). Amid all these challenges as teaching is digitized, adoption of the international tools should not be left behind so as to ensure that graduates are able to function in today world as employees and employers.

Lekopanye and Mogwe (2014) evaluated the views of Botho University staff and students towards ICT integration in the classroom. Their findings revealed that there are challenges to full adoption of educational technologies lack of robust ICT skills. They further highlighted that training is needed in this area so as to equip teachers and students with basic intermediately ICT skills. The researchers also alluded that most if not all Batswana are exposed to ICT technologies when they progress to tertiary education, and these contributes significantly to delays in ICT adoption owing to limited lack of ICT skills and experience.

Similarly, Nkhwalume (2013) also reported on efforts to integrate ICT in the mathematics fostered to motivate students towards the mathematics subject. The findings revealed that lack of teacher confidence, lack of teacher competence in using computers, negative attitude towards technology, resistance to change and lack of technical support were the main contributory factors impeding the successful integration of ICTs in teaching and learning. Therefore, a recommendation to train both teachers and students was pointed out from this study.

From the foregoing literature, it is suggested that if ICT is supported and utilized effectively in schools it can improve the overall performance of school management, teaching and learning. ICT utilisation can significantly improve student academic performance and professional development.

It has been learned that ICT promotes student-centered learning and allows students and teachers to think creatively while developing high order thinking problem solving skills.

The UNESCO ICT framework for teachers is a good tool for measuring ICT competencies. At the knowledge acquisition level, teachers learn how to integrate ICT into their traditional teaching approaches, in the knowledge deepening and creation levels; teachers learn how to support teaching and learning approaches that are student-centered (UNESCO, 2018). The aspect on the application of digital skills requires that teachers use ICT tools and platforms that demonstrate their competency in the application of digital skills for effective utilisation of ICT resources (p24). The aspect on the organization and administration measures the teachers' competencies in the management of digital assets and protection of learners. In the knowledge acquisition level, teachers ought to demonstrate competencies in the physical arrangement of learning resources such as computers, interactive boards and classroom setup fostered towards effective learning.

3.0 Methodology

The study reported in this paper adopted a survey quantitative approach to research. The aim was to determine the extent to which the UNESCO ICT framework was applied during teaching at Limkokwing University in Botswana. The sample of 240 students as respondents was reached enrolled in different programs taking the Web Design and Development Module. Mugenda and Mugenda (2003) asserted that using a larger sample ranging between 10 to 30 % of the entire population increases the chances of getting accurate results in exploratory studies; this research therefore sampled the participants at the rate of 20% with a response rate of 200 out of 240 constituting 83%. This study used a closed ended questionnaire and tested the hypotheses using Single-Factor Repeated Measures ANOVA at .05 alpha level. The respondents completed the questionnaire by indicating their level of agreement or disagreement on a 6-Likert scale. The 3 independent continuous variables had a minimum of 8 indicators and the Cronbach Alpha measuring the reliability index of them was between .64 to .85. Data entry was initially done using Excel Sheet then the dataset exported to SPSS for analysis.

4.0 Presentation and interpretation of results

Single - Factor Repeated Measures ANOVA was done to test the first hypotheses so as to find out if there were significant mean differences in the level of acquisition in each level of knowledge aspects during learning by Limkokwing university students (See Table 1). Results revealed that there are significant differences ($F(5) = F\ 7.27$, $p<.05$) in the levels of knowledge acquired during learning from the six aspects by Limkokwing University students and this led to the rejection of the null hypothesis.

With a significant F-value, a Post Hoc Least Significant Difference (LSD) test was performed to find out where the differences of paired aspects mean were significantly different.

LSD analysis revealed that there were significant differences in the levels of knowledge acquisition between the Pedagogy aspect (mean difference =. 525*, $p<.05$) and Organization and Administration; these results indicate that students were trained more on the pedagogical aspect than in the Organization and Administration aspect. Other significant differences were obtained

between Curriculum & Assessment (mean difference =.387*, p<.05) and Organization and Administration indicating that students acquired high levels of knowledge from the Curriculum & Assessment aspect than they did from the Organization and Administration aspect.
However, there are aspects that students perceived significantly equally acquired during learning such as Understanding ICT in education policy and Professional Learning (mean difference =.005, p>.05). The second hypotheses again using a

Table 2

Single - factor repeated measures ANOVA to measure the significant differences in the level of acquisition to each level of knowledge aspects during learning by Limkokwing University students

Type of Aspect	Mean Perception	SD	Std. Error	Source of Variation	Sum of Squares	df	ms	F	ρ <
Understanding ICT in education policy	4.83	.83	.058	Within-Subjects Effects	33.20	5	6.64	7.27	.000
Curriculum and Assessment	4.83	1.19	.083	Between-Subjects Effects	386.81	203	1.91		
Pedagogy	4.97	.90	.063	Interaction	926.630	1015	91		
Application of Digital Skills	4.69	1.02	.071	Total	1346.64	1223			
Organisation and Administration	4.45	1.33	.093						
Professional Learning	4.83	.86	.060						

Single - Factor Repeated Measures ANOVA was carried out to determine if Limkokwing students had learnt all levels of the knowledge deepening aspects equally (Table 2). A Post Hoc Test Least Significant Difference (LSD) was conducted to establish the sources of mean differences from the paired comparisons of Knowledge acquisition aspects

Table 2

Single - factor repeated measures ANOVA to measure the significant differences in the level of deepening to each level of knowledge aspects during learning by Limkokwing University students

Type of Aspect	Mean Perception	Standard Deviation	Std. Error	Source of Variation	Sum of Squares	df	MS	F	ρ <
Understanding ICT in education policy	4.59	1.214	.085	Within-Subjects Effects	16.928	5	3.386	4.355	001

Curriculum and Assessment	4.93	.888	.082	Between-Subjects Effects	382.497	203	1.884
Pedagogy	4.73	1.038	.076	Interaction	789.072	1015	.777
Application of Digital Skills	4.81	.961	.090	Total	1188.497	1223	
Organisation and Administration	4.92	.847	.087				
Professional Learning	4.87	.890	.062				

LSD results indicated that there were significant mean differences to the extent to which knowledge was acquired during learning from the Understanding ICT in education policy aspect and (mean difference =.-324*, p<.05) Organization & Administration. Another significant mean difference was obtained between Curriculum and Assessment (mean difference =.333*, p<.05) and Understanding ICT in education policy. Although there was a significant difference between Pedagogy (mean difference = -.201*, p< .05) and curriculum and assessment, results were found not significant between Curriculum and Assessment (mean difference =.010, p>.05) and Organisation and Administration meaning that Limkokwing university students learnt all levels of the knowledge deepening aspects equally.

The third hypotheses were also tested using Single - Factor Repeated Measures ANOVA in order to establish the levels to which student learnt each knowledge creation aspect in web design. Knowledge creation was significant at (F (5) = F 8.486, p<.05) meaning that this aspect was not learnt equally. Findings showed that Limkokwing students do not consider each knowledge creation aspect equally learnt in their different programmes of study (See Table 3) and the null was rejected.

Table 3

Single - factor repeated measures ANOVA to Measure the significant differences in the level of creation to each level of knowledge aspects during learning by Limkokwing University students

Type of Aspect	Mean Perception	Standard Deviation	Std. Error	Source of Variation	Sum of Squares	df	Mean square	F	ρ <
Understanding ICT in education policy	4.28	1.364	0.95	Within-Subjects Effects	41.524	5	8.305	8.486	.000
Curriculum and Assessment	4.65	1.084	.076	Between-Subjects Effects	993.310	203	.979		
Pedagogy	4.70	.964	.068	Interaction	739.362	1015	3.642		
Application of Digital Skills	4.59	1.156	.081	Total	1774.196	1223			

Organisation and Administration	4.28	1.417	.099
Professional Learning	4.72	1.108	.078

To establish the sources of paired mean differences between the knowledge Creation aspects, the study conducted a Post Hoc Least Significant Difference. LSD results revealed significant mean differences between Understanding ICT in education policy (mean difference =.-363*, p<.05) and Curriculum and Assessment, which implies that the levels of leaning in this aspects were not the same. There was also a significant difference between professional learning and (mean difference = .436*, p< .05) organisation and administration. LSD results also indicated that learning in Curriculum and Assessment (mean difference =.054, p>.05) and Application of Digital Skills was not different, therefore supporting that Limkokwing university students in web design considered each knowledge creation aspect equally learnt under these two aspects.

5.0 Discussions

These findings indicated that students at Limkokwing University acquired Knowledge acquisition, knowledge deepening and knowledge creation at different levels during learning. The pedagogy aspect was more emphasized while organizational and administration less emphasized during teaching. Results indicated that students are knowledgeable in how classroom practices correspond to and support ICT national policies. They also indicated that they acquired knowledge on how curriculum standards and ICT can be used pedagogically to support their own learning, as well as make appropriate ICT choices and identify the functions of computer hardware components.

Furthermore, results showed that the knowledge deepening aspects was acquired differently during learning. If the Limkokwing University students are not able to design and implement practices that seek to support institutional and national policies, in practice they will not be able to integrate ICT across other subjects and create a conducive ICT-enhanced learning environment. This will help bridge the skills mismatch reported by Botswana qualifications Authority (Batlotleng, 2016) and foster a digital competent society for safe and critical use of information technologies for work (Council of the European Union, 2018).

The knowledge creation aspect was also not adequately acquired by the students with professional learning highly acquired while understanding ICT in education policy and organisation and administration being the least acquired in the perception of the Limkokwing University students. This is in agreement with Anderson et al, (2018) findings which showed that lack of knowledge and high order thinking skills lack of intergration into the school strategy curriculum is the challenge.

These results therefore showed that lecturers were not consistent in the application of the UNESCO ICT framework most possibly because of their lack of understanding of its application. This study produced results which corroborate the findings of a great deal of the previous work in this field. This imply that we will most likely have graduate who do not understand the priorities as identified in Botswana's national ICT policy in Education and will not contribute to a knowledge-based

economy. It's important to note that if the teaching and the curriculum is aligned to national and international policies, then we will have graduates equipped with the relevant 21st century skills ready for the international job market. Teaching and learning frameworks such as the UNESCO ICT Framework should be aligned and integrated during curriculum development and all aspects be taught unswervingly.

5.1 Conclusion and recommendations

Findings from this study clearly indicate that ICT has proven to be very crucial in the classroom and important for giving students opportunities to learn and apply their 21st century skills while also been given the freedom to exercise student centered learning. It has also been noted that ICT helps teachers to present their teaching attractively to all learners at any level of educational programmes (UNESCO, 2018). Information and Communication Technologies (ICTs) exemplified by the use of the internet and interactive multimedia are clearly an important concept for future approaches in education, therefore, calling for the need to be effectively integrated into formal teaching and learning (Oyelaran, ,2007).

Different research findings have shown that ICT have a positive impact on student learning and that it promotes better teaching methods (Almadani et al, 2018). This finding then implies that in order to realize Botswanas' vision 2036, there is a dire need that education providers in Botswana adopt and align their curriculum with the UNESCO ICT Framework for teachers. Schools should ensure that teachers are equipped with the right skills and attitudes that would allow them to render the curriculum to students effectively. Most importantly, schools in Botswana should measure the capacities and skills of their teachers against the UNESCO ICT Framework, in order to identify areas that need to be improved.

5.2 Recommendations

The following recommendations were suggested based on the findings of this study:

- The Ministry of Education should ensure that ICT policies are implemented, incorporated into school curricula, and consistently monitored.
- The Botswana Qualifications Authority should ensure that tertiary schools produce graduates who are job-skills ready by aligning their ICT pedagogy and policies with international standards and frameworks such as the UNESCO ICT Framework.
- When delivering ICT pedagogy across all faculties, tertiary educators should be creative and innovative.
- Tertiary educators should be equipped with relevant ICT skills and given access to relevant ICT teaching resources in order to effectively integrate technology during learning.
- Given the problem at hand, further research with more focus on the impact of ICT policy on students' professional development for 21st century skills training is suggested.

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ARTICLE 11

The contribution of argumentation in the emergence of the reflective teacher in science teaching

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Abstract

Introduction: Argumentation stands out in research in the field of science. However, on one hand, teachers tend to adopt procedures more aligned with the technicist model, even in the face of the wealth and diversity of sources of information in which we live today, making argumentation increasingly absent in teaching and learning processes. On the other hand, studies that deal with argumentative actions are scarce, and few focus on the specific context of the use of argumentation as a reflexive process. Faced with this situation, we question what are the teacher's attributions in the development of argumentation in the classroom and how to correlate this with the characteristics of the reflective teacher? The present study sought to understand how the teacher manages argumentation in the classroom, based on pro-argumentation actions, correlated to the reflective teacher. Methodology: It is a theoretical study in which we position ourselves regarding argumentation and the reflective teacher, thus we problematize and discuss the two concepts, using the theoretical-conceptual approach proposed by Checkland and Holwell. Results: It is pointed out that the teacher can implement actions in the interest of building evidence for scientific explanations. In this process, this gives space for the student to argue and build discourses based on the information in their possession. Thus, these skills point to a change in practices, from the teacher acting in the technicist model, to the one of practical rationality, where the reflective teacher acts. Conclusions: This study reinforces the need for argumentation in science classes, by collaborating in the indication of pro-argumentation actions and revealing that it is impossible for the teacher to apply argumentation in classes without being reflective.

Keywords: *Argumentation. Science teaching. Reflective teacher. Pro-argumentation actions. Theoretical-conceptual study.*

1.0 Introduction

Given the range of information that we are faced with today, dictated by advances in communication technologies, the teacher is no longer the exclusive source of knowledge and the

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student is challenged to know how to deal with the variety of information in an active and critical manner. Therefore, students need to have independent and critical thinking that helps them to search for the necessary information, assess whether or not it is reliable, and finally, decide whether or not it is meaningful to them. In this context, information has to be organized by those looking for it, putting argumentation into action, because it needs people with "the ability to think and wisdom to decide based on information and solid knowledge" (Alarcão, 2003, p. 8, our translation).

However, researchers in the field of science teaching consider argumentation important, as they share the idea of its need in the classroom, for supporting information management, constructing and evaluating evidence that support the conclusions. (Hirdes, e*t al.,* 2018; Ibraim & Justi, 2017; Jiménez-Aleixandre & Erduran, 2007; Leal, *et al.,* 2019; Lourenço & Queiroz, 2020; Simon, *et al.,* 2006; Silva & Chiaro, 2018). However, although its relevance to science teaching and learning processes is recognized, argumentation has been described as practically non-existent (Queiroz & Sá, 2009).

In this context, a considerable movement of research on argumentation in science teaching, in recent years, has contributed to its inclusion, implicitly and or explicitly, in school curricula and, gradually, guidelines on argumentation come to be found in the literature and in some thematic plans of subjects offered in teacher education courses, but, Osborne, *et al*. (2004), point out that only a small number have been situated in the specific context of the science classroom. Lourenço, *et al*. (2016a) point out that,

"these problems stem, for the most part, from the fact pre-service teacher education courses are based on the model of technical rationality to train future teachers. This training model ends up directly influencing the classroom context, as it generally trains teachers who reflect little in a systematic way on their practice, interact little and discuss with their colleagues about teaching work and, above all, don't use theoretical aspects enough to understand and/or improve their practice" (p. 296, our translation).

For this reason, we raise the question, what are the teacher's attributions in the development of argumentation in the classroom and how can it be correlated with the characteristics of the reflective teacher? In order to answer, we followed the path of theoretical research framed in position papers, those in which the authors take a specific position on a given issue of science teaching; according to the precepts of Tsai and Wen (2005).

Through this position study, we problematize and discuss that argumentation needs to be managed by a reflective teacher, using referential indicators and drawing on the theoretical-conceptual study of Checkland and Holwell (1998). These authors guide the use of a conceptual framework in which the researcher connects different concepts (which have been tested and have a wide acceptance, but which do not apply to a specific reality), to support a research question, which seems to be the case of the concepts of argumentation and the reflective teacher.

This article aims to, firstly, understand how the teacher manages argumentation in the classroom and then list the argumentative skills of teachers in science learning environments, based on pro-argumentation actions, correlated to the reflective teacher. Thus, in the topic "argumentation in

science teaching" we present and discuss the reasons that dictate the need for argumentation in science teaching and in the topic "the use of argumentation by the reflective teacher" we discuss how thinking in classroom processes urges teachers in the use of argumentation and, in general considerations, we answer based on dialogues with authors (Chiaro & Leitão, 2005 and Ibraim & Justi, 2018) and to our best understanding, what argumentative skills teachers can use to teach science.

In this moment, it is justifiable to explain the role of argumentation in the emergence of the reflective teacher, pointing out certain skills so that the teacher not only teaches their students to argue, but also blossoms and explores their argumentative capacity, molding themselves in the context, a reflective teacher, as we do in later topics. In this way, we contribute to minimizing the "existing gap with regard to references that address argumentative teaching practices (Lourenço, *et al.*, 2016b, p. 513, our translation).

2.0 Some notes

2.1 Argumentation in science teaching

Argumentation is pointed out by the commission of researchers under the general coordination of the National Research Council of the United States of America (NRC) as one of the 8 scientific practices that facilitate the understanding of how students should engage in science teaching, since argumentation provides improvements in conceptual learning when students engage in building ideas, opinions and conclusions from evidence, as they develop meta-knowledge of science and engage in the argument of evidence already conducted (NRC, 2012). Therefore, argumentation is important in science teaching and learning, because, through evidence, acceptable conclusions are reached, being an epistemic, discursive, cognitive, social, reflective and critically necessary activity in scientific discourse. (Leitão, 2009 *apud* 2012; Van Eemeran & Grootendarst, 2004 *apud* Silva & Chiaro, 2018).

Two functions of argumentation are considered as central elements in learning: "one is as a heuristic to engage learners in the coordination of conceptual and epistemic goals and the second is to make student scientific thinking and reasoning visible to enable formative assessment by teachers or instructors" (Osborne, *et al*., 2004, p. 3).

Jiménez-Aleixandre and Erduran (2007), justify the need to introduce argumentation in science classes, pointing out that argumentation is "a solution to some learning problems, as it helps students to learn things that are difficult and, they are achieved except through argumentation, such as the assessment of evidence" (p. 12, our translation). Thus, the authors propose potential contributions of argumentation in science classes, which influence one another and that their realization is not necessarily guaranteed by the introduction of argumentation in the classroom, but when, among other aspects, the participants of the process assume certain roles. In this sense, they distinguish five potential contributions,

i) support access to cognitive and metacognitive processes by raising the performance of experts and enabling modeling for students, ii) support the development of communicative skills and particularly critical thinking, iii) support the achievement of scientific literacy and enable students to speak and write the languages of science, iv) support inculturation in the practices of scientific

culture and the development of epistemic criteria for assessing knowledge, and v) support the development of reasoning, particularly the choice of theories or positions based on rational criteria (Jiménez -Aleixandre & Erduran, 2007, our translation, emphasis added).

We raise the assumption that everything that is done in the classroom beforehand must eventually be provided for in the curriculum, because if it is necessary, it means thinking, not only about the foundations that make it exist, but also about the normative documents that guide it. In this sense, Jiménez-Aleixandre and Erduran (2007), when analyzing some curricular programs from South Africa, Israel and the United Kingdom, realized that the use of argumentation is not explicitly stated, but rather it is pointed to in the objectives and/or competences using a language of recognition, such as confirming and refuting hypotheses, using data to build conclusions, critically evaluating claims of scientific knowledge, justifying claims with evidence, thus showing concern for implicit argumentation. Unlike the science curricula of the United States, Spain, Chile, Turkey, Taiwan and Australia, where the authors explicitly identify argumentation.

The explicit and at other times implicit presentation of argumentation in the curricula, highlights the appreciation and concern with it for science teaching, highlighting the need to increase works that seek to stimulate argumentation in the classroom, empower students to seek information, build conclusions from evidence and defend their interests before others. However, "one of the main challenges to implement argumentation in the classroom is the lack of transformation of policy recommendations to educational practice" (Jiménez-Aleixandre & Erduran, 2007, p. 19, our translation).

This transformation implies the use of learning organization strategies that make the student active and that move away from the technicist model to adopt the practical model, because, otherwise, "science ends up being treated in a simplistic connotation, which disregards doubt, development, argumentation and dialogue in the construction of knowledge" (Lourenço, *et al*., 2016a, p. 296, our translation).

Lourenço and collaborators carried out a study that highlights the potential that the practical model has in the elaboration of knowledge of argumentation, pointing to the role of the reflective teacher, since, "the processes of reflection in action planning, reflection in action and reflection on action provided the basis for the development of teaching argumentation knowledge". Lourenço, *et al*. (2016a, p. 312, our translation).

2.2 The Reflective Teacher's use of Argumentation

The subject that closes the previous topic is continued and expanded in this one, reinforcing the foundation of the proponent of the reflective teacher, Schon (1983), who says that this type of teacher values professional knowledge and presents the role as an alternative to technical rationality, being a way for professionals to question themselves about their teaching practice, and Day (2001) and Fringe, *et al*. (2021) see reflective practice with high potential for professional development. In this sense, reflection provides opportunities to think and act in the moment of action, to go back and review events as the teacher goes through a process of change in their teaching practice.

From now on, we clarify that it is not important for us to distinguish the principles defined by Schon, of reflection in action, reflection on action and reflection on reflection in action, and much less to relate and or differentiate the concept of the reflective teacher from the concept of the teacher researcher, because, we understand that its meaning does not directly affect the specific application proposed in this work.

According to Schon, (1983, p. 49, 54, our translation) "our knowledge is normally tactical, implicit in our patterns of action and in our perception of the things with which we are dealing, [...] we are often unaware of having learned to do these things" The author reinforces that professional training must take into account the knowledge built in action, and thus, although the teacher has not learned about the argument, he/she thinks and reflects on his/her own practice and develops strategies, assuming the classroom as a research laboratory, where the analysis and search for solutions to specific situations end up favoring argumentation and providing professional development. In this space, the reflective teacher reflects on the situation and builds knowledge based on thinking about his/her practice (Alarcão, 2003).

We mean that reflection encourages teachers to analyze issues of their daily lives and to act on them consciously in relation to other actors in the process, especially the student. From this perspective, teachers think and reflect on the following classroom processes: i) about how knowledge is constructed, putting the student in the center, and in this sense they change their passive practices, and start to adopt interaction practices that favor dialogue and the development of reasoning, and thus, formulate directed questions, let the student speak and intervene more and, ii) if the conclusive statements of questions related to science are based on inference, affirmation or supposition, and thus potentiate justifications supported by evidence, by requiring the formulation of statements in the form of scientific discourses, by creating a moment for the student to think about his/her point of view when answering a question or when giving his/her opinion or statement, thus exploring the individual argument in the epistemic perspective, while exploring the social argument by promoting argumentation by contrasting the other, placing them in an environment where they can discuss in small groups, exchange impressions in a debate with the teacher and/or colleague.

We are aware that the unfolding of the reflective teacher in this process is not an easy task, but it is possible. Because argumentation is conceived as a self-regulated and self-regulating process of thought that compels the individual to reflect on the foundations and limits of their conceptions and perspectives on beliefs, concepts, hypotheses that individuals formulate about objects (Leitão, 2012). To show the feasibility of this practice, we rely on the ideas of Alarcão (2003), when considering the action research methodology as a scientifically supported social intervention that unfolds according to cycles of planning, action, observation, and reflection, to point it out with the potential to serve the purpose of a reflective teacher in the implementation of argumentation. We imagine that the teacher's desire to solve the problems they find in their practice, can make them implement movements that are guided by argument, even if they have not gone through a training program.

Likewise, we rely on the foundation of critical thinking that realizes that "students can be asked to explain and analyze their choices, considering their implications, as well as to make a public defense of them [...], encouraging each one to act in line with the values that they consciously and publicly assume" (Tenreiro-vieira & Vieira, 2021, 74, our translation). Critical thinking is defined by Costa, *et al*. (2021) as "ethical and effective thinking in various contexts and domains to solve problems and make decisions about what to believe or how to act responsibly and sustainably" (p. 148, our translation). In this way, teacher and student, moved by critical thinking, contrast beliefs, laws and theories based on evidence and develop, with greater ease, the ability to formulate critical discourses, as well as criticize them.

Finally, we understand that developing the ability to understand and implement argumentation requires an important process of reflection on previous experience. "It is this that initiates the process of reflection-in-action, or reframing – the process that helps teachers to construct new pedagogical understanding – in this case, of argumentation and its value for learning science" (Simon, *et al*., 2006, p. 257).

But then, what should be done? What argumentative skills can teachers use to teach science?

3. General considerations

In the previous topics we saw that the introduction of argumentation in the classroom requires a change in the form of teaching organization so that what is foreseen in the curriculum can be put into practice, either explicitly or implicitly, with the reflective teacher acting in the context. Therefore, differential behavior must occur with the teachers to develop students' argumentation, after all, according to Lourenço, *et al*. (2016a, p. 313, our translation) "the development of teacher knowledge related to argumentation is a necessary condition for the insertion of argumentation in science education". "This is because we consider that the teacher's work in the dialogic perspective or their knowledge of argumentation is almost a *sine qua non* condition for creating an argumentative environment in the classroom" (Ibraim & Justi 2018, p. 317, our translation).

However, this change first requires that, "science teachers be convinced that argumentation is an essential component for the learning of science. In addition, they require a range of pedagogical strategies that will both initiate and support argumentation if they are to adopt and integrate argumentation into the classroom." (Osborne, *et al*., 2004, p. 5).

The proposal is guided by the role of the reflective teacher, in pro-argumentation actions prescribed by Chiaro and Leitão (2005) and Ibraim and Justi (2018). Chiaro and Leitão (2005), when investigating teacher actions that promote argumentation, point to them on three planes, the pragmatic plane that involves the teacher's discursive actions, understood as conditions created by the teacher for a curricular topic to become argumentative, the argumentative plane, which concerns the conditions created by the teacher to expand and sustain argumentation and the epistemic plane, referring to the conditions created by the teacher to recover information, concepts, definitions related to the theme.

Ibraim and Justi (2018), aiming to analyze two classes of a Chemistry teacher, constructed an analytical instrument composed of 18 argumentative actions resulting from the literature in the field, based on the references of Driver, *et al*., 2000; Mork 2005; Simon, *et al*., 2006 and Scarpa

et al. 2015, regarding actions such as defining and exemplifying the concept of evidence and asking students to present evidence, which emerged from the data.

Based on these theoretical assumptions, we designed a scheme that shows an interactive cycle of development of skills in and about argumentation, represented below, in Figure 1. In it, it is possible to see that argumentation can be assumed as a field where teacher knowledge is developed, because throughout this cycle, on one hand, the development of argumentative skills occurs, and on the other, the development of skills to promote argumentation occurs (Lourenço, *et al*., 2016a; Lourenço, *et al*., 2016b).

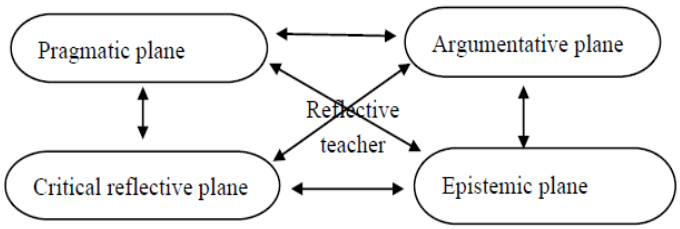

Fig. 1 Interactive cycle of argumentative actions, adapted from Chiaro and Leitão (2005)

It can be inferred that there was the creation of the critical reflective plane that we consider necessary to classify in order to accommodate actions created by the teacher to critically reflect on the argument, evaluating the evidence and conclusions. These actions accommodate those already pointed out in the literature and increase the performance of the reflective teacher.

The actions in these 4 planes work in an interactive cycle that starts on the pragmatic plane, then advances to the argumentative and epistemic planes, and end on the critical reflective plane, but do not follow a rigid logical sequence, and the actions can be resumed in any of the planes, when necessary, and actions in different planes can be achieved in an interaction course, over one or other classes.

We believe that the situations performed in the 4 planes can help the teacher to experience the process of argumentation in the classroom. However, it is understood that some actions, manifested in the pragmatic plane, start in planning (well before the class takes place), from the conception of teaching and goals that the teacher has. For, as reinforced by Simon, *et al*., (2006), "Students need to learn to listen and speak, justify statements, and so on, before they can debate. Likewise, teachers need to value and learn how to implement group discussion and immediate justification before they can orchestrate counterargument within their teaching." (p. 256, our translation).

Next, in Figure 2, we present the specific actions that can be manifested in argumentative skills in each of the 4 planes of the interactive cycle of argumentative actions.

Planes	Actions
1. Pragmatic: Inciting argumentation	1. Develop teaching strategies that allow students to be asked to build arguments in written and/or oral form;
	2. Formulate questions to engage students in the discussion;
	3. Speak and listen;

	4. Encourage discussion among students;
	5. Encourage students to listen to their peers' opinions;
	6. Encourage students to take a stand in the presentation of their ideas;
	7. Encourage students to role-play in discussion situations.
2. Argumentative: expansion and support of argumentation	1. Encourage students to provide justifications for their statements;
	2. Encourage students to formulate counter arguments;
	3. Request justifications for students' conclusions;
	4. Request arguments in the most varied forms (written and oral) after a group discussion;
	5. Present arguments that challenge students' ideas;
	6. Justify with evidence;
	7. Make arguments;
	8. Present evidence;
	9. Know the meaning of the argument;
	10. Define and exemplify arguments;
	11. Define and exemplify the concept of evidence.
3. Epistemic: information retrieval	1. Point out different interpretations to the problem question;
	2. Value the different positions of students;
	3. Formulate explanations;
	4. Relate information;
	5. Make predictions;
	6. Encourage the presentation of new justifications in addition to those initially presented.
4. Critical reflective: evaluation of arguments	1. Organize the discussion among students in order to encourage their reflection on the validity of different interpretations;
	2. Encourage students to evaluate arguments presented by peers;
	3. Encourage students to make judgments about the arguments they build;
	4. Evaluate arguments in relation to the evidence presented;
	5. Question students' conclusions;
	6. Counterargue/debate;
	7. Identify the reasons not stated;
	8. Identify and deal with irrelevances;
	9. Eliminate alternative conclusions;
	10. Review the whole situation and decide;
	11. Present conclusions.

Fig. 2 Pro-argument actions correlated with planes, adapted from Simon, *et al.* (2006) and Ibraim and Justi (2018)

We believe that the pro-argumentation actions shown in Figure 2 can be used as an analytical instrument, contributing to study teacher action from the perspective of Arruda, *et al*., (2021), in which the authors propose to investigate what the teacher actually does in the classroom and how their actions can be categorized. For many of them have already been validated in research, as can be seen in Simon, *et al*. (2006) and Ibraim and Justi (2018).

There is a need, during communication, to use strategies that put the student to develop logical reasoning, formulate valid arguments using evidence, as well as critically reflect, evaluating the

argument construction process, especially the conclusions supported by evidence, for different relative situations in science. However, the use of argument by the student and teacher is not innate, it has been built in a favorable environment and consolidated through practice over time, which forces them to adopt and appropriate actions in the context of the construction of discourses and, as very well emphasized by Simon, *et al*., (2006, p. 241, our translation), "it is not simply about changing your vocabulary, but fundamentally, assimilating new objectives that will foreground and support the discourse of argumentation in your teaching". In the past, teachers had to rethink their role, taking into account that their informative value has different levels, depending on the access that their students may have to other sources of information (Alarcão, 2003).

We imagine that teachers may have difficulties in expressing actions related to teaching on the argumentative practice, such as, for example, defining and exemplifying the concept of evidence, to the detriment of those directed to the teaching of scientific content based on argumentation, for example, encouraging students to present justifications for their statements, especially those that did not go through an educational institution where argumentation is explicit. For, in the explicit perspective, aspects referring to argumentative practice are highlighted by the teacher trainer and in this context, the teacher experiences direct instructions on what an argument is (Ibraim & Justi, 2017).

4. Conclusion

We return to our initial question of what the teacher's attributions are in the development of argumentation in the classroom and how to correlate it with the characteristics of the reflective teacher. From our discussion, we conclude that the answer points to a teacher who is constantly questioning themselves about what he/she does and why he/she does it. A teacher who works in the three planes suggested by Chiaro and Leitão (2005), that is, always checks and acts so that a curricular topic becomes argumentative, so that it expands and sustains an argument and retrieves the information for the construction of arguments. But also, a teacher who works in the critical reflective plane, so that students critically reflect on the learning process, evaluating arguments built by themselves, by colleagues and the teacher. And these skills are in line with the characteristics of the reflective teacher, indicating that argumentation is used by a reflective teacher, that is, it is impossible for the teacher to apply argumentation in their classes without being reflective.

The study reinforces the need for argumentation in science classes, by helping to clarify which skills related to argumentation should be developed by teachers, reinforcing those already listed by references in the area to analyze pro-argumentation actions. In this regard, we reiterate the opinion of Ibraim and Justi (2018), by suggesting that researchers establish a dialogue in order to discuss the potential and limitations of each instrument for analyzing argumentative actions.

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ARTICLE 12

Effect of Reciprocal Constructivist Instructional approach on Students' Achievement in Basic Science in Rigachikun Education Zone Kaduna State Nigeria

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Abstract

Science and Technology are considered to be the two key elements for Socio-economic development of all nations. Conventional practices such as traditional or lecture method and expository approach used by teachers in teaching in teaching Science and Technology have been blamed on poor achievement of students and also incapable of giving the desired learning outcomes among students. These seem not to help students acquire science process skills that will enable them understand scientific concepts thereby limiting their ability to self-reliant lives in the society after graduation from secondary school. The search for alternative but viable option could have led to the exploration of instructional strategies that are based on constructivism. It is against this background, that this paper seeks to highlights the effect of reciprocal constructivist instructional approach on students' achievement in Basic Science. The study employed quass-experimental design. Eighty-two (82) Basic Science students participated in the study through simple random sampling technique. Basic Science Achievement Test was used as instrument for data collection. Findings from the study revealed that Basic Science students exposed to reciprocal constructivist instructional approach performed significantly better than those taught using lecture method. It was also discovered that students taught Basic Science using lecture method were not actively engage in the teaching and learning of Basic Science. It is recommended among others that Basic Science teachers should plan and implement their lessons using reciprocal constructivist instructional approach which is activity-based teaching strategies that create conducive atmosphere for effective teaching and learning of Basic Science to enhance students' critical thinking skills, creativity, innovation and achievement.

Key words: *Reciprocal Instructional Strategy, Basic Science Achievement.*

1.0 Introduction

Science and technology are considered to be the two key elements for socio-economic development of all nations (Bala, 2010). For a country that aspires to address the problems of under-development; science and technology have to be at the fore front of every educational programme.

Basic science is one of the core subjects listed in the National Policy on Education (FRN, 2013) for Junior Secondary Schools in Nigeria. It is a basic subject that lays the foundation for the takeoff of the sciences (Biology, Chemistry and Physics) in the senior secondary classes. It is a subject meant to provide a solid foundation for senior secondary science subjects like Biology, Chemistry and Physics (Gadzama, 2012).

Basic science in the junior secondary school is a course of study which is designed and presented in such a way that students gain the concept of the fundamental unity of science, communality of approach to problem solving of scientific nature and help students gain understanding of the roles and function of science in everyday life and the world in which they live.

Basic science is a fundamental science which cut across subject boundaries that offers learners' experiences that help them to develop an operational understanding of the structure of science that could enrich their lives and make them responsible citizens in the society. Basic science occupies a central position in science education by exposing the learners or students to some basic science process skills. In furtherance to this, Okebukola (2007) stated that when one acquires the science process skills, such individual become specially equipped with tools required for scientific investigations. The science process skills are also required to facilitate the pursuit of profession or higher education which would make the individual self-reliant and independent economically (FME, 2004).

Ado (2012) and Ojimba (2013) opined that science education has experienced worldwide transformation in its outlook. In early 1960s and 1970s, Nigeria faced significant revolutions in its approach to teaching science. Eze (2012) asserted that for learning to be meaningful and effective in the classrooms, the teacher should be able to select the appropriate teaching strategies that will stimulate the interest of the learners and get them actively engaged in the process of learning. This brought a change in the trend of educational practice. These trends are daily occurrences that reflect positive change which is a move from transmission view of education to that of knowledge construction especially in the face of current world realities such as technological development. The National Policy on Education (2014) emphasizes paradigm shift in educational practices from teacher to learner centeredness, so as to enhance conceptual learning in science. As a result of the shift, conventional practices of teaching are now more in vogue.

Researchers have found that conventional practices such as lecture method and expository approach have scarcely proved the capability of giving the desired learning outcomes among students (Umoren & Aniashi, 2007; Atomatofa, 2013). These seems not to help students acquire science process skills that will enable them understand scientific concepts thereby limiting their ability to self-reliant lives in the society after graduation from secondary school. The search for alternative but viable option could have led to the exploration of instructional strategies that are based on constructivism. Constructivism, according to Orji and Ekpo (2013) is a learning theory on knowledge that argues that humans generate knowledge and meaning from interaction between their experiences and their ideas. Thus, in reciprocal constructivist instructional approach, learners interpret and process the incoming information through their senses to create knowledge. In reciprocal constructivist instructional approach, views are held that scientific knowledge are

personally constructed and reconstructed by the learners on their prior knowledge or experiences. One of the constructivist approaches considered in this study is the reciprocal teaching.

Reciprocal teaching is an instructional activity that takes the form of a dialogue between teachers and students regarding segments of text for the purpose of constructing the meaning of text. A reciprocal approach provides students to facilitate a group effort between teacher and students as well as among students in the task of bringing meaning to the text (Pelincsar, 1986). According to Sharman (1991) and Slavin (1991), reciprocal teaching is also an intervention in which students provide instruction or academic assistance to other students. This process transforms learning from a private to social activity by making learners to be responsible for their learning and that of others. In this process, students function reciprocally as both tutors and tutees. This role is beneficial because it enables students to gain from both preparation and instruction in which tutors are engaged and from the instructions that tutees received (Griffin and Griffin, 1997).

Reciprocal teaching focuses on four (4) thinking strategies namely:

i. Predicting
ii. Clarifying
iii. Questioning
iv. Summarizing

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

1.2 Research questions

i. What is the effect of reciprocal constructivist instructional approach on the mean academic achievement scores of students taught basic science using reciprocal constructivist instructional approach and those taught using lecture methods in Rigachikun Education Zone Kaduna State?
ii. What is the influence of gender on the mean academic achievement scores of students taught basic science using reciprocal constructivist instructional approach in Rigachikun Education Zone Kaduna State?

1.3 Null hypotheses

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

1. Ho_1: There is no significant difference between the mean academic achievements scores of students taught basic science using reciprocal constructivist instructional approach and those taught using lecture methods in Rigachikun Education Zone Kaduna State.
2. Ho_2: There is no significant difference between the mean academic achievement scores of male and female students taught basic science using reciprocal constructivist instructional approach in Rigachikun Education Zone Kaduna State.

2.0 Methodology

Quassi experimental research design was adopted for the study, specifically the pre-test, post-test, non-equivalent group. The population for the study consists of Eighty-two (82) basic science students randomly selected in two different classes in Government Secondary School Hayin Banki, Kawo Kaduna, which were divided into experimental and control groups. The instrument for data collection was Basic Science Achievement Test (BSAT) developed by the researchers to test the students' knowledge of the selected basic science concepts. The instrument was validated by the senior colleagues in the department of Academic Services of the National Teachers' Institute, Kaduna Nigeria.

2.1 Experimental procedure

Before the commencement of the study, subjects were pre-tested. They were divided into experimental and control groups. The experimental group was taught basic science concepts using reciprocal constructivist instructional approach for six weeks while the control group was taught same basic science concepts using lecture method.

2.2 Method of Data Analysis

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

Hypothesis One: There is no significant difference in the academic achievement of students taught basic science using reciprocal constructivist instructional approach and those taught using lecture methods in Rigachikun Education Zone Kaduna State.

Table 1.6.1a: t-test analysis on significant difference in academic achievement of student taught basic science using reciprocal constructivist instructional approach and those taught using lecture methods.

Group	N	Mean	SD	Df	α	t-cal	t-crit	Decision
Exp.	32	60.32	14.72	80	0.05	9.11	1.99	Rejected
Cont.	50	45.76	13.76					

The independent sample t-test statistics on table 1.6.1a revealed the mean score of 60.32 and the standard deviation of 14.72 for the experimental group, while the control group recorded the mean score of 45.76, with the standard deviation of 13.76. The table also shows the observed t-calculated value of 9.11 and t-crit value 1.99 at 0.05 level of significant. The null-hypothesis is thus rejected

because there was a significant difference in the academic achievement of students taught basic science using reciprocal constructivist instructional approach compared to those taught using lecture method in Rigachikun Education Zone Kaduna State.

Hypothesis Two: There is no significant difference in the extent to which gender difference affect the academic achievement of students taught basic science using reciprocal constructivist instructional approach in Rigachikun Education Zone Kaduna State.

Table 1.6.1b: t-test analysis on significant difference in the extent to which gender affects the academic achievement of students taught basic science using reciprocal constructivist instructional approach.

Gender	**N**	**Mean**	**SD**	**Df**	**α**	**t-cal**	**t-crit**	**Decision**
Male	18	56.46	16.03	30	0.05	1.66	2.04	Retained
Female	14	64.50	11.80					

Analysis on table 1.6.1b show the male mean score of 56.46 and the standard deviation of 16.03, while the female recorded the mean score of 64.50, with the standard deviation of 11.80. The table also revealed the t-calculated value of 1.66 and t-crit value 2.04 at 0.05 level of significant. The null-hypothesis is retained because there was no significant difference in the extent to which gender difference affect the academic achievement of students taught basic science using reciprocal constructivist instructional approach in Rigachikun Education Zone Kaduna State.

3.0 Discussion of result

The result in table 1.6.1a provide answer to research question one. It reveals that there is significant difference in the academic achievements of students in the experimental and control groups. This shows that reciprocal constructivist instructional approach enhances students' academic achievement. The result obtained is in line with the findings of Adedoyin (2010), Damole, Femi & Adoye (2004), whose findings reveals that instructional approaches that involves active participation of students would be effective.

The assessment of gender related difference in the learnt achievement of the learnt concepts revealed that there is no significant difference in the mean achievement of the male comparable to female. This result obtained is in line with the findings of Maikano, Bichi and Shaibu (2016), whose findings revealed that there was no disparity in the academic achievement of male and female students exposed to indoor and outdoor laboratory instructional strategy. This implies that reciprocal constructivist instructional approach is gender friendly.

4.0 Conclusion

It can be concluded that the use of reciprocal constructivist instructional approach enhances students' achievement in basic science than lecture method of teaching, because it boosts the academic achievement of students in Rigachikun Education Zone Kaduna State. Also, gender factor does not affect the academic achievement of students taught basic science using reciprocal

constructivist instructional approach because there was no significant difference in the achievement of male and female students taught basic science using reciprocal constructivist instructional approach in Rigachikun Education Zone Kaduna State.

5.0 Recommendations

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

1. Reciprocal constructivist instructional approach should be incorporated into the teaching of basic science at the secondary school level since it promotes student achievement in basic science.
2. Teachers should plan their basic science lessons with equal learning opportunities for both male and female students in Rigachikun Education Zone Kaduna State.

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ARTICLE 13

Effect of Evidence-Based Teaching Strategy on Students' Academic Performance in Biology Concepts in Kaduna Education Zone, Kaduna State-Nigeria

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Abstract

Education is the systematic development or training of the mind, capabilities or character through instruction. The impact of teaching and learning science using minds-on and hands-on activities cannot be overrated. Students poor performance in science has been greatly associated with the abstract nature in which science concepts are been taught in schools. This study aimed to explore the effectiveness of evidence-based teaching strategies in biological concepts. Quasi-experimental design was adopted. Sixty (60) randomly selected Senior Secondary School Biology students constituted the sample of the study. Biology Achievement Test (BAT) instrument was used for data collection. The findings indicated that Biology students taught using evidence-based strategy performed significantly better than those taught using lecture-based method. The result further showed that students' engagement/participation in the evidence-based lesson is better than those taught using lecture-based method. It is therefore, recommended that Biology teachers should plan and implement their lessons using evidence-based teaching strategies in order to encourage and promote active learners' participation and meaningful learning of biological concepts.

Keywords: *Biology, Cooprative learning, Evidence-Based Strategy, Participation, Academic Performance*

1.0 Introduction

1.1 Background to the Study

Education is the systematic development or training of the mind, capabilities or character through instruction. Education varies in its forms, philosophy, contents and methods as there are different societies in the world. In Nigeria, the National Policy on Education is an instrument 'per excellence' for effecting national development (FRN, 2013). It is further added that education shall continue to be highly rated in the national development plans because education is the most important instrument of change and that any fundamental change in the intellectual and social outlook of any society has to be preceded by educational revolution (FRN, 2013). Hafsat and Ibrahim (2017), opined that science and Mathematics education are disciplines that are concerned with training on the transmission of scientific and mathematics concepts mainly acquainted with questioning, experimenting and thinking.

Biology is recommended as one of the core science subjects in the senior secondary level of education in Nigeria. Biology as a subject is the science of life and deals with the study of living things. According to Ibe and Ukpai (2013); Akanbi and Kolawole (2014), biology is the study of different forms, evolution, structures, functions, growth, distribution and taxonomy which occupies a unique position in the secondary school curriculum. It serves as a pre-requisite to the study of other lucrative and challenging professions like; Medicine, Nursing, Pharmacy, Pharmacology, Biochemistry, Agriculture, Microbiology, Geology, Geography, Technological and other applied sciences. The vital role of the study of biology in the economic, industrial and public life of the learners and the general humanity cannot be overstressed. Umar (2011), stated that biology is a natural science which deals with the living world. It explains the structure, function, development and existence of living things, while also providing justifications for their reactions with the environment within which they exist. Peter (2015) declared that the study of biology provides an ideal preparation for a list of careers ranging from basic science to engineering. Biology concepts in the senior secondary school are thought using several available methods of teaching such as lecture, discussion, concept mapping, demonstration among others. Marzano (2010), opined that teaching is both a science and an art, where having content knowledge only, does not guarantee that one can effectively instruct others in a manner that facilitates content retention. Fullan (2011); and Hargreaves & Fullan (2013), opined that individual teachers all have their own personalities and experiences that in turn establish individual teaching styles. Improving classroom instruction and student learning necessitates that school administrators cultivate the individual as well as the collective capacity of teachers, as collaboration among teachers is one of the fundamental strategies needed to build capacity. The focus therefore, is not only on improving student learning but also on building teachers' knowledge base of current best practices and supporting them as they adapt and implement new instructional approaches (Quintis, 2011). Also, creating change in teachers' professional practices requires systemic and engaging professional development that empowers teachers to change their beliefs and instructional practices (Harris & Hofer, 2011; McLeskey, 2011).

Lecture and other methods of teaching such as discussion method is the teaching strategy commonly used by most teachers in Nigerian schools. This method, according to Olorunyomi (2013) is teacher-centred and characterized by the teacher talking to the class most of the time while the students listen and take down notes where possible and occasional asked questions. It does not involve the learners enough participation in the teaching and learning process. It was concluded that discussion method may degenerate into mere talk and may be monopolized by few individuals. In an environment of such an approach, according to Olkun and Uçar (2014), students are passive receivers. Doruk (2014), further ascertained that this approach renders students' passive in the teaching-learning process as it supposes learning to occur by means of the teacher transferring knowledge to passively listening students. The National Commission for Colleges of Education (NCCE, 2008) stated that for effective teaching and learning to be achieved, teachers ought to explore several methods of teaching. Eze (2012) further asserted that for learning to be meaningful and effective in the classroom, the teacher should be able to select the appropriate

teaching strategies that will stimulate learners' interest and get them actively engaged in the process of learning.

The National Policy on Education (2013) emphasizes paradigm shift in educational practices from teacher-centred to learner-centred approach and according to Ayhan (2011), students could rather have an active role as individuals who questions, interprets, reason, wonder and not only solve the problem but also construct it, showing the initiative of a typical scientist and forming their own cognitive structures with the help of activities as Petty (2006), ascertained that teaching is just too difficult to get right, it is always possible to improve. Increased attention to improved teaching and more student engagement in learning can result in high quality education (Bok, 2006). A key component of quality education is the use of teaching strategies that have extensive research evidence for their effectiveness. Groccia (2010) asserted that Evidence-Based Teaching strategy is the meticulous, unambiguous, and judicious integration of best available research on teaching technique and expertise within the context of all educational stakeholders such as student, teacher, and community characteristics. Research findings by Ambrose and others (2010) reveals that the seven principles of learning can sum up teaching by evidence-based approach. The principles are as follows:

i. Prior knowledge influences current and future learning.
ii. How students organize knowledge influences how they learn and how they apply what they know.
iii. Motivation determines, directs, and sustains learning.
iv. Students develop learning mastery by acquiring component skills and practicing combining and integrating them.
v. Goal-directed practice coupled with targeted feedback facilitates learning.
vi. Emotional, social, and intellectual climate factors influence learning.
vii. Metacognitive monitoring of learning facilitates further learning.

Evidence-based teaching does not dictate what a teacher should do; it just shows you how best to achieve your own values, priorities and goals. Evidence-based strategies re-professionalizes teachers, giving them control over initiatives to improve learning, even giving them control over the most important part of the curriculum. Finding by Hattie (2009) revealed that there is a consistent consensus for the effectiveness of eight strategies, all of which can be directly implemented by teachers, from early childhood through secondary education. Hornby, Pilgrim & Greaves (2019) therefore, proposed that these eight evidence-based strategies are key to improving student outcomes and that all teachers should learn how to use them effectively. The eight key strategies are: peer tutoring, direct instruction, metacognitive strategies, formative evaluation, functional behavioral analysis, student-teacher rapport, parental involvement and cooperative learning. Cooperative learning instructional strategy as an evidence-based approach is therefore examined in the study.

Cooperative learning is an instructional strategy which organizes students in small groups so that they can work together to maximize their own and each other's learning. A large and rapidly growing body of research confirms the effectiveness of cooperative learning in school (Smith,

Sheppard, Johnson & Johnson, 2005). Specifically, the cooperative learning approach to instruction is where students are arranged in pairs or small groups to help each other learn assigned material (Trowbridge, L. W., Bybee, R. W. & Powell, J. C., 2000). According to Felder and Brent (2010), it involves students working in teams on an assignment or project under conditions in which certain criteria are satisfied. These conditions include team members being held individually accountable for the completion of content which in turn facilitate the completion of the assignment or project. Similarly, Duplass (2006) and McKeachie (2007) further states that conditions under which student work to accomplish task in cooperative learning include positive interdependence, individual as well as group accountability, appropriate use of collaborative skills and group processing. Students in cooperative learning groups are likely to make more effort and take greater responsibility for their learning, since they are clear that their contribution to teamwork can be individually identified and assessed (Brown & Thomson 2000).

Interaction among students in cooperative learning groups is intense and prolonged (Borich, 2004). Unlike self-directed inquiry, students gradually take responsibility for each other's learning. Cooperative learning has been found to be useful in several areas such as helping learners acquire the basic cooperative attitudes and values they need to think independently inside and outside the classroom (Borich, 2004); promoting the communication of pre-social behavior; encouraging higher order thought processes; and fostering concept understanding and achievement (Trowbridge et al, 2000; Borich, 2004). Cooperative learning gains are not limited to a particular ability level or sex but to all who engage in it (Ajaja & Eravwoke, 2010). It brings about significant improvement in students' achievement in school science subjects as findings by Ajaja and Eravwoke (2010) indicated that students in cooperative learning group outscored those in the lecture group in an achievement test and a non-significant difference in achievement scores between male and female students in the cooperative learning group.

To actively engaged students in the process of learning, it is important that teachers adopt a teaching approach that suit the learning style of the students. A number of studies discovered that students learn better when teaching is interactive and student-centered. This is an indication that teachers must adopt more interactive approaches to leaching as the onus rests on the teacher to make teaching interesting, effective, and innovative (Otchie, 2018).

1.2 Research Questions

The following research questions were formulated to guide the conduct of the study:

1. What is the difference in the mean academic performance of students taught biology concept using evidence-based teaching strategy and that taught using lecture method in Kaduna Education Zone, Kaduna State?
2. What is the difference in the academic performance of male and female students taught biology concept using evidence-based teaching strategy in Kaduna Education Zone, Kaduna State?

1.3 Hypotheses

The study has the following null hypotheses to be tested at ≤0.05 level of significance:

1. **HO_1:** There is no significant difference in academic performance of students taught

biology concept using evidence-based teaching strategy and those taught using lecture methods in Kaduna Education Zone, Kaduna State.

2. **HO_2:** There is no significant difference in academic performance of male and female students taught biology using evidence-based teaching strategy in Kaduna Education Zone, Kaduna State.

2.0 Methodology

2.1 Research design

The study is quasi experimental with pretest, posttest, experimental and control groups. In the design, both the experimental and the control groups were pre-tested to ensure group equivalence, thereafter exposed to treatment and at the end post-test was administered to determine students' performance.

2.2 Population and sample size

The study population consists of all senior secondary school one (SSS 1) students in Government Secondary School, Badarawa located in Kaduna Education Zone, Kaduna State-Nigeria. Sixty (60) students were randomly selected and divided into two (2) equivalent groups: experimental group and control group. The experimental group was exposed to Evidence-Based teaching strategy in Biology concept while the control group was taught same concept using lecture method.

2.3 Research Instrument

Biology Achievement Test (BAT) instrument was developed by the researchers on the topic "skeletal system'. The instrument was validated by chief lectures from the Department of Biology, Federal College of Education, Zaria, Kaduna State-Nigeria.

2.4 Method of Data collection and Analysis

Biology Achievement Test (BAT) was used for data collection. Descriptive and inferential statistics were used to analyze the data collected. Mean and standard deviation were calculated and t-test was used to analyze the null hypotheses at 0.05 level of significance.

2.4.1 Null Hypothesis 1 (HO_1): There is no significant difference in academic performance of students taught biology concept using evidence-based teaching strategy and those taught using lecture methods in Kaduna Education Zone, Kaduna State.

Table 2.1: t-test analysis on significant difference in academic performance of students taught biology concept using evidence-based teaching strategy and those taught using lecture methods.

Group	N	Mean	SD	Df		t-cal	t-crit	Decision
Experiment	30	32.57	2.69	58	0.05	9.11	2.00	Rejected
Control	30	19.75.	2.09					

Table 2.1 indicated that the experimental group has a mean score of 32.57 and standard deviation of 2.69 while the control group has a mean score of 19.75 and standard deviation of 2.09. The table also reveals t-calculated value of 9.11 and t-critical value 2.00 at 0.05 level of significant. The findings therefore show that the null-hypothesis is rejected because there was significant difference in the academic performance of students taught Biology concept using evidence-based teaching strategy compared to those taught using lecture method in Kaduna Education Zone, Kaduna State.

2.4.2 Null Hypothesis 2 (HO_2): There is no significant difference in academic performance of male and female students taught biology concept using evidence-based teaching strategy.

Table 2.2: t-test analysis on significant difference in academic performance of male and female students taught biology concept using evidence-based teaching strategy in Kaduna Education Zone, Kaduna State.

Gender	N	Mean	SD	Df		t-cal	t-crit	Decision
Male	13	32.22	2.78	30	0.05	1.01	2.04	Retained
Female	17	32.84	2.62					

As observed in table 2.2 above, male has a mean score of 32.22 and the standard deviation of 2.78, while female has the mean score of 32.84 and a standard deviation of 2.62. It also revealed t-calculated value of 1.01 and t-crit value 2.04 at 0.05 level of significance. The null-hypothesis is therefore retained because there was no significant difference in the in the academic performance of male and female students taught biology concept using evidence-based teaching strategy.

3.0 Implication of Findings

The result of the study as indicated in table 2.1 shows that there is significant difference in the academic performance of students taught Biology concept using evidence-based teaching strategy (experimental group) and those taught using lecture method (control group. The experimental group performed significantly higher than the control group. Table 2.2 also indicated that there is no significant difference in the mean academic performance of male and female students taught Biology concept using evidence-based teaching strategy. This therefore mean that evidence-based teaching strategy is gender friendly.

This implies that evidence-based teaching strategy actively engaged students in the teaching and learning process and enhances academic performance in biology. This finding is in line with the study conducted by Eze (2012), for learning to be meaningful and effective in the classroom, the teacher must be able to select the appropriate teaching strategies that will stimulate learners' interest and get them actively engaged in the process of learning. Also, Bok (2006) opined that increased attention to improved teaching and more student engagement in learning can result in high quality education.

4.0 Conclusion

From the findings of this study, it could be concluded that Teaching strategy that teachers employ in science teaching has significant effects on students' performance. Evidence-based teaching strategy enhance effective learning of biology than the lecture method. Also, that male and female performed significantly better when taught biology using evidence-based teaching strategy.

5.0 Recommendations

On the basis of the findings and conclusions in this study, the following recommendation are made:

i. Evidence-based teaching strategy should be incorporated into the teaching of biology concepts at the senior secondary school level since it promotes students' achievements in biology.
ii. Teachers should plan their biology lessons with equal learning opportunities for both male and female students.

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Strand 4 # ICT Integration in STEM Education

1. Resources & solutions in learning STEM subjects
2. Learning STEM through games & robotics
3. Linking school & industry on STEM education

ARTICLE 14

District instructional management system for STEM learning

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Abstract

The key conceptual question in this paper is: How do educators continue to facilitate quality teaching and learning during a global pandemic? The purpose is how to maintain undisrupted learning during the COVID-19 outbreak, based on the Chinese and local experiences during the national lockdown in South Africa. These experiences are aligned with critical education priorities to the crisis as the problem statement, in order to ensure continuity of academic learning for students. The hard lockdown in South Africa, on 26 April 2020 has shown that the national shutdown caused serious disruptions in all sectors. Lessons learnt from 2002 SARS and the H1N1 flu in 2009 pandemics threatened the lives of people, and led to school closures in Europe and Asian countries. The Chinese Ministry of Education launched in 2020 an initiative titled "Disrupted classes, undisrupted learning" to provide a sustainable alternative to millions of students outside of schools. This initiative resulted in the Handbook which indicated that the availability of a 'learning tool' is most crucial in school-based institutions. SISOPEN ensures that students from poor and marginalised communities have access to quality education through the district instructional management system for schools (DIMS). It is an online learning tool that provides access to students with high quality teaching, facilitation of learning and assessments functionalities beyond face-to-face school experiences. DIMS is a web-based learning system, connects and aligns with the flexible online learning of the Chinese initiative. This paper argues that through the DIMS as a methodology of monitoring and evaluation, allows district officials to manage student learning in all schools at the same time, 24/7. We'll share experiences of schools servicing communities with serious socio-economic challenges. However, the resilience of these schools during the pandemic is replicable and sustainable within the current resource and budget constraints of similar schools and district.

Key words: *COVID-19 pandemic, teaching, facilitation of learning, learning, heutagogy, district instructional management system/tool (DIMS).*

1.0 Introduction and background

The large-scale outbreak of the COVID-19 pandemic and South Africa's response with a hard lockdown on 26 April 2020 has shown that the national shutdown caused serious disruptions in the economic, health as well as the education sectors. Lessons learnt from the 2002 SARS pandemic that threatened the lives of people, show that countries like China banned face-to-face teaching in several regions. Similarly, the outbreak of H1N1 flu in 2009 resulted in school closures in Bulgaria, Serbia, China, France, Italy, Japan, New Zealand and Thailand (Cauchemez et al., 2014).

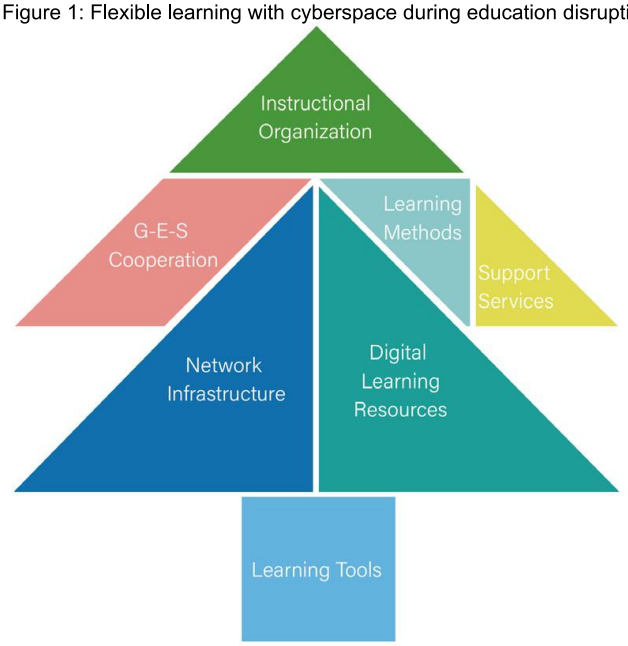
The Chinese Ministry of Education indicated that they managed 518,8 thousand schools, 16,7 million full-time teachers and 276 million students during 2018 (Huang 2020). We can therefore learn for China with the biggest population and education system in the world. Since 2002, China has been consistently affected by these outbreaks therefore, the Chinese Ministry of Education launched an initiative titled "Disrupted classes, undisrupted learning" in a response to a national threat such as a pandemic and to provide a sustainable alternative such as flexible online learning to millions of students outside of onsite schools. This initiative resulted in the "Handbook of facilitating flexible learning during educational disruption", with seven factors for online education. While these factors were constructed, in terms of priority, through three designs namely (i) government-led, social-service and school-based (figure 1). It is specifically interesting that the school-based design identified the availability of a 'learning tool' as the most crucial factor in school-based institutions "that can be used online as well as offline to manage or create different learning resources" (Huang 2020, p.13).

SISOPEN, a non-profit organisation in South Africa (Cape Town), was registered in May 2019 to ensure that students from poor and marginalised communities have access to quality education through quality assurance technologies, and serves as a support to teachers and/or schools. One component of this initiative includes a district instructional management system (DIMS), through its online learning tool, provides access to students with high quality teaching as well as facilitation of learning and assessments beyond their face-to-face school experiences. This DIMS is a web-based learning system, connects and aligns with the flexible online learning of the 2020 Chinese initiative of "disrupted classes, undisrupted learning" as it facilitates flexible learning.

In South Africa, the 'disrupted classes with undisrupted learning' was located mostly in schools with their own learning management system (LMS), whether web-based or through a manual process. In the web-based DIMS, students and teachers will engage through their specific portal system such a Moodle, etc. This could have been in place before COVID-19, and therefore the engagement between teachers and students would exist. These learning tools are personalised between the teachers and students, and the school management structure will have monitoring and evaluation privileges to have an overview of the processes.

Schools without a web-based system, will have a manual process of following the policy requirements as per the curriculum and assessment policy statements (CAPS, 2011), the national policy for assessment (NPfA, 2011), and similar policies and regulations. Constructing these policies and regulations in an organised and sequential process would be challenging, but possible. More challenging is when some of the skills sets are based at district level, but not supported at school level. A typical example of this system is the New York State Education Department (https://www.engageny.org), where the specific curriculum has been divided into the individual curriculum chunking bites (Marzano & Brown, 2009), to allow teachers to deliver their daily activity plans (https://www.engageny.org/resource/grade-8-mathematics-module-1) from the modules. In this process, the curriculum policy and resources are aligned to the specific weeks and days through their curriculum mapping. The curriculum resources are either located at the national and/or provincial level, while the education officials relevant to this engagement with teachers will be at district levels. The current South African resources at national and provincial level have the potential to benefit teachers, if they are organised, aligned and mapped. But these resources are primarily focusing on teaching, while learning is missing from this design. And the system is useful during face-to-face learning, but have to utilise WhatsApp and other systems to get the 'learning' back from students.

Figure 1: Flexible learning with cyberspace during education disruption



However, the real focus is about schools that experienced the 'disrupted classes with disrupted learning', and with a lack of an instructional management processes for the year. This disrupted learning has been a problem before COVID-19. There are enough references (Bipath, 2005; Gallie, 2010) to the lack of protecting the 170 instructional days by schools and education officials.

2.0 Literature review

This section will deal with the key concepts that form the basis of this paper:

2.1 COVID-19 pandemic or crisis

COVID-19 pandemic was described by activist Arundhati Roy in Arnove (2020, p.43) as "a pathway that leads to a reconfigured future, one that must be different from the world we previously knew." The inequalities within the education system around the world, meant that the most marginalised and poor students were affected by their government's inability to offer online instruction to students. Multiple researchers (d'Orville 2020; Soudien 2020) reported on the lack of computers, Wi-Fi and learning space at home, at a micro level, as well as the lack of instructional

management tools at micro- and macro-levels of educational departments and governments in general. d'Orville (2020, p.11) argues that the "vulnerable and disadvantaged students who rely on schools for a range of social services, including health and nutrition" were "disproportionately hurt" by the pandemic.

UNESCO launched a Global Education Coalition in order to "coordinate and innovate action, seeking solutions that will support students and teachers" (d'Orville 2020, p.12), but the organisations affiliated to this Coalition are internationally based whilst smaller organisations that are locally based, such as my own non-profit organisation, sees this an opportunity to have an international focus with the potential to make a difference beyond COVID-19.

Zhao (2020) argues that "if we treat COVID-19 as a short-term crisis, then whatever we do to help extend learning when schools are closed will be only temporary. As soon as schools are reopened, the status quo will be restored", while the current education system "has broken rhythms and routines, shattered patterns and norms, and exposed the best and worst of humanity and human institutions" (p.29). By replicating the schooling system through online resources, broadcasting content to students, duplicating and stapling notes to be collected, and even letting students decide what they want to do, has not showed a real commitment to change the current education system.

A deeper question focuses on 'changing the HOW of learning', since COVID-19 has changed the situation of how to learn. More specifically, Soudien asked whether "individualised learning" is "big and perhaps too difficult a prize to present". We will show that individualised learning in every school in South Africa and other countries, is possible within the current financial constraints – it is about thinking transformative within the current realities of developing countries.

2.2 Understanding teaching and learning in classrooms

The leading education researchers during COVID-19, indicate that the "unprecedented closure of learning institutions, one of the most pressing tasks facing educators is to ensure that students' learning is uninterrupted" (Popa 2020, p.1) While the UNESCO (2020) article highlights the importance that learning of students should not stop, the author argues that we "need to make sure that learning specifically quality learning actually happens" (Popa 2020, p.1). In South Africa, the same conversation about learning has become relevant during lockdown as the focus was also on 'learning during COVID-19', which was mainly highlighted by print media and social spaces in the country. However, the conversation was driven by an equivocate (mix up) of the concepts of 'teaching' and 'learning'.

Teaching is essentially what teachers will do in classrooms, while learning is what students do in order to know, understand and display their learning. For the most, the 'online' websites were either focusing on 'teaching' (sharing of textbooks, videos, workbooks, etc.), or on 'learning' and 'assessment'. Only a few online sites from the national, provincial and districts in the country were focusing on 'facilitating learning', which came from foreign countries that focuses on 'skills-based', 'capacity-based', 'performance-based' and 'standards-based' learning, where the learning outcomes are clear and defined. The South African curriculum (CAPS) is 'content-based' as an input measure of teaching while the previous countries are learning 'output or outcomes'

focussed. Therefore, the online 'free resource' websites had different roles in the continuum of instruction: (i) teaching; (ii) facilitating of learning; (iii) learning; and (iv) assessment.

Learning is about the students and their (i) dreams and hopes; (ii) risk(s) through quantitative and qualitative data; (iii) needed to improve learning; (iv) knowledge, skills and experiences; and (v) targets beyond the risk margin for pass/fail, and working towards mastery and teachers will utilise the most effective research, informed pedagogy, and relevant theories to ensure that students are successful. These are about teachers being "mindful of what our new learning about learning" (Soudien 2020, p.66) could tell them.

While teaching is primarily delivered by the teacher, and learning is the responsibility of the student, it is facilitation of learning that connections these two activities. Facilitation of learning intends to support students to use their information and/or knowledge acquired (through teaching) to increase their understanding through independent tasks such as (i) individual work; (ii) pair work; (iii) group work; and (iv) role play. It is through COVID-19, that the lack of relationship building between teachers and students, and similarly between subject advisors and teachers, was glaring. It has been reported by adults that students were not responding to the WhatsApp requests of teachers; and subject advisors could not contact teachers due to the lack of shared contact numbers. Many schools spent the first month during lockdown just to get hold of the contact numbers of students.

2.3 Heutagogy

The lack of instructional processes, patterns and strategies were exposed during COVID-19, since most schools are accustomed to the normal action of students and teachers going to the physical classroom. School leaders know very little what is going on in the classroom, other than doing observations. During lockdown, they had no clue whether teacher engagements with students as requested took place. As endorsed by one of the senior education leaders in South Africa, there were 'operational and implementation blindness' among those responsible for monitoring and evaluation of learning. Those teachers who have built strong relationships with their students before lockdown, and in particular, through digital teaching platforms, had a significantly different experience than their peers who engaged with traditional teaching.

The investment in a good classroom culture and instructional strategies is crucial, and therefore to empower teachers during professional development workshops (Donaldson 2015, Chapter 5) is crucial. The relationships between teachers and students will therefore be based on their learning contract in and outside the classroom. In the absence of this learning contract, teachers could not demand these relationships during COVID-19, and particularly during the 'social distance' situation of remote learning.

Heutagogy is all about students driving their own learning, and emphasising the development of autonomy, capacity and capability. Although some students naturally have the capacity and ability to learn on their own, the majority of students have to be developed in order to become self-directed students. The Gradual Release Model (Fisher and Frey, 2003) gives teachers a process and tools on how to organise the instruction process within the classroom that empowers and helps students come independent.

2.4 Learning tools

With the rapid increase of technology in education, the way teachers deliver their lessons, and the way students will engage and make sense of learning will have to change. However, most education systems have been stagnating despite the emergence of these learning tools. There are numerous online tools that supplement information to students, while providing learning with many different options for from teaching to learning. Learning tools are any programme, application or technology that can be accessed via an internet connection and enhance a teacher's ability to supplement and enhance the instructional processes through blended, flipped and distance education classrooms.

The Chinese research (Huang 2020, p.13) identified the learning tool as a crucial factor after basic network infrastructure in schools, that will allow school leaders to manage what they know, rather than engaging blindly in new territory, and as opposed to sharing with students from a library of resources. The research covered an extensive list of categories of learning tools (Huang 2020, p.20), far beyond the UNESCO and Commonwealth of Learning (2019, p.12) on open resource policies, as it focuses on a specific uniqueness of interaction and synchronisation.

3.0 Methodology

3.1 About the study

This quantitative and qualitative study combines curriculum analysis, conceptual engagement and critical policy analysis within the praxis domain (showing theory within practice). By examining the ways in which the curriculum gets made through the interplay of curricular policy formulation and implementation, and other discursive practices, this study contributes to the development of curriculum as a social practice of logic and stability in instructional leadership and management. Instead of conceptualizing curriculum as a syllabus to be implemented, this approach moves towards more nuanced strategies that construe curriculum making as a multi-layered series of social practices, differentiated not by institutional boundaries (government, schools, etc.), but by their effects as social transformation and justice (Priestley and Philippou 2018, p. 156). Although critical curriculum policy analysis has conventionally reflected education policy *other* than curriculum policy, applying critical curriculum analysis as a lens for curriculum inquiry can effectively conceptualize such complexities.

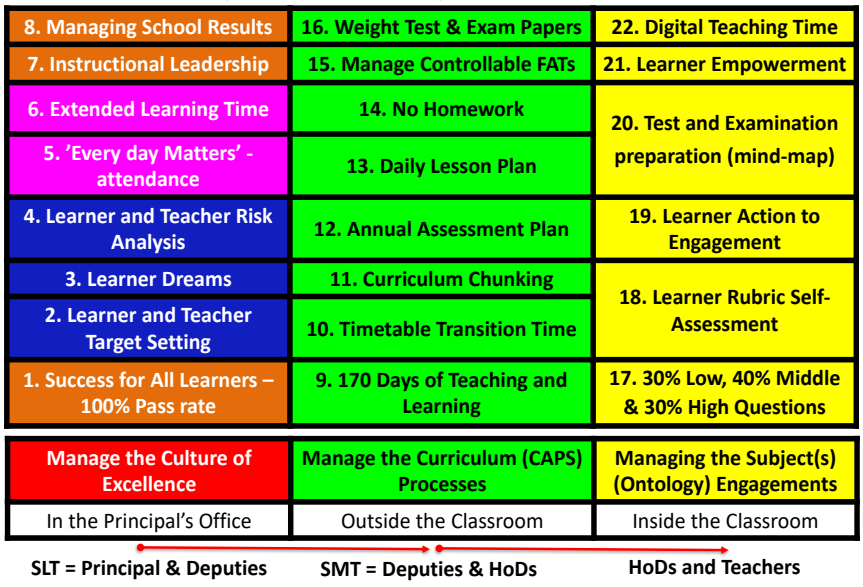
Ball, Braun, and Maguire's (2012) enactment framework is employed to conceptualize the positioning of teachers in curriculum policy formulation and practices. It reframes the role of principals as the change agent of instructional leadership and implementation (Awuah, 2019), who *enact* rather than merely *implement* policy in the school and classrooms. An enactment approach focuses on analysing the interpretive policy work of teachers within their specific contexts and recognizes that "policy is done by and done to teachers; they are actors and subjects, subjects to and objects of policy" (Ball, Braun, and Maguire 2012, p. 3). Examining the *discursive practices* that constitute curriculum enactment illuminates the sets of practices in knowledge formation (policy in action), and the rules that govern or explain what is possible to say (policy in use) (Bacchi and Bonham 2014).

Through analysing the entire curriculum management policies and processes in CAPS, it is clear that it includes multiple ideas (promises) taken from developed countries. Although these ideas sound promising, there are major gaps between the content promises and the context realities in developed, developing and poor countries.

3.2 District Instructional Management System (DIMS) for schools

We conceptualised the School of Excellence Methodology (SEM), as the basis of SISOPEN's foundation of the open technology within the software system. It includes three domains, namely (i) creating the culture of excellence through principal leadership; (ii) innovative curriculum management processes that are aligned; and (iii) learning-centred classroom activities that create student ownership and success. The purpose and focus of this paper is the curriculum management domain, with the first 5 strategies of the methodology (strategies 9 – 13 in figure 2).

Figure 2: 22 Strategies of Excellence



The alignment of these strategies create an innovative system of curriculum management that leads to accountability from students, teachers, heads of department, principals, curriculum advisors, circuit managers and district directors. This thinking process therefore connect the responsibilities of both the school and district within the same accountable zone.

In order to construct the District Instructional Management System (DIMS), there are 5 strategies, namely (i) the total number of instructional school days; (ii) the instruction time per week; (iii) the curriculum mapping (chunking) process; (iv) the formal assessment tasks for the year; and (v) the total number of hours per subject, per grade for the year. These strategies are sequential, since the early numbers inform and influence the latter. The calculations below will be based on the public (government) schools sector requirements from policy documents, and therefore don't include calculations that are different and/or flexible to private school sectors and others. However, the process below is generic and relevant to all schools and districts intended to generate their DIMS.

a) Protecting 170 days of Instructional Activities

The first strategy is about identifying the total number of compulsory school days available for teaching, learning and assessment (excluding the examination and other school days such as sports, religious, etc.) in the country. The dominant design number of school days per year is more or less 200 days (https://school-days.blog), which is the case in South Africa. However, although the

school days per year is legislated through the schools calendar for every year (about two years in advance), there is no legislated policy directive that definitively indicate the total number of teaching, learning and assessment days per year. The deductive reasoning from the curriculum assessment policy statements (CAPS) documents can be assumed that 170 days should be used for that purpose. These days are clear in most countries (www.ecs.org), including the maximum hours per day. The only reference to the concept of 170 days of instruction is a speech made by the Minister of Basic Education on 12 July 2016, that "(o)ne of the critical factors that often reduce curriculum coverage is loss of teaching days. Therefore, from a management perspective there is a need to protect at least 170 days of teaching time. Punctuality and attendance (time on task) has to be consistantly monitored through the use of appropriate tools." (DBE 2016). Although the 'need to protect the 170 days of instruction' is symbolically and conceptually important in the minds of school leaders, it should be the responsibility of circuit managers (school inspectors) to monitor and evaluate the implementation weekly. There should be a system that ensures that the 170 days will be managed for 34 weeks during the school calendar year, with no 'surprises' during term 3 and/or 4, since the instruction days have been planned and managed through the year in a weekly proactive way.

b) Allocated Instructional timetable per week

The second strategy is about the calculations related to the instruction time per week, as well as the total number and length of class periods. This is located in all the CAPS documents (p.5), indicating the 'allocation time' for foundation phase covering grade R, 1 and 2 is 23 hours, grade 3 are 25 hours; intermediate phase for grade 4 – 6 is 27,5 hours; senior phase for grade 7 – 9 is also 27,5 hours; and further education phase for grade 10 – 11 are also 27,5 hours (figure 3). This information is utilised by those who construct the timetable at schools, and must be verified and endorsed by the circuit managers (school inspectors) and curriculum advisors before the start of the new school year. However, the endorsement of the timetable is assumed by district officials, that principals will implement the allocated working time consistently, every week of the school calendar. The lack of monitoring and evaluation of the 'time on task' on an ongoing basis, is one of the major failures of the education system, at the monitoring and evaluation (district) level. Furthermore, most schools in South Africa do not cater for 'moving time' within their timetable. Moving time refers to the total number of minutes, utilised between every period when students and/or teachers physically move from one class or group to the next as per timetable.

Figure 3: Subject Hours per Week

	HL	FAL	Math/MLit	LS/LO	NatSc	Tech	SocSc	EMS	CA	FET-B1	FET-B2	FET-B3
Grade R	10		7	6								
Grade 01	7	3	7	6								
Grade 02	7	3	7	6								
Grade 03	7	4	7	7								
Grade 04	6	5	6	4		3,5	3					
Grade 05	6	5	6	4		3,5	3					
Grade 06	6	5	6	4		3,5	3					
Grade 07	5	4	4,5	2	3	2	3	2	2			
Grade 08	5	4	4,5	2	3	2	3	2	2			
Grade 09	5	4	4,5	2	3	2	3	2	2			
Grade 10	4,5	4,5	4,5	2						4	4	4
Grade 11	4,5	4,5	4,5	2						4	4	4
Grade 12	4,5	4,5	4,5	2						4	4	4

c) Curriculum chunking

The third strategy is about the process of curriculum chunking or mapping, that enables districts to gather data on what is actually being taught and what learners are actually learning, in a systemic and transparent way. The result of this process is a map that teachers use as a tool to stay organised/on track and serves as a framework for daily activity plan in order to prevent learning loss. The reference to chunk, is about ensuring that the daily activity 'chunk' should be small enough and be handled by all students, especially the weaker learners. "Too much information at a specific time swamps the working memory of some students. Therefore, students should be allowed to actively process new content in small chunks or increments based upon their readiness levels and background knowledge." (Marzano & Brown, 2009, p.58). The subject advisor is responsible to take the entire year's subject, and break them up (chunking) into 'digestible bites' (puzzles) and through the daily activity plans, form and build the picture of the subject. Different subjects will have different numbers of subject hours per grade, since the CAPS document (also on p.5) identify the allocation time. The figure 4 indicates the list of subject hours per week – varying from 380 hours for Home Language in the reception grade, while mathematics and/or mathematical literacy is given the second highest number of hours, and the reduction of hours in grade 12 to 30 weeks per year due to the earlier National Senior Certificate (NSC) examinations.

Figure 4: Subject Hours per Year

	HL	FAL	Math/MLit	LS/LO	NatSc	Tech	SocSc	EMS	CA	FET-B1	FET-B2	FET-B3	Total	Hrs p.w.	Wks p.y.
Grade R	380		266	228									874	23	38
Grade 01	266	114	266	228									874	23	38
Grade 02	266	114	266	228									874	23	38
Grade 03	252	144	252	252									900	25	36
Grade 04	204	170	204	136	119		102						935	27,5	34
Grade 05	204	170	204	136	119		102						935	27,5	34
Grade 06	204	170	204	136	119		102						935	27,5	34
Grade 07	170	136	153	68	102	68	102	68	68				935	27,5	34
Grade 08	170	136	153	68	102	68	102	68	68				935	27,5	34
Grade 09	170	136	153	68	102	68	102	68	68				935	27,5	34
Grade 10	153	153	153	68						136	136	136	935	27,5	34
Grade 11	153	153	153	68						136	136	136	935	27,5	34
Grade 12	135	135	135	60						120	120	120	825	27,5	30
Total	2727	1731	2562	1744	663	204	612	204	204	392	392	392			

d) Annual assessment plan of formal assessment tasks (FATs)

The fourth strategy is about the formal assessment plan (formal assessment tasks [FATs]) for the year (indicated by district officials as the school-based assessments [SBAs]). The FATs performance of students is very important since students pass or fail through FATs, at the end of the examination. There are no examinations in foundation phase (grade 1 – 3), and therefore these students pass based on their FATs. However, FATs marks contribute 75% of the final mark of students in intermediate phase (grade 4 – 6), while for senior phase students the FATs marks make up 40% (grade 7 – 9), and in further education phase (grade 10 – 12) the FATs marks for students contribute 25% of the final mark.

It is therefore important that the principal provides teachers with a systemic approach of evaluating how well students progress in every subject and grade (NPfA, p.16), and the FATs hours per year

is calculated at 20% of the total instructional hours (see figure 5). Teachers must ensure that the assessment criteria are clear to the students before the start of the assessment process, and explain to the students which knowledge and skills are being assessed as well as the required length of responses needed to succeed (NPfA, p.16). Furthermore, the teacher must submit the annual formal programme of assessment to the school management team (SMT) before the start of the school year. The role of the SMT is to proactively draw up a school assessment plan in each grade that should be provided to students and parents in the first week of the first term (NPfA, p.17). This is a legal obligation and requirements that are currently not implemented in most schools. And of those schools that have school assessment plans ready at the begin of the year, the FATs are often not dated (planned), and/or not given to all the relevant stakeholders (students and/or parents).

The compulsory mapping (planning) of the FATs cannot occur due to the lack of curriculum mapping (strategy three) including the related daily activity plan dates as clarified in strategy three. Since school leaders must submit the annual assessment plan to their district officials, they tend to target week eight (out of the 10 weeks in term 1 and 3), and the last two weeks just before examinations (in term 2 and 4), which lead to chaos since the teachers and students must complete twenty FATs per grade and principals and SMT members to manage over 100 FATs multiply by the amount of students in the school. Furthermore, these FATs (at least two FATs per subject) are not aligned to the weeks these learning work was completed with students, and this even becomes a major administrative burden in schools. For example, the summary of grade 10 annual teaching plan (CAPS FET Accounting, p.12) provides guidance to schools as to when the FATs should take place, in line with the topics and weeks related to the FATs.

Figure 5: Formal Assessment Tasks (FATs) Hours per Year

	HL	FAL	Math/MLit	LS/LO	NatSc	Tech	SocSc	EMS	CA	FET-B1	FET-B2	FET-B3	FATs p.y.	FATs p.w.	Wks p.y.
Grade R	76		53	46									175	4,6	38
Grade 01	53	23	53	46									175	4,6	38
Grade 02	53	23	53	46									175	4,6	38
Grade 03	50	29	50	50									180	5	36
Grade 04	41	34	41	27	24		20						187	5,5	34
Grade 05	41	34	41	27	24		20						187	5,5	34
Grade 06	41	34	41	27	24		20						187	5,5	34
Grade 07	34	27	31	14	20	14	20	14	14				187	5,5	34
Grade 08	34	27	31	14	20	14	20	14	14				187	5,5	34
Grade 09	34	27	31	14	20	14	20	14	14				187	5,5	34
Grade 10	31	31	31	14						27	27	27	187	5,5	34
Grade 11	31	31	31	14						27	27	27	187	5,5	34
Grade 12	27	27	27	12						24	24	24	165	5,5	30

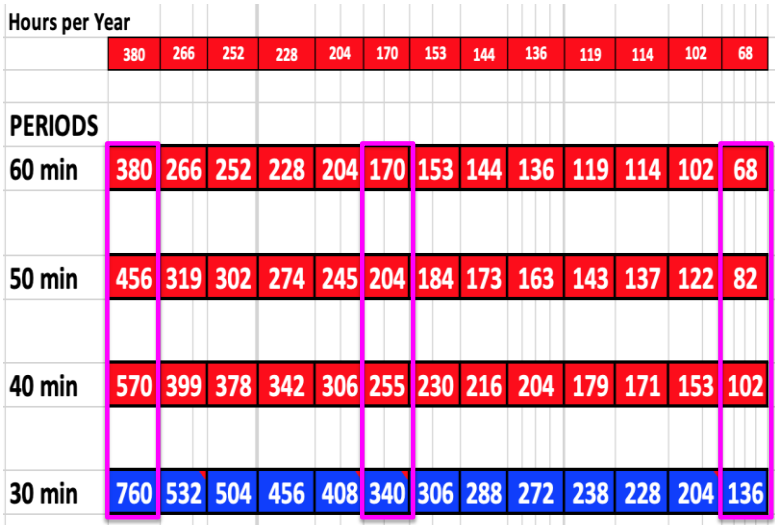
However, it is the responsibility of curriculum advisors to guide and support school principals and teachers in constructing their annual teaching plan (similar to the annual assessment plan) per subject. This support from curriculum advisors could be guidance since the central curriculum is generic, but can allow the school annual teaching plan with minor adjustments (limited flexibility) due to their contextual conditions. There are multiple annual teaching and programme of assessment plans (ATPs and PoAs) from the Department of Education (DBE), but the focus is primarily on the 'teaching' rather than the 'learning' processes in schools, and therefore loses its importance as powerful planning and organising instruments.

e) Total number of Daily activity plans per year

The fifth strategy refers to the total number of daily activity plans per subject for the year, dependent on the period time per timetable design. The timetable design is often a once-off compliance requirement by principals to circuit managers (school inspectors), despite the commitment of principals to protect and honour the timetable design for 34 weeks of the school year. Based on the hours per subject and/or per grade as covered in second strategy, these hours per week should be calculated for the 34 weeks (170 days of instruction) for the year. Figure 6 indicates the amount of subject hours per subject, per year.

This strategy allows curriculum advisors to monitor and evaluate the curriculum completion or progress by teachers through implementing their daily activity plans on a weekly basis. Similar to the circuit managers regarding the protection of the 170 days of instruction, the same could apply by curriculum advisors, since the hours will be known to all per week. It is crucial to understand that the subject hours per year will be influenced by the period time per school. Some schools have the autonomy to decide their timetable based on 30, 40, 50 and 60 minutes per period, while others use either less or more minutes per period. However, while the total subject hours per year will be the same for all teachers as per CAPS, the total number of daily activity plans will be different to subject teachers depending on the period length minutes choice of schools. As indicated in figure 6, a teacher with 170 subject hours per year (in the middle), will have to plan and implement 170 daily activity plans for the year, if the duration of the school period length is 60 minutes. However, the same subject teacher in another school, with a 30 minutes period length will have to plan 340 daily activity plans (shorter 'in time' per period, per activity plans), and those other schools with different period length will be affected differently in terms of the number of daily activity plans. It is therefore important to know how daily activity plans are constructed in different schools with different period length.

Figure 6: Period Time – 60 min to 30 min



Within the SEM (methodology), daily activity plans consist of three components, within one daily activity plan or over multiple daily activity plans. However, the one or multiple daily activity plans will consist of (i) teaching; (ii) facilitation of learning; and (iii) group and independent learning. Most teachers have been trained to focus on teaching, and assumes that learning will take place automatically (naturally). It is only possible when the methods of teaching (instruction) facilitate the space, experience and atmosphere for facilitation of learning to take place.

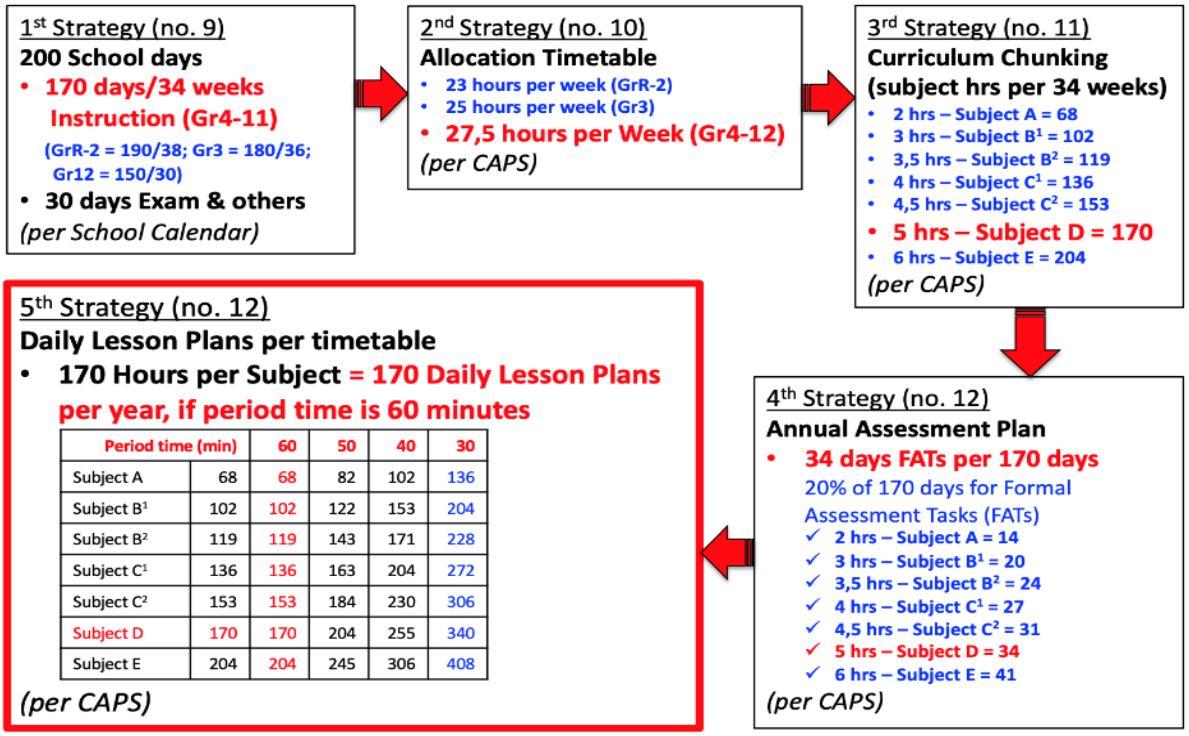
As argued in the literature section, the confusion between teaching and learning in the South African schooling context is real (Soudien 2020) and has to be engaged in order to move beyond

the current practices which is mostly about teaching and expecting student 'learning' to take place at home. This is precisely why our strategy 14 in the SEM (methodology) promotes schooling without homework, but rather classwork to happen at school.

In summary, knowing the total number of days for instruction, and the hours per day (or per week) that lead to an average (grades 4 to 11) of 935 hours of instruction per year, must be protected and managed by teachers, principals and district officials. These hours are divided among different subjects with defined hours of instruction for the year. If the period time in the school is known, then officials know what the total daily activity plans will be, given the three strategies mentioned earlier (170 days/34 weeks X 5,5/27,5 hours of allocated time per day/week X 6/11 period time per day of 1 hour/30minutes periods). And through the DIMS, officials are able to know the specific topic of the daily activity, on a specific day/week within the school calendar year.

3.3 The logic of alignment

Figure 8: Logic Alignment of DIMS (5 strategies)



Period time (min)		60	50	40	30
Subject A	68	68	82	102	136
Subject B1	102	102	122	153	204
Subject B2	119	119	143	171	228
Subject C1	136	136	163	204	272
Subject C2	153	153	184	230	306
Subject D	170	170	204	255	340
Subject E	204	204	245	306	408

Numerous countries design their curriculum to mould and develop students towards the ideas and/or intentions of being productive and contributing citizens after the schooling and education system. It is therefore important to align the curriculum (ideas/intentions) and assessment (outcomes/impact) as an important principle in a coherent education system (Ziebell, Ong, and Clarke 2017). Over the last decade, backwards design has become a common approach to policy makers, curriculum planners, school leaders and educators, by identifying the desired outcomes, determining how the desired outcomes will be assessed, and planning the delivering of teaching and learning accordingly. The perceived benefit of alignment is synchronicity between intent and outcome (Mercurio, 2005). As indicated by Ziebell et al. (2017, p. 190), "assessment is highly

influential in communicating the knowledge and skills that are valued", and drives implicitly and explicitly on the enactment of curriculum.

The gap between the curriculum policy intentions and practice, which is referred to as 'chaos by design', has highlighted the need for a logic alignment between the curriculum policy and implementation (operational) practice. There are two approaches needed to remedy this gap namely, (i) to align the quantitative policy components as covered by the 5 strategies as argued above, with the development of monitoring and evaluation (M&E) processes of accountability through the DIMS; and (ii) district officials (circuit managers and curriculum advisors) take responsibility for the M&E processes on at least a weekly basis, including facilitating support and development workshops to empower school leaders. The logic of alignment among these components as illustrated in figure 6: the DIMS prepares principals to identify the instructional days to be protected and will be prioritised on a daily basis. However, the common assumption is that the more time is spent on instruction, the more students will benefit from extended time for learning, and will encourage teachers to strive for excellence among all students rather than only focusing on gifted students (Connell 2009; Tuinamuana 2011).

4. Results and discussion

4.1 Analysis of the South African education system problems

When analysing the preparedness of the South African education system to respond to the context of the COVID-19 pandemic, we identified the following:

a) During lockdown:

** We don't have a dominant online teaching and learning culture among our teachers:* The vast majority of our schools were not ready to rapidly switch or respond? to online learning during the Covid-19 period. The lack of access to devices, connectivity and sharing of devices or only having one per student in a household are all challenges faced by most students and to some extent teachers as well. Furthermore, many teachers are not familiar with digital learning pedagogies and there is also a lack of capacity at the district level (who are mostly relying on those organisations outside the department) to support online teaching. Despite having young teachers in schools and most of them are comfortable with technology and devices, many do not know how to incorporate technology as a medium to facilitate teaching and learning, other than to use them for their own personal usage. Teacher training institutions are also lacking in equipping teachers for the digitalisation world and preparing the future teachers.

** Focusing on Project work for learning, rather than teaching for curriculum completion:* During the lockdown period, we should focus on students doing projects, investigations and assignments (formal assessment tasks/school-based assessments) and enrichment (giving them a second and multiple opportunities to improve their current performance level), in the absence of tests and examinations. The role of teachers with regard to guidance and facilitation in the teaching process is important – parents cannot be expected to take over this role. If it is expected for students to learn and acquire new topics and knowledge through online teaching, then according to Dynarski

(2018), students face an "online penalty", which is more severe for vulnerable and struggling students with low prior achievement.

** The benefit of teachers who have built relationships of care with students and have been facilitating learning skills in their classrooms:* Teachers who have skills set of relationship building with student and who invested in knowing their students by having their contact numbers due to their relationship of care, had no problem to continue communicating with these students through the WhatsApp and other platforms. The relationship of care includes respect and trust in the teacher-student relationship, as opposed to teachers having no relationship other than contacting students for administration purposes. The administrative teachers struggled to get students to join their WhatsApp groups, since there has been no prior relationship of care other than that of an administrative one. Teachers who moved beyond the traditional teaching processes by facilitating learning in their classrooms, managed to get students involved in their WhatsApp groups, and their engagement which may have started as a trial and error exercise saw the mistakes and being vulnerable as part of the facilitating of learning process in the classroom.

b) After lockdown:

* *Planning for re-entry*: The perception that schools will go back to normal as soon as the lockdown is over, might be misleading. Like any war, the pandemic will leave a serious aftermath in all sectors of society including education and schools. Many students who faced challenges at home or in their community such as poverty, crime, disengagement, illness or death in the family, must have missed all or most of their learning during the reopening of school. Teachers will not be immune to these challenges faced by their students. The psycho-social aspects of re-entry formally into the schooling system is crucial, and must be considered post lockdown or beyond COVID-19 as an adjustment to the new norm.

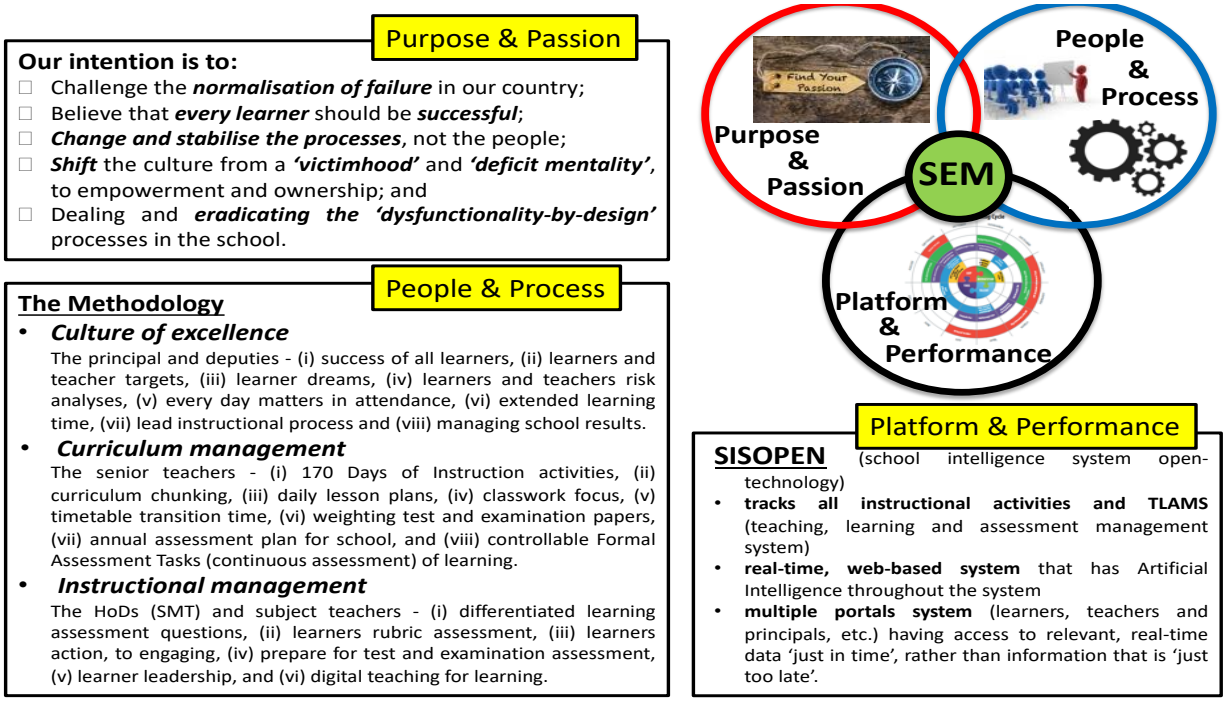
Although most schools were scrambling to set up modes of learning during the re-entering of students after the Minister of Basic Education announced that schools must re-open, district officials concentrated more on guiding schools' leadership to focus on planning ahead. There should have been a greater emphasis on: What will be taught in our school for the next period until end of year? And what and how the resumption of teaching will not prejudice the learning process due to impact of the pandemic? Inadequate or proper planning before re-entering the schooling system created confusion on how to continue with and will have an impact on the planning of the year 2021 and beyond.

c) The awareness process of COVID-19

** Building an education system with real-time monitoring and evaluation capacity at a district and provincial level:* The indirect benefit of the Covid-19 pandemic means that even though social or physical distancing were advocated to curb the spread of the virus, individuals found new ways of listening to each other at a distance – students, teachers and principals, district- and provincial officials. Although education is often referred to as a system that consist of different levels, the COVID-19 pandemic showed that officials were stunned by operational and implementation blindness – not knowing what was going on. The different levels in education only reported on what was going on in their own level (silo) and had no relationship and connection between the different levels above and below. Although there was a great demand and motivation on students to continue learning, but the same demands should have reflected a certainty that all the teachers, principals, and education officials will continue rendering the service directly and/or indirectly to students.

** Clarify the supportive role of circuit managers and curriculum advisors during COVID-19 or similar pandemics:* What was seriously missing was the role of education officials during the lockdown process, other than providing online websites to schools as opposed to ensuring that the

Figure 7: The Infographic of School of Excellence Methodology



particular sections, topics, etc. were useful and relevant and its outcomes are aligned to the curriculum. Even the reference to 'free online' was actually not free, and mostly for 'view' purposes before having to buy resources. Many online links were sent to students and schools without verifying that the content is linked to an activity plan or particular learning outcome. A more coordinated effort could have been made in ensuring that all students are covered or reached.

4.2 School intelligent system at education district as solution

The benefit of having a school intelligence system located at education district level will benefit all schools, and close the class- and economic gaps among communities in the same district. In the schools where the system was implemented, which are primarily in townships, principals had immediate access to student details and could manage the cellular numbers of students (more than 500) in their schools – it is time consuming and a waste of skills to focus on getting information in a crises and where there are lack of clear processes. The benefit of the system is that if through effective communication and reporting such as teachers (class group teachers) reporting to their immediate senior – in this case a SMT member, the system would be able to indicate what the state of play is in the province. If there are some students outside the province – the system will provide that information immediately, rather than having those students become invisible. The monitoring and evaluation processes in the education system creates designers the opportunities to analyse, fix and/or improve the operational processes in schools. A system is assuming that the different parts are connected, in some way, to one or more components to make it part of the system. The development of school intelligence system with open-technology (see figure 7) over the past 5 years is precisely to connect the different sub-parts, and with the COVID-19 pandemic, the importance of a holistic system that captures and connects the various components has been reconfirmed. The system has been presented at the Education Lekgotla in January 2020, under the theme: Business intelligence in education as it is a system that differs from CEMIS, SA-SAMS or the DDD dashboard. It is an intelligence system that provides information what is going on at different levels (all levels mentioned above) in the system, from the Superintendent General of the provincial education department to students anywhere in the province.

5. Conclusion

The COVID-19 pandemic has been devastating to the economy, and other sectors in society, but for change agents in education that have been arguing for a fundamental change in education, has been greatly assisted in advancing the debate and hopefully the practice. Most issues related to teaching and learning, the lack of facilitation of learning, the traditional teaching of rote learning, etc., have been exposed during lockdown. The resistance to introduce technology into the classroom, due to the disruptive nature of devices as argued, has shown that the effects of blended and flipped classroom will outweigh the benefits compared to the current challenges of these new approaches. Teachers who shied away for technology and other electronic devices had no choice but to engage with their students through WhatsApp and other applications, and most teachers discovered an innovative process of engagement between them and their students that can only benefit student and their learning.

However, a major opportunity created by the pandemic is in the field of educational leadership, and in particular the management of instructional processes at school and district levels. The paper indicates that the gap between the schools with multiple resources, compared to those schools without these resources, can be narrowed in a very short space of time, by the proactive engagement of education district officials to construct both electronic and manual processes to stabilise the curriculum management processes in schools. It is the stability within the district instructional management systems (DIMS), that will yield the greatest results within the

'classroom learning' and/or 'home learning', irrespective whether there is a pandemic or not. We know that the DIMS will brings vulnerability in terms teacher accountability, but the benefit to teachers will be that significant amounts of students can now take ownership of their own learning. For parents, care givers, and guardians, the process of teaching, facilitation of learning, learning and assessment is exposed to them, without expecting them to become 'the teacher' during lockdown.

But the biggest benefit to education is the enhancement of monitoring and evaluation processes related to student learning, especially the instructional processes as covered by the five strategies within the school of excellence methodology. For parents who are not specialists in education, they will benefit from knowing what was delivered by teachers on a particular day(s), as per the daily activity plans, and the quality assured resources through the TLAMS that will become an electronic 'tutor' (assistant) to students without the financial burden. Although these resources are freely available at different platforms, it is the the alignment between the daily activity plan, and the relevant and appropriate resources such as videos, classwork, multiple choice and other questions, past tests and examination papers, etc. that can assist parents when they don't have the know-how. Similarly, school leaders and district officials that support schools, will know what is going on, and where they can assist where there are challenges and improvements are necessary. And the electronic process brings a real-time opportunity of 'correcting before it is too late' excitement that should be explored greatly, to the benefit of each and every student in education. The technological challenges such as WIFI and internet connects will only become a priority if we see the potential of these systems like DIMS and others, that can make our education system more successful and exciting. It is therefore argued that the district and school leadership can be responsive to the education disruptions caused by COVID-19, and can ensure that learning will continue during lockdowns.

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ARTICLE 15

School to industry linkage platforms and STEM education in Mozambique: The case of Instituto Industrial e Comercial de Nampula

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Abstract

This study investigated "School to industry linkage platforms and STEM education in Mozambique: The case of Instituto Industrial e Comercial de Nampula". It studied norms and conditions created by *Instituto Industrial e Comercial de Nampula* (IICN), to enable female students successful embrace STEM education and labor market. The paper was submitted to participate in the strand of Teacher Professional Development in Africa. The study based on the theory of University-Industry linkage (UIL) and Gender balance. The study used content analysis for interviews conducted with the director, deputy and heads of discipline at IICN leadership and statistical analysis of the database containing trainers and trainees by discipline. IICN has established a multiplex informal platform of its stakeholders. However, it requires an upgrade for a more formal one, and, later a digital platform to ensure sustainability. Concerning STEM education, there is a serious gender imbalance. So far, only 10% of the 70 STEM trainers are female. Nevertheless, IICN has started an incentive program to increase female students through a compulsory minimum of 10% female admissions. Although this percentage is still low, it is better than nothing. To reduce this gender gap, a positive gender exclusion is required in terms of hiring only female trainers till the 30% goal stated by IICN strategic plan is met, so that those female trainees can serve as role models in STEM disciplines.

Key words: *Platforms, employability, STEM education, gender balance*

1. Introduction

In recent years, debates related to the linkage between school and industry have been gaining ground in education fora. The involvement of girls in STEM education is one of the greatest challenges today. The research aims to bring real information about the mechanisms adopted (platform) by educational institutions in order to foster the access of girls in STEM disciplines, girls' attraction strategies and real data on the rate of engagement of women in general in natural sciences and mathematics and areas of industrial techniques. The relationship between vocational training centers and industries is essential for the creation of employment opportunities. Therefore, the business community and education sector should create, through education, strong linkage to overcome the challenges and needs of employability, build a collective identity, act together as facilitating agents for development. Many technical training institutions and universities carried out isolate initiatives to establish relationship with employment industries, including other

stakeholders, in the process of economic growth. They seek to combine intellectual training and practical activities by promoting events such fairs, scientific tournament days and other actions within the school space, contributing to encouragement of companies to participate, as well as to raise funds for their projects to reduce gender imbalance.

Despite these initiatives on gender, inequalities persist in the educational system as a whole, especially in STEM related courses, such as mechanics, electricity and engineering. While there is a greater appreciation of female education through the increase in parity in the entry and retention of girls and boys in the 1st cycle of primary education and an increase in the number of women entering university, there is prevalent poverty among families, especially in rural areas, associated with the costs of schooling. The inclusion of girls in the labor market is another challenge in Mozambique. According to the Ministry of Gender, Children and Social Action (2020), there are fewer female than male teachers. Stereotypes related to women performance in the workplace does not contribute to changing perceptions about the potential of women. The stereotype is extended to teacher training program which does not include compulsory or optional gender subjects, which would allow teachers to understand how gender inequalities form and their role in reducing it.

2. Platform concept

The word platform is a closed compound that results from a fusion of the term plat - a terrain or a map or plan of an area of land that shows real or proposed features and form - visible configuration of something (Cgiar, 2013). According to the Oxford English Dictionary, this word has several descriptions, such as: (1) "a level and elevated surface on which people or things can stand,"; (2) "A raised floor or stage used by speakers or performers so that they can be seen by the audience" ; "(3) An elevated structure along the side of a railway where passengers enter and exit trains at a station'; (4) An elevated structure standing at sea from which oil or gas wells can be perforated or regulated"; (5) An elevated structure or an orbiting satellite from which rockets or missiles can be launched'; (6) A standard for the hardware of a computer system, which determines what types of software can be run.

A platform is, therefore, defined according to area and objective. A product platform is a set of common components, modules or parts from which a flow of derived products can be created and launched efficiently (Momade, 2019). This definition is merely applied in the field of industrial economics. However, broadly speaking, a platform is "the collection of assets that are shared by a set of products" (Robertson, 1998), where assets can include components, processes, knowledge and people (Nederlof et al., 2011). Another interesting and more comprehensive definition of the term relates to its use in industry.

The term platform in the educational context is the set of definitions, agreements and protocols created between universities [schools], communities and partners that facilitate innovations aimed at creating jobs for their graduates. Thus, it is used in other fields of knowledge to refer to the set of actors in a given sector or activity follow-up, such as the civil society platform in Nampula, which is the set of institutions, organizations and people who work in thematic groups with common interest. (MOMADE 2019:24).

Platforms are positioned at the highest level of innovation systems as they have an interaction interface between innovators. They also increase the possibility of creating products and sub-products where the operating axis is the same. In this case, a platform refers to a set of stakeholders that are brought together by their shared interest (FARA, 2007).

In the context of education, a platform presents itself as a physical or virtual forum to explore opportunities, address common problems, investigate, and implement joint solutions. Stakeholders in a platform should have a common goal of coming together, with clear objectives to all participants and translate them into a commitment to cooperate (Hall & Janssen, 2006). Momade (2019:25), states that platforms provide opportunities that can be explored by its stakeholders in the identification of problems that, through research, can be transformed into solutions that benefit all platform players, as they become available. Thus, all stakeholders are called to commit and converge the results they intend to achieve with the platform.

2.1 Employability platforms

The employability of graduates from technical schools, training institutes and universities is a global debate (Gascón, Bañares & Arriaga 2014, Thoilliez, 2014, Momade, 2019). These authors agree that employability is the ability of a graduate to adapt to the demands of the labor market. This involves developing a set of skills that enable graduate to compete professionally in his/her filed of training.

The most popular theory in employability studies is University-Industry Collaboration (UIC), (Huang and Chen, 2015, Ivascu, Cirjaliu, and Draghici, 2016). This theory is also called University-Industry Linkages (UIL) by Zavale and Macamo (2016). In all cases, the theory assumes that in order to improve graduates' employment market access, it is necessary to establish an environment that favors collaboration between training institutions and the labor market.

Studies conducted by Zavale & Macamo (2016) and Momade (2019) are the best known regarding to application of University-Industry Linkages (UIL) theory in Mozambique, which analyze collaboration between training institutions and the labor market. The latter suggests the implementation of employability platforms to ensure that there are mechanisms, protocols, and procedures that foster interaction. Momade presents a list of activities which increase employment opportunities, namely: professional internships, coaching, professional journeys, innovation fairs, call for idea for funding competition, joint ventures, partnerships with the private sector and angel investor, (Momade, 2019; Huang & Chen, 2015, and Mickiewicz, 2016).

3. STEM education

The concept of STEM - Science, Technology, Engineering and Mathematics, is yet to be standardized Langdon, (McKittrick, Beede, Khan, & Doms, cited in Reinking & Martin, 2018). However, Shapiro and Williams (2012) and, Israel, Maynard, Williamson (2013) agree that STEM education is an approach which, to one extend, supports student participation in engineering and technology, and that improves students' learning in science and mathematics, to another extend, it emphasizes student centeredness and collaboration in the four STEM disciplines. There are several theories about gender gap when it comes to STEM education. Some of them are gendered

socialization, peer groups, stereotypes of STEM professionals (Dasgupta and Stout 2014, Gunderson et al., 2011, You, 2011, Girls, Inc.2016). With regards to the theory of gendered socialization, while there is an increase of the number of women who earn their bachelor, master or doctoral degrees in STEM fields (Hill, Corbett, & St. Rose, 2010), the gap is still huge given the privilege that historically males have been incentivized in STEM related subjects while women have been incentivized (Burton, 1986). This is where parents, teachers and society are called to incentivize girls to promote gendered socialization (Leaper, 2014). The peer groups theory is based on the idea that peers influence on the behavior and development of others, that is, one's acceptance within the peer group is essential to boast his/her motivation to pursue a STEM related course (You, 2011). The peer groups theory is based on the idea that students' stereotypes about the culture of STEM related disciplines and the kind of people working in these fields, the scope of work, and the values of the field including how these girls are bombarded with assumptions that they are unable to excel in these disciplines, teer girls away from choosing to enter them, (Cheryan, Master, & Melzoff, 2015).

Reinking & Martin (2018), propose two engagement strategies, STEM movements and educational strategies; and three recommendations for teachers, such as provision of experiences, use of role models, and facilitation of positivity and curiosity doe girls. In Mozambique STEM education plays an important role given the need to implement science and technology initiatives since the discovery of natural resources which requires specialized labor.

4. Methodology

To carry out this study, we resorted to inductive method, as this is a case study, we met school head of students' affairs at *Instituto Industrial e Comercial de Nampula* (IICN) in order to gather relevant information regarding the procedures applied by the institution for the promotion and placement of its graduates in the labor market. The application of a data collection instrument appropriate to the size and nature of the study was essential, so the interview guide was used as a data collection instrument. In addition to the interview, IICN provided information on the number of students per course, number of trainers per course, an institutional brochure that allowed for a better perception of the IICN course offer.

5. Results and discussion

There are two dimensions of analysis that this research work has embarked on. The first has to do with the linkage between *Instituto Industrial e Comercial de Nampula* (IICN) and the marketplace where the professional who graduated this institution are expected to work, and the second has to do with the landscape of STEM education. In the second dimension, there is a discussion as per how women are represented in this intuition.

5.1 Platform's landscape

IICN is a public professional training institution, which started as Escola Industrial e Comercial Neutel de Abreu, founded in 1960 to run among others courses, the course of Electric Assembling, Mechanical Meltworks, and Administration and Commerce, with installed capacity of 500 trainees. Since its foundation until the mid-1970s, the school had 24 classrooms, including

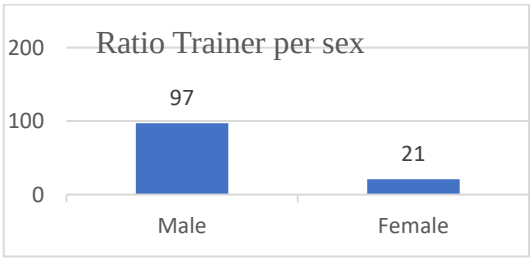
multipurpose and specific, and 6 workshops. After Mozambique's independence, this school was renamed to *Escola Industrial e Comercial 3 de Fevereiro*, and the number of multipurpose classrooms was increased to 36 in 1980. Nowadays, the institution is called *Instituto Industrial e Comercial de Nampula* abbreviated as IICN and offer classical three years course and modular course where in the latter, the trainee gets a certificate of competence at each level.

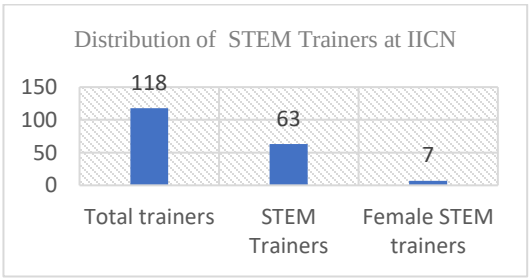
The conditions and mechanisms created at IICN can be classified as a platform. Based on the concept that a platform is a set of mechanism, conditions and protocols created in in order for students to be able to interact with the market place. The first encounter that could describe the presence of platform in that institution is the partnership documents, which they have signed with several institutions for implementation of academic activities and professional internship. There are two types of memoranda that IICN signs with the institutions. The first type is the academic memorandum that allows exchanges between the students of the Institute and other training institutions. For instance, it has established academic partnership with *Universidade Rovuma, Universidade Lúrio, Universidade Católica de Moçambique, Academia Militar Marechal Samora Moises Machel*, and *Apolitecnica*. The second type is the professional memorandum that allows professional internships and integral internships. These types of partnerships are established with private or public companies. Some of those companies are Kenmare, Corredor Desenvolvimento do Norte (CDN), Electricidade de Moçambique (EDM), Cervejas de Moçambique (CDM), Bakreza Group, Corredor Logístico de Nacala (CLN), and Hidroeltrica de Cohora Bassa (HCB). At the moment of Data collection IICN was negotiating a memorandum with Coca-Cola. Academic and professional internships do not render money for the interns and last up to 30 days. When they are extended professional internships last more than 30 days and are paid.

5.2 Gender in STEM at IICN

IICN offers commercial courses such as general accounting, management, human resources management and industrial, such as electricity and mechanics. There are 118 trainers distributed into commercial and industrial (STEM) disciplines.

Chart 1: Ratio and distribution of STEM trainer at IICN



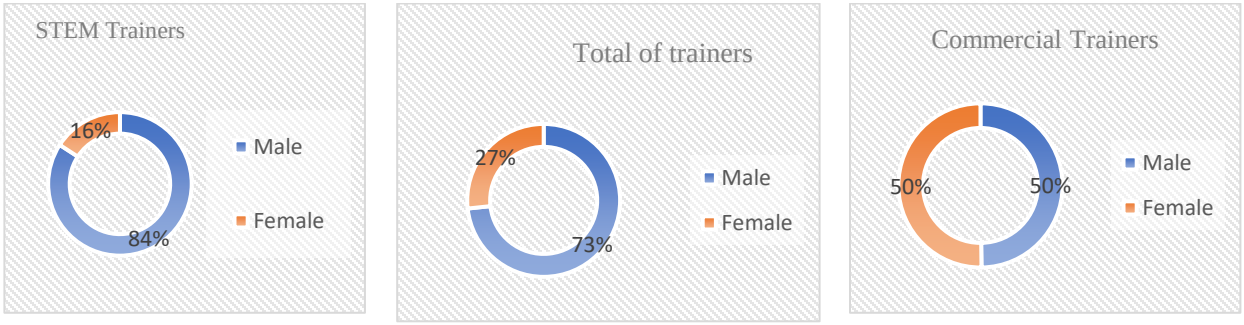


Source: IICN, 2021

The 118 trainers are 70 teach STEM disciplines and 48 teach commercial disciplines including general subjects such as Portuguese Language and English Language. There is a gender imbalance

in this institution because of 118 trainers that exist at IICN only 21 equivalents to 18% are women and the remaining 82% are men assigned to courses in the commercial and industrial fields.

Gender balance in Commercial and STEM course



Source: IICN, 2021

The data above indicate gender balance in commercial courses but imbalance in STEM related courses. In commercial courses, for instance, 50% of trainers are male and another 50% a female. However, when it comes to STEM disciplines in the industrial field (STEM), which constitutes the analysis of this study, there are 70 trainers where only 7 are female, corresponding to 10% and the remaining 90% are male. Note that in the area of mechanics there only one female trainer.

Table 1: Gender balance of IICN STEM students

Ord.	Courses	Distribution per sex		
		H	M	H/M
01	Industrial Electricity	342	88	430
02	Civil Construction	113	30	143
03	General Mechanics, automobile Mechanics, Industrial mechanics,	474	57	531
Total		929	175	1104

Source: IICN, 2021

IICN reported to have 1104 students in all STEM related courses available, where 175 are female students corresponding to 16% and 84% male students. Surprisingly, mechanics, the course with only one female trainer has 11% of female students while Industrial Electricity and Civil Construction has 20% and 21% respectively. It could be a worth stating the few the trainers in STEM course the fewer will be female students in that course. while no declared goal with regards to female trainers, IICN has declared a goal to admit at least 10% of girls in STEM related courses. On top of that, female students have exception of payment in enrollment if they choose to do Industrial courses. Which goes partially along with Reinking & Martin (2018) proposals.

5.3 Discussion

The modus operandi of the employment platform at IICN is quite open to stakeholders. The activities can be initiated by students, teachers, the leadership or partners. Students are allowed to

find a company that they find attractive for their internship. But trainers can also identify company and recommend to their students. It is allowed for companies to write to IICN and request students in a specific field to do their internship. On top of all that IICN has identified key partner companies for each course. These is an excellent example of platform stakeholder commitment, (Momade, 2019, Nieuwerburgh, 2014). To ensure coaching, IICN indicate one trainer to be director of new stream per course. This director does follow-up of the group until its graduation. Then he/she is indicated to new stream. This allows coaching (Inzelt, 2004, Huang & Chen, 2015, Geisler, 1995) in Momade (2019). IICN trainees participate in all show-day events implemented by the academic partners to demonstrate their innovations. One example in 2020, students presented manual machine for maize post-harvesting which will enter into mass production for commercial purpose.

The insignificant number of students in STEM related disciplines can be explained by the theories of gendered socialization, peer groups, stereotypes of STEM professionals (Dasgupta and Stout, 2014, Gunderson et al. 2011, You, 2011, Girls, Inc. 2016), which we have explained earlier in this paper. Probably implementation of positive gender exclusion could create balance in the next few years. With positive gender exclusion we mean hiring female trainers only till the 30% goal they say to be stated in their strategic plan is met. So that female students can see themselves represented in STEM courses.

Following Reinking and Martin account for engagement strategies, IICN with its partners could implement STEM movements where female professionals at local national and international levels who works in STEM related field could serve as role models, offering coaching, lectures, financial incentives, experience sharing, travelling to places to see other female students in STEM field, to encourage as many female students to pursuit STEM courses.

6. Conclusion

School and Industry linkage platform continue an important resource to explore in order to enable prompt and timely response of labor market demand in Mozambique and elsewhere. Indeed, IICN has built a strong reputation in the national professional labor market in the area of commercial and industrial personnel training. Although There is a lasting debate regarding to the quality of education in Public Education institutions, the private sector looks at IICN graduates with appreciation given the fact that important public and private companies seek IICN to sign memoranda to work together. Therefore, this is due to the platform that is in place which enables trainers, trainees, companies, other training institutions to interact well. However, the platform could be improved if there was defined system in a document that is presented to the public as per how to work with IICN. This platform could upgrade to digital platform where all the stakeholders are registered and have protocols to interact for strengthening of the IICN and market linkage.

STEM education is another crucial task that IICN does for social good and a lot of work is required to meet gender balance. Gender balance is global debate and all social and economic actor are called to put efforts together to reduce inequality. In this point, there might an urgent need to develop a global gender balance platform for STEM education. IICN has started with small action in that respect but policy makers could quickly intervene in this subject matter to accelerate the

inclusion of female students in STEM related disciplines, courses and works. As suggest by Reinking & Martin (2018), STEM movements and educational strategies are potential actions where development organization, such Girl move referred to by Momade (2019), and teacher training institutions can embark on to make their contribution to this global challenge.

The statement above does not intend to reduce the important of boys' education in STEM related areas because they are currently securing these fields. Further, this is not a feminist advocation. It is worth to acknowledge that men and women have equal potential and there a need to explore both to ensure sustainable development. In that regard, men and women are called to join this battle whether individual or group once the results of balanced benefit both.

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ARTICLE 16

Attitude of teachers towards the application of information and communication technology (ICT) in teaching and learning of STEM in Rigachikun Education Zone, Kaduna State, Nigeria

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Abstract

The study investigated the attitude of teachers towards the application of Information and Communication Technology (ICT) in teaching and learning of STEM subjects in Rigachikun Education Zone, Kaduna State, Nigeria. A sample of 150 teachers (80 Males, Females 70) was selected through stratified random sampling. A 20 items self-report questionnaire was developed by the researches on attitude of teachers towards ICT application (ATTICT) to elicit information from the participants. The data obtained were analyzed using independent t-test statistics. The result of the study revealed that, majority of the teachers had a very poor attitude towards the application of ICT in their teaching/learning process. It was observed that female teachers had a negative attitude towards ICT application, while male teachers showed positive attitude. Looking at STEM as a philosophy composed of Science, Technology, Engineering and Mathematics, it needs a very sound background to be taught in an interdisciplinary and applied approach rather than teaching the four subjects independently. Thus, the application of Information and Communication Technology (ICT) in its delivery will greatly help in proper utilization of learning resources and effective learning of STEM subjects by the students at different levels, and in turn it will lead to the production of STEM productive graduates that will fit into different scientific and technological industries for economic and social development of a country. Therefore, this paper recommend that continues in-service ICT training be made for teachers in Rigachikun Education Zone of Kaduna State to enhance their capacities in applying ICT in teaching/learning process.

Key words: *Attitude, Teachers, Information and Communication Technology (ICT).*

1.0 Introduction

1.1 Background of the Study

Teaching is regarded as the most essential and strategic profession that intensifies national development, any misconception or non-challenge attitude to it on the part of teacher(s) may render the generations yet unborn to suffer the consequences according to Hunyibo (2000). The progress and success of any educational system which determines the future of a country depends on the quality, competence, effectiveness, and efficiency of its teachers. Information and Communication

Technology (ICT) according to Longe (2010) is a combination of Technologies made possible by the convergences of computer and telecommunication technologies. Yekini and Lawal (2012) Sees ICT as: a powerful collection of elements which include computer hardware, software, telecommunication networks, workstations, robotics and smart chips, which is also at the root of information systems.

Ayeni (2000) reported that through the support of information technology activities like creation, storage, and manipulation of information have become possible. For a functional secondary education in Nigeria, there is a need to consciously develop and employ the use of ICT as it involves internet services. The increasing usage of the internet provides teachers with more information and tools that will support their own ways of understanding Lapite and Adeniyi (2015). To Abdul (2010) ICT can provide opportunities to schools to communicate with one another through e-mail making list news groups and chat rooms. These ICT resources enable communication between scholars as they can post students assignment, books of test on on-line materials.

The benefits of Information and Communication Technology (ICT) to the teaching of STEM subjects for better understanding in Rigachikun Education Zone depend largely on its application and utilization of in the teaching process. Evidence shows that very few teachers have access and skillfulness to ICT facilities. Some do not have the confidence to explore ICT support in teaching activities, while some lack the basic ICT skills and knowledge. With ICT gaining global acceptance and its integration in every field of endeavour, therefore, it is very important all teachers not only for STEM to be equipped with ICT knowledge and skills for effective delivery. Lack of skilled teachers with relevant knowledge and competence on the use of ICT in teaching determine student's the level of success or failure. Teachers play a crucial role in the adoption and implementation of ICT in Education, thus, lack the necessary knowledge and skills hinders the process Yadav (2015).

According to Nwagbo and Ugwunyi (2012) improving the quality of education training is a critical issue particularly at a time of Education expansion. In this regard, ICT can enhance the quality of Education in several ways by increasing learner's motivation and engagement, by facilitating the acquisition of basic knowledge and skills of ICT and by enhancing its teacher Continuous Professional Development (CPD). Various commissions and committees have recommended method of bringing about qualitative improvement in Education, as a result of which teachers are motivated, inspired and endured to develop better curricular textbooks and teaching aids for effective teaching and learning. But all the efforts are meaningless unless teachers are having the positive attitude towards proper utilization of ICT in their teaching/learning process.

The teaching and learning process has been greatly influenced by rapid advances in Information and Communication Technology (ICT) and its Integration in the classroom helps to create an environment for students' activities that lead to meaningful and sustainable learning experiences. This study therefore aimed at investigating the attitude of teachers towards the application of ICT in teaching/learning of STEM subjects in Rigachikun Education zone with a view to proffering

solution(s) to the challenges faced in the course of teaching and learning process for effective delivery and meaningful learning outcome.

1.2 Statement of the Problem

Teaching and learning of STEM subject is gaining popularity day-by-day, as the key subjects at lower and upper basic for technological advancement. Due to the dynamic nature of teaching the subjects, the use of Information and Communication Technology (ICT) will enhance the process for better outcome. As a result of this study, it was discovered that the attitude of many teachers in Rigachikun education zone towards the use of ICT in teaching and learning of STEM subjects is really poor due to the lack of proper knowledge and skills of ICT, to the extent they could not effectively apply it in the teaching/learning process. Therefore, if the teachers can integrate the use of ICT in the teaching and learning of STEM subjects it will be more productive and yield better learning results.

1.3 Objectives of the Study

The study sought to achieve the following objectives:

1. To compare the Attitude of Male and Female teachers towards the application of ICT.
2. To study the Attitude of Secondary school teachers towards the use of ICT in Education.
3. To compare the Attitude of Science and Arts teachers towards the use of ICT.

1.4 Research Questions

To guide the conduct of the study, the following research questions were raised:

1. Is there any gender difference in the attitude of teachers towards ICT?
2. Is there any difference in the attitude towards ICT between selence and Arts teachers?

1.5 Hypotheses

1. There is no significant gender difference in attitude of teachers towards ICT.
2. There is no significant difference in attitude towards ICT between Science and Arts teachers.

1.6 Methodology

The study adopted a survey approach in which a stratified random sample method was used to select participants from five secondary schools in Rigachikun Education zone of Kaduna State, Nigeria. The sample comprised of 150 teachers (80 males and 70 females), A total of 150 copies of the questionnaire were randomly distributed to the selected participants. This had a 100% return rate which subsequently formed the basis for statistical analysis.

1.7 Instrumentation

A structured questionnaire developed by the researchers was used. The questionnaire was a 20-item self-report inventory on Attitude of Teachers Towards application of ICT (ATTICT) in teaching STEM subjects. The questionnaire had two sections. Section A sought demographic information of the participants, while section B was geared towards finding out information from the participant's attitude towards ICT application. It has a likert type questionnaire on a 4-point

scale ranging from strongly Agree (SA) to Strongly Disagree (SD). It consists of 20 items in attitude towards ICT application.

1.8 Validity and Reliability

The researchers established the psychometric proportion of the instrument (validity and Reliability) by giving the developed instrument to three experts in Science and Technology Education Department Kaduna State University. All the corrections and some ambiguous items were put in proper shape before the final print out of the instrument. The reliability of the same instrument was confirmed by the use of split half method of reliability in which all the scores of the even items and of the odd items were correlated with the use of Person moment correlation. A reliability of 0.7R was obtained hence the instrument was statistically adjudged reliable and considered suitable for the research.

1.9 Results

1.91 Hypotheses Testing

There will be no significant gender difference in the attitude of teachers towards ICT Table 1:
Table 1: t-test table showing gender differences in teacher attitude towards ICT.

Gender	Mean	SD	Df	t-cal	t-table
Male	39.14	4.49			
Female	37.45	4.23	198	2.132*	0.416

Table I shows that male teachers have a higher rating on perception with average perception score of 39.14 while the female had an average perception score of 37.45. To verify whether the difference is significant or not t-test was employed since the level of the t-cal (2.132) is greater tn the value of the s tab (0.416) the null hypotheses is rejected. This means that there is significant difference in the attitude of male and female teachers with respect to ICT.

1.92 Test of Hypothesis 2

Table 2: Descriptive statistics of attitude with respect to science and Arts teachers

Department	N	Mean	SD	Standard error Mean
Arts	107	39.2430	5.00536	-48389
Science	93	37,2043	3,36723	-34917

Table 3: t-test table showing difference in attitude towards ICT between Science teachers and Arts teachers

Gender	Mean	SD	Df	t-cal	t-table	Remark
Arts	39.24	500				
Science	37.20	3.36	198	0.562	0.416	Significant

Since t-cal (0.562) is greater than 1-tab (0.416) it implies that there is a significant difference in the attitude of teachers with respect to department the hypothesis is therefore rejected.

2.0 Discussion

The first hypothesis states that there is no significant gender difference in the attitude of teachers to ICT was rejected. This study revealed that there was a high level of discrimination by the female teachers. They believe they cannot cope with the use of computer, however the findings of the study contradict that of Yusuf and Balogun (2011) who reported that gender has no place in determining the attitude of teachers towards ICT.

One the second hypothesis which states that there is no significant difference in attitude towards teachers towards ICT between Science and Arts teachers revealed that there was a significant difference in the attitude towards ICT between Science and Arts teachers. Regardless of attitude, the level of awareness of ICT of the Arts teachers is very low. This may be because they are not mathematically oriented. The study revealed a non-challenged attitude of the Arts teachers towards ICT.

This finding is similar to that of Olisame, Odumosu and Esho (2011) on the use of internet for teaching. They found out that science teachers in schools make use of available ICT facilities for example, the use of internet for power point and documentaries to teach science enhance students learning of science. On the contrary the findings contradict that of Etiubon and Etiubon (2012) who found out that science teachers had poor or negative attitude towards ICT also lack the basic skills of ICT.

2.1 Conclusion

This paper analysed the attitude of teachers towards ICT. The findings of the study have shown that most of the teachers had poor attitude towards ICT. Therefore, teachers' capacity on ICT needs to be built consistently, so as to enable them effectively apply it in their teaching and learning for better outcome, thus, attending workshops, seminars and conferences on ICT trainings will update their knowledge and improve their professional skills.

2.2 Implication of Findings

From the study, it was established that teachers had pour attitude towards ICT. This is because teachers do not teach learners how to use the internet fin study. The school system however is generally accepted as a major agent of Education while the teacher remains central in the task of Education. There is need therefore to provide and put infrastructure in place to train and equip teachers for ICT skills to move the Education reform agenda forward.

Secondly the implication of the study revealed that our secondary school teachers have negative or poor attitude towards ICT There is a need to create awareness of ICT as it affects teachers and students' performance in Education. There is the need for ICT Education in our various schools and guidance-oriented activities as regards its usage and accessibility.

2.3 Recommendations

The following recommendations were mad based on the findings of the study:

1. Government should try and equip Nigerian secondary schools with necessary information and communication technology (ICT) infrastructures to expose the potential of ICT in our secondary schools' teachers and students.
2. All the necessary ICT facilities should be installed the schools for effective functioning of the established infrastructures.
3. Well trained ICT personnel should be employed to manage the ICT centers and train the school teachers and effective utilization of the installed resources for learning output and quality education.
4. Conferences, Seminars and workshops should be organized periodically for teachers to acquire relevant ICT competencies needed for the improvement of teaching and learning process.
5. Government should partner with ICT based industries to make ICT tools available, accessible and affordable for teachers at subsidized rates.
6. Teacher Continuous Professional Development (TCPD) training in Nigeria should always include ICT training to enable the teachers master the skills and knowledge for its utilization and application in teaching/learning of all subjects not the STEM.

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