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ADEA Inter-Country Quality Node on Mathematics and Science Education

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REPORT

The Status of STEM Education in Secondary School Level in Africa

By ADEA's Inter-Country Quality Node on Mathematics and Science Education (ICQN-MSE)-2024

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ADEA	Association for the Development of Education in Africa
AU	African Union
CAT	Central African Time
CEMASTEA	Centre for Mathematics, Science and Technology Education in Africa
CFP	Country Focal Persons
COL	Community of Learning
COP	Community of Practice
COVID-19	Corona Virus Disease
EAT	East African Time
EC	Executive Committee
ECD	Early Childhood Development
ECE	Early Childhood Education
ERA	European Research Area
EU	European Union
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GMT	Greenwich Mean Time
ICQN-MSE	Inter-Country Quality Node for Mathematics and Science Education
ICT	Information Communication and Technology
IPA	Innovations for Poverty Action
JICA	Japan International Cooperation Agency
LtP	Learning through Play
LTPT	Learning Through Play Technology
NGOs	Non-Governmental Organizations
NSF	National Science Foundation
OECD	Organisation for Economic Cooperation and Development
PASEC	Programme for the Analysis of Education Systems
PISA	Programme for International Soudent Assissent
PREMST	Projet de Renforcement de l'Enseignement des Mathématiques, des Sciences et de la Technologie
SAST	South African Standard Time
SC	Steering Committee
SDG	Sustainable Development Goals
SMASE	Strengthening of Mathematics and Science Education
STEM	Science, Technology, Engineering, and Mathematics
STI	Science, Technology, and Innovations
TIMSS	Trends in International Mathematics and Science Study
TPD	Teacher Professional Development
UIS	UNESCO Institute of Statistics
UN	United Nations
UNESCO	United Nations, Education, Scientific, and Cultural Organisation
UNICEF	United Nation Nations International Children Emergency Fund
USA	United States of America
VSO	Volunteers Service Organisation
VVOB	Flemish Association for Development Cooperation and Technical Assistance
WAT	West African Time

EXECUTIVE SUMMARY

Overview

Africa has one of the highest annual population growth rates, with an estimated 504 million children aged 0-14 years. Nine in ten children in Africa cannot read with comprehension by the age of 10, which denies them an opportunity for social mobility. Globally, there is a growing trend toward the use of innovative pedagogical approaches that place children at the centre of their learning to promote higher achievement. Play-based learning approach is an integrated approach to learning that promotes holistic learning in children, contributing to their physical growth, cognitive and socio-emotional development. It is based on five integrated principles that include joyful, meaningful, actively engaging, iterative, and socially interactive learning. These five principles are manifested in a range of innovative pedagogical approaches including active learning, cooperative learning, experiential learning, guided discovery learning, inquiry-based learning, problem-based learning, project-based learning and collectively, these approaches are described as playful pedagogies. Furthermore, play-based learning approach and STEM education have a natural, strong, and complementary nexus given that STEM involves discovering, creating, experimenting, and building, a process that is creative, iterative, challenging, and playful. The goal of STEM education is to create critical thinkers, increase science literacy, and promote innovations. Therefore, STEM education is aligned with play-based learning approaches given that when learners engage in STEM, their work is social as they collaborate in designing solutions to address challenges and getting feedback from one another, thinking creatively as they solve problems.

The aim of the situation analysis was to establish the status of play-based STEM education at primary schools in Africa. The study was conducted in ten sample countries in Africa: Eswatini, Kenya, Ivory Coast, Malawi, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, and The Gambia. In order to achieve a comprehensive overview of the status of play-based STEM education at primary schools in Africa, the study focused on five objectives. These included (a) understanding and perspectives of key stakeholders in education, (b) prioritisation of play-based STEM education, (c) on-going initiatives, (d) current teaching and learning practices, and (e) barriers and enablers of play-based STEM education at primary schools in Africa. The study focused on the primary school education level which in most countries in Africa comprise grades one to six. The choice of the primary school level was informed by the fact that ADEA had in 2020 conducted a situational analysis on the status of STEM education at the secondary schools in Africa and there was still a gap in understanding the situation in the primary school schools.

Methodology

In this study play-based STEM education at primary schools in Africa was conceptualized as a developmental process with interconnected and complex interactions across multiple layers and stakeholders. The concept of play-based approach is a relatively new concept globally and in Africa, with inadequate understanding on implementation modalities because of non-available data or documented study reports. Therefore, the exploratory research design was adopted in gathering information from targets groups more likely to have a better understanding of play-based approach. The data collection involved desk review, survey of educators, focus group discussions with primary school learners, and interviews with parents in 10 sample countries reaching a total sample of 638 participants. The field data collection was done through mobile data collection platforms.

Findings

Understanding of play-based STEM education.

Four general categories of study participants emerged in terms of understanding of played-based STEM: These are (a) sceptics – had limited or no understanding of play-based approaches and did not see its place in the teaching and learning process at primary schools, (b) optimists - had little understanding of the approach but acknowledged the potential for play-based approach to promote learning of STEM subjects, Other participants were (c) Indifferent - were aware of the play-based approach, but indicated that play-based approaches were not being practiced at the primary school level and they were not doing anything about it, The fourth group comprised the (d) Champions – who demonstrated good understanding of play-based approaches that are already being applied at the primary school level, but also acknowledged that not all teachers are applying the approach. Furthermore, a high proportion of teachers, school heads, and education officials were aware of play-based approaches, with some having been trained on the approach. and this varied across countries, gender, and cadre of staff. Meanwhile, a high proportion of teachers, school heads, and education were ready to adopt the play-based approach.

Prioritisation of play-based STEM education

Across the 10 countries, prioritisation of play-based STEM education at primary schools was diverse with some countries having detailed articulation of play-based approaches and STEM education including the corresponding performance indicators for tracking progress, while others lacked clarity. Furthermore, there was a range of terminologies that were used to characterise play-based approaches. The key priorities that were associated with play-based STEM education at primary schools were: (a) teacher professional development, (b) review of the curriculum, (c) development of a policy on STEM education at basic learning levels, and (d) commitment to increase resources and facilities for STEM education.

Initiatives focused on play-based STEM education at primary schools in Africa.

Several initiatives focused on improving the quality of education including play-based approaches and STEM education at the primary school level were on-going in Africa. A number of these are donor funded projects within and across countries, focused on promoting interactive and engaging teaching and learning. The key activities being implemented through these projects were teacher professional development to improve pedagogical practices coupled with provision of teaching and learning resources and facilities including online platforms. For instance, teachers in some countries were being supported with teacher pedagogical boxes stocked with contextualized teaching and learning materials to address the lack of conventional science laboratories in primary schools. Some initiatives were voluntarily organized and led by teachers of science and mathematics subject associations at country level to promote student science fairs, clubs, and forums as a strategy for stimulating more interest towards science and mathematics among the learners. Still governments in the region in partnership with development partners funded other programmes A range of strategies were being implemented through these initiatives including: (a) in-service teachers training, (b) teacher coaching and mentoring support, (c) and communities of practice with teachers either at school or cluster of schools meeting regularly to address challenges in teaching and sharing best practices. The teachers, school administrators, and education officials acknowledged that the in-service training, coaching and mentoring support, and communities of practice have positive impacts in terms of improved teaching and learning.

Barriers to integration of play-based STEM education at primary schools in Africa.

The key barriers fall under three categories: technical, institutional, and resources.

a. **Technical barriers:** These include the low foundational skills in reading and numeracy for learners in primary schools in Africa that impede their capacity for learning, which coupled with a foreign language of instruction creates an additional barrier to understanding scientific and mathematical concepts. Additionally, the inadequate number of and insufficiently qualified teachers of STEM subjects as well as the limited awareness of play-based approaches at primary schools further compound the problem. Furthermore, the heavy demand on teachers to deliver an overloaded curriculum leaves them with little room for adopting innovative pedagogical practices, including play-based approaches that are crucial for engaging students in STEM learning. Additionally, student performance in STEM subjects at the primary school level is low, reinforcing the attitude among teachers, parents, and learners that these subjects are difficult. This perception may hinder the adoption of play-based approaches, which are designed to make learning more enjoyable and accessible. Furthermore, the sample countries lack comprehensive monitoring and evaluation systems for tracking progress in the quality of STEM at primary

schools. This presents a challenge not only in how to evaluate progress but also in making decision on how to design effective STEM education improvement programmes and prioritize areas for resource allocation.

b. **Institutional:** the large class sizes at primary school's present classroom management and pedagogical challenges that need to be considered when designing and implementing teacher professional development and school improvement programmes in Africa. The situational analysis revealed that none of the sample countries had a standalone policy on STEM education at the basic learning level which presents a challenge in designing programmes, resource mobilisation and allocation for the implementation of STEM education improvement programmes.

c. **Resources and facilities:** The lack of resources and facilities for delivery of STEM subject curriculum at the primary schools in Africa was a constant theme in this study. Very few public primary schools have science laboratories and equipment for practical lessons in STEM subjects. Furthermore, there is inadequate funding for the implementation of the STEM subject's curriculum. Therefore, investment in STEM education improvement interventions will require funding for staffing and infrastructure, which were frequently mentioned to be inadequate in all the sample countries.

Conclusion

Understanding of play-based STEM education.

The existing level of awareness of and readiness for adoption of play-based approaches among educators in Africa presents an opportunity for integration and institutionalization of play-based approaches in the provision of STEM education at primary schools in Africa.

Prioritisation of play-based STEM education:

The emerging global trend towards playful pedagogies in education and the on-going review of the education sector plans and national curriculum at the basic learning levels in several countries in Africa is an opportunity that could be leveraged as an entry point for integration and institutionalization of play-based approaches into the curriculum and education sector plans.

Initiatives focused on play-based STEM education at primary schools in Africa.

The on-going initiatives focused on the improvement of the quality of STEM education at the primary school level in several African Countries including in-service teachers training, school-based teacher coaching and mentoring support, and teacher communities of practice are potential avenues for integration and institutionalization of play-based approaches in the provision of STEM education at primary schools in Africa.

Barriers to integration of play-based STEM education at primary schools in Africa.

There are technical, institutional, and resource barriers that are likely to impede the successful integration and institutionalization of play-based approaches at the primary school level in Africa. These barriers need to be addressed in the process of integrating and institutionalising play-based approaches in the provision of STEM education at primary schools in Africa.

Recommendations

Policy on STEM education at basic learning level

The education authorities in Africa should develop and implement a policy on STEM education at the basic learning level as a commitment towards accelerated investment in this critical sector.

Mapping of play-based STEM education interventions

Given the lack of an inventory of interventions on play-based STEM education in African countries, the government should conduct a mapping of all existing interventions. The mapping should document scale of operations, focus geographies, key strategies, timelines, reach, impact, and funders. The mapping will enhance learning of best practices and synergizing of efforts.

Resource mobilisation to fund play-based STEM education.

Play-based approaches have the potential for improving the quality of STEM education at the primary schools' level in Africa. Therefore, education authorities in African countries should provide adequate funding to support accelerated integration and institutionalization of play-based approaches for improved holistic learning outcomes.

Adequate staffing with STEM teachers at primary school.

Primary schools should be staffed with adequate number of teachers while the potential to support teacher subject specialisation, at least in the upper primary grades, should be considered.

Regular teacher professional development in STEM pedagogical practices.

A sustainable model for regular capacity building of STEM teachers at primary schools through different modalities should be implemented in each country.

School leadership training programmes on management of STEM education.

To ensure institutionalization and sustainability of play-based STEM education at primary schools in Africa, the school leadership should be trained on management of these approaches as a strategy to secure their commitment and support.

Improve conditions of service for teachers.

A recurring theme was the poor conditions of service for teachers. Therefore, strategies should be devised to attract people into the STEM teacher field, reduce teacher attrition, and improve commitment to delivering the STEM curriculum.

Provision of resources and facilities.

Provision of resources and facilities, including laboratories and laboratory equipment that were the most frequently mentioned resources and facilities.

Equipping of schools with adequate ICT infrastructure.

It was evident that delivery of play-based STEM education could benefit from the integration of ICT in the pedagogy. This was amplified during school closure in the advent of COVID19 pandemic where education authorities and individual schools explored opportunities of utilising ICT for continued learning at home. Therefore, education authorities should consider increasing investment in ICT infrastructure and internet connectivity for primary schools in Africa as a model for curriculum delivery to ensure equitable access to quality STEM education at the primary schools in Africa.

Monitoring and Evaluation System for STEM education.

Drawing from the policy on STEM education at the basic learning levels, education authorities in Africa should develop and deploy a monitoring and evaluation system for tracking of the STEM education at the primary school level.

Sensitisation programme for parents and communities on STEM education.

Parents should be encouraged to support learners to enhance their interest and uptake of STEM courses and careers. Parents and communities should also support school level STEM education improvement initiatives.

Science and Technology fairs and excursions.

Education authorities should promote student science and technology fairs as they enhance student interest and passion for STEM subjects.

1. INTRODUCTION

1.1 Overview

This chapter presents a background to the study on the situational analysis of play-based STEM education at primary schools in Africa. It articulates the relevance of the study in terms of the key considerations justifying the commissioning of the study. Given the breadth and depth of issues that could be covered in this type of a study, the objectives and scope of the study articulate the relevant focus issues, participants, and target countries. It also covers the assumptions of the study and briefly describe how the play-based STEM education was conceptualized. Furthermore, the chapter articulates how the findings could support actions by duty bearers at different layers in the education system. Finally, the theoretical framework underpinning the study is discussed followed by definition of key terminologies relevant to the study are presented.

1.2 Background

Africa is faced with myriad challenges including climate change, water scarcity, biodiversity loss, desertification, energy crisis, health insecurity, rapid population growth rate, and food insecurity (UN Economic Commission for Africa, 2011). The COVID-19 pandemic led to contraction of the Real GDP in Africa to 2.0% in 2020 down from 2.6% in 2019, a decline of 0.6 percentage points (World Bank, 2021). Furthermore, economic growth in Sub-Saharan Africa (SSA) decelerated from 4.1% in 2021 to 3.3% in 2022 as a result of a slowdown in global growth, rising inflation exacerbated by the war in Ukraine, adverse weather conditions, a tightening in global financial conditions, and the rising risk of debt distress (World Bank, 2022a).

On the demographic front, Africa is home to over 1.2 billion people and has one of the highest annual population growth rates, currently estimated at 2.6% (World Bank, 2022b). Among the 1.2 billion people in Africa are 504 million children aged 0-14 years, representing about 42% of Africa's population, most of whom are within the primary school going age (World Bank, 2022c). By the age of 10, a child should be able to read and do basic numeracy, the foundational skills necessary for further learning and the development of advanced skills (Ezekwesili, 2022). However, while the primary school gross enrolment rate is relatively high in Africa at 98.8%, nine in ten children in Africa cannot read with comprehension by the age of 10, a phenomenon called learning poverty (Ezekwesili, 2022; World Bank, 2022d). Without these basic skills, many children in Africa are unprepared for the learning at secondary schools or higher education and are not guaranteed an opportunity for productive employment and social mobility (Ezekwesili, 2022). The low learning outcomes is a major contributor to human capital deficits, and even with high levels of enrolment, it undermines

development efforts in Africa. Additionally, gender disparities persist in education outcomes in Africa, with male achieving higher completion and literacy rates than female with wide disparities across the countries (Error! Reference source not found.).

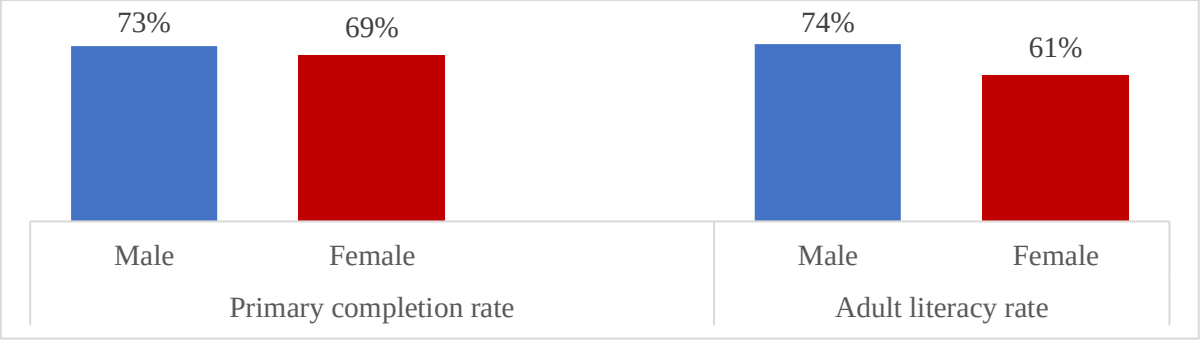


Figure 1: Primary school completion and adult literacy rates (World Bank 2022)

Governments in African countries have prioritized the provision of quality education for their citizens as education has long been identified as one of the most powerful instruments for reducing poverty and inequality and a panacea for sustainable development of any society (Ohanyido, 2018). The outcomes of education are useful citizens who contribute positively to social, economic, and cultural progress of the society and the world community. Therefore, education is a pre-requisite for personal and social improvement, ensuring a safer, healthier, prosperous, and environmentally sound world. Education forms the basis for developing innovation, science, and technology to harness resources, industrialise and participate in the global knowledge economy (African Union, 2005). However, although Africa has made progress in enrolment at basic education since the 1990s, there remains a major gap in provision of quality education which is an important predictor of socio-economic development. Studies have increasingly shown that it is cognitive skills and learning, not years of schooling that makes the difference for economic development in the long run. For example, analysis of student achievement and economic growth of 50 countries from 1960 to 2000 show that gain in cognitive skills contributes to a country's economic growth with a 10% increase of children attaining basic literacy contributing 0.3 percentage points of annual GDP growth rate of a country (Hanushek & Woessmann, 2010). The reason is that cognitive skills foster innovation, promote technology diffusion by equipping the workforce with the ability to absorb, process, and integrate new ideas into production and service delivery (Ohanyido, 2018). Cognitive skills are assessed by measures of literacy, numeracy, and science skills and competencies.

In 2014, the Programme for the Analysis of Education Systems (PASEC) assessed student abilities in mathematics and reading in Francophone Countries[1] in West Africa revealed that despite gains in access, countries in the region still face a great challenge in providing quality education (Kattan, 2018). Furthermore, the study revealed that in most of the countries, almost two thirds of the children complete primary education without sufficient competency in numeracy and literacy. Notably, children who do not attain sufficient competency in numeracy at grade six are unable to perform arithmetic involving decimals or identify a basic mathematical procedure needed to solve a problem. Meanwhile, it is now widely acknowledged that teacher quality is a key determinant of student learning outcomes (Bold, et al., 2017). Therefore, any efforts to achieve quality education are increasingly focusing on teacher quality as many teachers in Africa are unqualified or underprepared to meet the educational demands of the 21st Century (UNESCO, 2012a). Teachers hold the promise of closing the gap between poor and good quality education by maximizing the benefits of learning in every classroom for every child (UNESCO, 2014).

The teaching approaches have the greatest effect on learning outcomes (Wenglinsky, 2001). The teaching approaches are those teaching and learning activities and interaction processes within a classroom (Li & Oliveira, 2015; Kahan, Cooper, & Bethea, 2013). Effective teaching approaches incorporate learners' prior experiences, locally available resources, and project-based learning among others (Herr, 2001; Bleakley & Carrigan, 1994; Sharma, 2016). Additionally, the ability to meaningfully engage learners through the learning activities, interactions, and practical activities contributes to effective teaching approaches (Ottevanger, Akker, & Feiter, 2007).

In Africa, there is a large STEM skills gap between market demand and the enrolment in STEM related courses which implies a large market exists for STEM training (CEMASTEA, 2019). Therefore, a strategic response in the education sector to close the gap in STEM skills is accelerated investment in STEM education in Africa (Formunyam, 2020). Although there is a huge potential for African countries to address the perennial problems of unemployment, poverty, and health by increasing STEM related jobs, most of these jobs are currently being performed by expatriates from the developed world as most of the workforce in Africa is unable to do these jobs due to lack of the requisite skills (Jamme, 2020). For instance, infrastructure construction projects, research programmes, mining industries, control of disease pandemics such as Ebola, and the Corona Virus Disease (COVID)-19 are outsourced to expatriates and multi-nationals, which adversely affects the ability of African governments to invest in STEM skills for the future (Jamme, 2020). Against this

[1] In 2014, ten Francophone Countries participated in PASEC: Cameroon, Burundi, Republic of Congo, Côte d'Ivoire, Senegal, Chad, Togo, Benin, Burkina Faso and Niger

background, African countries continue to lament about the lack of STEM workforce and high unemployment rates among the youth (ibid). However, with better planning, millions of youths in Africa could be trained in STEM skills, creating new employment opportunities, and making great contribution to the African economy (ibid).

The African Union (AU) recognizes that STEM education is critical to the development of a well-equipped human capital capable of competing in the increasingly science and technology-driven and knowledge-based global economies (African Union, 2015). However, the AU also acknowledges the inability of the workforce in Africa to fill the existing STEM jobs due to lack of requisite STEM skills. This raises a concern on the relevance of the current basic education in Africa in terms employability, technical and vocational training, and progression to tertiary education. Meanwhile, the Association for Development of Education in Africa (ADEA) has been coordinating efforts in addressing challenges of STEM education at the basic learning levels in Africa through the Inter-Country Quality Node on Mathematics and Science Education (ICQN-MSE). While these efforts are commendable, it is now time for the governments in African countries to take decisive actions to improve the quality of STEM education at the basic learning levels and accelerate equipping of youth with relevant STEM skills to take advantage of emerging opportunities in the STEM careers. These measures will guarantee sustainable opportunities for youth employment while accelerating economic growth in African countries.

1.2.1 Teaching and learning.

The way a teacher teaches is important in that with the right methods and techniques, the learner can grasp concepts and ideas while poor methods and techniques frustrate learners and minimize their chances of success (Nancino-Brown, Oke, & Brown, 1982; Oliver & Reschly, 2007; Munna & Kalam, 2021). When learners are actively involved in a learning task, they learn more than when they are passive recipients of instruction (Patricia, 1987). Among teacher attributes that contributes to student learning outcomes, classroom practices have the greatest effect. (Wenglinsky, 2001).

1.2.2 Play-based learning approach.

Learning through play has emerged as an important strategy to promote student engagement, inclusion, and holistic skills development (Parker, Thomsen, & Berry, 2022). Play is the natural means by which children explore and investigates their environment, enabling them to build an understanding of how the world works (Kids of Excellence, 2016; UNICEF, 2018). Evidence suggest that playful pedagogies are more effective in fostering social, emotional, physical, cognitive, and creative skills than traditional or more highly guided pedagogical approaches used in the primary school classroom (Parker & Thomsen, 2019).

1.3 Justification

The provision of quality of STEM education at primary schools in Africa remains constrained by a range of challenges including poor teacher pedagogical practices and inadequate resources among others. Currently, there are several STEM education improvement initiatives in African countries supported by both governments and development partners. A situational analysis on the status of STEM education at secondary schools in Africa revealed strategic issues that necessitated a similar study at primary schools to provide a holistic view (ADEA, 2020). Countries in Africa have not adequately identified and characterised the gaps that derail the provision of quality STEM education and integration of play-based approaches at the primary schools that could enable the formulation of relevant policy interventions to address these gaps. Therefore, the situation analysis focused on establishing the gaps in the provision of play-based STEM education at primary schools in Africa. The findings will inform strategic interventions to enhance the quality of STEM education and adoption of play-based approaches at primary schools.

1.4 Purpose

The situational analysis on the status of play-based STEM education at the primary schools in Africa will inform the agenda for engagement with key stakeholders in education and guide policy direction in this critical sector. Specifically, the findings will inform the development of the ADEA ICQN-MSE STEM Education Strategic Framework and STEM Toolkit. The Framework and Toolkit will enhance the capacity of countries in Africa in policy interventions for integration and institutionalization of play-based learning approaches for the provision of quality STEM education at the primary schools.

1.5 Objectives of the study

The overall objective of this study was to establish the status of play-based STEM education at primary schools in Africa. Specifically, the study aimed to:

a. establish the understanding and perspectives of play-based STEM education by different education stakeholders.
b. establish prioritisation of play-based STEM education at primary schools in Africa.
c. identify initiatives on play-based STEM education at primary schools in Africa.
d. establish play-based teaching and learning practices at primary schools in Africa.
e. identify the barriers and enablers for integration of play-based STEM education at primary schools in Africa.
f. Make recommendations for promoting play-based STEM education at primary schools in Africa.

1.6 Scope

The study was conducted in ten sample countries: Eswatini, Kenya, Ivory Coast, Malawi, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, and The Gambia. The study focused on the primary schools which in most countries in Africa comprise of grades one to eight. The choice of the primary schools was informed by the fact that ADEA had in 2020 conducted a situational analysis on the status of STEM education at secondary schools, and this was a follow-up study for a holistic view of the status of play-based STEM education at the basic learning levels.

1.7 Assumptions

This study was anchored on three assumptions. First, that play-based STEM education is conceptualized, defined, and characterised with specific elements. These elements include the content, instructional practices, and learning experiences that constitute play-based STEM education. Secondly, that there is sufficient consensus among stakeholders in play-based STEM education on these elements and thirdly, that the key stakeholders engaged in play-based STEM education at multiple levels and their interactions within the play-based STEM spectrum can equally be characterized. It is based on these assumptions that the ecological system theory was adopted as the underpinning paradigm on which the study design and approaches were grounded.

1.8 Significance

The findings from this study will be applicable to a range of stakeholders. Education authorities in African countries will have a source of useful findings and recommendations for catalysing actions for integration and institutionalization of play-based STEM education at the primary schools. The planners in education will find a reference for engagement with stakeholders in education to secure their commitment for increased investment in play-based STEM education. Equally, the study findings will be a valuable resource for engagement with development partners who are supportive of STEM education initiatives in Africa. Meanwhile educators will have a reference in planning for play-based STEM education initiatives at the primary school level. Additionally, the findings will contribute to the body of knowledge on play-based STEM education and serve as basis for further research in this critical sector.

1.9 Theoretical framework

The situational analysis was underpinned by the ecological systems theory where STEM education at the primary school level in Africa was conceptualized as a developmental process within a microsystem, mesosystem, exo-system, macro-system, and chronosystem (Bronfenbrenner, 1979) (**Figure 2Error! Reference source not found.**).

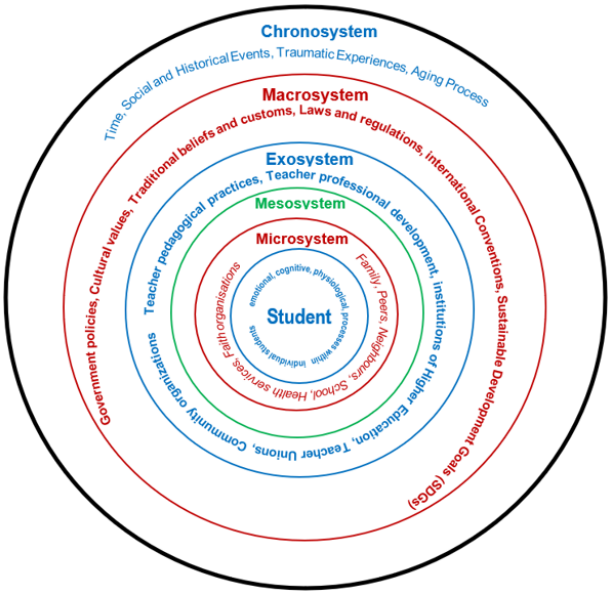


Figure 2: Theoretical framework (adopted from Bronfenbrenner, 1979)

The ecological system theory provides a framework for understanding the interconnectedness and complex interactions that occur across multiple systems in the STEM education among policy makers, curriculum developers, development partners, teachers, parents, and learners (Stewart, 2000; Basham, Israel, & Maynard, 2010). In this study, learner development in STEM skills is anchored within the context of the system of relationships that form the learners' environment. Each of the complex layers of the learners' environment influence learner development in STEM skills, either directly or indirectly. Further, success in transforming the education system for provision of quality STEM education requires partnerships, commitment, and ownership of the key stakeholders. For instance, to gain the support and collaboration of parents in STEM education initiatives, there must be shared understanding of the initiatives to ensure their comfort in supporting their children with homework and discussion on the potential of STEM courses and careers. Furthermore, teachers of STEM should be supported to provide learners with a meaningful and engaging learning environment by offering an innovative pedagogy that seeks to create an organized, coherent approach to learning STEM subjects. At the broader system level, educators alone cannot support STEM education initiatives, and for a STEM initiative to succeed, people must come together and provide supportive networks and partnerships for STEM initiatives. Additionally, the cultural, economic, and social beliefs systems in a country must be supportive of STEM education, and this is manifested in the cultural values, customs, and laws regarding STEM education. For instance, if it is the predominant cultural belief that girls are not meant to pursue STEM careers, then it is less likely that girls will be supported to engage in STEM education, courses, and careers. Therefore, at country level, STEM education initiatives reflect the interplay of cultural, economic, social beliefs, and the political

objectives that emerge from those beliefs. For example, if a country is concerned about the economy, global competitiveness, and how these are related to learner achievement in STEM subjects, then it is likely that STEM education will gain higher priority in education planning and policy. When the STEM education policies, frameworks, and mechanisms are in place at the national level, the education system will be catalyzed to initiate the expected changes for the provision of quality STEM education. Therefore, for a comprehensive understanding of learner development in STEM skills, it is important that the interactions in the learner's environment are clearly understood. It is on the basis of this understanding that the design, methods, and approaches in this study were underpinned by the ecological systems theory.

1.10. Definition of terminologies

Play-based approach: Play-based learning approach is an integrated approach to learning that promotes holistic learning in children, contributing to their physical growth, cognitive and socio-emotional development. It is based on five integrated principles that include: joyful, meaningful, actively engaging, iterative, and socially interactive learning.

Primary School Primary school refers to the elementary schooling offered before secondary school, and in most countries in Africa ranges from grade one to eight.

STEM Science, Technology, Engineering, and Mathematics.

STEM Education In this study, STEM education is defined as the integration of the disciplines of science, technology, engineering, and mathematics through appropriate teaching and learning approaches, enabling learners to develop the 21st century skills in preparation for STEM courses and careers, and enhance their capability for solving of societal problems.

2. LITERATURE REVIEW

2.1 Overview

This chapter presents a review of literature on play-based STEM education with a particular focus on Africa. The meaning of STEM education and play-based learning approaches is presented while demonstrating their interconnectedness, and complementarity in the holistic skills development of learners at primary schools.

2.2 Introduction

The chapter presents a review of the literature on play-based STEM education at primary schools in Africa. The focus is on the meaning of STEM education, the play-based approach, and the global and regional perspectives on the play-based approach and STEM education at the primary school level in Africa.

2.3 Meaning of STEM Education

Globally, there is a lack consensus on the meaning of STEM education (Holmlund, Lesseig, & Slavit, 2018). However, there is emerging consensus on the core attributes that are associated with STEM education (Freeman, Marginson, & Tytler, 2019). For instance, the International Bureau of Education – UNESCO identifies the core feature of STEM education as the use of scientific, mathematical, technical, engineering knowledge to solve problems in the society (IBE-UNESCO, 2019). Other key attributes associated with STEM education include: learner actively engaging instructional practices, the twenty-first century skills, and helping learners to make connections between school learning, problem solving, and careers (Kloser, 2014; LaForce, et al., 2016; Kelley & Knowles, 2016; Buck Institute, 2020). In this study, STEM education is defined as the integration of the disciplines of science, technology, engineering, and mathematics through appropriate teaching and learning approaches, enabling learners to develop the 21st century skills in preparation for STEM courses and careers, and enhance their capability for solving of societal problems.

2.3.1 Overview of global perspective on STEM education

The field of STEM education gained greater focus from the 2000s in the United States when these disciplines started to be more integrated after more understanding of the strong linkage between prosperity and jobs that were increasingly based on science and technology, and the need for innovations to address emerging challenges in society (Gonzalez & Kuenzi, 2012; OECD, 2016). Despite this realization, the performance of students in the United States in STEM disciplines was found to be low, compared to those in other countries, based on international comparative studies

such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). Furthermore, evidence was gradually emerging that a country that does not accord greater attention to STEM education will have a poorly prepared workforce and cannot compete in the global economy (OECD, 2016). Therefore, concerted efforts to address STEM education in the United States brought together not only the academia but also the political leadership and philanthropists, among other key stakeholders.

Globally, STEM education has taken the centre stage in human development discourse and several international commitments recognising the place of science, technology, and innovation in sustainable economic development. Indeed, Science, Technology, and Innovations was a central theme of the United Nations seventieth session on 'Transforming our world: the 2030 Agenda for Sustainable Development' of 2015, and specifically the Sustainable Development Goals (SDGs) 1, 2, 4, 5, 7, 9, 14, and 17 (United Nations, 2015). This strong commitment at the global level is further demonstrated by the fact that over 23 Agencies, Committees, and Divisions of the United Nations have a specific focus on Science, Technology, and Innovations as a crosscutting area in their mandates (United Nations, 2020). Meanwhile, the STEM agenda has expanded in other countries beyond the USA, with programmes developed in Japan, Australia, China, France, South Korea, Taiwan, the United Kingdom, and the European Union, with the aim of increasing STEM skills and expanding the workforces of scientists and engineers (OECD, 2016). The commitments to the STEM education agenda have led to an increase in the number and scope of initiatives in this sector with the aim of preparing the workforce for the competitive global economy (Ahmed, 2016).

2.3.2 Overview of Africa perspective on STEM education

It is estimated that there will be numerous job opportunities in Africa over the next decades, that will require basic STEM literacy (Ahmed, 2016). However, the concept STEM education is not widely understood in Africa and its implementation in education systems is currently inadequate, despite the many STEM programmes funded by both governments and development partners. This implies the need for more planning and commitment by governments in Africa in making education policies more responsive to the need for high quality STEM education. One of the critical barriers that need to be addressed in promoting STEM education in Africa is the limited number of people adequately qualified in these subjects. The African Union Agenda 2063 Framework Document for African Renaissance recognize the shortage of STEM skills in Africa (African Union, 2015). However, Countries in Africa lack adequate laws, legislations, plans, policies, frameworks, and strategies for promoting quality STEM education (Ahmed, 2016; Jamme, 2020). Furthermore, there is inadequate understanding among national leaders in Africa regarding the implication of STEM education on the

continent's economies and workforce (Jamme, 2020). For instance, while thousands of expatriates from the developed countries are working in high-skilled STEM jobs in Africa, the youth unemployment rates continue to rise in Africa (Jamme, 2020). Therefore, governments in Africa need to consider increasing investment in STEM education as a strategic pathway in the development of scientists, engineers, and technologists that are the backbone of industrialisation, and economic growth (Asabere & Mereka, 2009; Jamme, 2020).

2.3.3 Importance of STEM education

STEM education creates critical thinkers, increases science literacy, and enables the next generation of innovators (Engineering for Kids, 2020). There is now greater consensus that embedding mathematics, science, technology, and engineering concepts in the curriculum, will better prepare students for courses and careers in STEM fields leading to innovations of new products and services that will sustain future economies (Koketso, 2015). Furthermore, the United States Department of Commerce estimates that STEM occupations are growing at 17% annually, almost double the rate for other occupations at 9.8% and that STEM degree holders have higher incomes (U.S. Department of Commerce, 2020). Science, technology, engineering, and mathematics workers play a key role in the sustained growth and stability of a country's economy.

2.4 Teaching and learning approaches.

The teaching and learning process has been defined as the process where a teacher supports a learner to achieve desirable learning by acquiring or changing some knowledge, skill, or attitude that can be used later when need arises (Nancino-Brown, Oke, & Brown, 1982; Ayot & Patel, 1992; Munna & Kalam, 2021). The way a teacher teaches is important in that with the right methods and techniques, the learner can grasp concepts and ideas while poor methods and techniques frustrate learners and minimize their chances of success (Nancino-Brown, Oke, & Brown, 1982; Oliver & Reschly, 2007; Munna & Kalam, 2021). For instance, when learners are actively involved in a learning task, they learn more than when they are passive recipients of instruction (Patricia, 1987). Therefore, the approach adopted by a teacher is paramount and teachers should therefore have a choice of effective teaching and learning approaches for effective learning to occur.

It is widely acknowledged that teacher quality is a key determinant of student learning outcomes and there is consensus that teachers will play a key role in closing the gap between poor and good quality education by maximizing the benefits of learning in every classroom for every child (UNESCO, 2014; Bold, et al., 2017). Globally, most of the unqualified teachers, lacking in both subject and pedagogical content knowledge, are in Sub-Saharan African countries (UNESCO-UIS, 2006). A study in Kenya

revealed that only 34% of teachers at primary schools demonstrated minimum subject content knowledge of the subject they are teaching (Bold, et al., 2017). The study further noted that these teachers had poor pedagogical content knowledge and the ability to assess students' learning. The implication at the classroom level is that teachers are poorly prepared to deliver lessons and use inappropriate teaching methodologies which translates into low learning outcomes (Wanjiru, 2017). Among teacher attributes that contributes to student learning outcomes, classroom practices have the greatest effect (Wenglinsky, 2001). Classroom practices are the teaching and learning activities, tasks, and interaction processes within a classroom system that enable contextualization of the content that is taught and learnt (Li & Oliveira, 2015; Kahan, Cooper, & Bethea, 2013). Further, the classroom practices that teacher adopt in engaging with learners play an important role in the understanding of concepts and the learning outcomes (Ottevanger, Akker, & Feiter, 2007).

Globally, there is a growing trend toward the use of innovative approaches that place children at the centre of their learning to promote higher achievement (Briggs & Hansen, 2012; Darling-Hammond, Flook, Harvey, Baron, & Osher, 2020). Learning through play has emerged as an important strategy to promote student engagement, inclusion, and holistic skills development (Parker, Thomsen, & Berry, 2022). Play-based learning can be traced back to the early works of Dewey, Rousseau, Froebel, and Piaget, among others who emphasize the concept of first-hand experiences through play for young children as a pre-requisite for learning (Moore, Edwards Susan, Cutter-Mackenzie-Knowles, & Boyd, 2014). Play is the natural means by which children explore and investigates their environment, enabling them to build an understanding of how the world works (Kids of Excellence, 2016; UNICEF, 2018). Furthermore, play not only contributes to children's physical growth but also promotes their cognitive and socio-emotional development (Ali, Constantino, Hussain, & Akhtar, 2018; Parker, Thomsen, & Berry, 2022; UNICEF, 2018). Evidence suggests that playful pedagogies are more effective in fostering social, emotional, physical, cognitive, and creative skills than traditional or more highly guided pedagogical approaches used in the primary school classroom (Parker & Thomsen, 2019). Play is important for building social competence and confidence in dealing with peers, a life skill that is essential for functioning in school as well as in life on the job (Singer, Golinkoff, & Hirsh-Pasek, 2006).

show the five learning experiences that characterise play-based learning that include meaningful, actively engaging, joyful, iterative, and socially interactive experiences (Zosh, et al., 2017; Parker & Thomsen, 2019).

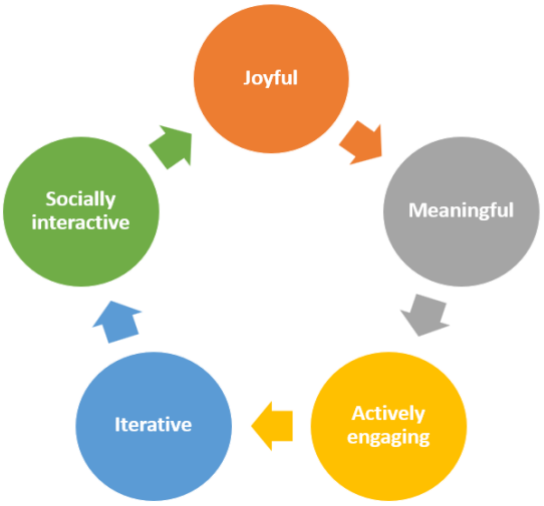


Figure 3: Domains of play-based learning (Zosh, et al, 2017)

These five attributes are manifested in a range of pedagogical approaches including active learning, cooperative learning, experiential learning, guided discovery learning, inquiry-based learning, problem-based learning, project-based learning and collectively, these approaches are described as playful pedagogies (Parker & Thomsen, 2019). The following is a description of the five domains of play-based learning approaches:

a. **Joyful:** Enjoyment, excitement, pleasure, motivation, thrill, positive emotion,
b. **Meaningful:** Connecting to something they already know and use it as the starting point for expanding their understanding.
c. **Actively engaging:** Hands-on, minds-on, hearts-on (physical, mental, and emotional immersion) into the learning activity or process, resistance to distraction
d. **Iterative:** Trying out possibilities, revising hypotheses, and discovering the next question, leads to deeper learning.
e. **Socially interactive:** Sharing with others promotes deeper understanding, communication of ideas, coherence, builds more powerful relationships.

A natural, strong, and complementary nexus exists between play-based learning and STEM education given that STEM involves discovering, creating, experimenting, and building, a process that is creative, iterative, challenging, and playful (Hadani & Rood, 2018). STEM education creates critical thinkers, increases science literacy, and enables the next generation of innovators (Engineering for Kids, 2020). Studies have reported that students in a learning setting that involved play outperformed those in a control group in both mathematics and literacy (Wright, 2016; Oers & Duijkers, 2012). Play provides learners with context and purpose for learning, and opportunities for access, engagement, and extension of STEM content learning (Roberts, et al., 2018). Therefore, the

integration of STEM education with play-based learning connects important content areas in hands-on ways that allow students to apply what they are learning. Through play, learners deploy tools and resources that inspire learning of STEM concepts by posing problems, exploring solutions, and developing an understanding of their environment, enhancing their cognitive and problem-solving skills (Hirsh-Pasek & Hadani, 2020; Parker, Thomsen, & Berry, 2022). Therefore, STEM education is well aligned with play-based learning approaches given that when learners engage in STEM, their work is social as they collaborate in designing challenges and getting feedback from one another, thinking creatively as they solve problems. However, while teachers value STEM education, they encounter pedagogical, curriculum, and structural challenges that derail their effectiveness. These issues could be addressed through effective professional development to enhance their capabilities. (Margot & Kettler, 2019).

3. DESIGN AND METHODOLOGY

3.1 Overview

This chapter presents the methods and approaches that were used in this study that include the study design, target groups and samples. It further describes the approaches and process of data collection from the different target groups, as well as how the data were analysed and presented.

3.2 Study design

The methods and approaches adopted in this study were informed by the nature, purpose, objectives and expected deliverables of the study. Play-based STEM education is a relatively new concept, not only in Africa but globally. Further, little is currently known about the status of play-based STEM education at the primary school level in Africa as there is little data available and very few studies for reference. Therefore, the exploratory research design was adopted in gathering information from targets groups who were more likely to have a better understanding of this subject matter to ensure efficiency in the delivery of the study. Additionally, both qualitative and quantitative was gathered to ensure both depth and breadth of information that was gathered on the status of play-based STEM education at primary schools in Africa. Specifically, the study adopted (a) desk review of relevant reports, policies, and research studies on play-based STEM education in Africa; and (b) survey through questionnaires and interviews of educators including teachers, and education officials at local and national levels, and parents on play-based STEM at primary school level, In addition, (c) interviews with key informants in the respective countries, (d) focus group discussions with primary school students. The tools developed to enable gathering of information through these approaches are described in sub-section 3.5.

3.3 Target groups

The choice of the target groups in this study was informed by the need to reach the right people with a stake on play-based STEM education at primary school level in Africa based on their training, professional practice, experiences, interests, and influence in this matter. Therefore, the key target groups in this study were teachers of STEM at primary schools, primary school administrators, education officials at the local levels in charge of teacher support and quality assurance, senior education officials at the national level in charge of policy formulation and education management. Other key target groups were the students at primary school and parents who were engaged through focus group discussions and interviews respectively. Meanwhile, the study also targeted organisations in Africa that are implementing play-based STEM education initiatives at the primary school level.

3.4 Sample

The number and distribution of countries participating in the study was purposefully selected based on the criteria of regional economic blocks and language groups in Africa. Therefore, the final 10 countries[2] are representative of the five economic blocks in Africa, and the respective languages. A total of 638 participants were reached (**Table 1**) with an overall response rate of 73%, with an almost equal gender split at 51% male and 49% female (**see detailed sample in Annex A**).

Table 1: Sample Size

Target Group	Target	Achieved		Total	Response rate
		Male	Female		
Teacher	400	150	123	273	68%
School head	200	76	63	139	70%
Local education official	40	10	10	20	50%
Senior education official	40	10	5	15	38%
Parent	100	35	52	87	87%
Learner	100	45	59	104	104%
Total	**880**	**326**	**312**	**638**	**73%**
Percentage		**51%**	**49%**		

3.5 Data collection tools

3.5.1 Content of tools

Based on the objectives of this study, the issues that were explored fell under five thematic areas that affect play-based STEM education at primary school level in Africa. These are : (a) understanding and perspectives of play-based STEM education by different education stakeholders, (b) existing initiatives and interventions in play-based STEM education, (c) extent to which the education policies including the national curriculum have a focus on play-based STEM Education, (d) current teacher instruction practices and learning experiences that reflect play-based STEM education, (e) barriers and enablers of play-based STEM education.

In gathering information on the thematic areas, eight tools were adopted including, (a) document review guide, (b) questionnaire for teachers, (c) questionnaire for school administrators, (d) questionnaire for local education officials, (e) interview guide for senior education official, (f) focus

[2] Eswatini, Kenya, Ivory Coast, Malawi, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, and The Gambia.

group discussion guide for students, (g) questionnaire for parents, and (h) key informant interview guide. The use of multiple tools to gather data from a cross section of target groups enabled triangulation of information in order to enrich the accuracy of information gathered.

Table 2 presents the matrix that guided in development of the respective tools.

Table 2: Matrix for development of tools

Thematic area	Key questions	Target/source	Tool
1: understanding and perceptions of Play-based STEM education by different education stakeholders at the primary school level in Africa.	• What are the understandings of key education stakeholders on play-based STEM education? • What are the perceptions of key education stakeholders on play-based STEM education as pedagogical practice	• Document review • Teachers • School administrators • Local education officials • Senior education officials • Students • Parents	• Document review guide • Teacher questionnaire • School administrator questionnaire • Local education official questionnaire • Senior education official questionnaire • Students focus group discussion guide • Parents / Caregivers questionnaire
2: extent to which the education policies and national curriculum prioritize play-based STEM education at the primary school level in Africa.	• Do the education policies prioritize play-based STEM education? • Does the national curriculum incorporate play-based STEM education?	• Document review • Teachers • School administrators • Local education officials • Senior education officials	• Document review guide • Teacher questionnaire • School administrator questionnaire • Local education official questionnaire • Senior education official questionnaire
3: existing interventions in play-based STEM education at the primary school levels in Africa.	• Which programmes are focused on play-based STEM education? • Which organizations are implementing interventions on	• Document review • Teachers • School administrators • Local education officials • Senior education officials	• Document review guide • Teacher questionnaire • School administrator questionnaire • Local education official questionnaire • Senior education official questionnaire

	play-based STEM education? • What are the focus areas of interventions on play-based STEM education?	• Key Informant (Organizations)	• Key Informant Interview Guide
4: current teaching and learning practices on play-based STEM education at the primary school level in Africa.	• Which play-based STEM education teaching and learning practices are being applied at primary school level?	• Document review • Teachers • School administrators • Local education officials • Senior education officials • Students • Parents	• Document review guide • Teacher questionnaire • School administrator questionnaire • Local education official questionnaire • Senior education official questionnaire • Students focus group discussion guide • Parents / Caregivers questionnaire
5: barriers and enablers of play-based STEM education at elementary (primary) education level in Africa.	• What barrier exists to successful adoption of play-based STEM education pedagogical practices? • What opportunities are there for successful adoption of play-based pedagogical practices?	• Document review • Teachers • School administrators • Local education officials • Senior education officials • Students • Parents	• Document review guide • Teacher questionnaire • School administrator questionnaire • Local education official questionnaire • Senior education official questionnaire • Students focus group discussion guide • Parents / Caregivers questionnaire

3.5.2 Validity and reliability of the tools

The tools were developed by the ADEA Resource Person and further reviewed by the ADEA technical team to ensure that they are valid for use in collection of accurate information on the thematic areas that were identified for this study. Meanwhile, triangulation of both the source and

methods in data collection was an additional measure to ensure accuracy of the information gathered for drawing valid conclusions and making appropriate recommendations.

3.6 Field data collection

3.6.1 Negotiating Entry

The ADEA Coordinator led the overall management of the study for the ICQN on Mathematics and Science Education (ICQN-MSE). The coordinator used the existing communication protocols and mechanisms in the ADEA establishment in sharing information and briefings about the study with respective authorities in the Ministries of Education in the 10 target countries. The coordinator also shared an overview with the Country Focal Persons (CFP) on the operational aspects of the study including timelines for the study, and logistical considerations. Further, the Coordinator through the Country Focal Person ensured that the relevant informed consent was granted for data collection from the identified study participants.

3.6.2 Management of data collection at country level

The ADEA Coordinator for ICQN-MSE liaised with the Ministry of Education in each of the 10 target countries to appoint a focal person at the headquarters who managed the process of data collection at the country level. Given the broad thematic areas and the strategic nature of this study, the focal person was appointed by the Minister for Education at the level of Director of Education or equivalent status. Involvement of the country focal persons ensured not only high response rate, but also participation and contribution of critical stakeholders in this study, enhancing relevance and ownership of the findings and final report. The specific roles and responsibilities of the country focal person in each country included:

a. Identification of two (one male and one female) senior education officials at the Ministry of Education headquarters for interview and providing their contacts (telephone and email address) to the ADEA Coordinator ICQN-MSE.
b. Selection of 20 public primary schools, 20 school administrators of these schools in one region of the country who responded to the questionnaire for school administrators on the status of play-based STEM education in their schools. The country focal person ensured gender representativeness in the selection of the schools and school administrators and guidelines for this process were shared.
c. Selection of two (one male, and one female) teachers of STEM from each of the 20 selected primary schools, total 40 (20 males and 20 female) teachers per country. Data from these teachers was collected using the teacher questionnaire.

d. Selection of two (one male and one female) local education officials at the sub-national level to respond to the questionnaire for local education official on the status of play-based STEM education at the primary schools in their region. The local education officials were drawn from the same regions as the teachers and schools. The selected official was in-charge of the teacher pedagogical support and or quality assurance at the regional level.
e. Identification of 20 enumerators that were trained by the ADEA Resource Person on data collection at the school level. In selecting the two enumerators, a key consideration was the possession of an Android Smartphone that was used for mobile data collection. Under the supervision of the focal person, the two enumerators per country administered an online teachers' questionnaire through KoboCollect App to the teachers in the 20 target schools, administered school administrator questionnaire, conducted student group interview in at least two schools (5 students each total 10 students), and conducted parents' interview in at least two schools **(**5 parents each total 10 parents).
f. The focal person provided the email addresses and mobile phone numbers for selected senior education officials, local education officials, and teachers of STEM in the 20 target schools.
g. The focal person liaised with the school administrator in identifying five students (two males and three female) in grade six for a student focus group discussion, and invitation of five parents (two males, three female) of students at grade six for a parent's interview.

3.6.3 Desk review

Relevant and current policy documents, education sector plans, education reports, research and evaluation studies that are relevant to play-based STEM education in Africa were identified through searches on the internet. The key words that were used in the search included a combination of ***'play-based STEM education in Africa'***, and '***'play-based mathematics and science education in Africa'*.** Meanwhile the country focal persons shared or referred the ADEA Resource Person to existing policies, education sector plans and reports that are relevant to play-based STEM education in Africa. The documents gathered through these processes were further reviewed using the criteria of a ***'play-based STEM education at primary school level in Africa'*** to obtain a short list of documents that were reviewed using a document review guide developed for this purpose.

3.6.4 Training of enumerators

The ADEA Resource Person trained the enumerators that led in data collection at the schools online through Zoom link. The training session (**Table 3**) took four hours and the two enumerators were trained country by country to ensure the local context was addressed during the training. However, enumerators from Nigeria and Eswatini were trained on the same day and in total six enumerator

trainings of four hours each were conducted. Further, for enumerators from Kenya and Senegal, an additional refresher training of one hour each was conducted as there was a lapse of time between the first training and actual data collection. The refresher training ensured that enumerators were adequately prepared on both the technical data collection and the process of access and navigating through the KoboCollect App during data collection and submission.

Table 3: Sample enumerator training programme

Time	Agenda Item	Lead
0900 -0910 hrs GMT	Opening remarks and introductions (10 mins)	ADEA ICQN MSE Coordinator
0910-0940 hrs GMT	Part 1: Overview of the study (30 mins)	ADEA Resource Person
0940-0950 hrs GMT	Questions, Comments (10mins)	ADEA Resource Person
0950-1000 hrs GMT	Short Break (10mins)	All
1000-1100 hrs GMT	Part 2: Mobile Data Collection – KoboToolbox (1 hr)	ADEA Resource Person
1100-1120 hrs GMT	Long Break (20 Mins)	All
1120-1220 hrs GMT	Part 3: Data Collection Tools (1 hour)	ADEA Resource Person
1220-1250 hrs GMT	Part 4: Logistics and operational support (30 Mins)	ADEA ICQN MSE Coordinator
1250-1300 hrs GMT	Closing remarks (10 Mins)	ADEA ICQN MSE Coordinator

3.6.5 Field data collection

a. Teacher, school administrators, and local education officials' surveys

The questionnaires that were used for the teachers, school administrators, local education officials, and parents were digitalized in KoboCollect and shared with the enumerators during the training for enumerators. The enumerators administered the teacher questionnaire, school administrators'

questionnaire, local education officials' questionnaire, and parents' questionnaire one on one while inputting the data directly in the KoboCollect App. The direct administration of the questionnaires for teachers, school administrators, local education officials, and parents by enumerators was informed by experience from other studies that these cadre of target groups have lower access to internet connectivity and devices and therefore would not support direct data collection through an online platform. This approach was also cost effective as it reduced on manual data collection and entry. Further, in addition to timeliness in data submission through upload of data at the end of each day, the mobile data collection improved on data quality and accuracy due to the inbuilt logics including skip options, constraints and required field entries that allowed for funnelling and routing of questions for participants based on responses in previous questions within the questionnaire. Using KoboCollect App, the enumerators collected the data in offline mode and later connected to the internet and uploaded the data at the end of each day. The questionnaires for teachers, school administrators, local education officials, and parents took approximately 45 minutes to complete.

b. Interviews for senior education officials

Interviews were conducted with two (one male and one female) senior officials in the Ministry of Education headquarters. The country focal person selected the two senior officials at the ministry of education headquarters for the interviews and shared their email addresses and mobile phone numbers with ADEA. Additionally, the country focal person supported in booking appointments for the interviews, while the ADEA Resource Person shared Zoom links with the respective officials. The identified senior education officials had a responsibility on education management, quality assurance, policy formulation or interventions in STEM education. The interviews were conducted through Zoom by the ADEA Resource Person and took approximately 45 Minutes. Additionally, the interviews were recorded with permission from respective senior education officials, and later transcribed to ensure all the gathered information was documented. A schedule of interview dates was prepared by the ADEA Resource Person and shared with the country focal person for interview appointment with the identified senior education officials.

c. Focus group discussion with primary school learners.

In each country, at least two schools were identified where focus group discussions for students were conducted, and a total of two focus group discussions for students were conducted in each country. Five students, two males and three females were selected from grade six (6) or an equivalent grade for the focus group discussions. The choice of grade six (6) was informed by the assumption that students at this grade level have had more exposure to the primary school mathematics and science curriculum and learning experiences. Therefore, students at this grade level are more likely to have

formed opinions and perspectives regarding play-based STEM education that they could easily articulate. Furthermore, grade six is the final primary grade for several of the countries in the study sample. During the student focus group discussions, one enumerator led in engaging the students in questions, while the second enumerator recorded the responses and observations in KoboCollect App.

d. Interview with parents or caregivers

In two of the twenty sample schools per country, five parents were invited, two males and three females for a one-on-one parents' interview. During the interview, one enumerator led in engaging the parent in questions, while the second enumerator recorded the responses in the KoboCollect App.

e. Key Informant Interviews

Key informant interviews were conducted with technical staff of organisations in Africa that are implementing play-based STEM education initiatives at primary school levels. The focus of key informant interviews was on the enablers and barriers to integration of play-based STEM education at the primary school level, and recommendations thereof. The interviews were conducted through Zoom and took approximately 45 Minutes. Additionally, the interviews were recorded and later transcribed to ensure all the gathered information was documented.

f. Quality Assurance and technical backstopping

The guidelines on the process of data collection (Annex C) at the country level were used for the induction of the Country Focal Person, training of enumerators, as well as served as a guide in the data collection process at the country level. The guidelines articulated both the process and key considerations to ensure quality data collection. Meanwhile, the ADEA technical team reviewed progress in the implementation of the study at key milestones to ensure the quality of deliverables. Furthermore, the ADEA Resource Person supported the enumerators during the actual data collection to address any technical issues regarding the survey items or navigation of the KoboCollect App. Therefore, the ADEA Resource Person offered technical backstopping to the enumerators in the field in each country through WhatsApp and this process was efficient. The ADEA Resource Person reviewed the submitted data at the end of each data collection for completeness. Further, the training of enumerators and digitization of the data collection tools ensured high quality data was collected and submitted.

3.7 Data analysis and report writing

The quantitative data gathered from this study was summarized through descriptive statistics in form of frequencies, percentages, and means using both MS Excel and SPSS version 22 to establish trends on the status of play-based STEM education at the primary school levels and any unique occurrences. The findings were presented in Tables and Graphs as appropriate. Meanwhile, the qualitative information from the interviews were recorded and transcribed to ensure that during the qualitative analysis all relevant information was documented. Both the transcriptions and qualitative data from the open responses in the survey were subjected to content analysis which involved coding of the textual responses using key words and establishing themes, with supporting narratives from the information. The responses from multiple target groups were subjected to comparative analysis to establish any notable and significant divergences or convergences in trends and patterns in the identified themes. Additionally, representative verbatim excerpts from the interviews and open responses were isolated, captioned and used to reinforce the observed trends from the analysis for clarity in interpreting the findings. Similar to quantitative analysis, some of the findings from qualitative data were presented in tables, figures, and reinforced with representative narratives as appropriate. Meanwhile the findings were subjected to further analytical review to identify gaps between the observed status in the five thematic areas, and the expectations as defined in policy documents and education plans. This enabled an understanding of the existing gaps to inform recommendations and development of a policy brief for engagement with key stakeholders on education in Africa.

3.8 Stakeholders' validation workshop

The draft report was shared with ADEA for review and feedback and after incorporation of the feedback, the revised report was presented to key education stakeholders in the Ministries of Education drawn from the 10 sample countries through a webinar for validation and further feedback. Upon validation and incorporation of the feedback, a final report was compiled and submitted to ADEA through the Coordinator ICQN-MSE.

4. STUDY FINDINGS

4.1 Overview

This chapter presents findings from the study organized into six sections as (a) demographic information, (b) understanding play-based STEM education, (c) prioritization of play-based STEM education (d) initiatives focused on play-based STEM education, (e) integration of play-based STEM education, and (f) barriers and enablers to integration of play-based approaches in STEM education.

4.2 Demographic Information

This section presents the demographic information of the respondents.

4.2.1 Teacher Demographics.

A total of 273 (55% male and 45% female) teachers of STEM subjects at primary schools were surveyed in the seven study countries. Eight out of in ten (79%) had at least a college diploma certificate, with both Eswatini and The Gambia having the highest proportion of teachers in this category, while Côte d'Ivoire and Senegal had the lowest proportion of teachers (

Table ***4***). Overall, more than three quarters were teachers of STEM subjects and on average across the countries the teachers had taught for 15 years with a low of 10 years in Nigeria and a high of 20 years for teachers in Mauritius. Some of the teachers were also teaching other subjects besides STEM such as languages, social studies, physical and religious education. The teachers were handling an average class size of 73 learners, with a wide range across countries. For instance, teachers in Mauritius had the least class size with an average of 25 learners, while those in The Gambia had a proportionately higher-class size with an average of 133 learners. Across the countries, the teachers were teaching an average of 20 hours per week with a low of 13 hours in Nigeria and a high of 36 hours per week in Côte d'Ivoire. Further, nine in ten teachers had additional responsibilities besides teaching, including co-curricular and administrative duties. These findings could imply that the teachers had a good understanding of the teaching and learning of STEM subjects at primary schools and therefore could provide relevant information based on their experience and training. Further, based on the teaching load and additional responsibilities, the teachers may have little room for engagements in other activities. Therefore, any efforts to engage teachers in additional activities such as trainings need to be carefully planned to ensure the use of the teachers' time is maximized without overburdening them.

Table 4: Teacher demographics

Category	Characteristic	Côte d'Ivoire (47)	Eswatini (42)	Kenya (40)	Mauritius (44)	Nigeria (40)	Senegal (19)	The Gambia (41)	All (273)
Sex	*Male*	34	22	18	17	20	10	29	150
	Female	13	20	22	27	20	9	12	123
	Male (%)	72%	52%	45%	39%	50%	53%	71%	55%
	Female (%)	28%	48%	55%	61%	50%	47%	29%	45%
Age	*25yrs and below*	0%	0%	0%	0%	3%	0%	12%	2%
	26-35yrs	9%	24%	25%	9%	63%	16%	51%	29%
	36-45yrs	62%	55%	38%	55%	23%	47%	29%	44%
	46-55yrs	23%	21%	30%	36%	13%	37%	7%	22%
	56+yrs	6%	0%	8%	0%	0%	0%	0%	2%
Academic Qualification	*Secondary school certificate*	70%	0%	0%	0%	0%	5%	0%	13%
	Advanced school certificate	0%	0%	25%	2%	25%	53%	0%	8%
	Diploma college certificate	17%	43%	38%	75%	13%	32%	95%	46%
	Undergraduate certificate	9%	50%	38%	18%	48%	11%	2%	27%
	Master certificate and above	4%	7%	0%	5%	15%	0%	2%	6%
	At least diploma level college certificate	30%	100%	75%	98%	75%	43%	100%	79%
Teaching Subject	*Science*	100%	52%	83%	100%	68%	47%	56%	78%
	Mathematics	100%	62%	65%	100%	63%	21%	61%	79%
	English	0%	7%	35%	100%	43%	100%	5%	16%
	Social studies	0%	14%	35%	100%	33%	21%	5%	10%
	French	0%	0%	0%	100%	3%	0%	0%	19%
	Agriculture	0%	14%	30%	0%	38%	26%	2%	13%
	Art & Design	0%	7%	40%	0%	30%	11%	2%	29%
	Home science	0%	17%	25%	0%	33%	5%	2%	18%
	Physical education	0%	2%	38%	0%	23%	37%	0%	8%
	Computer science	0%	2%	3%	0%	43%	11%	7%	10%
	Additional language	0%	10%	30%	0%	13%	47%	0%	32%
	Religious education	0%	10%	25%	0%	15%	21%	0%	8%
Other responsibilities	***Academic***								
	Head of subject	0%	36%	53%	0%	34%	0%	49%	28%
	INSET trainer	4%	43%	37%	0%	10%	6%	24%	20%
	Head of department	0%	14%	21%	0%	21%	0%	38%	15%
	Examination teacher	0%	0%	13%	0%	14%	0%	0%	4%
	Library teacher	7%	0%	3%	0%	0%	0%	0%	2%
	Co-curricular								
	Games sports	42%	10%	26%	92%	3%	0%	5%	31%
	Welfare	47%	2%	18%	30%	17%	6%	5%	21%
	Sanitation & hygiene	22%	0%	16%	0%	10%	12%	8%	10%
	Club patron	7%	0%	26%	0%	3%	6%	11%	8%
	Guidance & counselling	0%	12%	26%	0%	3%	0%	3%	7%
	Pastoral programme	0%	0%	13%	3%	0%	0%	0%	3%
	Administrative								
	Class master / mistress	0%	0%	55%	0%	10%	0%	3%	11%
	Deputy school administrator	18%	2%	5%	11%	3%	76%	0%	7%
Teaching attributes	*Average class size*	57	73	50	25	57	37	133	73
	Female students (%)	51%	47%	50%	48%	51%	47%	53%	50%
	Teaching experience in years	16	16	18	20	10	17	10	15
	Teaching load in hours per week	36	18	16	15	13	29	14	20
Language of Instruction	*English*	0%	100%	100%	95%	100%	0%	100%	81%
	French	100%	0%	0%	48%	0%	100%	0%	27%
	Kiswahili	0%	0%	88%	0%	0%	0%	0%	14%
	Hausa	0%	0%	0%	0%	20%	0%	0%	3%

4.2.2 School administrator demographics

A total of 139 schools heads were surveyed with proportionately more male than female (55% male and 45% female) (**Table 5**). Eswatini, Kenya, and Mauritius had an equal gender split in the proportion of school heads, while Nigeria had a relatively higher proportion of female school heads

(62%), and both Senegal and The Gambia had a relatively higher proportion of male school heads at 89% and 70% respectively. Across the countries, eight in ten school heads (80%) had at least a college diploma certificate with a higher proportion of school heads in Eswatini, Mauritius, and The Gambia having this qualification. However, Côte d'Ivoire had a proportionately higher number of school heads with lower qualifications as only two in ten had a diploma level college certificate. Overall, a high proportion of the school heads (six in ten) were teachers of STEM subjects. Further, school heads had on average 28 years of work experience with a low of 24 years and a high of 35 years. Meanwhile, the school heads had on average 14 hours of teaching per week, with a low of 2 hours in Mauritius and a high of 33 hours in Côte d'Ivoire. Overall, these findings could imply that the school heads have a good understanding of the teaching and learning at primary schools and STEM subjects in particular, and therefore are able to provide relevant information on the teaching and learning of these subjects at the primary schools.

Table 5: School administrator demographics

	Country	Côte d'Ivoire (25)	Eswatini (20)	Kenya (20)	Mauritius (24)	Nigeria (21)	Senegal (9)	The Gambia (20)	All (139)
Sex	Male	14	10	10	12	8	8	14	76
	Female	11	10	10	12	13	1	6	63
	Total	25	20	20	24	21	9	20	139
	% Male	56%	50%	50%	50%	38%	89%	70%	55%
	% Female	44%	50%	50%	50%	62%	11%	30%	45%
Age	26-35yrs	0%	0%	0%	0%	0%	0%	5%	1%
	36-45yrs	16%	0%	25%	0%	29%	0%	0%	12%
	46-55yrs	72%	70%	50%	29%	57%	56%	40%	53%
	56+yrs	12%	30%	25%	71%	14%	44%	55%	35%
Academic Qualification	Secondary school certificate	80%	0%	0%	0%	0%	11%	0%	15%
	Advanced school certificate	4%	0%	5%	0%	19%	0%	0%	5%
	Diploma college certificate	0%	5%	25%	67%	10%	67%	95%	33%
	Undergraduate level certificate	4%	45%	50%	25%	48%	22%	5%	28%
	Master certificate and above	12%	50%	20%	8%	24%	0%	0%	18%
	At least diploma level college certificate	16%	100%	95%	100%	81%	89%	100%	80%
Teaching Subject	Mathematics	100%	18%	21%	100%	35%	100%	35%	61%
	Science	100%	35%	42%	100%	30%	100%	20%	59%
	Agriculture	0%	18%	16%	0%	25%	33%	0%	31%
	Computer Science	0%	0%	0%	96%	30%	100%	0%	28%
	Art & Design	0%	0%	16%	96%	30%	0%	5%	25%
	Home Science	0%	0%	26%	0%	25%	33%	0%	24%
	English	0%	12%	16%	67%	45%	44%	15%	23%
	French	0%	0%	0%	67%	0%	22%	0%	15%
	Additional language	0%	0%	37%	67%	15%	33%	5%	14%
	Physical Education	0%	0%	0%	0%	20%	0%	5%	13%
	Social studies	0%	35%	26%	50%	45%	67%	15%	10%
	Religious Education	0%	12%	53%	0%	30%	33%	0%	10%
	School administration only	0%	0%	0%	0%	10%	0%	60%	4%
	Teaching experience in years	24	28	27	32	25	27	35	28

Country	Côte d'Ivoire (25)	Eswatini (20)	Kenya (20)	Mauritius (24)	Nigeria (21)	Senegal (9)	The Gambia (20)	All (139)
Teaching load hours per week	33	5	8	2	9	30	11	14

4.2.3 Education official demographics

A total of 20 education officials at the sub-national level with equal gender split were surveyed and all had at least a diploma college level qualification (**Figure 4**). Further, a higher proportion of education officials had post-graduate qualification with eight in ten having at least a master degree certificate and all education officials in Côte d'Ivoire, Eswatini, and Kenya were in this category. This finding could imply that the education officials at the sub-national level are well-versed with education issues and therefore could provide relevant information on the teaching and learning at the primary school level.

Figure 4: Background information of education officials

Variable	Country	Côte d'Ivoire (5)	Eswatini (3)	Kenya (2)	Mauritius (2)	Nigeria (3)	Senegal (3)	The Gambia (2)	All (20)
Sex	Male	0	2	1	1	2	2	2	10
	Female	5	1	1	1	1	1	0	10
	Total	5	3	2	2	3	3	2	20
	Male (%)	0%	67%	50%	50%	67%	67%	100%	50%
	Female (%)	100%	33%	50%	50%	33%	33%	0%	50%
Age	36-45yrs	0%	0%	0%	0%	33%	0%	0%	5%
	46-55yrs	100%	0%	100%	50%	67%	33%	50%	60%
	56+yrs	0%	100%	0%	50%	0%	67%	50%	35%
Academic qualification	Diploma college certificate	0%	0%	0%	0%	0%	33%	0%	5%
	Undergraduate certificate	0%	0%	0%	50%	33%	0%	50%	15%
	Master certificate+	100%	100%	100%	50%	67%	67%	50%	80%

4.2.4 Parents demographics

At total of 67 parents, 40% male and 60% female, were surveyed through interviews and most were either the mother or father while a few were another adult, either a relative or non-relative (

Table *6*). In Nigeria, proportionately more male (73%) than female parents were surveyed, while in The Gambia, proportionately more female (70%) than male parents were surveyed. Additionally, more than half (54%) of the parents had completed at least secondary education, while at least nine in ten (85%) had completed primary education. This could imply that a higher proportion of the parents had a good understanding of primary schooling and therefore could provide relevant information on teaching and learning at this level.

Table 6: Parent demographics

Country		Côte d'Ivoire (16)	Eswatini (10)	Kenya (10)	Mauritius (10)	Nigeria (11)	Senegal (11)	The Gambia (11)	All (67)
Gender	Male	5	4	4	4	8	8	2	35
	Female	11	6	6	6	3	12	8	52
	Total	16	10	10	10	11	20	10	87
	Male	31%	40%	40%	40%	73%	40%	20%	40%
	Female	69%	60%	60%	60%	27%	60%	80%	60%
Relationship to child	Mother	63%	50%	60%	60%	27%	45%	70%	53%
	Father	31%	30%	40%	30%	73%	30%	20%	36%
	Other adult relative	6%	20%	0%	0%	0%	25%	10%	10%
	Other adult non-relative	0%	0%	0%	10%	0%	0%	0%	1%
Age	36-45yrs	50%	70%	70%	50%	64%	35%	60%	54%
	26-35yrs	25%	10%	20%	30%	18%	20%	30%	22%
	56+yrs	19%	10%	0%	0%	0%	35%	10%	14%
	46-55yrs	6%	10%	10%	10%	18%	10%	0%	9%
	25yrs and below	0%	0%	0%	10%	0%	0%	0%	1%
Education level	None	19%	0%	10%	0%	0%	15%	10%	9%
	Some primary school	13%	0%	0%	0%	0%	30%	20%	11%
	Completed primary school	6%	10%	30%	10%	0%	25%	40%	17%
	Some secondary school	31%	20%	0%	40%	0%	15%	0%	16%
	Completed secondary school	13%	0%	30%	30%	0%	10%	10%	13%
	Some post-secondary school	0%	10%	0%	0%	0%	0%	10%	2%
	Completed post-secondary	13%	40%	20%	10%	45%	5%	10%	18%
	Undergraduate	0%	20%	10%	10%	36%	0%	0%	9%
	Master's level	6%	0%	0%	0%	18%	0%	0%	3%

4.2.5 Student demographics.

A total of 104 students in grade six, 43% male and 57% female were reached through focus groups discussions (**Table 7: Students of primary schools in sample countries**).

Table 7: Students of primary schools in sample countries

Sex	Côte d'Ivoire	Eswatini	Kenya	Mauritius	Nigeria	Senegal	The Gambia	All
Male	4	5	8	5	10	9	4	45
Female	6	7	12	5	12	11	6	59
Total	10	12	20	10	22	20	10	104
Male (%)	40%	42%	40%	50%	45%	45%	40%	43%
Female (%)	60%	58%	60%	50%	55%	55%	60%	57%

4.3 Understanding of play-based STEM education.

The first objective in this study was to establish the understanding of play-based STEM education among educators including senior education officials at the national level, education officials at the sub-national level, teachers of STEM subjects at primary schools, and school heads. The understanding of play-based STEM education was established by assessing whether the key educators were exposed to play-based approaches through awareness programs or trained on the approach.

4.3.1 Understanding of play-based STEM Education by Senior Education Officials

The senior education officials held mixed views and understanding of play-based approach and the following are the key summary of findings from interviews with this cadre of education officials:

a. ***Play-based activities as peripheral add on to the 'normal' teaching and learning approaches.***

Some of the senior education officials had little or no understanding of play-based approaches and associated them with leisure activities or peripheral add-on to the 'normal' teaching and learning activities. Equally, they were sceptical on whether play-based activities could contribute to any meaningful learning, and the following verbatim excerpt illustrates this perception:

> *Play-based activities are done only in the areas where people are able to do so using scrap materials from the waste or receive manufactured materials from donors. However, these play-based activities remain less developed and less practiced in the country. Not all activities are covered, and even the play-based activities that are implemented in teaching and learning are often neither generalized nor institutionalized. I'm all for hands-on activities that can be done while playing, but not just any play-based activities that might in the long run override the activities' goal of promoting teaching and learning of science.*
>
> ***Senior education official***

b. ***Potential for play-based approach to improve learning.***

Some of the senior education officials acknowledged the potential for play-based approach to promote learning of STEM subjects as illustrated in the following verbatim excerpts from the interviews:

> *Obviously, when we say play-based activities, I'm not thinking of just any game. For me, I'm thinking more of the educational play-based activities whereby the game allows to experiment through practice. The activity should allow pupils to do practical experiments with science*

before trying to memorize them. However, I also know that there are play-based activities that lead us directly to the practice of science and mathematics. These kinds of games are helpful in improving the teaching and learning of science and mathematics, which is currently at a very low level (less practiced) in our country. Of course, play-based STEM education can go a long way toward problem solving and developing creative minds in students. I always say that the difficulty of science in children is the abstract nature of science. With their mind and their psychology, a child is oriented towards the concrete rather than towards the abstract. Now, when we are in the concrete life, students can solve mathematics problems while playing.

Senior education official

c. Play-based STEM education does not exist at primary school level.

While aware of the play-based approach, some of the senior education officials also acknowledged that play-based approaches are not being practiced at the primary schools. Further they acknowledged that play-based approaches are practiced at the pre-primary level but not at the primary school. Here is a verbatim excerpt from one of the senior education officials:

The play-based STEM education exists at the pre-primary school level only. Unfortunately, primary school teachers are not prepared to use play-based activities in their classrooms. I think this problem is linked to the training of teachers, simply because this aspect is not considered during pre-service teacher training programme.

Senior education official

d. Existing play-based learning activities.

Some of the senior education officials demonstrated good understanding of play-based approaches that are already being applied in STEM education at the primary school level. They were also supporting the teachers in applying the approach, though not all teachers are applying them. Here are some illustrative examples:

Example 1 of a play-based learning activity

I am really an eyewitness to many difficulties that children have had to overcome through practice. For example, students had problems in reading the time through a watch in the classroom, so through the activity called "les roues tournantes' meaning 'spinning wheels',

a student is asked to pick up numbers and draw them to write the time of day, and I see many children succeeding in this way when they had difficulty in directly reading the time using a watch. Through this game, I see them solving the problem of reading time of the day. This is just one example among others.

Senior education official

Example 2 of a play-based learning activity

I'm talking about my experience as a teacher. Of course, it depends on specific teachers to decide how to use activities in their classrooms. So, I'll take let's say length. We have the arbitrary units in grade one and two, where they do not use the tape measure or the meter rule, but they use their hands span or fingers. So, they use their hand span or finger span to measure distances. Additionally, they can use one-liter plastic bottle to measure how many bottles would be required to fill up a pail with water. The drawback is that not all the teachers carry out these activities.

Senior education official

4.3.2 Understanding of play-based STEM Education by teachers, school heads and education officials.

In assessing the understanding of play-based approach, teachers, school heads and education officials at the sub-national level were required to indicate whether they were aware or trained on play-based approaches shows that about eight in ten teachers, school heads, and education officials were aware of play-based approaches, with slightly more teachers being aware than both schools heads, and education officials. Additionally, proportionately more female than male teachers and school heads were aware of play-based approaches. Furthermore, at least six, five, and eight in ten teachers, school head, and education officials respectively were trained on play-based approaches. Meanwhile, proportionately more female than male teachers and school heads were trained on the play-based approaches. Overall, proportionately more teachers, school heads, and education officials were aware of play-based approaches than were trained on the approach.

Across the countries, awareness of and training on play-based approaches was higher for teacher and school heads in Nigeria, Mauritius, and Kenya while the least awareness was among teachers and school heads in Côte d'Ivoire and Senegal. Meanwhile, Mauritius had the highest proportion of teachers who had been trained on play-based approaches followed by Kenya and Nigeria in that order. Similarly, Nigeria had a higher proportion of school heads trained on play-based approaches followed

by Mauritius and Kenya. Additionally, Côte d'Ivoire had the least proportion of teachers and school head trained on play-based approaches. Furthermore, proportionately more education officials in Eswatini, Mauritius, and Nigeria were aware of the play-based approaches, while Cote d'Ivoire, Eswatini, and Mauritius had a high proportion of education officials trained on the approach. Overall, proportionately fewer school heads than teachers and education officials had been trained on the approach.

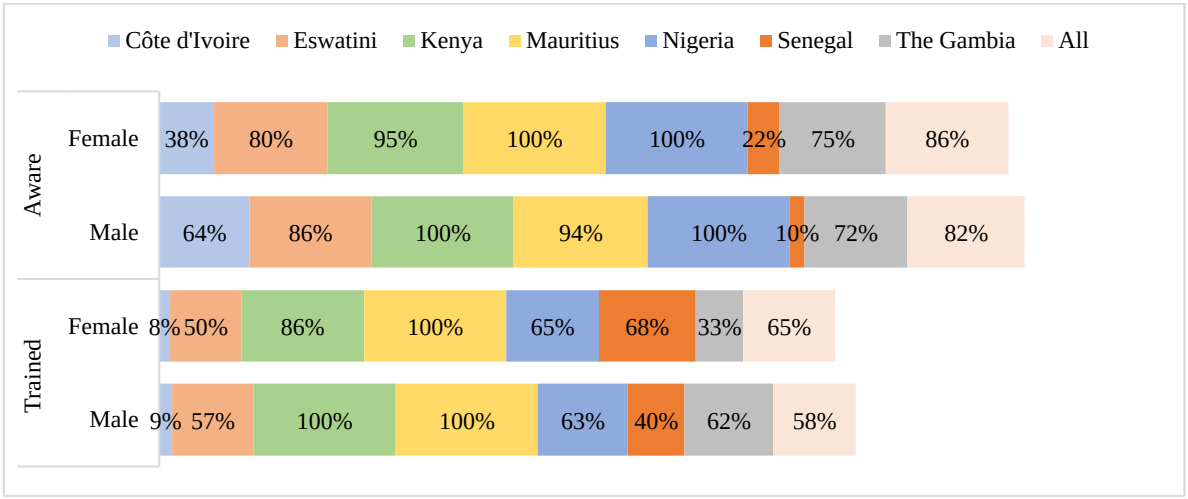


Figure 5: Teacher exposure to play-based approach.

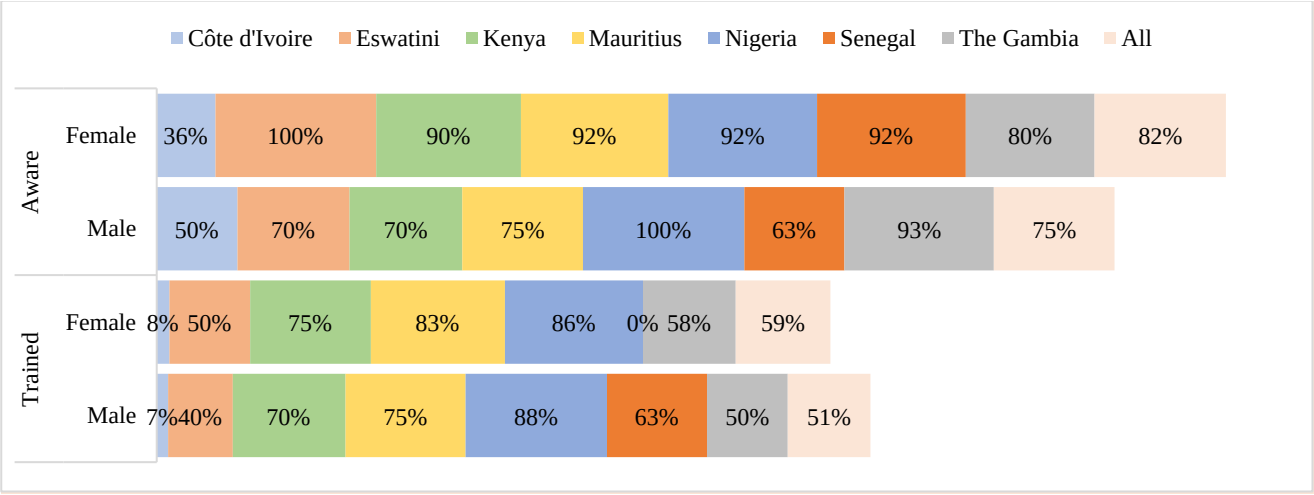


Figure 6: School head exposure to play-based approach.

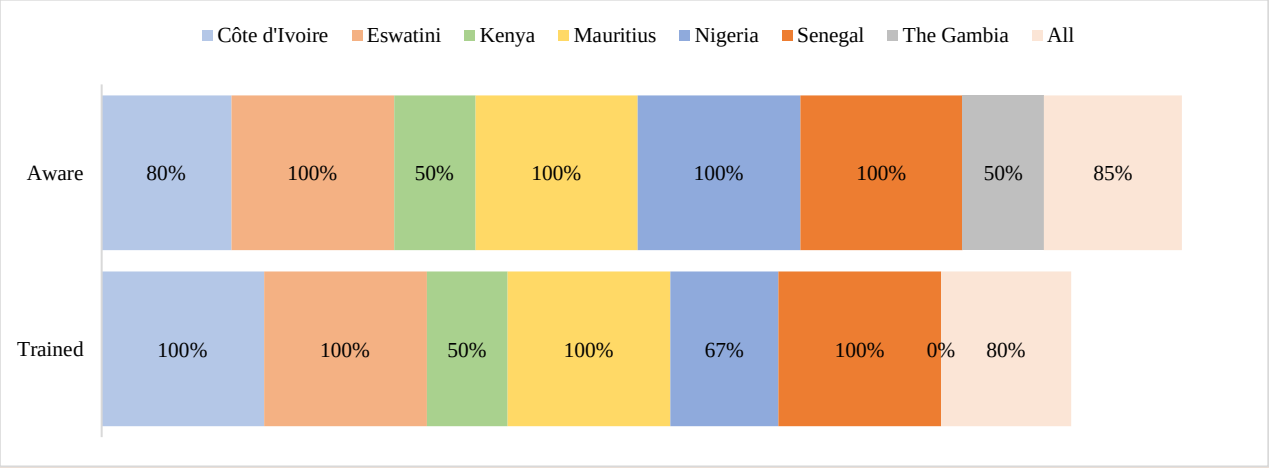


Figure 7: Education official exposure to play-based approach.

4.4 Prioritization of play-based STEM education at primary schools in Africa.

The second study objective was to establish the extent of prioritization of play-based STEM education at primary schools in Africa. The information used to establish prioritization of play-based STEM education was gathered through (a) review of the education sector plans from the sample countries, (b) interviews with senior education officials at the national level, and (c) survey of education officials at the sub-national level.

4.4.1 Prioritisation of play-based STEM Education in the Education Sector Plans

The current education sector plans of the 10 sample countries were reviewed to assess prioritisation of play-based STEM education in primary schools. It was established that there is a wide range in the level of prioritisation of play-based STEM education across the sample countries, with some countries having detailed articulation of play-based approaches and STEM education including the corresponding performance indicators for tracking progress, while others lack explicit articulation of play-based STEM education. In addition, a range of terminologies were used to characterise play-based approaches in the education sector plans.

The following is a summary of the key highlights of priorities and specific strategies in the education sector plans of the 10 sample countries that have a bearing on play-based STEM education:

a. Côte d'Ivoire

The Education Sectoral Plan 2016-2025 of the Ministry of National Education, Technical Education, and Professional Training of the Republic of Côte d'Ivoire has identified some initiatives at the primary school level in order to improve teaching and learning. These are : (a) supporting teachers to

improve their pedagogical practices through provision of continuous professional training coupled with pedagogical supervision., (b) strengthening the integration of digital technology in educational activities, (c) training of educators in the production of digital educational resources and use, (d) supplying primary schools with educational tablets.

b. Eswatini

The Education Sector Strategic Plan 2022–2034 of the Kingdom of Eswatini has identified specific strategies that have a focus on play-based STEM education at the primary school level. These strategies include (a) provision of laboratories, libraries and related equipment to primary schools, and (b) rolling out the new competency-based curriculum and providing ongoing support to teachers to deliver the new curriculum. In addition, (c) integration of ICT in primary schools, (d) strengthening teacher knowledge of interactive participatory teaching practices, (e) supporting prospective teacher students to choose STEM subjects, and (f) supporting teachers to make use of locally available teaching and learning materials.

c. Kenya

The National Education Sector Plan 2018-2022 of the Ministry of Education in the Republic of Kenya has identified 'Quality and Relevance in Primary Education' as one of the five key priorities at primary school level of education. Under this priority area, several strategies have been proposed that are supportive of play-based STEM education. These strategies include (a) curriculum reforms and adoption of competency-based curriculum, (b) integration of ICT in teaching, learning, and assessment in primary education, (c) promotion of Science, Technology, Engineering and Mathematics (STEM). Further, (d) development of science kits for primary schools, (e) building the capacity of primary school teachers in STEM subjects, (f) establishing science laboratories in primary schools to encourage hands on learning, and (g) developing a policy on STEM education and training.

d. Malawi

The National Education Sector Investment Plan 2020-2030 of the Ministry of Education in the Republic of Malawi have a key strategic objective of 'improving equitable access to quality learning for all children in Primary Education'. A key outcome is to improve quality and relevance of teaching and learning in primary school education. Some of the proposed initiatives with a bearing on play-based STEM education include: (a) providing schools with appropriate teaching and learning materials while promoting utilisation, (b) use of ICT enabled pedagogy to enhance learning outcomes, and (c) supporting teachers with opportunities for continuous professional development for improved teaching and learning practices.

e. Mauritius

The Education and Human Resources Strategic Plan 2008-2020 of the Ministry of Education, Culture and Human Resources, Republic of Mauritius overall goal for primary education is to 'sustain equitable access to quality education'. Some of the strategies with a bearing on play-based STEM approaches include (a) curriculum review to ensure the acquisition of sound literacy, numeracy and ICT skills as well as the desirable skills of critical thinking, creativity and innovation required for further learning. In addition, (b) improving quality of teaching through the provision of in-service teacher training re-skilling teachers on innovative pedagogical approaches, and (d) enhancing learning environment by providing primary schools with teaching and learning materials. Further to this, (e) embedding a science culture and support technologies to provide a rich variety of learning experiences to pupils with emphasis on science, technology and social skills, and (f) integration of ICT in education to support both learning and school management.

f. Mozambique

The Education Sector Plan 2020-2029 of the Ministry of Education and Human Development of the Republic of Mozambique has the overall goal of 'ensuring that all children have the opportunity to complete quality, inclusive Primary Education'. One of the key strategic objectives is to 'ensure quality learning, in reading, writing, arithmetic and life skills. Several strategies are identified with a bearing on play-based STEM education. These include (a) inclusive pedagogical practices by teachers with more competences into the system and (b) supporting schools with diversified teaching and learning materials such as maps, books, models of the human body, markers and colored paper, scissors, films, computers, handicrafts, utensils, clay, etc., to complement the teacher's work and motivate the learning of children. Other strategies include (c) integrating into the local curriculum of learning outside the classroom (in the community, in nature) and openness of the school to outside participants. In addition, (d) adopting inclusive pedagogical practices, including innovative and student-centered pedagogical practices, (e) diversifying the teaching and learning process using ICT, (f) facilitating pedagogical support of schools, and (g) identifying the training needs of school managers in curriculum and pedagogy.

g. Nigeria

The Ministerial Strategic Plan 2018-2022 of the Federal Ministry of Nigeria has identified several strategies that are supportive of play-based STEM education at the primary school level. These are (a) building of science and mathematics laboratories to promote regular practical experiments, hands-on activities, creativity, innovation and skills acquisition in sciences, (b) provision of modern science equipment, kits, chemicals, reagents, text books and other instructional materials to promote the conduct of regular practical experiments, hands-on training, creativity and innovation, (c) building the capacity of science, technical and vocational education teachers and laboratory technicians to promote quality education, and (d) establishing science based clubs and societies in schools.

h. Rwanda

The Education Sector Strategic Plan 2018-2024 of the Ministry of Education, Republic of Rwanda has articulated nine strategic priorities; (a) strengthening STEM across all levels of education to increase relevance of education.

Also (b) delivering school and cluster based coaching and mentoring programmes for teachers to promote their competencies and (c) greater use of local resources in teaching and learning of science in primary schools to develop students' interest in these subjects from an early age. In addition, (d) encourage science in primary schools through the provision of materials and strengthening teacher capacity to use locally and readily available resources for scientific investigation in the classroom, and (e) improve laboratory facilities in schools for STEM subjects by equipping them with modern laboratories and other STEM-related facilities and equipment.

i. Senegal

The Education and Training Sector Plan 2013-2025 of the Ministry of Women, Children and Female Entrepreneurship, Ministry of Education, Ministry of Higher Education and Research, and Ministry of Vocational Training, Apprenticeship and Handicrafts of the Republic of Senegal has identified the strategies to improve learning outcomes. These are (a) review of the curriculum to ensure that it is focused on the promotion of science and technology (b) developing contextualized teaching and learning materials. In addition (c) improving the support system for teacher training and supervision (d) strengthening pedagogical support for teachers at the elementary level while ensuring all teachers have access to pedagogical support, (g) equipping all academies with adequate teaching and learning resources to improve the school environment and teaching and learning conditions at all levels of the basic cycle.

j. The Gambia

The Education Sector Policy 2018-2030 of the Ministries of Basic and Secondary Education and Higher Education Research Science and Technology of The Gambia is committed to promoting holistic development of the individual for the positive realisation of full potential and aspirations. The sector policy has identified key priorities across the sub-sectors including the primary school grades to promote the quality of education that are supportive of play-based STEM education. These strategies include (a) provision of digital materials for students and teachers (b) establishment of an e-learning centre for teacher professional development that promotes gaming using tablets as an instructional approach, and (c) supporting female students to access STEM courses and careers.

4.4.2 Prioritisation of play-based STEM Education by Senior Education Officials

Four key priorities emerged from the interviews with the senior education officials in-charge of education management and planning at the national level with regard to play-based STEM education at the primary school level. These priorities include (a) teacher professional development, (b) STEM curriculum review and (c) development of a policy on STEM education in addition, to (d) making provision of resources and facilities for STEM education in order of priority. These priority areas are discussed in the following sub-sections.

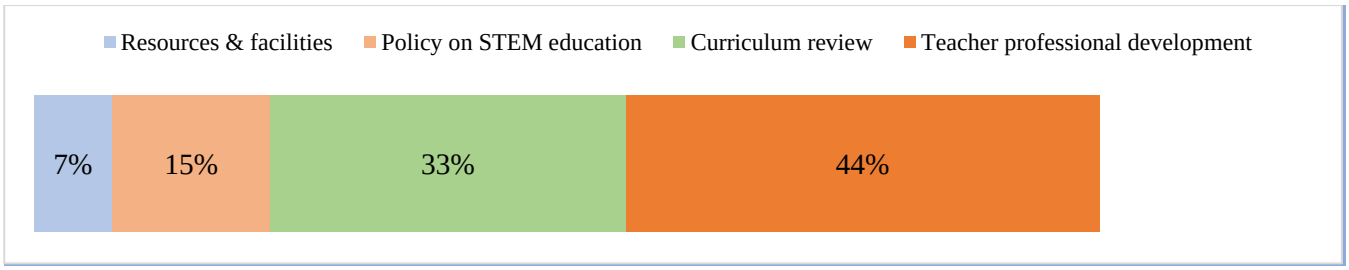


Figure 8: STEM priorities at primary schools

a. Teacher professional development

In most of the sample countries, teachers at the primary school level are trained to teach all subjects in the curriculum and are expected to teach all the subjects. However, there are some exceptions, where in some schools, teachers have a bias towards the teaching of STEM subjects. In addition to the pre-service training, teachers in the sample countries had a range of in-service training programmes including teaching and learning of STEM subjects. Specific to the in-service training programmes, there is increasing orientation towards learner centered instructional approaches that are delivered at school level through mentorship programmes, at cluster level where teachers in a cluster of schools meet at one of the schools, or at designated pedagogical training centres which are mandated for delivery of continuous teacher professional development programmes. The in-service

teacher training programmes come under different terminologies including ***new pedagogical practices, instructional approaches, play-based learning, pedagogical support for teachers,*** and ***learner centred approaches.*** The following are illustrative verbatim excerpts describing the teacher professional development programmes focused on STEM at the primary schools in the sample countries:

> ***Pedagogical and in-service training centre.***
> *As far as teachers are concerned, we have a pedagogical teaching system whereby in each region there is what we call "a pedagogical and in-service training centre" responsible for strengthening teachers' capacity. So, the structure exists, but to get funding to provide training to the teachers remains a problem because the resources are not sufficient despite our determination; the available resources do not allow us to train all the teachers. For example, if we want to integrate different science subjects, we need to think about training the teachers.*
> ***Senior education official***

In some of the countries, there are initiatives focused on the play-based approaches at the primary schools, but they have not been fully integrated in the teaching and learning and the following are verbatim excerpt of some of the initiatives:

> ***New pedagogical practices.***
> *For almost two years now, our country has been experimenting with new pedagogical practices that break with the traditional teaching style whereby pupils sit in the classroom and the teacher stands and presents the lesson. With the new practice, pupils even come out of their classrooms to do the lesson under the trees with their teachers. Here, the teacher gives the pupils work to do, and the pupils get together as a group to discuss and play some games, for example. This is what is being done, but I'd like to make it clear that it's still in an experimental phase that hasn't yet been generalized in the country. The concept itself of teaching and learning through play-based games is not yet part of our national educational approach. So, the whole system hasn't yet been put in place, which means there's no play-based educational system, no group work or class activities along with this concept. We do have very little I could say and according to me, it should be inbuilt. Like in pre-service teacher training. It should be in-built from the very start and we should have policies of play-based STEM education.*
> ***Senior education official***

However, in some of the countries, play-based pedagogies are not prioritized at the primary school level as demonstrated in the following verbatim excerpt:

> ***Play-based STEM education approach.***
> *Although we understand the need to prioritize play-based pedagogies in the classroom, making the classroom more interactive, and more engaging in the teaching and learning at the elementary schools in our country, the reality is that it is only in the pre-primary schools where play-based approaches are being applied. Therefore, currently play-based approaches are not part of the education curriculum, because it is not officially legalized at the national level as it is at the pre-primary school level. At the pre-primary school level, we can say that play-based education does exist but at the post pre-primary school level, teaching and learning through play are not applied.*
> ***Senior education official***

b. STEM curriculum review

Several countries in the region have undertaken curriculum review towards competency-based curriculum or are in the process of reviewing or intending to review towards the competency-based curriculum. Overall, the competency-based curriculum demands new teaching and learning approaches that are learner centred and already some countries have been preparing teachers for implementation of the new competency-based curriculum. Here are illustrative verbatim excerpts of the senior education official experiences with the competency-based curriculum:

> ***Competency-based approach***
> *About the pedagogical approaches, we're currently using the competency-based approach, and, in fact, we should be able to do inter-disciplinary activities in class, but the education, as I say, needs adapted training for teachers, equipment for schools and well-oriented curricula. Otherwise, teaching programs are compatible with the STEM practice of interdisciplinary subjects. For example, it's easy to take a problem and get students to work on it, while taking various aspects into account, the fact that at elementary school, it's the same teacher that teaches all the subject in class, so it's possible for him or her to involve several subjects in solving a problem, but teacher needs support and reinforcement of their capacity so that he or she can feel comfortable with the pupils in classroom.*
> ***Senior education official***

New curriculum

Our priority area for primary schools is the competency of teachers to teach this new curriculum. As you know, it is a new curriculum, coming with a new pedagogical approach, as opposed to what we have been using before. Our priority area is to build more capacity among teachers because this is a new curriculum. So, it's new for everyone including the curriculum development Centre, so they had to learn along the way as they were developing. We have since identified gaps in the way we are implementing the new curriculum, and we're focusing on capacitating teachers. As of next year, we will seek more budgetary allocation to ensure effective implementation of the curriculum. A bone of contention mainly is on assessment, that is integrating assessment in teaching, for teaching, as well as assessment of teaching. So, we want to capacitate them in that level so that they're able to report effectively on learner performance, specifically to the STEM subjects.

Senior education official

c. Development of a policy on STEM education

Some of the countries in the region are currently developing a policy on STEM education at the basic learning level that includes the primary school level.

d. Resources and facilities for STEM education

The provision of resources and facilities for the implementation of STEM curriculum at the primary school level is a key priority of the education authorities in the region. While the governments are committing budgetary allocations for this component, there are partnerships with development partners either in the past or currently for the provision of resources and facilities including laboratories, equipment, and physical classrooms.

4.4.3 Prioritisation of play-based STEM Education by Education officials at sub-national level.

Eight in ten education officials at the sub-national level indicated that play-based was a priority instructional approach that is promoted by the education authorities and more female than male

education officials indicated this to be the case.**Error! Reference source not found.**

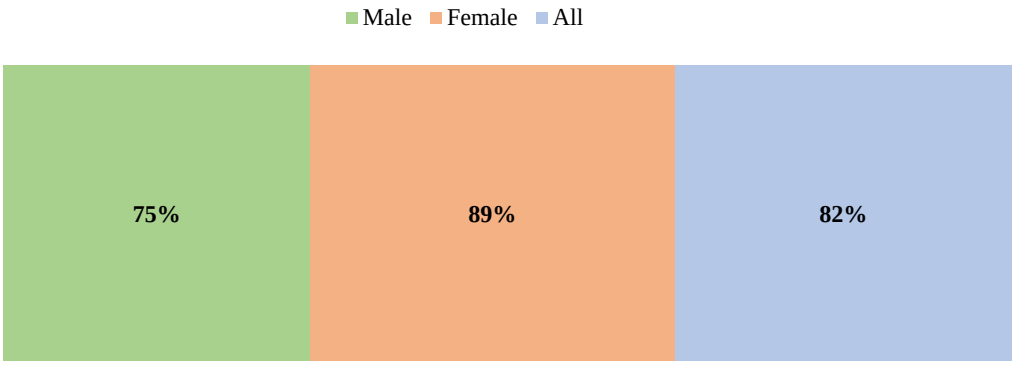


Figure 9: Prioritization of STEM education by education authorities

Across the countries, the specific priority areas were ***'making the classroom more engaging'***, ***'play-based approaches'***, ***'pair work and group work'***, and ***'creating student materials'***. Further, more female than male education officials identified specific priority instructional practices that were supportive of play-based approaches.

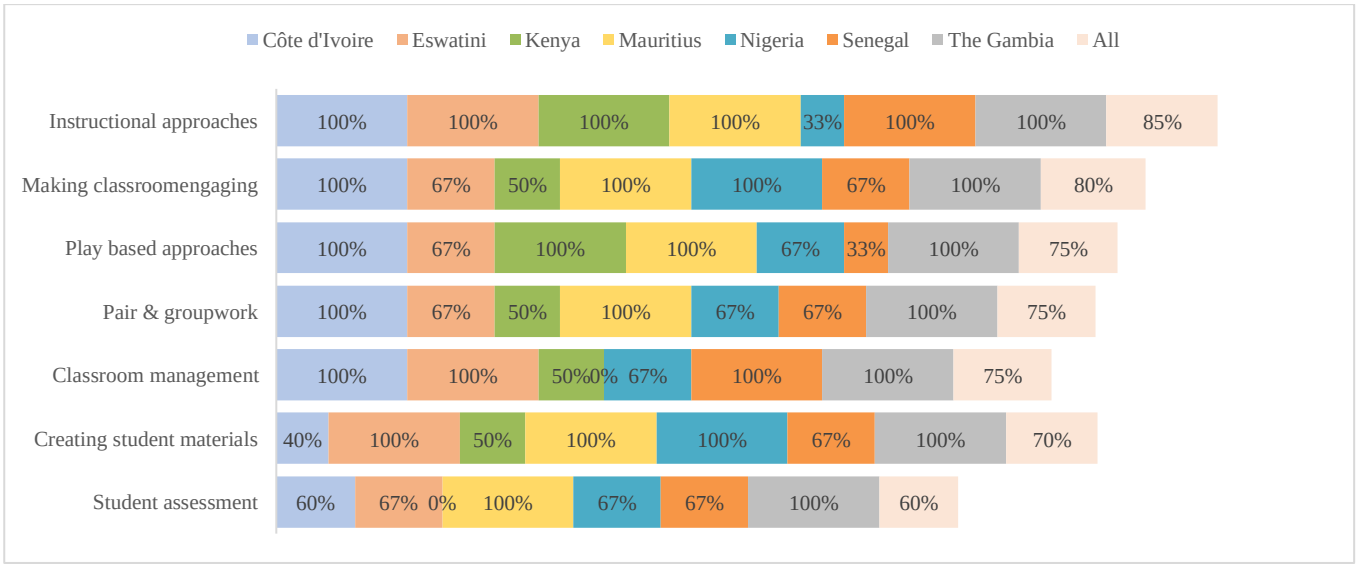


Figure 10: MOE STEM priorities – education official

4.5 Initiatives focused on play-based STEM education at primary schools in Africa.

The third study objective was to establish existing initiatives that are focused on play-based STEM education at primary schools in Africa. This information was gathered from review of relevant sample projects being implemented in the region, interview with senior education officials at the national level, survey of education officials at the sub-national level, teachers, and school heads.

4.5.1 Play-based STEM Education Initiatives from review of projects.

There are several initiatives focused on improving the quality of education including STEM education with a bearing on play-based approaches at the primary schools in Africa. The following are some of the on-going initiatives with that demonstrates best practices with a bearing on play-based STEM education in Africa.

Case 1: MTN e-Mfundvo

Country	**Eswatini**
Name of Initiative	MTN e-Mfundvo
Implementing Organisation	Ministry of Education Eswatini
Funder	MTN
Timelines (Years)	2020 and ongoing
Scale	National
Goal	Improving access to learning, initially during the COVID19 pandemic
Target groups	Primary and secondary school students
Key activities	Delivery of online lessons

Case 2: Kenya Play (KPLAY)

Country	**Kenya**
Name of Initiative	Kenya Play (KPLAY) Project: holistic, gender responsive approach to scaling Learning Through Play with Technology (LTPT)
Implementing Organisation	IREX
Funder	LEGO Foundation
Timelines (Years)	Ongoing
Scale	Local
Goal	• Help playful learning become the standard for good teaching and learning in Kwale and Kilifi counties, equipping female, and male students for today's world. • Offer Kenya a workforce with fundamental skills in computational and design thinking, manufacturing, critical problem-solving, empathy, self-directed learning, creativity, and collaboration. • Equip practitioners and champions of Kenyan-contextualized, gender-responsive Learning Through Play Technology (LTPT) teachers, school leaders, parents and communities, local and national NGOs,

	and county and national education officials, sustainably embedding Kenyan LTPT in Kwale and Kilifi County schools.
Target groups	90,000 students in primary schools in the underrepresented counties of Kwale and Kilifi in coastal Kenya
Key activities	• Curriculum and Learning Guide Development: • Teacher and School Leader Training • School Play Lab Models • LTPT Ambassadors: • Community Outreach

Case 3: Empowering Learners with ICT Skills

Country	**Regional (Several countries in Africa – Malawi, Rwanda, Kenya)**
Name of Initiative	Empowering Learners with Skills for Economic Opportunity
Implementing Organisation	Team4Tech and partners
Funder	Multiple Funders including philanthropic foundations
Timelines (Years)	Ongoing
Scale	Regional
Goal	To improve the quality of education for under-resourced learners through technology solutions and training.
Target groups	All levels of education from early childhood development through to tertiary education.
Key activities	• Provision of ICT Labs to increase student engagement and skills in STEM. • Training of teachers to build their technology skill and be able to integrate ICT in teaching and learning including delivery of online learning. • Supporting children to access online reading materials. • strengthen teacher training and help them more effectively use digital reading and resources with their learners in the classroom.

Case 4: Experimento International STEM education program

Country	**Regional – Including Kenya, Nigeria, Ghana**
Name of Initiative	Experimento International STEM education program
Implementing Organisation	Siemens Stiftung
Funder	Siemens Stiftung
Timelines (Years)	On-going
Scale	Global

Goal	Expanding STEM education (science, technology, engineering, mathematics)
Target groups	4-18 years
Key activities	A range of hands-on teaching and learning materials for science and technology lessons that are modular and adaptable to country-specific needs. Around 130 experiments for age groups 4-7 years (Experimento | 4+), 8-12 (Experimento | 8+), and 10-18 (Experimento | 10+) ensure continuous knowledge that builds along the entire education chain.

Case 5: IT'S PLAY

Country	**Regional – Including Rwanda, Uganda, Zambia**
Name of Initiative	IT'S PLAY (Improving Teaching Skills on Playful Learning for Africa's Youngest)
Implementing Organisation	VOB, Innovations for Poverty Action (IPA), VSO and Plan International
Funder	LEGO Foundation
Timelines (Years)	2021-2025
Scale	Regional
Goal	Teachers in Zambia, Uganda and Rwanda have strengthened skills to facilitate learning through play for emergent literacy and numeracy in early childhood education. These changes at classroom level catalyse change at national system level and in the community.
Target groups	ECD
Key activities	• integrating learning through play (LtP) into government ECE policy and instruments • strengthening the capacity of in-service TPD providers on LtP • supporting TPD providers to train and coach 1,600 teachers. • building awareness of key stakeholders like school leaders and parents

Case 6: Learning Passport

Country	**Regional – Including Nigeria**
Name of Initiative	Learning Passport
Implementing Organisation	UNICEF
Funder	Microsoft and Partners
Timelines (Years)	On-going
Scale	Global online and offline platform
Goal	**The Learning Passport is an Online, Mobile, and Offline Platform** that enables continuous access to quality education. It is highly **flexible and adaptable**, allowing countries to adopt the Learning Passport easily and

	quickly as its national learning management system or use it to complement existing digital learning platforms.
Target groups	**The Learning Passport is also an 'education model' for early childhood education, primary & secondary education, adolescent skills, and technical & vocational education,** tailored to the needs of children and youth who are either out of school, or in need of support to ensure the education they are receiving is of sufficient quality. Every user has a personalized record of their learning history that is unique to them and can be taken across physical and digital borders subject to context. **It is also a model for teachers and parents** to receive the necessary training and tools to be empowered and help support student learning.
Key activities	The platform serves **local, contextualized content as well as global supplementary resources** to support learners and improve learning outcomes.

Case 7: Plug-In Play (PiP)

Country	**Rwanda**
Name of Initiative	Plug-In Play (PiP)
Implementing Organisation	Right to Play
Funder	LEGO Foundation
Timelines (Years)	Ongoing
Scale	6 districts in Rwanda (Kayonza, Ruhango, Rubavu, Musanze, Nyanza, and Nyagatare)
Goal	1. Learning through Play with Technology (LtPT) and approaches to LtPT are implemented and support the delivery of the formal primary education curriculum. 2. LtPT and approaches to LtPT are integrated into a range of teacher professional development programs 3. Improved knowledge, attitudes, and behaviours of teachers to incorporate LtPT
Target groups	755 P4-P6 teachers from 310 Rwanda public primary schools 114,000 P4-P6 learners from 310 Rwanda public primary schools
Key activities	• Curriculum implementation guides and teacher manuals on LtPT to support delivery of the curriculum developed • Training and orientation program for LtPT and approaches developed for pre-service teachers and rolled out into Teacher Training Colleges (TTCs) • Teacher professional development package developed for in-service teachers • P4-P6 Science and Elementary Technology (SET) subject teachers trained in LtPT • Teachers supported through school visits, coaching and mentorship interactions • Teachers assisted to conduct peer to peer support and learn from each other through Communities of Practice

	• Workshops organised to strengthen capacity of school leaders and education stakeholders at district level to support LtPT in schools • Teachers are provided with support on the use of LtPT by School Head Teachers and Director of Studies • Advocacy and awareness raising sessions with school leaders and education stakeholders conducted • Awareness raising events held for PTAs, parents, caregivers and community members on LtPT

4.5.2 Play-based STEM Education Initiatives from Interviews with Senior Education Officials.

The Senior Education Officials reported several initiatives that were supportive of both play-based approaches and STEM education at the primary schools in the sample countries. The following are some illustrative initiatives, both past and on-going in the sample countries:

a. Pedagogical boxes

The inadequacy of physical laboratories for conducting practical science lessons in primary schools in Côte d'Ivoire, led to the development of an innovative strategy called pedagogical boxes. Inside the boxes are contextualized science teaching and learning materials that support teachers in delivering science lessons in a normal physical classroom. However, the pedagogical boxes are not available in all schools. Further, even in schools equipped with the boxes, they are not fully utilised as expected partly because some of the teachers do not know how to use them.

b. STEM Project

In Eswatini, the science teacher's subject association under which the student science fairs, ICT fairs, and mathematics symposiums are organized runs a STEM project. These forums enable the teachers to share knowledge on how to handle the STEM subjects. The fairs take place annually and the students are encouraged to form science clubs in schools.

c. Mathematics and Science Improvement Programme

In Kenya, the Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) delivers mathematics and science improvement programmes for teachers of primary and secondary schools in Kenya and other countries in Africa. The programme focuses on learner centred pedagogies that enhance play-based approaches.

d. Provision of Tablets to primary school students

In Mauritius, students at primary schools are provided with tablets with preloaded interactive content which enables them to learn STEM concepts through play.

e. SMASE program

In Nigeria, the Strengthening of Mathematics and Science Education (SMASE) programme, initially funded by the Japan International Corporation Agency (JICA) from 2006 to 2014, was institutionalized as a programme that is implemented by the Federal Ministry of Education focused on strengthening mathematics and science education at the primary school level through teacher professional development. The programme aims at building the capacity of teachers in promoting learner-centered approaches in STEM subjects at the primary education level.

f. PREMST project

The Programme to strengthen the teaching of Mathematics, Science and Technology (PREMST) project in Senegal was implemented from 2007 funded by JICA focusing on strengthening mathematics and science at the elementary school level through in-service teacher training. It was institutionalized within the Ministry of Education to deliver teacher professional development programmes.

4.5.3 Play-based STEM Education Initiatives – teacher, school head, and education official.

Specific to teachers, school heads, and education officials at the sub-national level, the specific information that was gathered on play-based STEM Education included, in-service teacher training, teacher coaching and or mentoring support, and teacher communities of practices. For of each of these initiatives, areas that were assessed were (a) whether the initiative exists; (b) how often the teachers benefit from the initiative, (c) whether the initiative prioritizes play-based approaches, and (d) the effect of the initiative on teaching and learning.

a. In-service teacher training.

The teachers, school heads, and education officials were required to indicate whether teachers had received in-service training, when they last received the training, and the training sessions that they found most useful for teaching and learning practices. Additionally, they were required to indicate whether the teaching practices of target teachers had improved because of the in-service training, whether the training prepared them to implement play-based approaches and whether the training had improved students learning. A high proportion of teachers had received in-service training with approximately nine in every ten teachers confirming they had received in-service training and slightly more male than female teachers had received in-service training except for Cote d'Ivoire where more

female than male teachers had received in-service training. Across countries, proportionately more teachers in both Kenya and Mauritius had received in-service training, while fewer teachers in both Senegal and The Gambia had received in-service training. Meanwhile, all school heads and education officials indicated that the teachers in respective schools and regions had received in-service training.

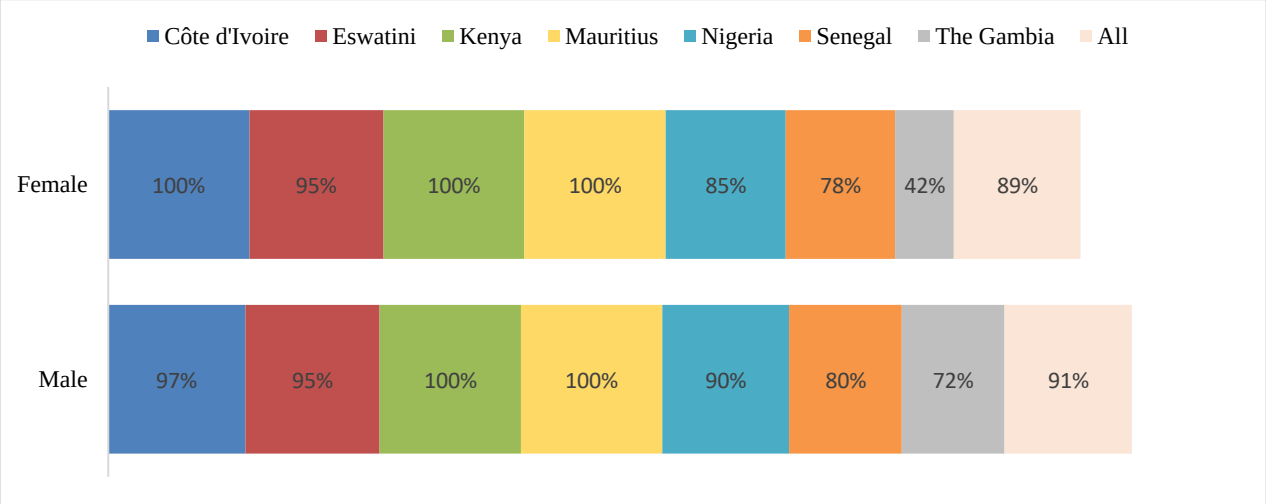


Figure 11: Teacher support with in-service trainings – teachers

Frequency of teacher in-service training.

The most frequent teacher in-service training had been conducted in the previous six months, as indicated by six and eight teachers and school heads out of ten respectively. Further, Mauritius, Nigeria, and Kenya had the highest proportion of teachers who had received in-service training in the last six months, while The Gambia had proportionately fewer teachers who had received INSET in the last six months. Across the sample countries, except for Mauritius, proportionately more school heads than teachers indicated that teachers had received INSET in the last six months. The discrepancy between the teachers and school heads could be a pointer to the gaps in clearly understanding, either on the part of the teachers or the school heads, the existing mechanisms for the provision of in-service training for teachers.

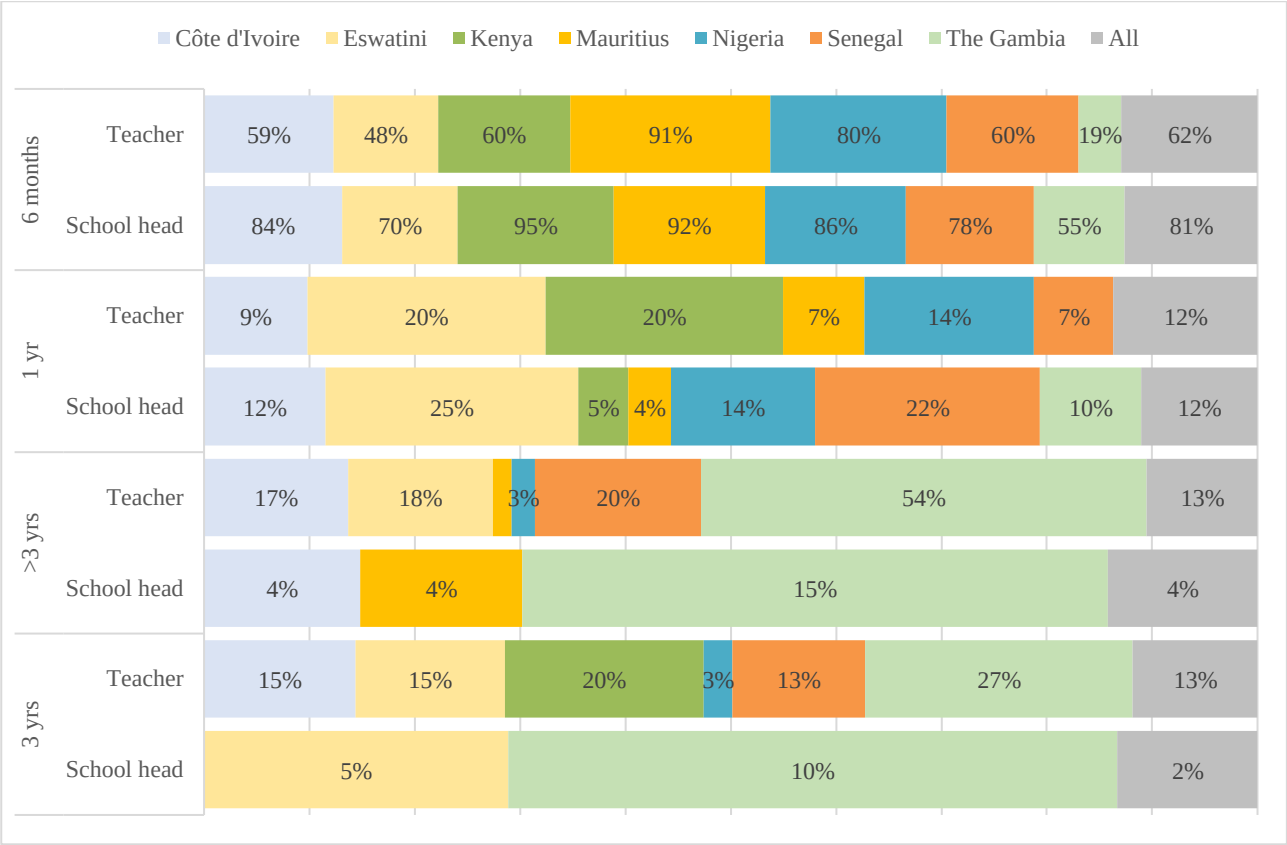


Figure 12: Most recent teacher in-service trainings – teachers and school heads

Most useful in-service training content.

Overall, at least five in ten teachers and school heads mentioned the most useful in-service training content for teachers to be *(i) new instructional approaches, (ii) learner centred teaching and learning strategies, (iii) lesson development,* and *(iv) creating teaching and learning materials*, with teachers having more preference for these content areas than school heads. *These content areas are aligned with play-based approaches and therefore presents an opportunity for integration and mainstreaming of play-based approaches in primary schools in Africa.* However, there were differences across countries. For instance, more than six in ten teachers and school heads in Kenya prioritized all eight content areas, while half of the teachers and school heads in The Gambia, Nigeria, Eswatini, Mauritius, and Senegal prioritized at least three to seven of the content areas respectively. Meanwhile, teachers and school heads in Côte d'Ivoire prioritized 'new instructional approaches' only. *Overall, these findings have implications for in-service training content offered to teachers in the different countries in Africa and it demonstrates the need for considering the specific context and needs of each country.*

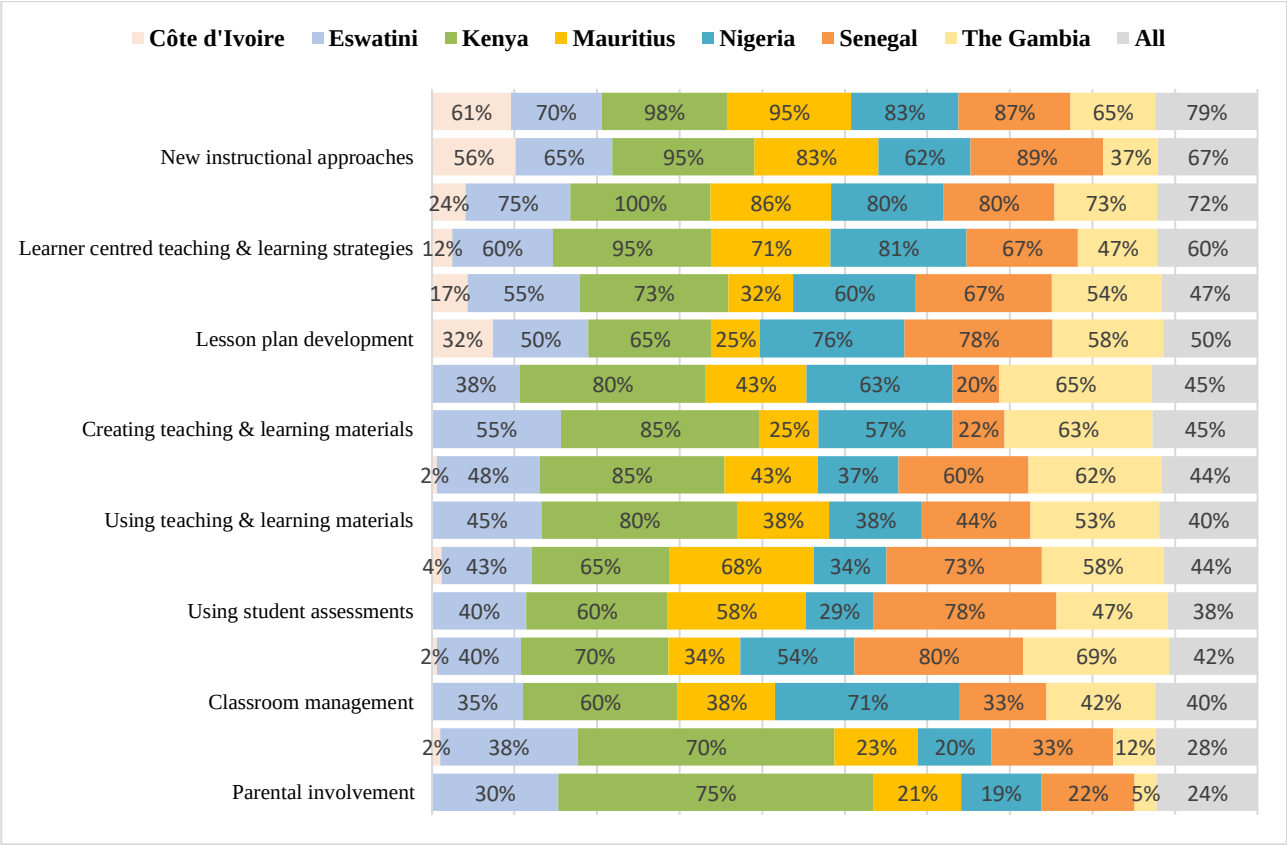


Figure 13: Most useful in-service training content – teachers and school heads

Similar to teachers and school heads, the education officials also indicated that the most useful content for teacher in-service training are; (***i) new instructional approaches, (ii) learner centred teaching and learning strategies,*** and ***(iii) creating teaching and learning materials*** **(Figure 14**). Meanwhile, proportionately more education officials in Cote d'Ivoire, Eswatini, Kenya, Mauritius, Senegal, and The Gambia indicated at least one of the top three content was most useful. *The top three content areas that were found most useful have a bearing on play-based approach and could be considered as an enabler for integrating play-based approaches in STEM education at the primary school level.*

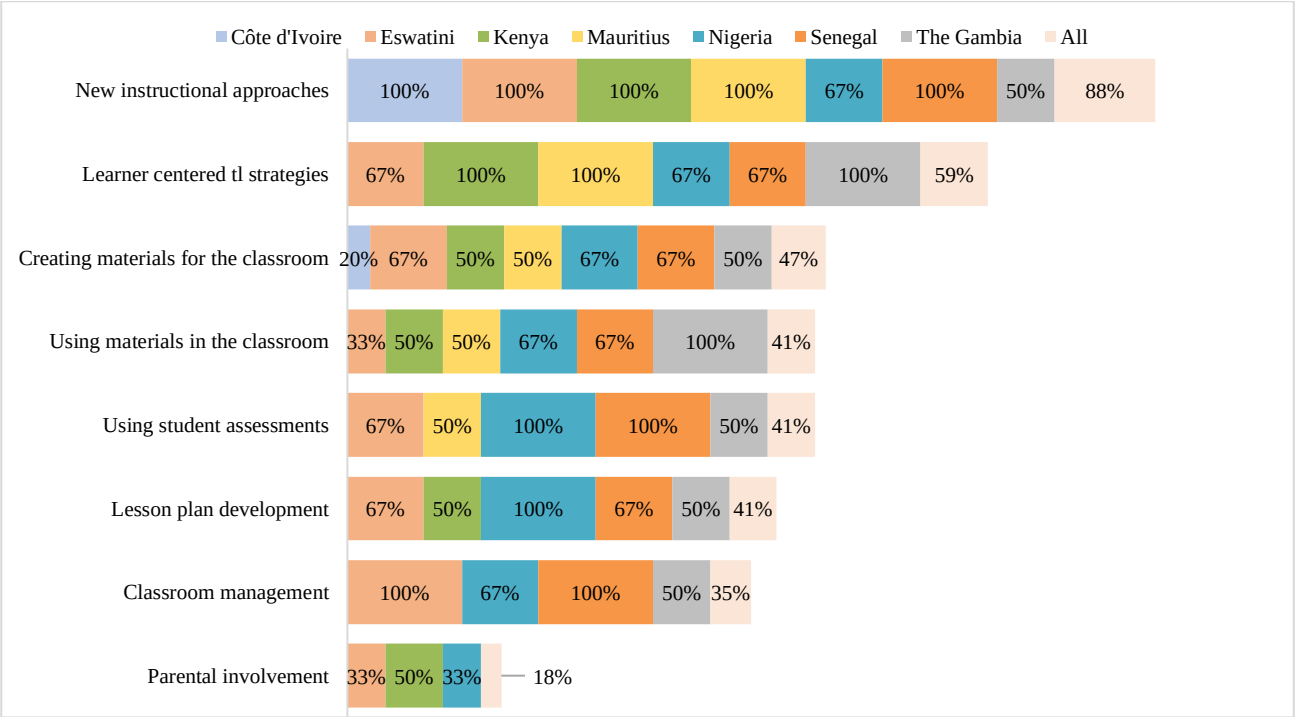


Figure 14: Most useful in-service training content – education officials

Effects of the teacher in-service training.

Teachers and school heads expressed high value for in-service training, with over nine in ten teachers and school heads indicating that it prepared them for implementation of play-based approaches, improved teaching, and student learning.

Figure 15: Effects of teacher in-service training sessions – teachers

Figure 15: Effects of teacher in-service training sessions – teachers

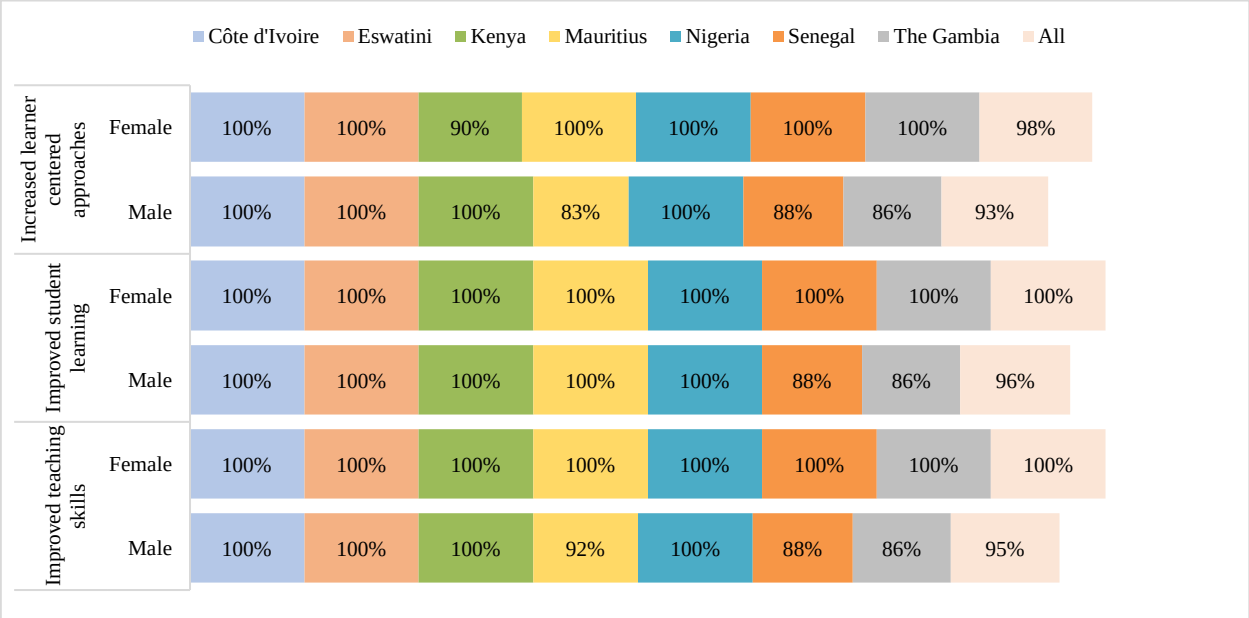


Figure 16: Effects of teacher in-service training sessions – school heads

The education officials also identified improved teaching and learning, and preparation of teachers for play-based approach as a key outcome of the recent in-service teacher training. *These findings could imply that in-service teacher training is a key pathway for integration and mainstreaming of play-based approaches for teachers in primary schools in Africa.*

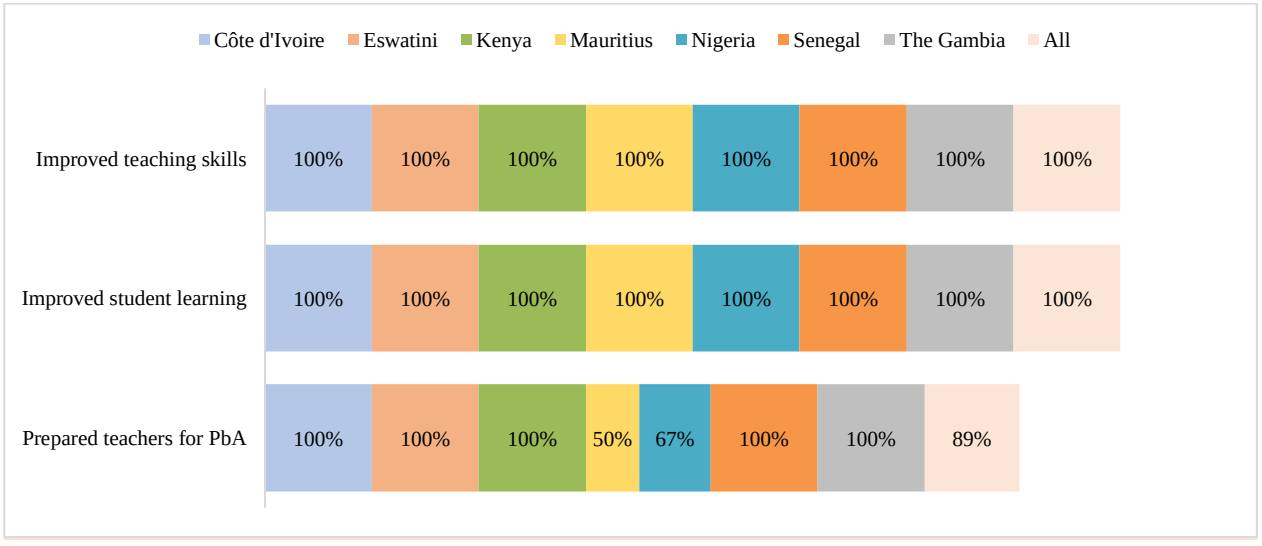


Figure 17: Effects of the teacher in-service training sessions – education official

b. Teacher coaching and mentorship.

Overall, at least eight in ten teachers and school heads indicated that teachers had received coaching or mentorship support. However, there were disparities across the countries and gender. Proportionately more female than male teachers indicated to have received coaching and mentorship support. Mauritius and Kenya had the highest proportion of teachers who reported receiving coaching and mentorship support, while Eswatini had the lowest proportion of teachers reporting to have received coaching and mentorship support. Meanwhile, in Nigeria, The Gambia, and Eswatini, proportionately more female than male teachers had received coaching and mentorship support. ***The findings suggest that the practice of coaching and mentorship support for teachers is existing in primary schools in Africa, and this presents an opportunity to integrate and mainstream play-based STEM education approaches in primary schools in Africa.***

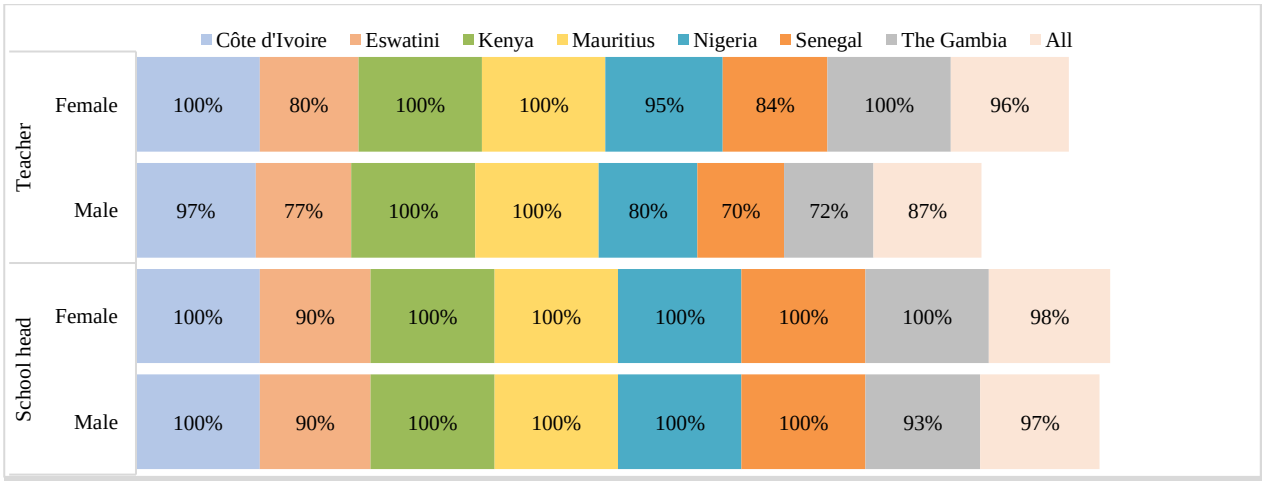


Figure 18: Teacher support with coaching or mentorship

Frequency of coaching or mentorship support provision

Across the countries, four in every ten teachers had received coaching or mentorship support at least three times a year, while at least three teachers in every ten had received coaching or mentorship support once per month.**Error! Reference source not found.**However, there were disparities across the countries, for instance, in Nigeria, Mauritius, and Kenya, at least half of the teachers had received coaching or mentorship support at least three times in a year. Meanwhile, seven and four in ten teachers in both Eswatini and Côte d'Ivoire respectively had received coaching or mentorship support only once a year. Further, across the countries, while teachers reported a lower frequency of coaching and mentorship support (three times a year), school heads reported a higher frequency of coaching

and mentorship support (once per month and more than once per month). Meanwhile, education officials frequently mentioned the provision of coaching or mentorship more than once a month. ***The findings could imply that there is need to harmonise the strategy of coaching and mentorship support for clarity.***

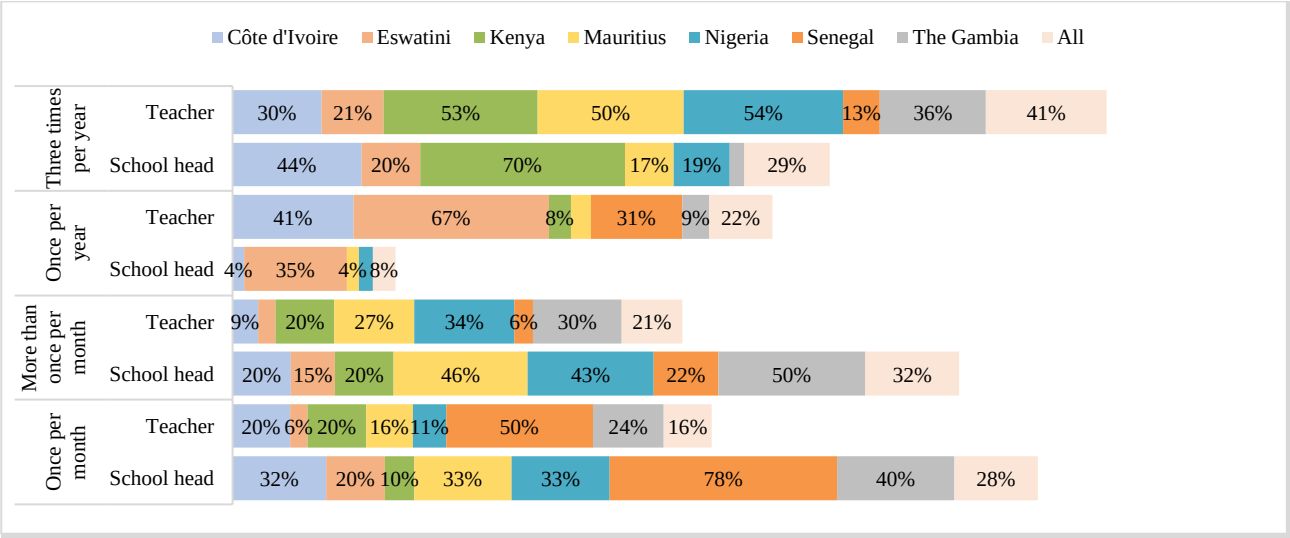


Figure 19: Frequency of teacher coaching or mentorship – teacher and school head

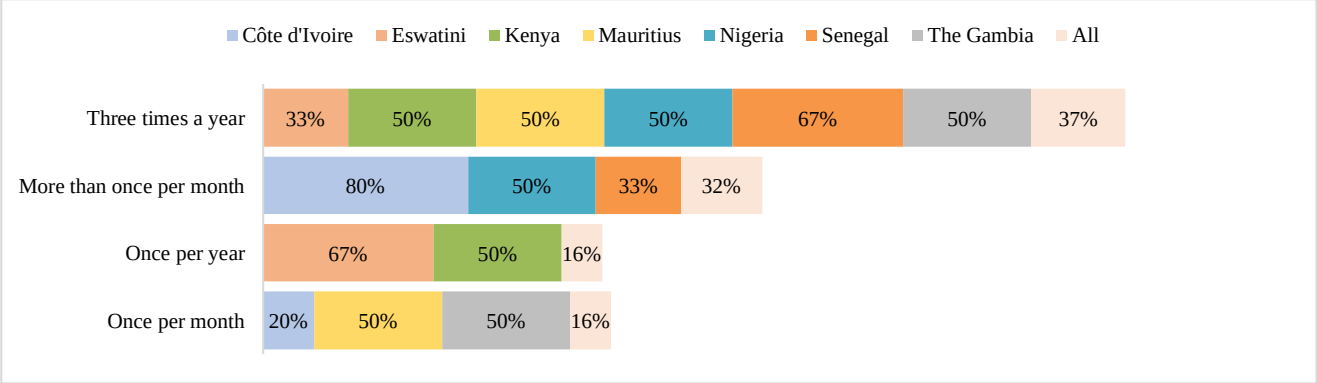
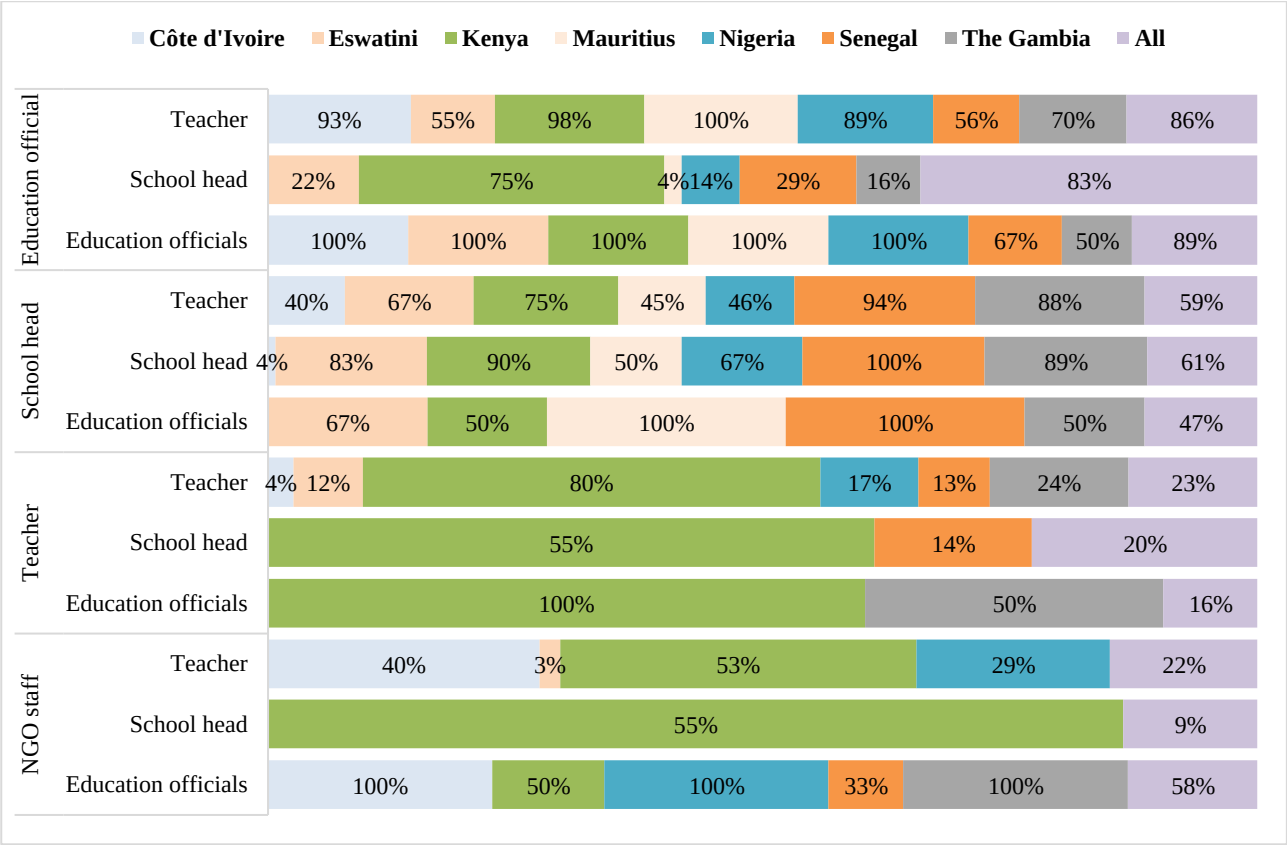


Figure 20: Frequency of teacher coaching or mentorship - education officials

Who conducts coaching or mentorship?

Overall, education officials provide most of the coaching and mentorship support with at least eight in ten teachers, school heads, and education officials indicating this to be the case



Additionally, six in every ten teachers and school heads indicated that coaching and mentorship support was delivered by the school head. Two in ten teachers had received support from a fellow teacher or a staff of a non-governmental organisation. However, there were some discrepancies across countries between the teachers and school heads on who most often provided coaching and mentorship support. For instance, while teachers indicated that the education official as the main provider of this support, the school head identified themselves as the main provider of the support. Furthermore, there appears to be consensus between the teachers and school heads that the school head is a key provider of coaching and mentorship support. Other providers of coaching and mentorship support were fellow teachers and staff of non-governmental organizations. Meanwhile, there was consensus between the teachers and education officials on the education official as the key provider of coaching and mentoring support. However, the education officials identified staff of non-governmental organizations as the second key provider of coaching and mentoring support for teachers in the region. ***The findings further indicate that there could be some gaps in understanding the mechanisms of provision of coaching and mentoring support for teachers which may need to be addressed as it may act as a barrier in attempts to integrate and mainstream play-based STEM education at primary schools in Africa.***

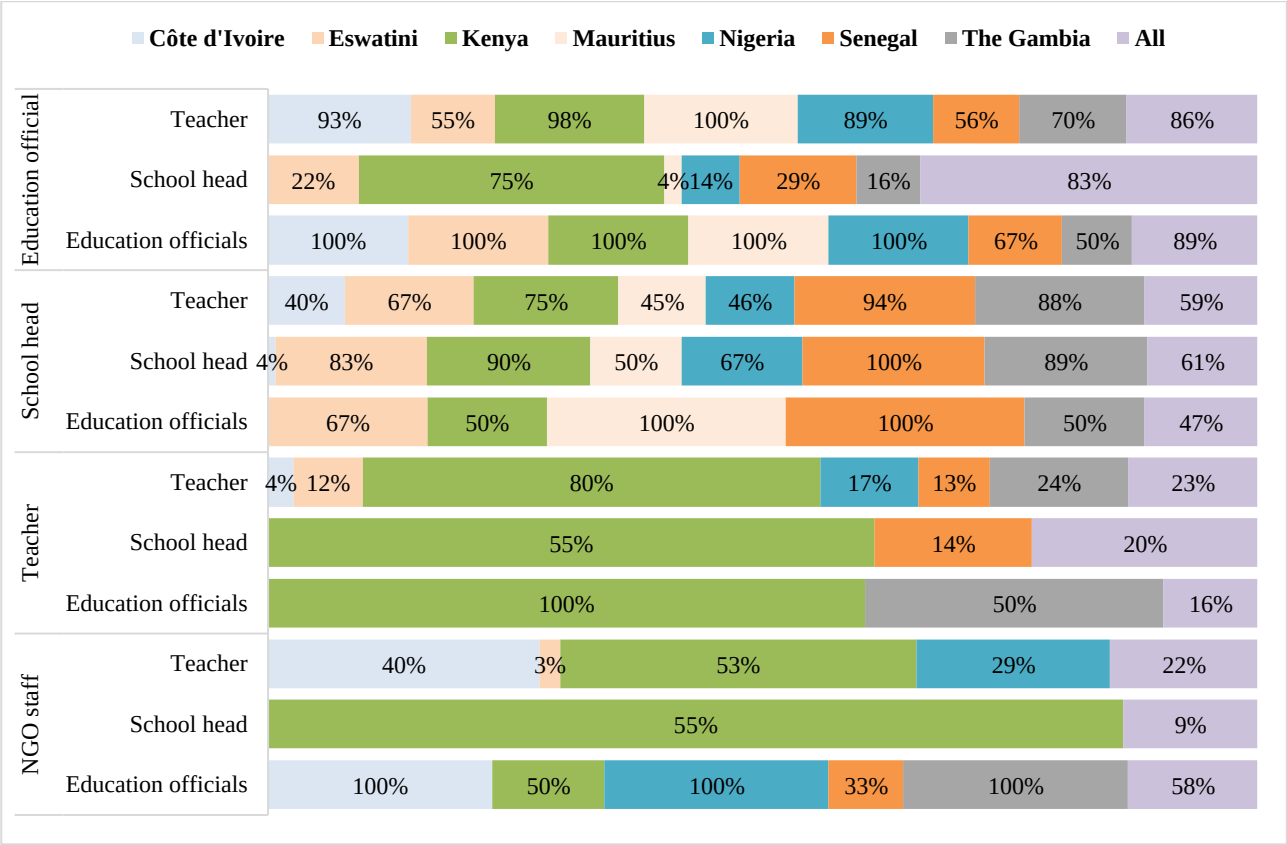


Figure 21: Teacher coach or mentor – teacher and school head and education official

Most effective coaching or mentorship strategies

More than eight in ten teachers and school head indicated top three most helpful strategies in coaching and mentorship to be; *(i) feedback on teaching, (ii) observing teaching, and (iii) identifying skills and practices that the teacher should focus on*.

Other important strategies identified by the teachers and school heads were feedback on student learning. Although debriefing with other teachers and modelling of instruction by the coach were identified as useful strategies, they were not highly prioritized by teachers and school heads. Meanwhile, school heads in Côte d'Ivoire appeared to highly prioritize all the coaching or mentorship strategies as being helpful. In consensus with the teachers and school head, the education officials indicated that observing teaching and feedback on teaching as the most useful coaching and mentorship strategies with nine in ten indicating this to be the case.

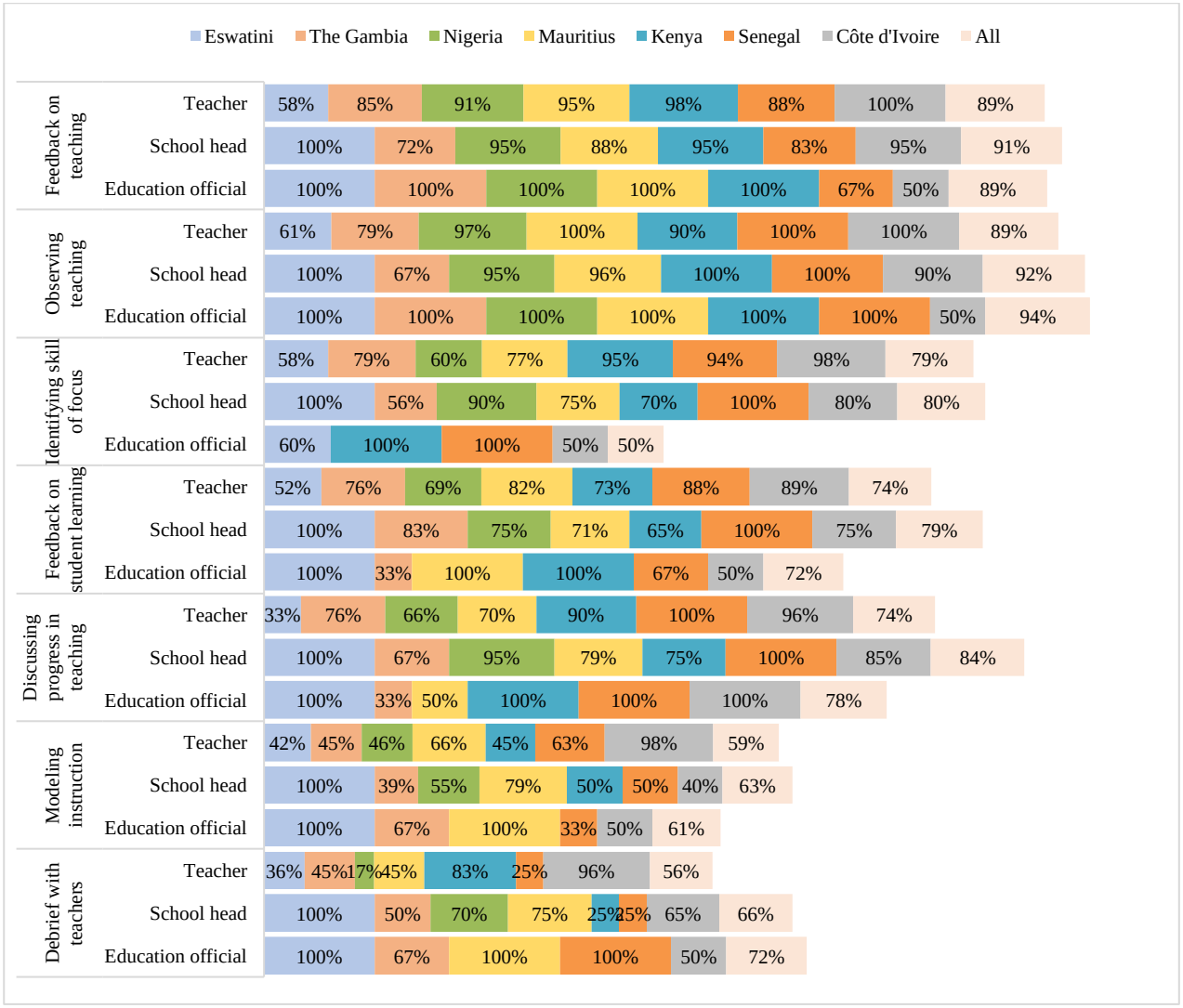


Figure 22: Most effective coaching or mentorship strategies – teacher, school head and education officials

Specific topics covered during coaching or mentorship session.

The top three topics that are covered during coaching and mentorship sessions are; (***i) instructional approaches, (ii) making the classroom more interactive***, and ***(iii) classroom management*** with at least five to seven out of ten teachers mentioning these topics.

Additionally, across the sample countries the two least covered topics during coaching and mentoring sessions were ***(i) creating student material***, and ***(ii) increasing play-based approach*** with only four out of ten teachers mentioning each of these topics. Across countries the priority topics varied with a higher proportion of teachers in Mauritius and Kenya indicating that instructional approaches are covered while Nigeria and Kenya had a higher proportional of teachers mentioning ***making the classroom more interactive***. Further, The Gambia, Nigeria and Eswatini had a proportionately higher priority on classroom management while proportionately more teachers in Kenya indicated that ***play-based approaches*** were covered during coaching and mentoring sessions.

Topics covered during coaching or mentorship sessions - teacher.

The top three topics that teachers found most useful from the coaching or mentorship sessions were ***(i) instructional approaches, (ii) making the classroom more interactive***, and (***iii) classroom management.***

Additionally, proportionately fewer teachers rated the topics covered during coaching or mentorship sessions as most useful. For instance, while seven out of ten teachers mentioned ***instructional approaches*** as topic covered during coaching or mentorship sessions, only five teachers in ten indicated this topic was useful. This discrepancy between the topics covered during coaching or mentorship sessions and what teachers found most useful was more apparent in some countries than others. For instance, while five out of ten teachers in Eswatini mentioned ***instructional approaches*** as a topic covered during coaching or mentorship sessions, only two out of ten teachers indicated that this topic was useful. *The findings could imply that while these topics appear well aligned with teacher professional development, there could be a challenge in the delivery mechanisms that need to be reviewed. Overall, it is also apparent that play-based approaches are least prioritized during teacher coaching and mentorship sessions.*

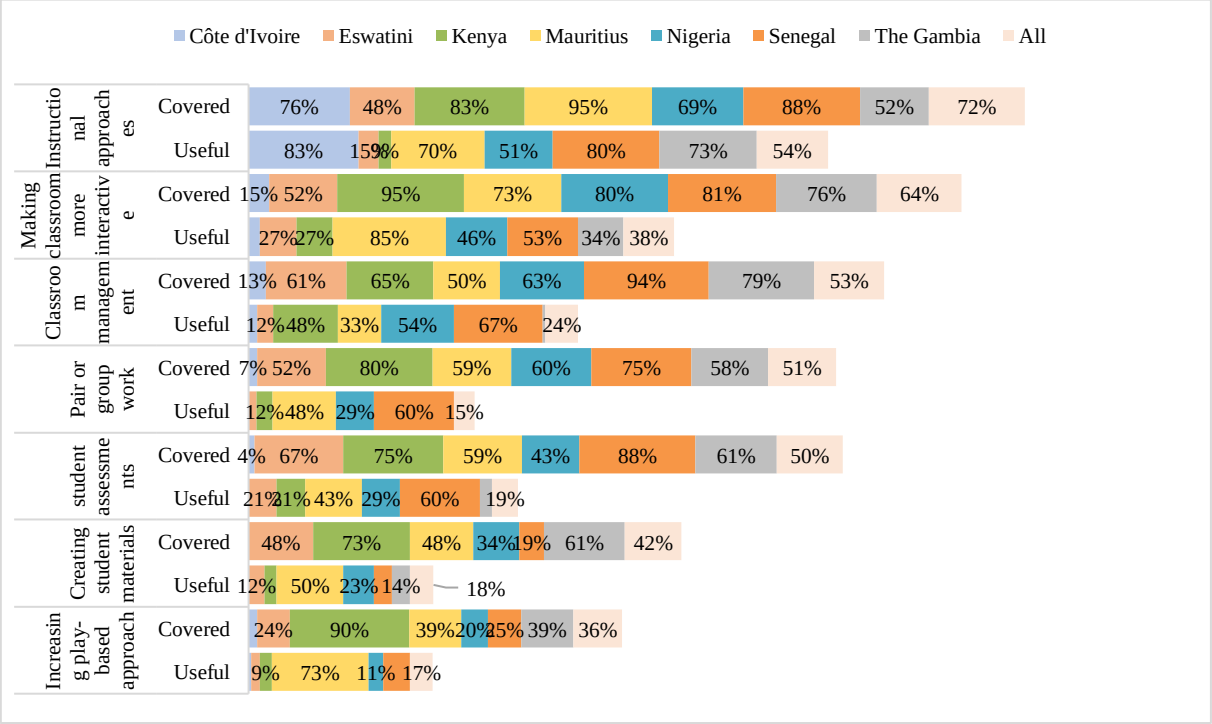


Figure 23: Topics covered during coaching or mentorship sessions – teacher

Similar to the teachers, school heads identified top three topics that are covered during coaching and mentorship sessions as; ***(i) instructional approaches, (ii) making the classroom more interactive***, and ***(iii) classroom management*** in that order with at least seven school heads in every ten mentioning these topics.

Across the sample countries, and like the teachers, the school heads indicated, ***play-based approaches*** as the least covered topic during teacher coaching and mentoring sessions. Furthermore, across countries, topics that were covered varied with a higher proportion of teachers in Mauritius, Nigeria, and Kenya indicating that ***instructional approaches*** were covered while Kenya, The Gambia, Eswatini, and Mauritius indicated that ***making the classroom more interactive*** was covered during these sessions. Further, The Gambia, Nigeria and Eswatini had a proportionately higher number of school head indicating that classroom management was covered during these sessions. Meanwhile, proportionately more school heads in The Gambia and Kenya indicated that '***making of student materials*** and '***play-based approaches*** respectively were covered during the sessions.

Likewise, the top three topics that school heads found most useful from the coaching or mentorship sessions were ***(i) instructional approaches, (ii) making the classroom more interactive,*** and ***(iii) classroom management*** in that order**.** However, across the sample countries, and like the teachers, proportionately fewer schools indicated the topics that were covered during coaching or mentorship sessions to be useful. For instance, while seven in ten school heads mentioned ***classroom management*** as a topic that is covered during coaching and mentorship sessions, only two in ten school head indicated this topic to be useful. This discrepancy between the topics covered during coaching or mentorship sessions and what school heads indicated to be useful out of these sessions was more apparent in some countries than others. For instance, while eight in ten school heads in The Gambia indicated '***Creating student materials'*** was covered, only one in ten indicated this topic to be useful. ***The finding could imply that while these topics appear well aligned with teacher professional development, there could be a challenge in the delivery mechanisms that may need to be reviewed.***

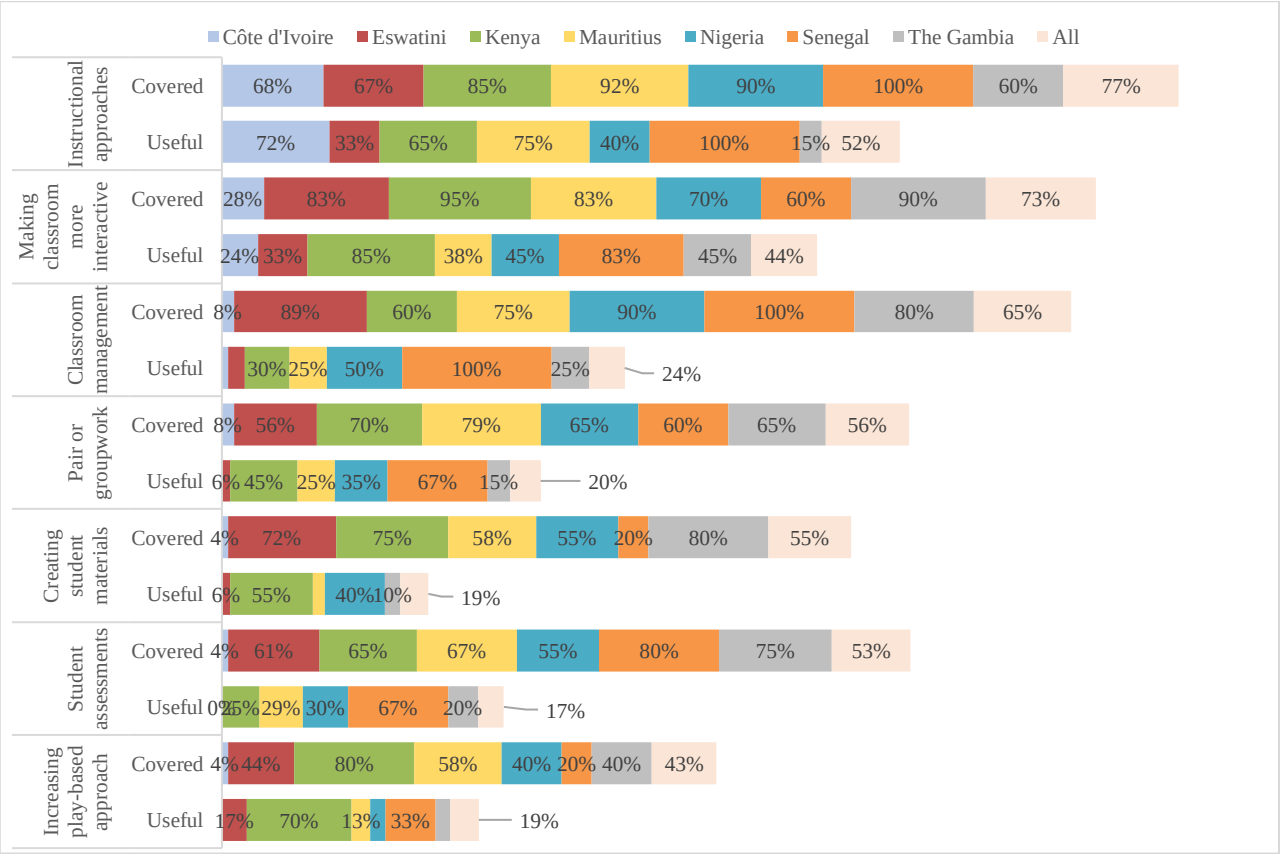


Figure 24: Topics covered during coaching or mentorship sessions – School head

Like teachers and school heads, proportionately more (nine in ten) education officials indicated '***instructional approaches'*** as a topic covered during coaching and mentoring sessions for teachers, followed by ***'classroom management'*** (six in ten), and ***'creating student materials'*** (four in ten teachers).

Furthermore, a similar trend to that observed with teachers and school heads emerged where proportionately more education officials indicated topics that were covered during the coaching and mentoring sessions, but proportionately fewer of them indicated the same topics to be useful. ***Overall, the findings imply that the topics that were covered during the teacher coaching and mentoring sessions were not necessarily the most useful, because across the countries, proportionately fewer teachers, school heads, and education officials indicated the topics to be useful compared to the number of topics covered.***

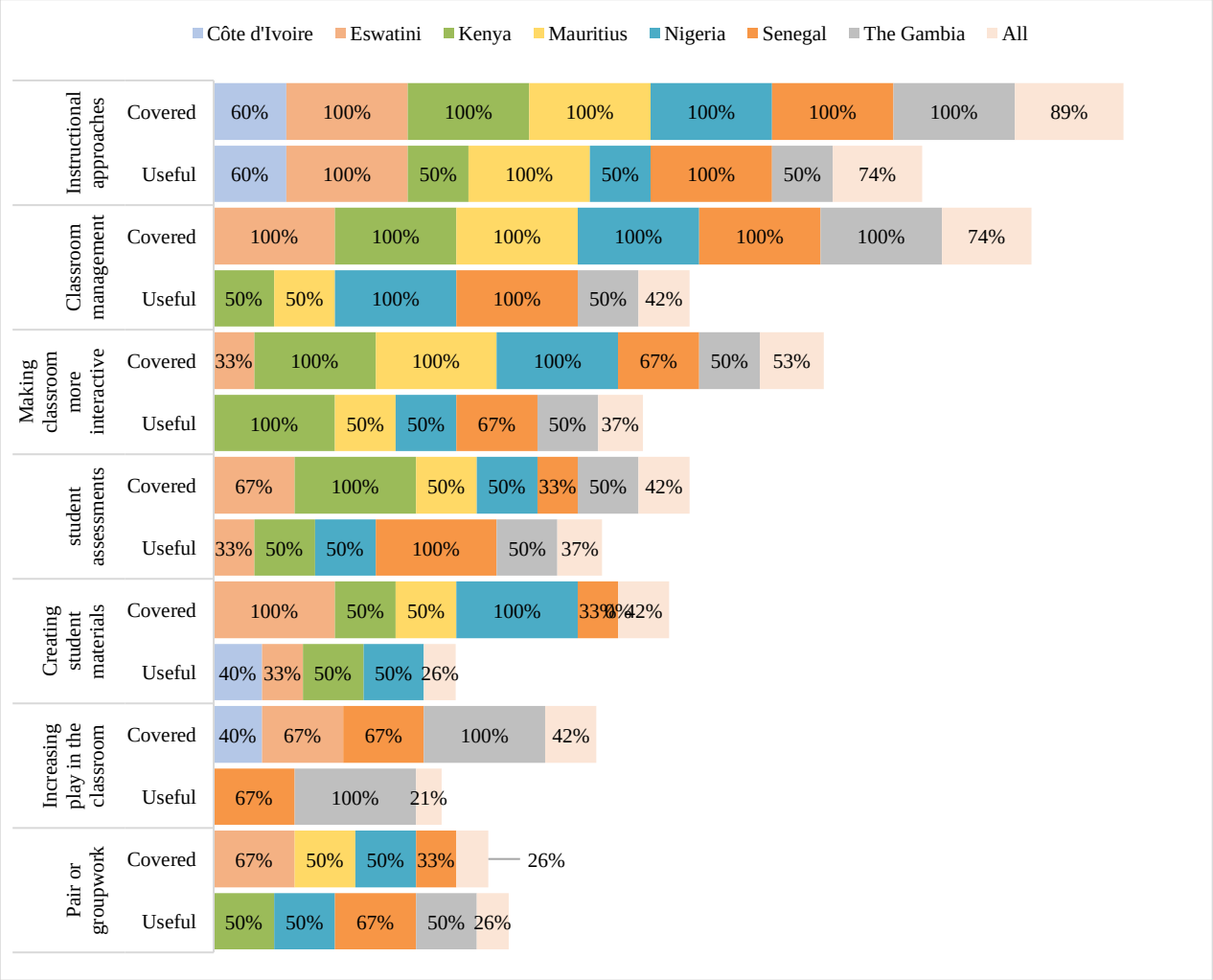


Figure 25: Covered and Useful Topics covered during coaching or mentorship sessions – Education Official

Effects of coaching on teachers

Nine in ten teachers reported *'improved teaching'* and *'confidence to teach'* because of the coaching and mentoring support they had received and proportionately more male teachers than female teachers indicated this to be the case **(**Error! Reference source not found.**)**. However, only four in ten teachers reported they *'increased play in the classroom'* because of the coaching and mentoring support they had received. *These findings could imply that play-based approaches were not being prioritized in the coaching and mentoring sessions.* Further, there were cross-country and gender differences, and across countries, proportionately more male than female teachers in Eswatini, Kenya, Mauritius, and Nigeria reported *'improved teaching skills'* as a result of coaching and mentoring support, while more female than male teachers in Cote d'Ivoire and The Gambia reported *'improved teaching skills*. Conversely, proportionately more female than male teachers in Kenya, Mauritius, and The Gambia reported *'increased confidence to teach'* because of the coaching and mentoring support they had received, while more male than female teachers in Eswatini reported *'increased confidence to teach'*

due to the coaching and mentoring support. Over eight in ten school heads reported that teachers had acquired *'improved teaching skills'*, and *'increase confidence to teach'* as a result of the coaching and mentoring support received. Meanwhile, *'increase in play in the classroom'* was reported by proportionately fewer male (seven in ten) than female (eight in ten) school heads as an outcome of coaching and mentoring support. The findings tally with those reported by the teachers in the study. Additionally, education officials particularly female officials identified increased play in the classroom as a positive effect of teacher coaching and mentorship (**Figure 27: Effects of coaching and mentorship on teachers – School head**

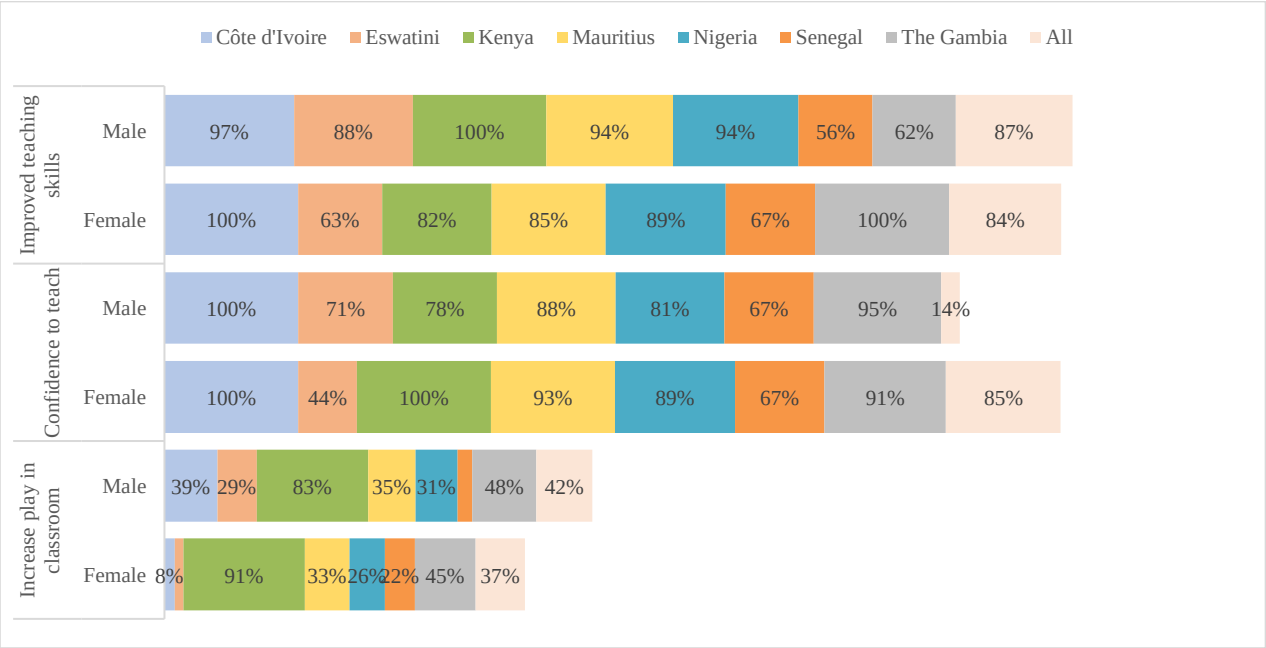


Figure 26: Effects of coaching and mentorship on teachers – teacher

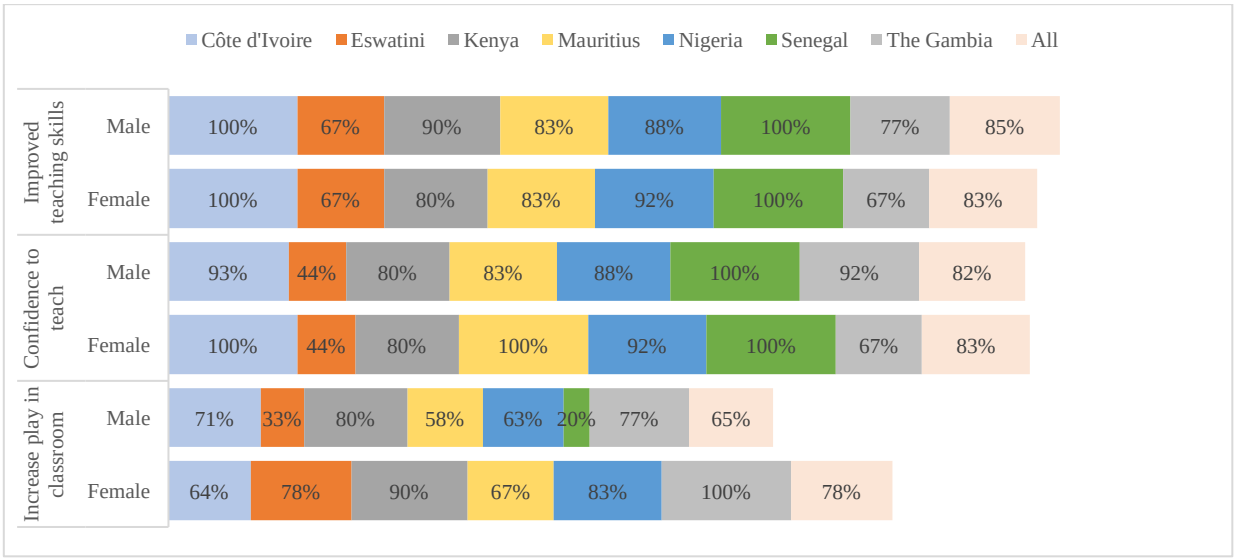


Figure 27: Effects of coaching and mentorship on teachers – School head

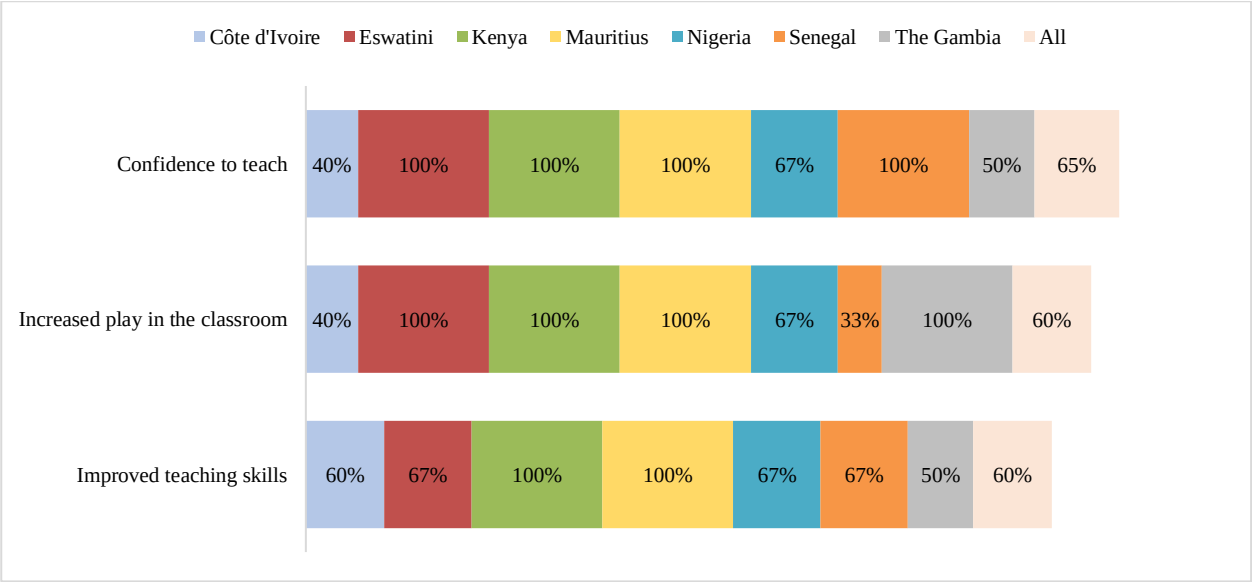


Figure 28: Effects of coaching and mentorship on teachers – Education

c. Teacher communities of practice.

Content covered during teacher communities of practice.

Most of the content areas that are covered during teacher meetings and communities of practice relate to teaching and learning practices. The top three content areas that were mentioned include; (i) areas to improve in teaching, (ii) challenges faced in teaching, and (iii) how to make instruction more engaging, and these were mentioned by at least seven to nine out of every ten teachers, school heads, and education official.

Figure 30: Content areas covered in teacher COPs – School Head

However, the development of play-based materials was the least mentioned content area by teachers, school head, and education officials as a content area was covered during teacher communities of practice. Additionally, there were more female than male teachers and school heads who identified *'development of play-based materials'* as a content area that is covered during teacher communities of practice. However, fewer female than male education officials indicated *'development of play-based materials'* as a content area that is covered during teacher communities of practice.

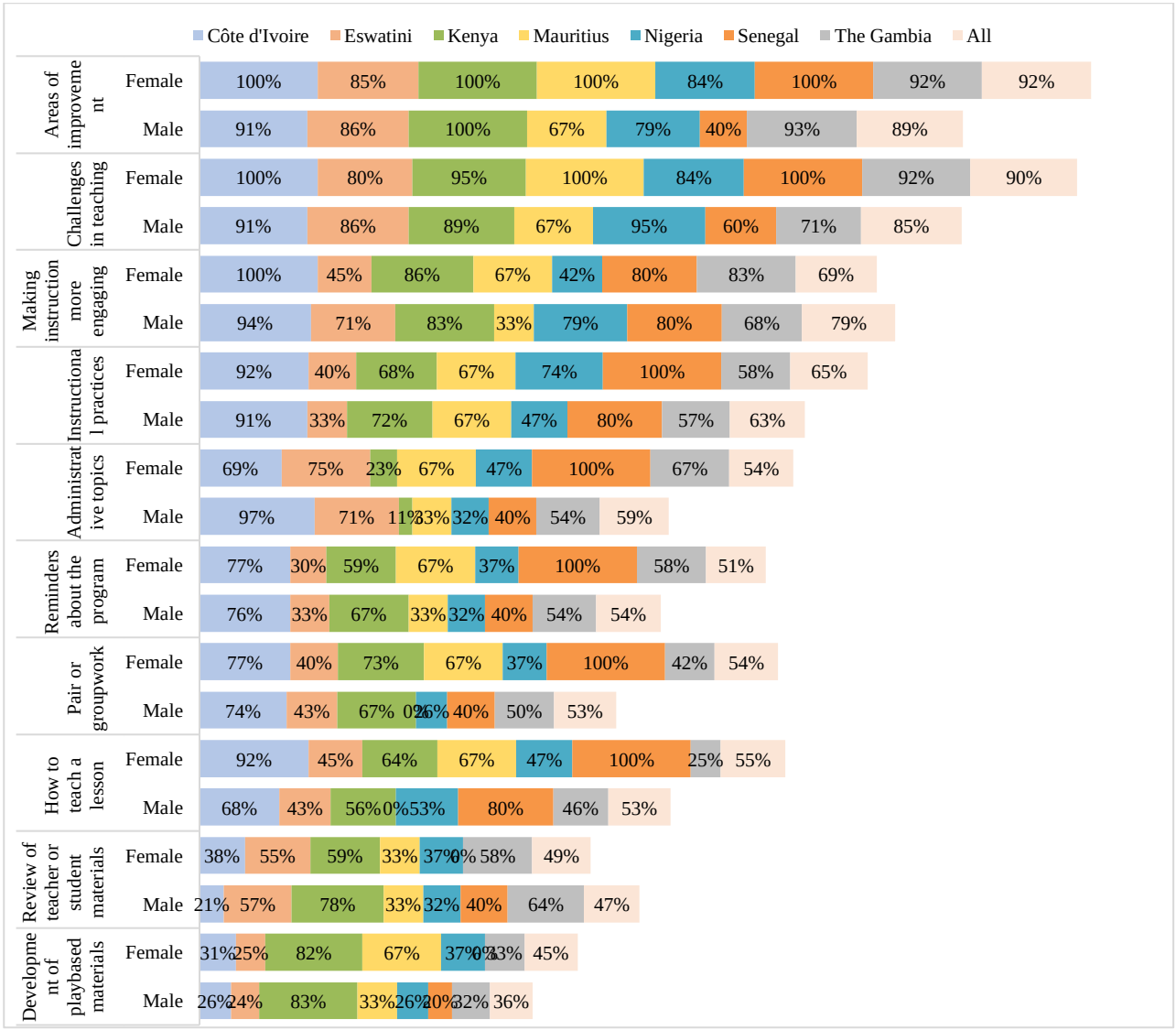


Figure 29: Content areas covered in teacher COPs – Teacher

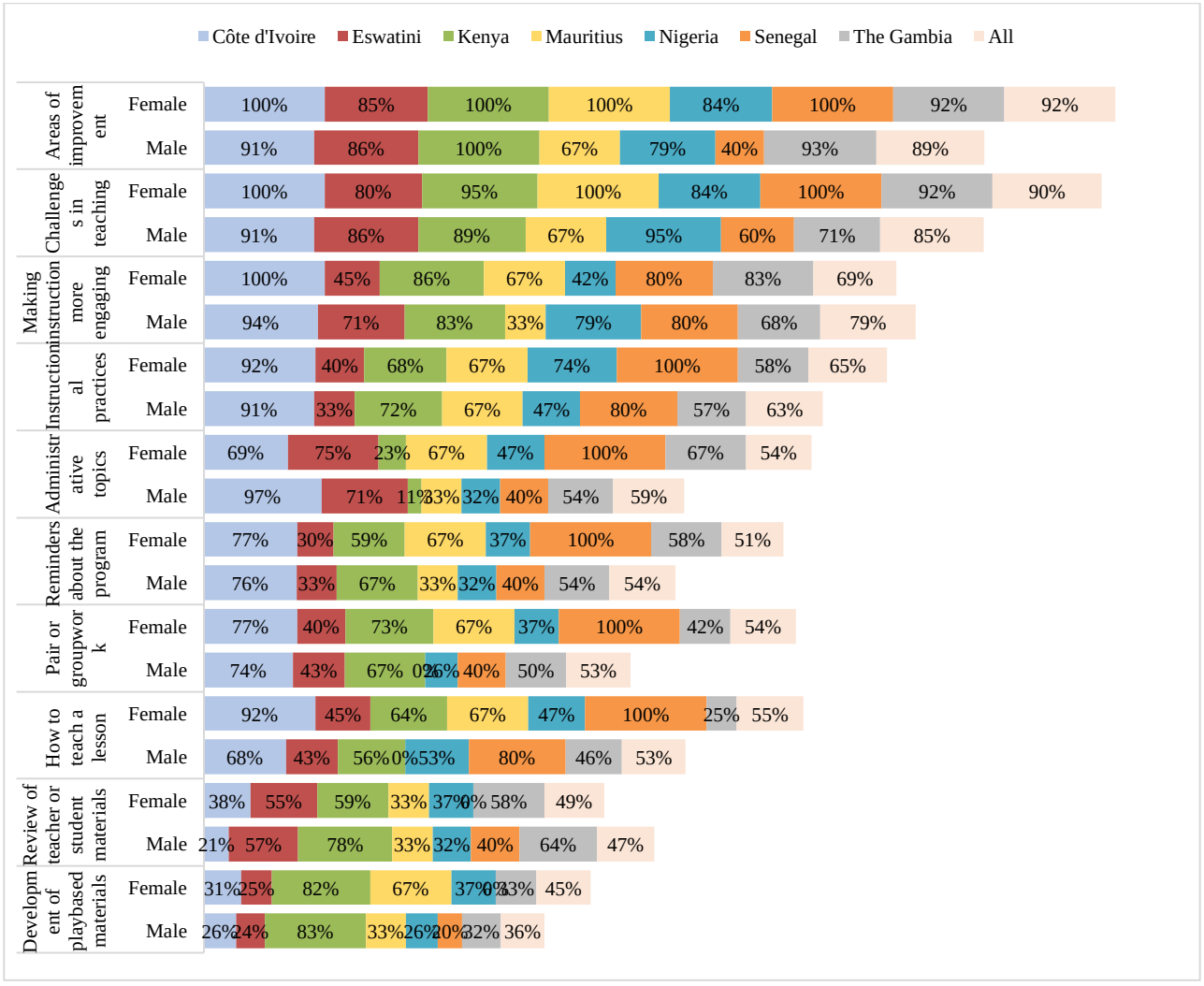


Figure 30: Content areas covered in teacher COPs – School Head

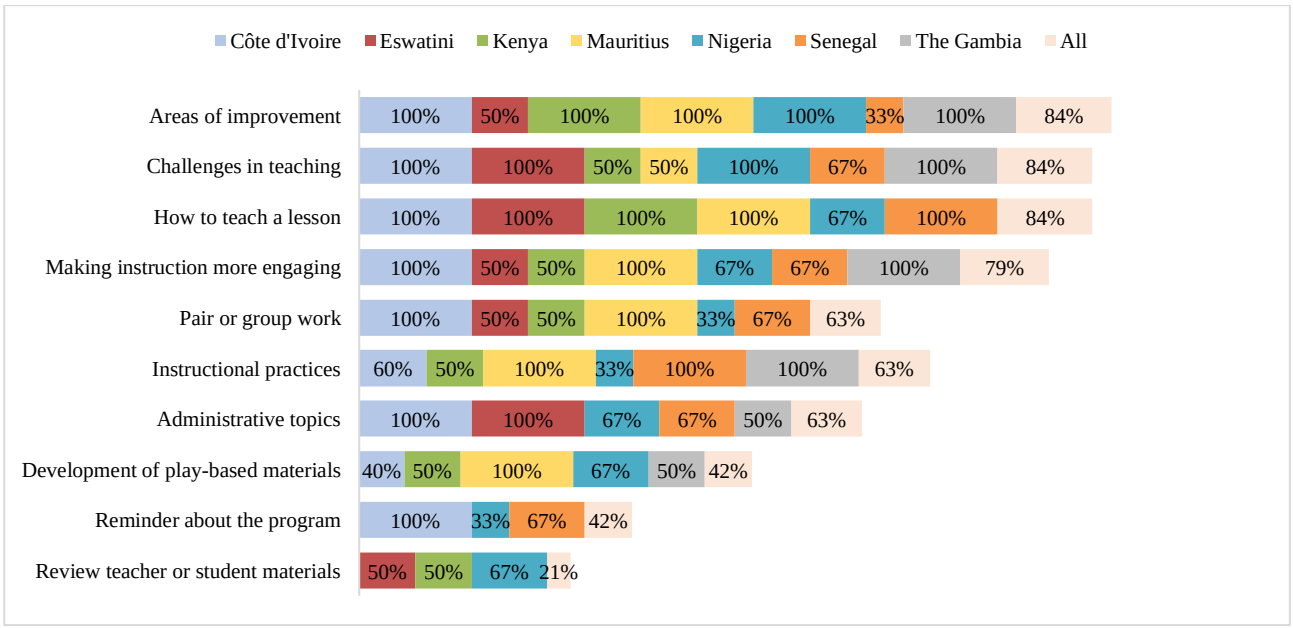


Figure 31: Content areas covered in teacher COPs – Education official

Most useful content areas covered in teacher communities of practice.

The content areas that were mentioned by teachers, school heads, and education officials as most useful during the teacher meetings and communities of practice were mainly related to teaching and learning practices. The top three content areas that were indicated as most useful were; (i) feedback on how to improve teaching, (ii) learning new teaching approaches, and (iii) discussions on teaching with other teachers which were mentioned by at least five to eight out of every ten teachers in the sample.

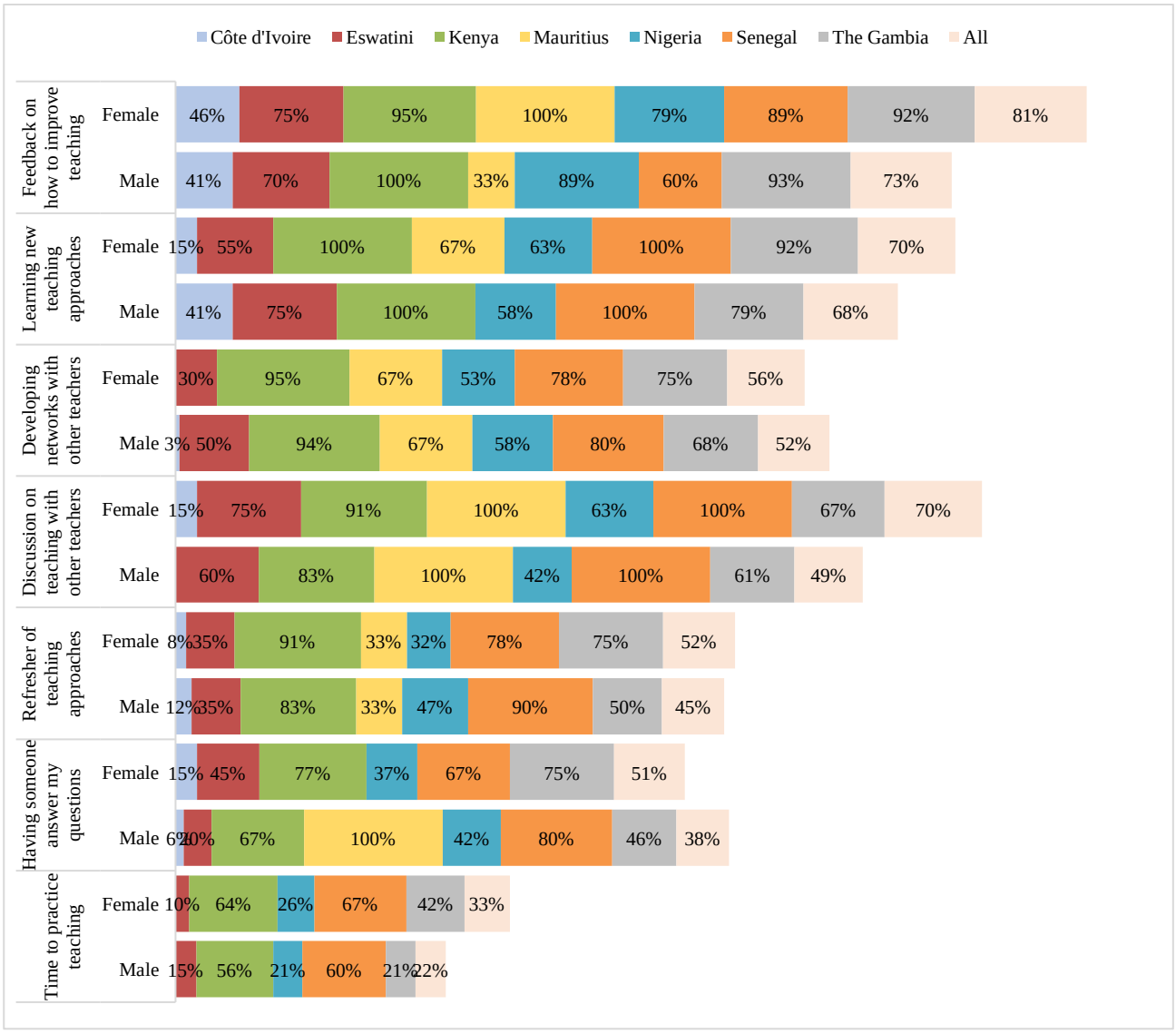


Figure 32: Most useful content areas covered in teacher communities of practice - Teacher

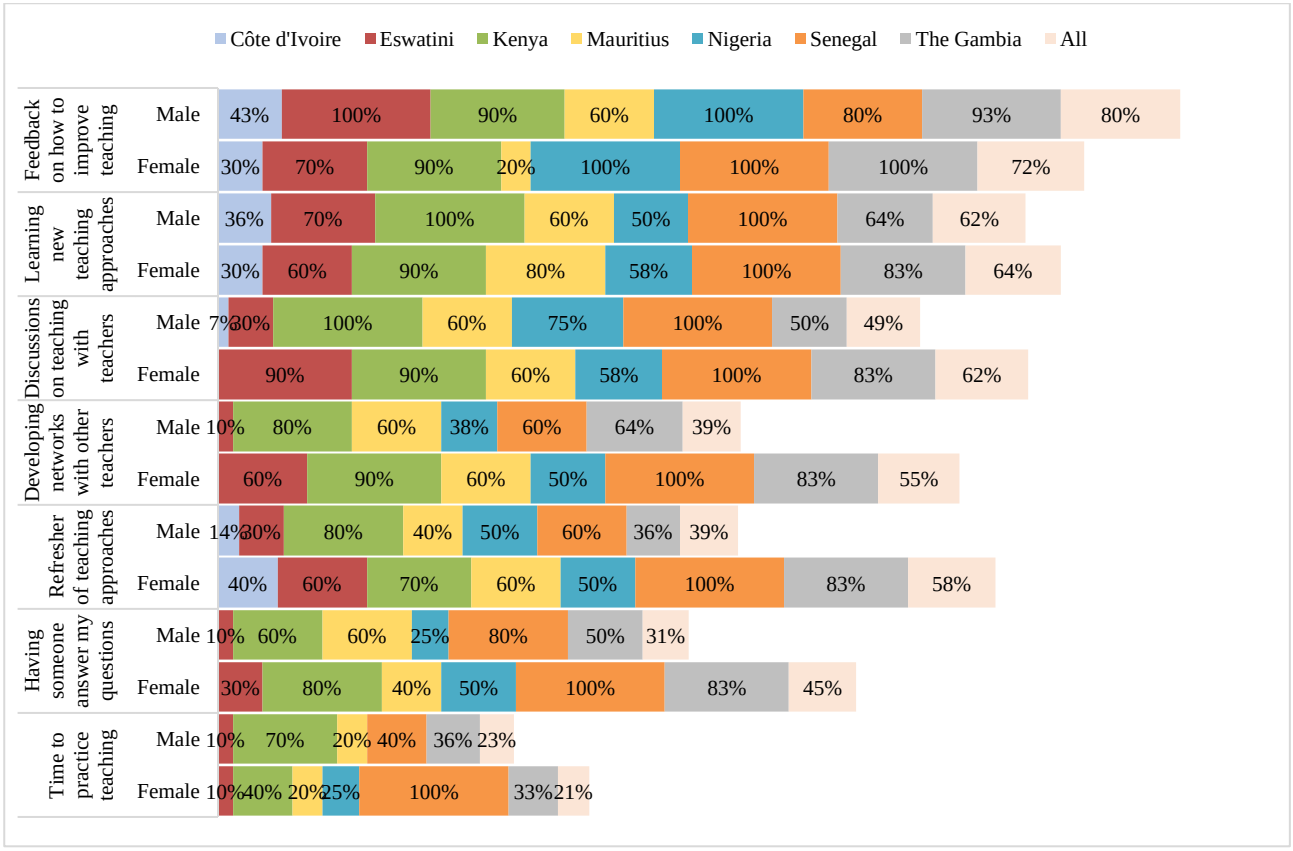


Figure 33: Most useful content areas covered in teacher communities of practice – School Head

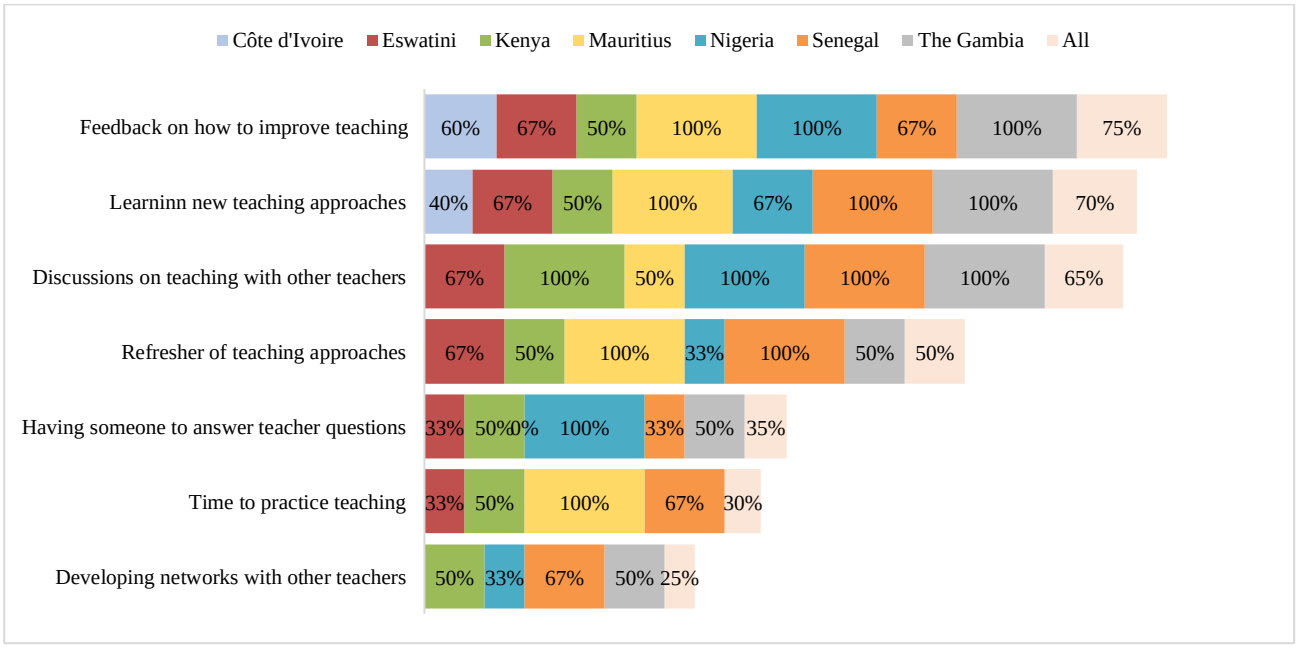


Figure 34: Most useful content areas covered in teacher communities of practice – Education official

d. Teacher support materials.

Overall, proportionately more teachers, school heads, and education officials mentioned teaching aids and teacher guides as the top two most useful teacher materials. More teachers and school heads than education officials mentioned these materials.

Figure 35: Most useful teacher support materials – teachers

Play-based materials were mentioned less than the teaching aids and teacher guides, at a distant fourth and third position for teachers and school heads respectively in a list of seven materials. Similarly, to teachers and school heads, the education officials mentioned both teaching aids and teachers guide as the most useful teacher materials while play-based materials were third in the list of six materials. The level of priority for play-based materials varied across the sample countries, with teachers, school heads, and education officials in Côte d'Ivoire indicating a high preference for these material with at least nine out of ten teachers and school head mentioning these materials. Additionally, more male than female teachers and school heads, education officials mentioned the play-based materials as important teacher support materials. This was more so for education officials in Côte d'Ivoire, Nigeria, and The Gambia. ***Overall, there appears to be a lower prioritization by teachers, school heads, and education officials of teacher support materials that promote play-based approaches, which is an indicator of lower prioritization of adopting these approaches.*** However, the fact that these materials were mentioned by teachers, school heads, and education officials indicates there is an opportunity, which is an enabler for promoting adoption of play-based approaches in primary schools in Africa.

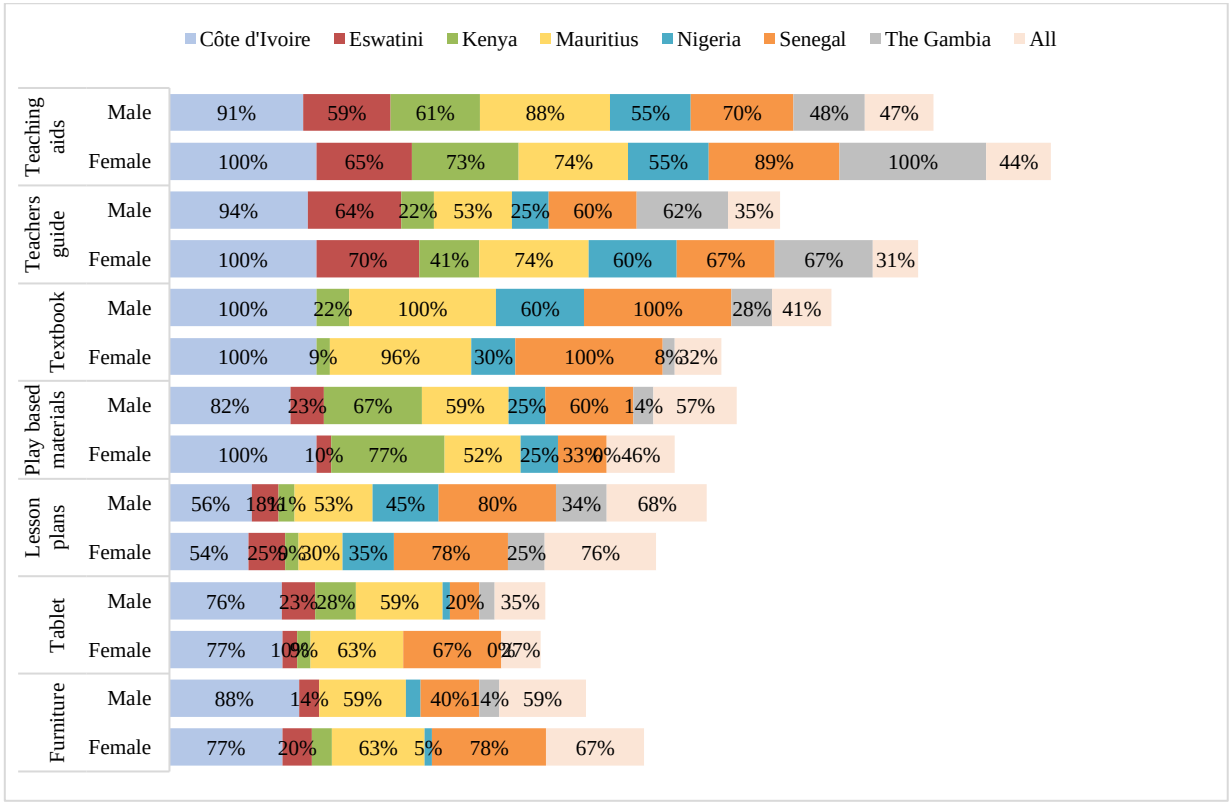


Figure 35: Most useful teacher support materials – teachers

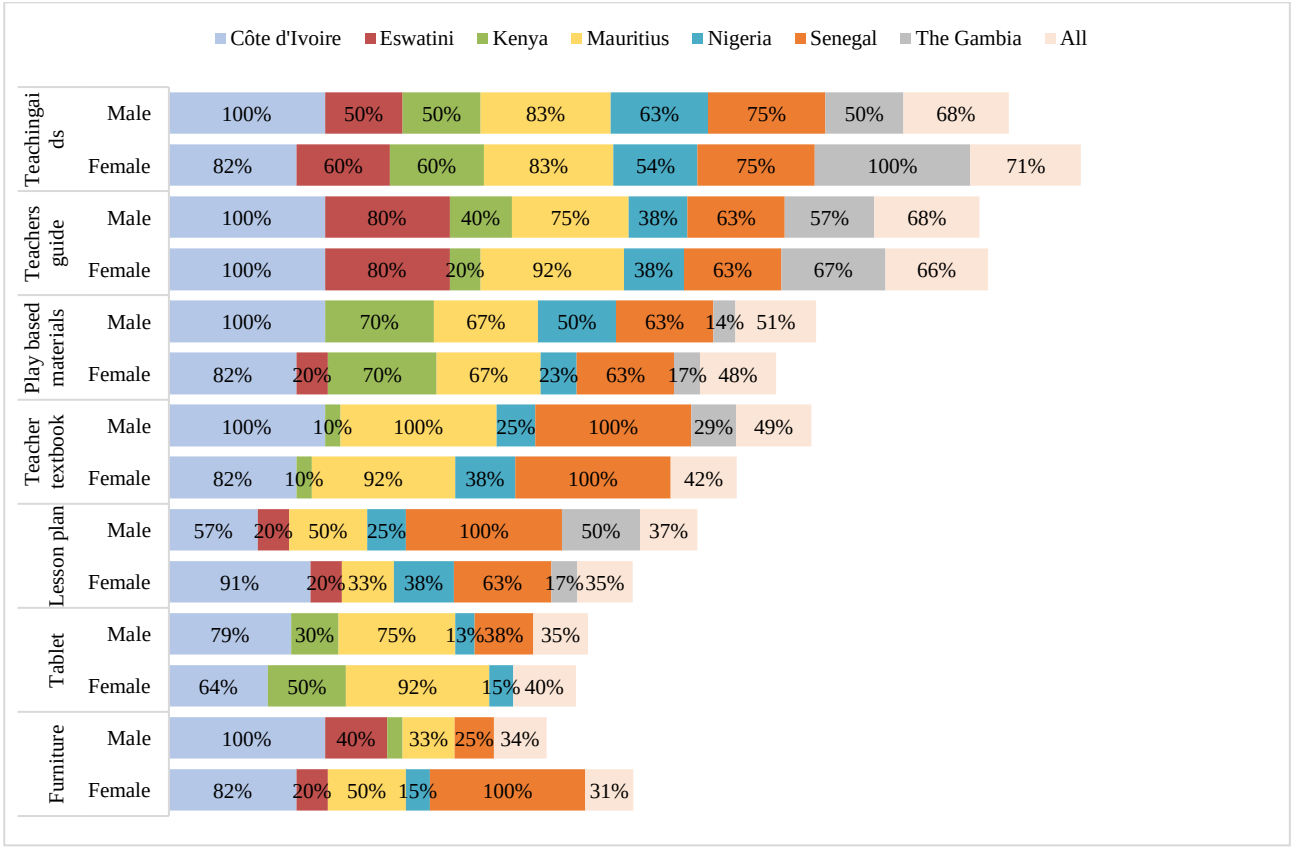


Figure 36: Most useful teacher support materials – school head

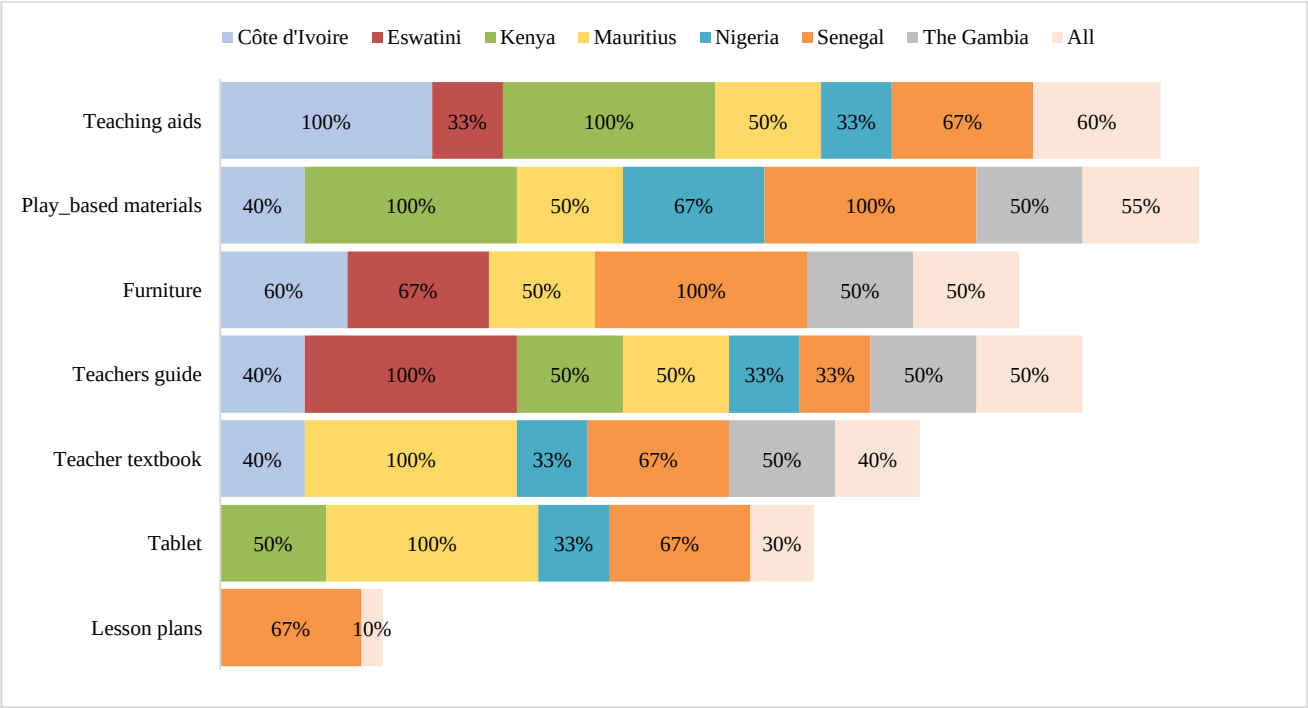


Figure 37: Most useful teacher support materials – education officials

e. Student support materials.

At least nine out of ten teachers, school heads, and education officials mentioned students' textbooks as the most useful support material and as the top priority.

Figure 38: Most useful student support materials - teacher

Like the most useful teacher support materials, proportionately fewer teachers identified play-based materials as a priority student support material. About a half of the teachers indicated this compared to six out of ten school heads who considered these materials a priority. Meanwhile, proportionately fewer education officials than teachers and school heads indicated play-based materials as priority support material for student, with less than half of them considering this to be the case. Furthermore, across countries, proportionately more teachers and school heads in Côte d'Ivoire than the other countries indicated all the seven materials as priority student support materials. Specific to the play-based materials, nine in ten teachers and school heads in Côte d'Ivoire considered these materials to be priority support materials for students. Additionally, nine and five in ten teachers in Kenya and Mauritius respectively indicated the play-based materials as priority support materials for students. Likewise, eight and seven in ten school heads in Kenya and Mauritius indicated the play-based materials as priority support materials for students. Meanwhile, only two in ten teachers and school heads in both Eswatini and The Gambia indicated the play-based materials as priority materials for

students. ***Overall, like the teacher support materials, there appears to be a lower prioritization by teachers, school heads, and education officials of student materials that promote play-based approaches, which could be an indicator of low prioritization of adopting this approach.***

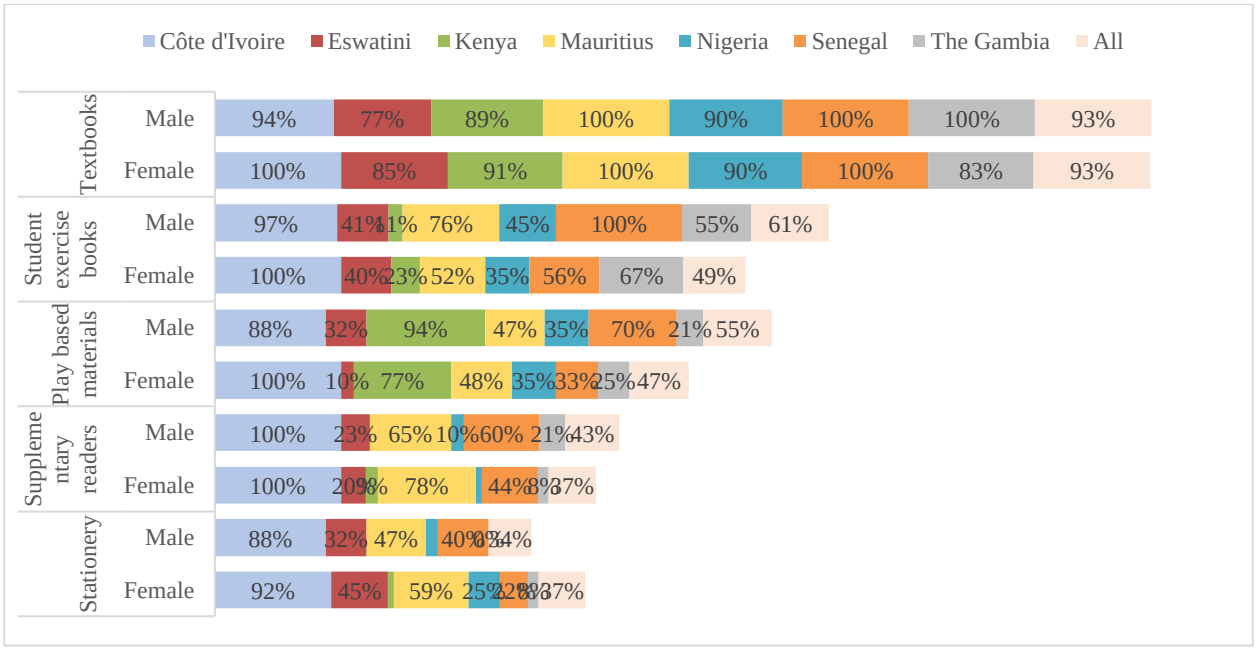


Figure 38: Most useful student support materials - teacher

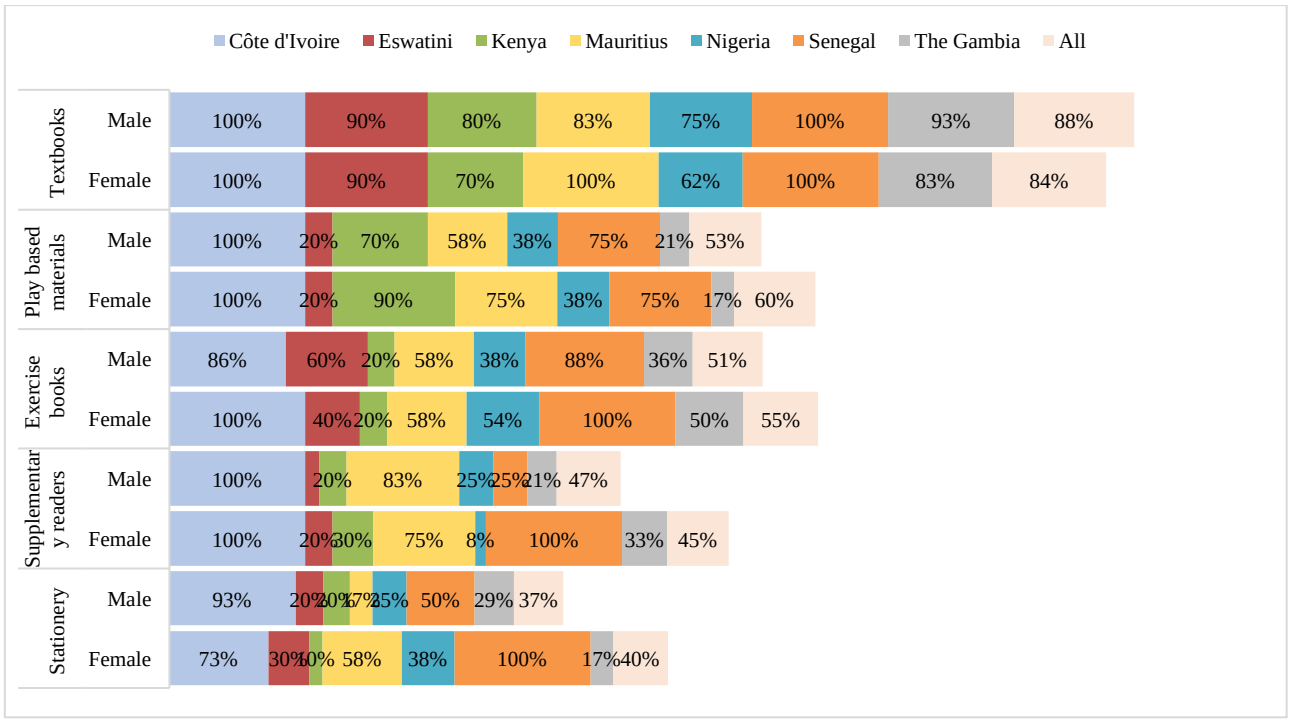


Figure 39: Most useful student support materials – school head

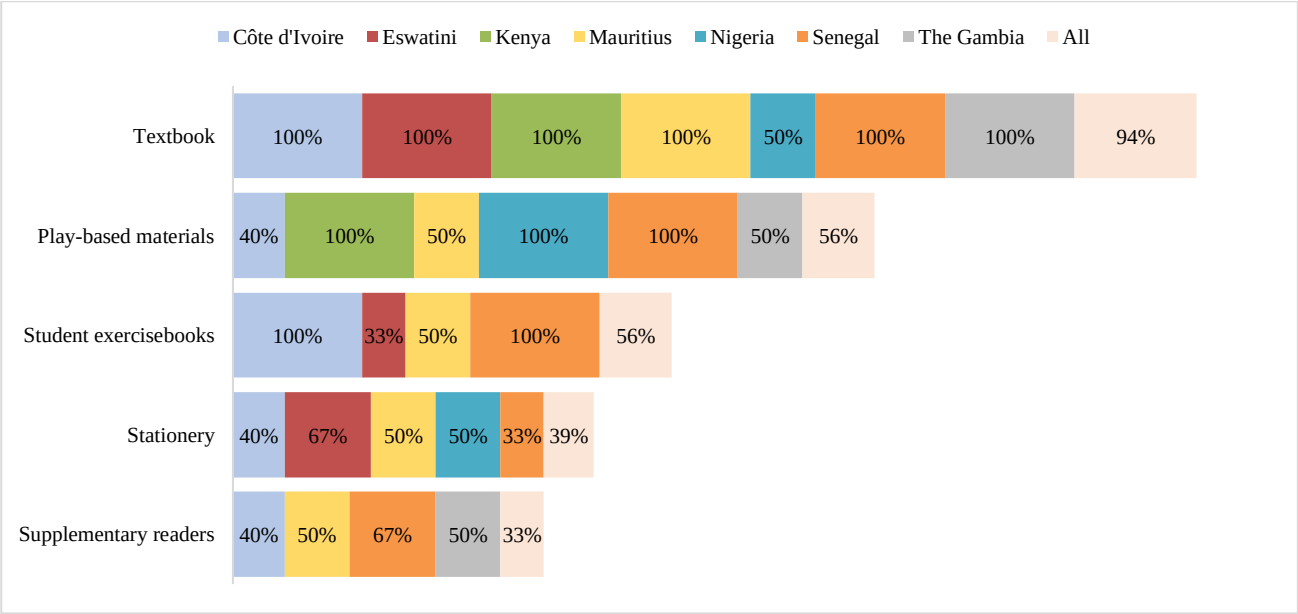


Figure 40: Most useful student support materials – education official

f. Parental support for learning at school.

Parents' attendance of school events

Overall, at least eight in ten (82%) of the parents had attended a school event in the last 30 days (**Figure *41***) with most parents attending one school event. Proportionately more parents in Eswatini (five in ten) had attended a school event once in the last 30 days. Meanwhile, a relatively higher number of parents (four in ten) in Côte d'Ivoire had attended a school event at least five times in the last 30 days, while proportionately more parents (six in ten) in The Gambia had not attended a school event in the last 30 days.

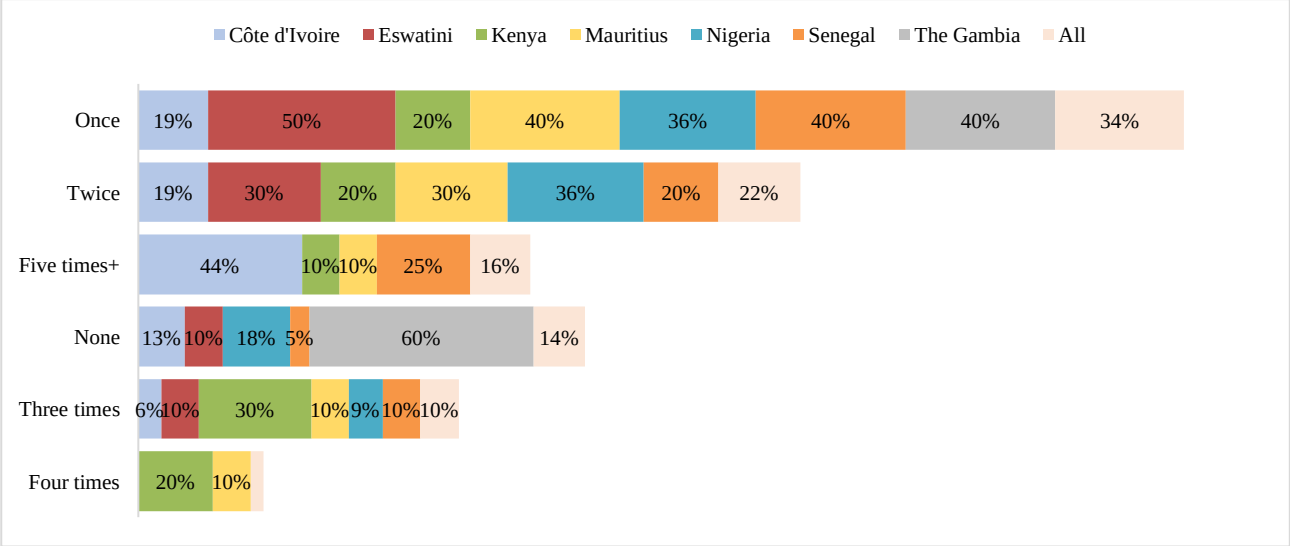


Figure 41: Parents attendance of school events

Parent engagement in learning at schools

Almost all the parents had spoken with the classroom teacher on the children's progress in the last 12 months and most of this was happening monthly. Proportionately more parents in Mauritius (five in ten) were speaking to the classroom teachers monthly while a relatively higher number of parents in Kenya (six in ten) were speaking to the classroom teacher weekly. Meanwhile, a relatively higher number of parents in Côte d'Ivoire a few times in the last 12 months.

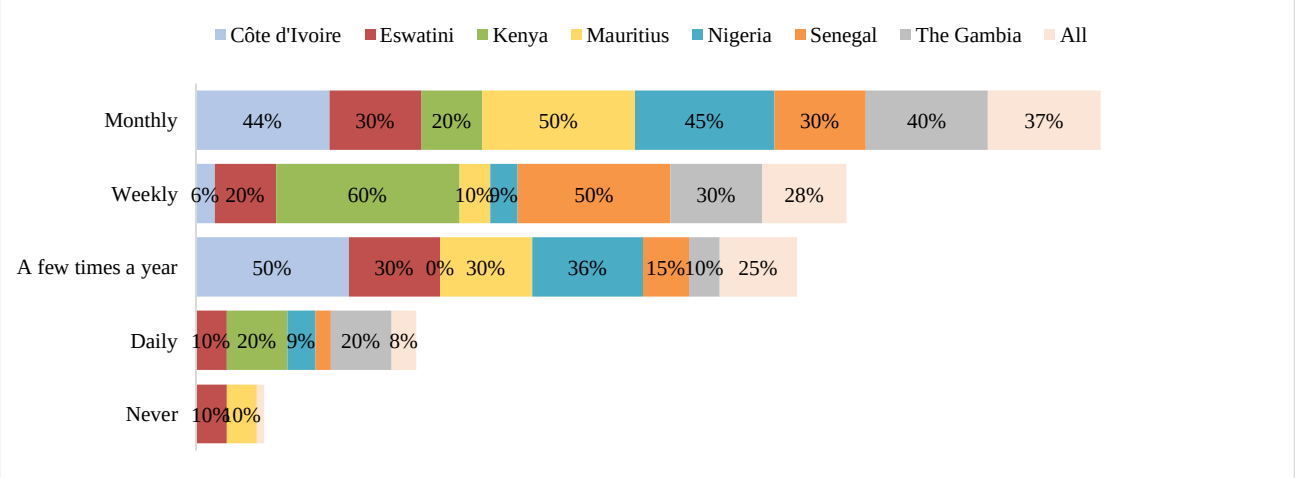


Figure 42: Parents interaction with classroom teacher

g. Parent support for learning at home

Most parents support children with learning at home. Eight in ten parents help the children to complete homework and a proportionately higher number of parents in Kenya, and Cote d'Ivoire indicating this to be the case. Parents also engaged with children in a range of activities that could be characterized as play-based learning activities, for instance playing a game inside or outside the house, cooking together, and telling a story. However, reading for children at home, and where it was done, this most often happened a few times in week (**Figure 43: Parent support with learning at home**

Across countries, proportionately more parents in Kenya, Mauritius, and Nigeria were likely to read to their children at home while those in The Gambia and Côte d'Ivoire were the least likely to read to their children.

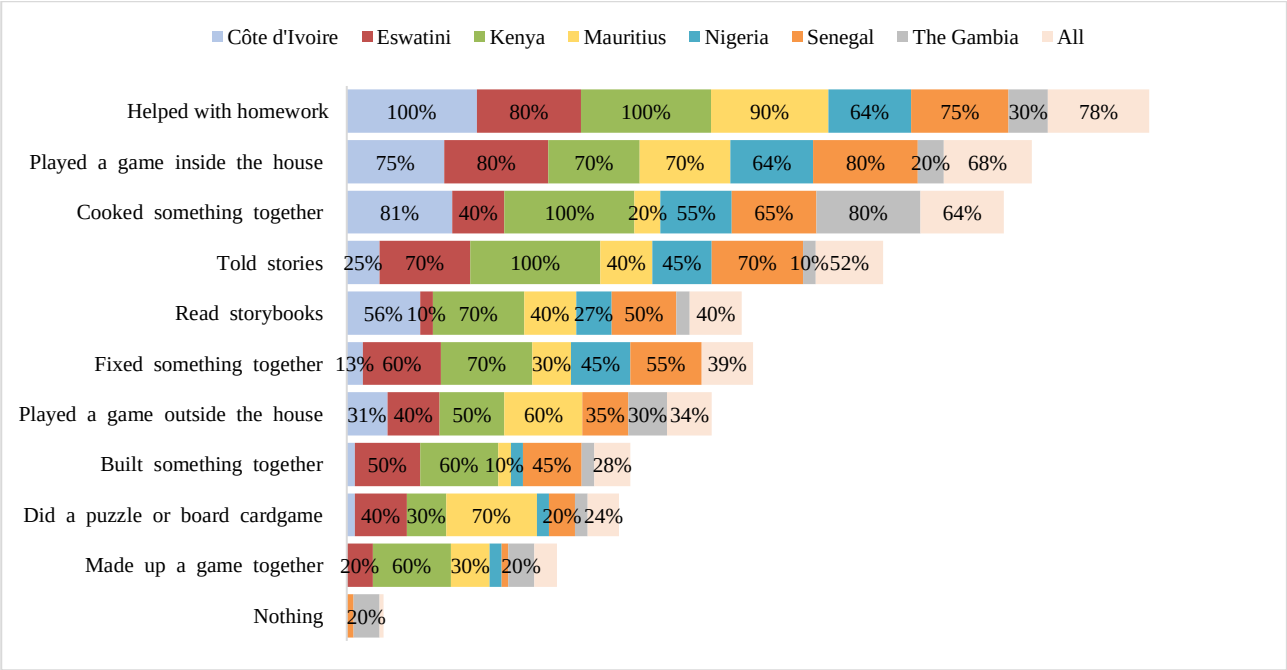


Figure 43: Parent support with learning at home

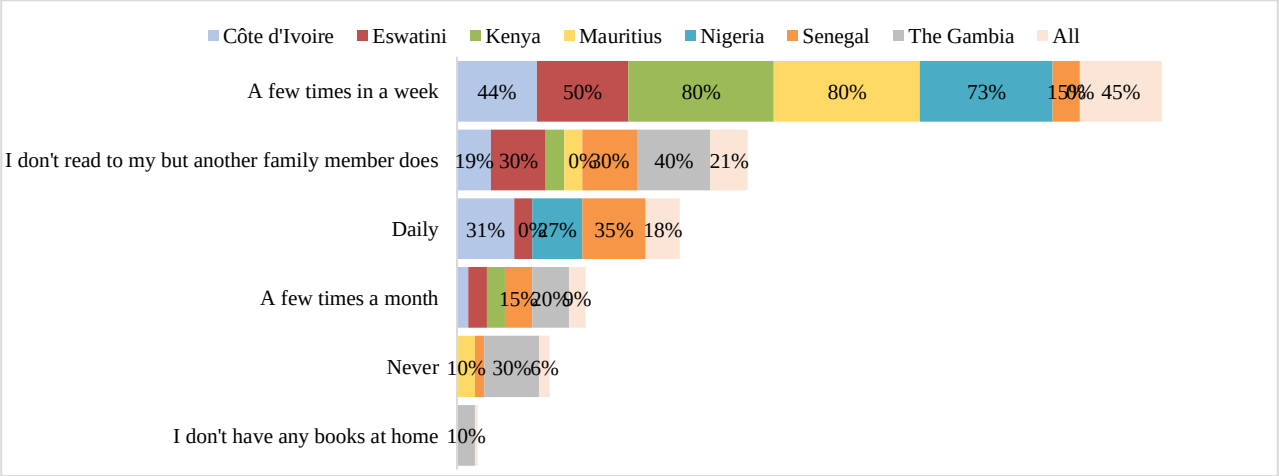


Figure 44: Reading for children at home

h. Students' materials at home

A high proportion of parents (eight in ten) indicated that there is a range of play items at home that are accessible and used by the children**.** Further, a range of materials that are supportive of play were available at home particularly in Mauritius and The Gambia. However, books were the most available student materials at home.

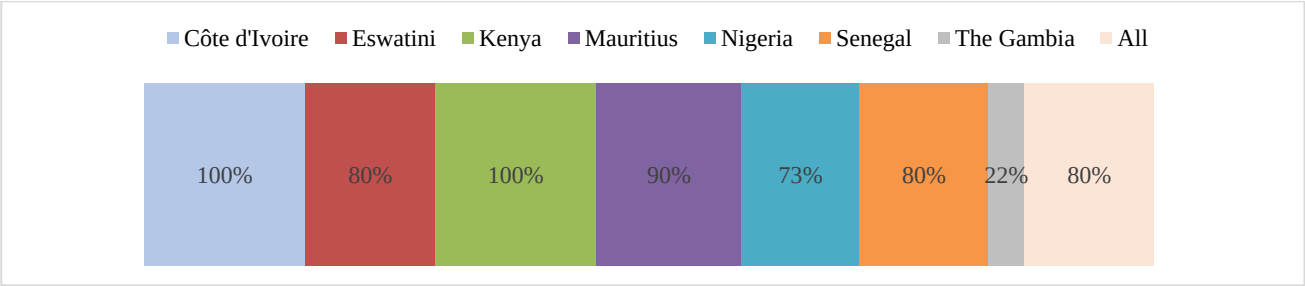


Figure 45: Availability of play materials at home

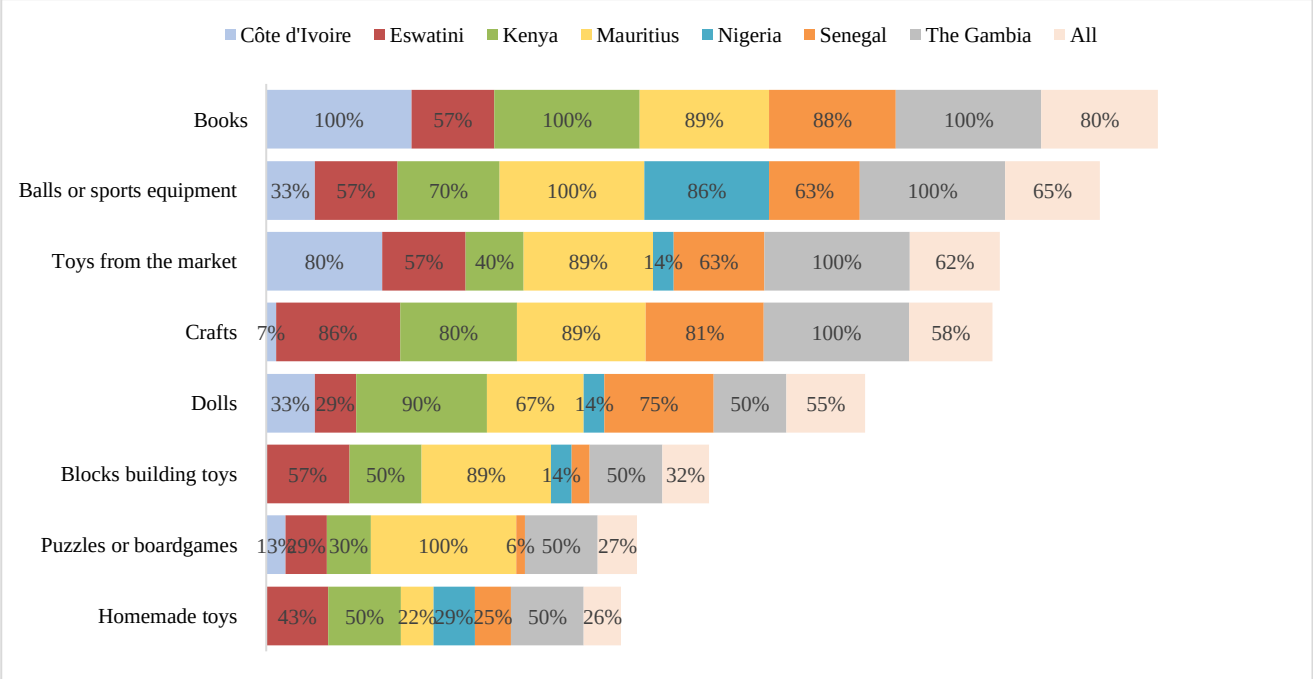


Figure 46: Student learning material at home

4.6 Play-based teaching and learning practices.

The fourth objective was to establish teaching and learning practices that are aligned with play-based STEM education. The readiness of teachers, school heads, and education officials to adopt play-based approaches was used as a proxy indicator of teaching and learning practices. This strategy was adopted as classroom observation was not part of the study design. The readiness to adopt play-based approaches was assessed with items that focused on (a) the self-belief on the effectiveness of play-based approaches in promoting student learning, (b) level of confidence in the abilities to adopt the approach, and (c) the existing environment in the classroom, school, and region that is supportive of play-based approaches.

4.6.1 Teachers, school heads, and education official's readiness to adopt play-based approaches

Overall, the level of readiness to adopt play-based approaches was lower for teachers, school heads, and education officials, than the levels of awareness and training. Furthermore, less than half (46%) of both teachers and school heads across the sample countries had high readiness to adopt play-based approach in teaching and learning practices, in this, school heads were less ready than teachers to support the approaches. Additionally, proportionately more education officials than teachers and school heads more willing to adopt the approaches with at least six in ten education officials showing a high level of readiness. The readiness to adopt the play-based approach for teachers and school heads varied across countries. For instance, male teachers in Eswatini and Kenya had the highest level of readiness while male teachers in Nigeria and The Gambia reflected the lowest level of readiness to adopt the approach. Further, male school heads in Kenya and Cote D'Ivoire had the highest readiness for adoption, while female school heads in Eswatini and Nigeria had the lowest readiness for adoption. Education officials' readiness was high in Côte d'Ivoire, Kenya, Mauritius, and Senegal with ten out of ten reporting high readiness. However, the level of readiness was lower for education officials in Nigeria and the Gambia. Across the countries, proportionately more male than female teachers and school heads indicated higher readiness to adopt the play-based approaches, and this contrasted with the awareness and training where more female than male teachers were aware and trained on the approach.

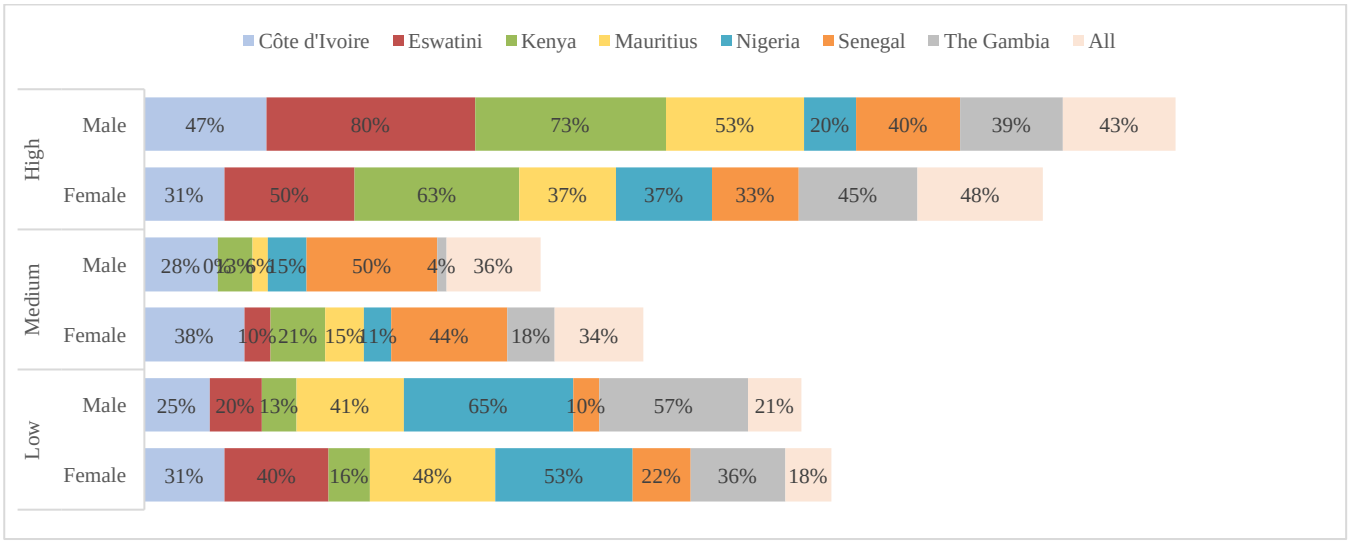


Figure 47: Teacher readiness to adopt play-based approach by country and gender.

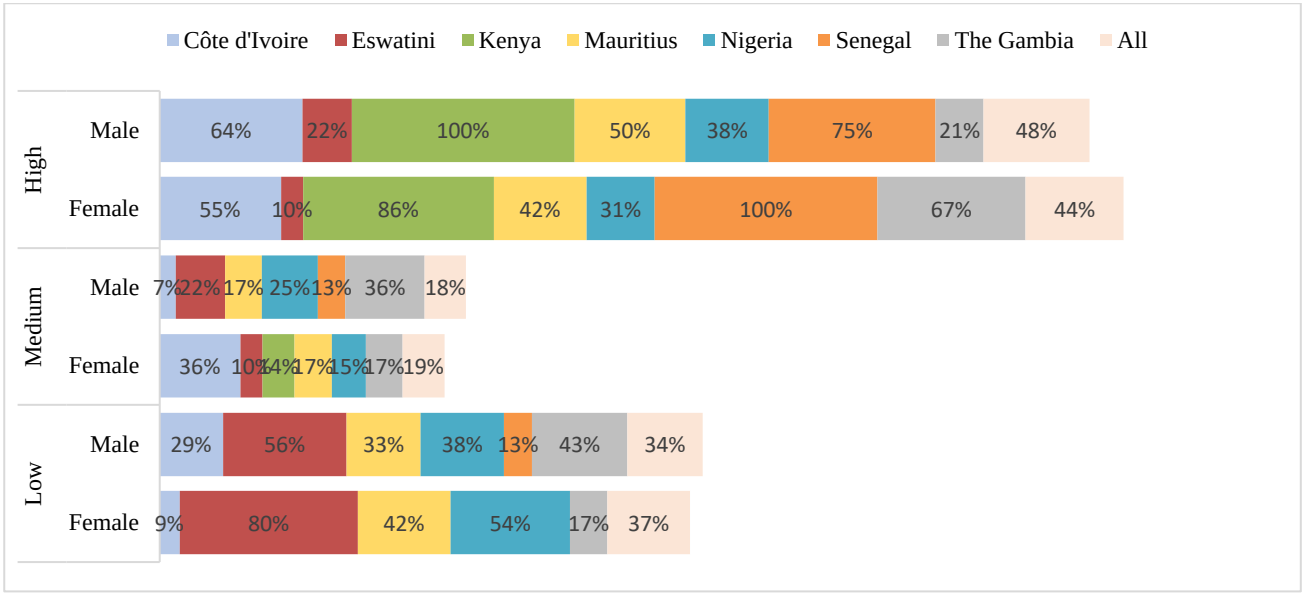


Figure 48: School head readiness to adopt play-based approach

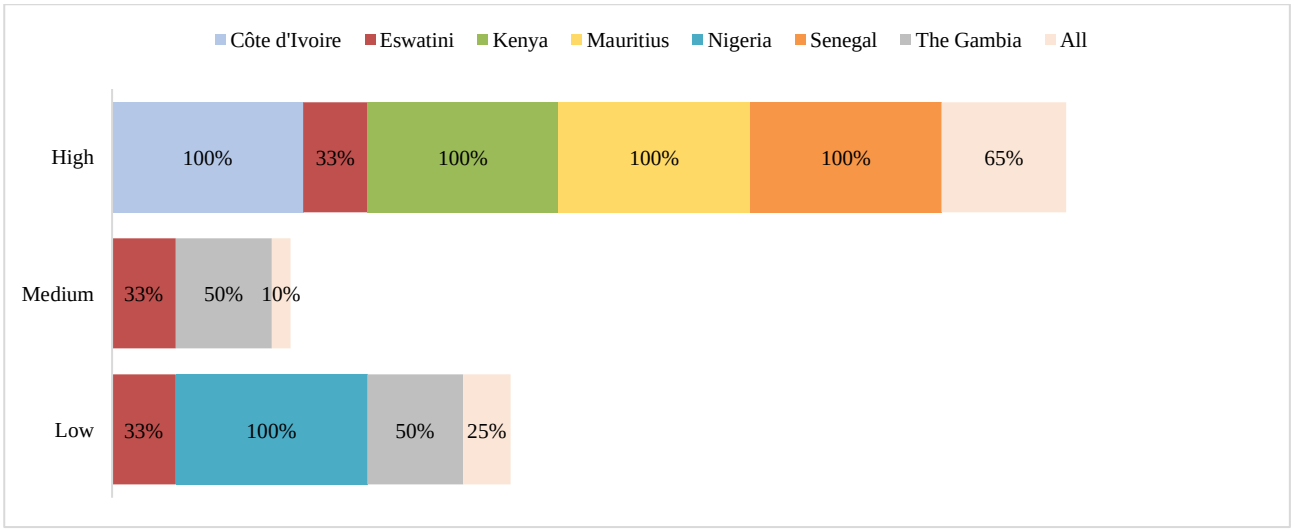


Figure 49: Education official readiness to adopt play-based approach by country

4.6.2 Parents' readiness for play-based approaches.

The parent readiness for play-based approaches was assessed with 15 items that were statements of teaching and learning practices that are associated with play-based approaches. A high proportion of parents were supportive of play-based approaches. For instance, more than half of the parents were supportive of 13 of the 15 teaching and learning practices that are associated with play-based approaches. However, some of the practices were rated higher, for instance, the top three practices were, ***(a) children should be encouraged to ask questions in class, (b) sometimes it is better to let children express their thoughts in class, and (c) when children explore a topic by themselves, they can make new discoveries.*** Furthermore, there were some differences between male and female

parents' rating of the specific practices (**Figure 50: Parents readiness for play-based approach by practices by country**

This finding could imply that with more understanding through awareness raising sessions, of the positive learning implications of play-based approaches, parents are likely to support these approaches and accelerate their integration and institutionalization into the teaching and learning processes.

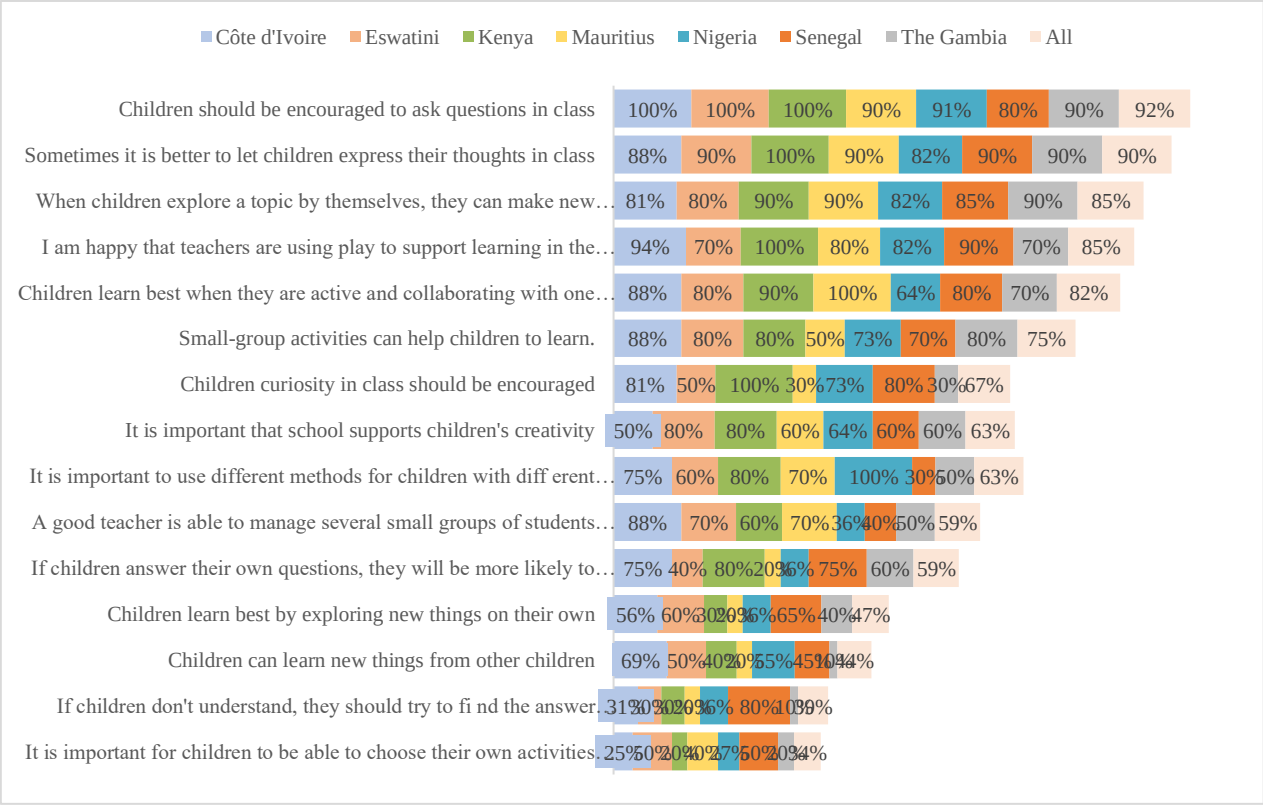


Figure 50: Parents readiness for play-based approach by practices by country

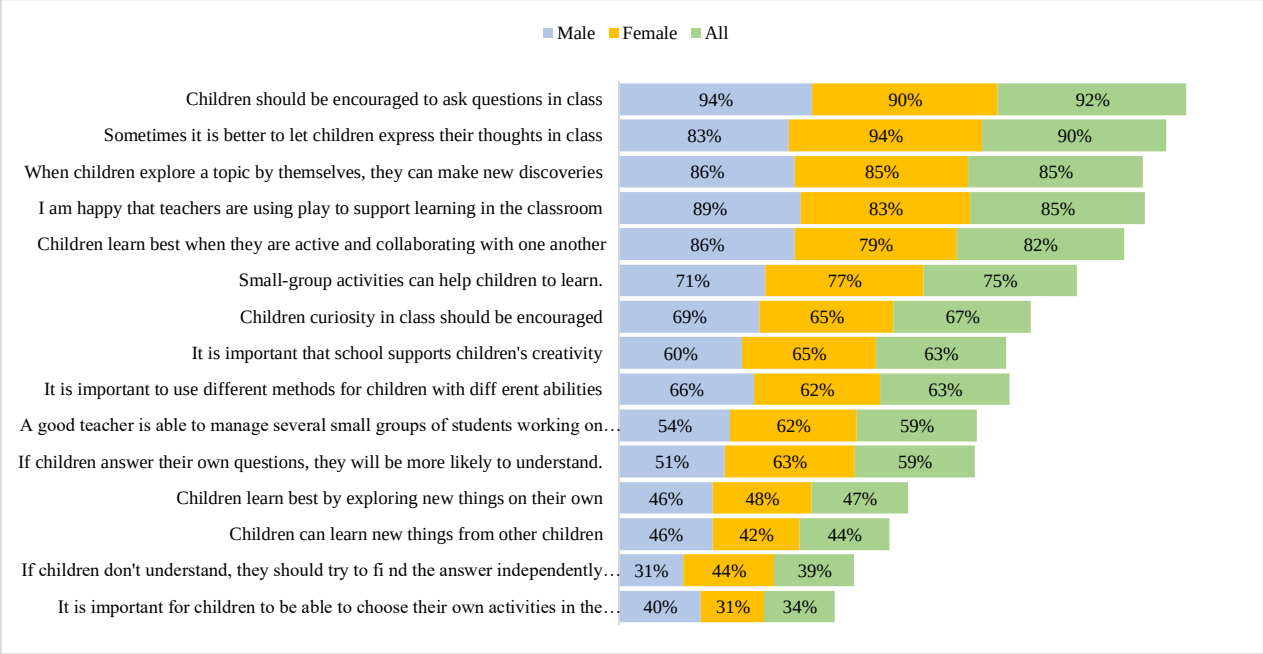


Figure 51: Parents readiness for play-based approach by practices by gender

4.6.3 Learner readiness for play-based approaches.

The learner readiness for play-based approaches was assessed with 14 items that were statements of teaching and learning practices that are associated with play-based approaches. Similar to parents, a high proportion of learners were supportive of play-based. For instance, more than half of the students were supportive of 10 of the 14 teaching and learning practices that are associated with play-based approaches. However, some of the practices were rated higher, for instance, the top three practices were, (a) when children explore a topic by themselves, they can make new discoveries, (b) children should be encouraged to ask questions in class, and (c) children learn best when they discuss with one another. The first two practices were also among the top three identified by parents. Additionally, there were some differences between male and female students rating of the specific practices.

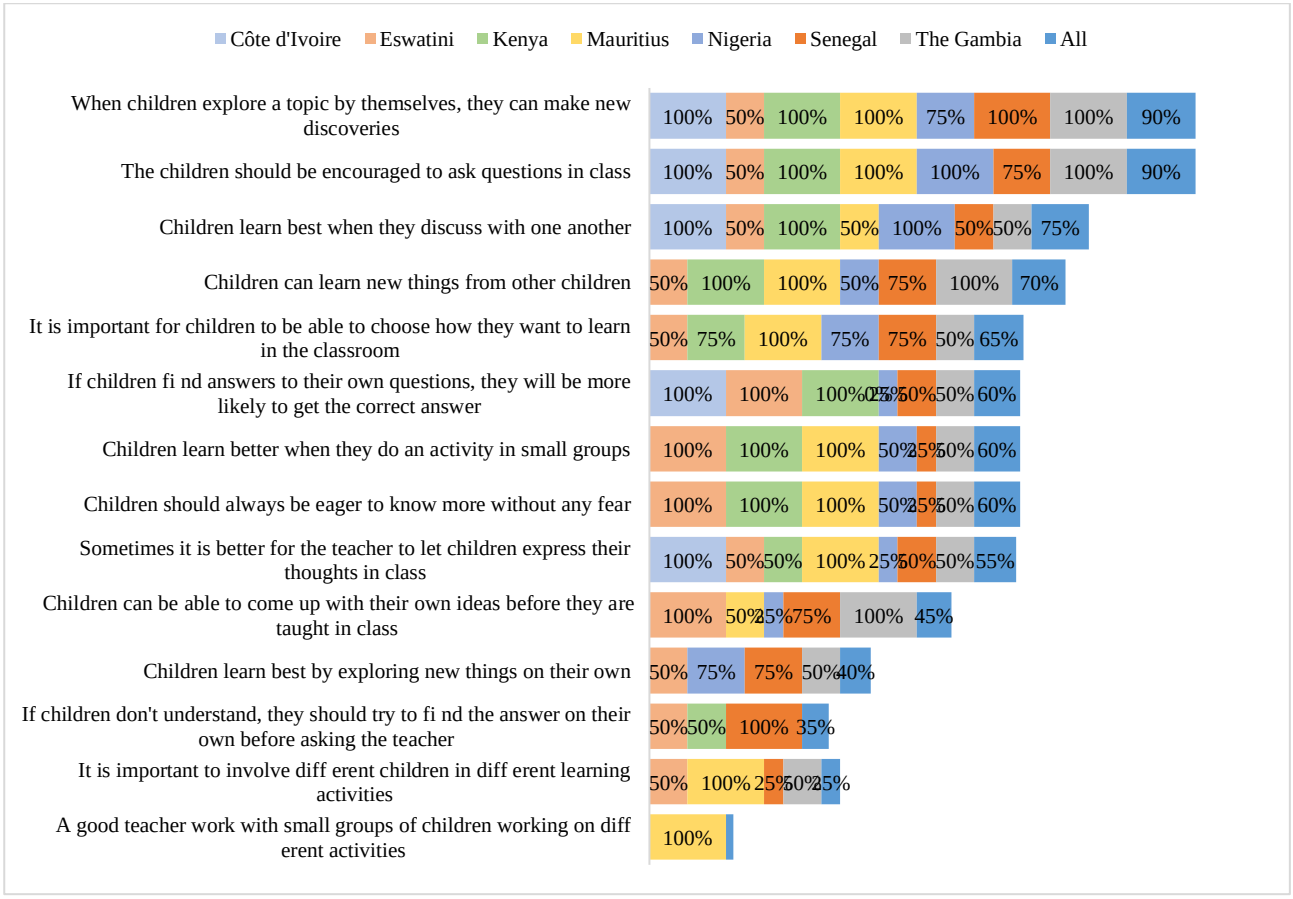


Figure 52: Student readiness to adopt play-based approach by practices

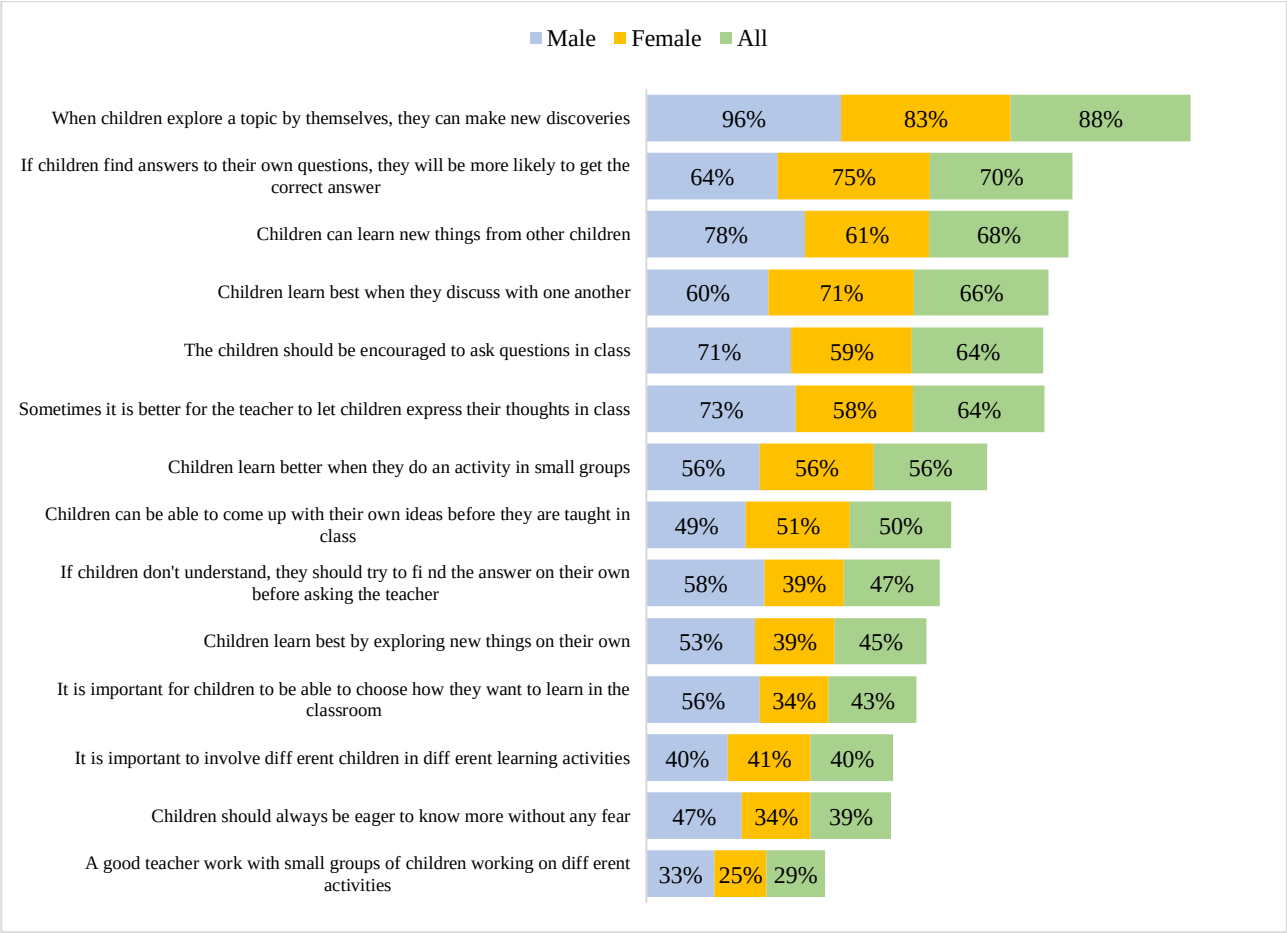


Figure 53: Student readiness to adopt play-based approach by gender

4.7 Enablers and barriers to integration of play-based STEM education at primary schools

The fifth study objective was to identify enablers and barriers to the integration of play-based STEM education at the primary schools in Africa. The enablers will focus on conditions, structures, and systems that support integration of play-based STEM education, while the barriers will focus on the key challenges to integration and institutionalization of play-based STEM education at the primary schools level in Africa. The key enablers to integration and institutionalization of play-based STEM education at the primary school level include:

a. **Level of awareness of and readiness for play-based approaches:** There is some level of awareness of and readiness for adoption of play-based approaches among educators including teachers and education officials in Africa.

b. **Review of education sector plans:** There are on-going reforms in Africa including review of the education sector plans and national curriculum at the basic learning levels in several countries in Africa providing an entry for play-based STEM education.

c. **On-going play-based and STEM education improvement initiatives:** There are currently on-going initiatives focused on play-based approaches and improvement of the quality of STEM education at the primary school level in several African Countries including in-service

teachers training, school-based teacher coaching and mentoring support, and teacher communities of practice.

The key barriers are:

a. **Low foundational skills in reading and numeracy:** as noted earlier, the foundation skills in reading and numeracy are still low in several African countries. Consequently, governments and development partners have in the past focused on the basic foundational skills development in education namely reading, writing, and counting numbers at the primary school level at the expense of STEM education. However, there are emerging trends of greater focus in STEM education at the primary schools in Africa.

b. **Inadequate staffing:** Both the teachers and technical staff in STEM within the ministries of education are inadequate in terms numbers and expertise. All the countries in the sample echoed the inadequate number of quality assurance staff for STEM subjects. Further, it emerged that most teachers in primary schools particularly the female teachers are not confident to teach mathematics and science which are considered difficult and more demanding as compared to the languages and social studies. Teacher quality remains a challenge because most are not adequately prepared to deliver the play-based STEM curriculum at the primary school level. This is amplified by lack of subject specialization at the primary school level because they are expected to teach all the subjects. Meanwhile, the terms and conditions of service for teachers remain a deterrent in attracting highly qualified staff.

> ***The ratio between inspectors and teachers is 1 inspector for 250 teachers, which is too much work. Ideally, there should be 1 inspector for every 50 teachers. How to support all these teachers at the same time is therefore a challenge?***
> ***Senior education official***

c. **Large class sizes:** The tremendous increase in gross enrolment in African countries in the recent past has not been matched with increased infrastructure and staffing. In the study, the average class size was 73 students and some countries like The Gambia has an average class size of 133 students. The large class size presents classroom management and pedagogical challenges that need consideration during planning and implementing teacher professional development and school improvement programmes in Africa.

d. **Student performance in STEM subjects:** The performance of students in the STEM subjects at the basic learning level including primary schools is low, and this reinforces the attitude among teachers, parents, and students that these subjects are difficult. Efforts to integrate play-based approaches in STEM education as a strategy for improved holistic learning outcomes need to be considered in the design and implementation. This is realizable in terms of technical components in order to mitigate long held attitudes that STEM subjects are difficult by key stakeholders in education.

e. **Resources and facilities:** Lack of or inadequate resources and facilities for delivery of play-based STEM subject curriculum at the primary schools in Africa remains a constant theme in this study. For instance, very few public primary schools have established science laboratories and equipment for practical lessons in STEM subjects. This is more relevant now as the countries in the region gradually shift towards the competency-based curriculum that increasingly demands more resources and facilities for effective implementation.

f. **Inadequate funding for STEM education:** Investment in STEM education improvement interventions require adequate funding for staffing and infrastructure which were frequently mentioned to be inadequate in all the sampled countries. However, strategies that address the assumed high cost of funding STEM subjects in terms of laboratories and equipment need to be institutionalized. Some of the emerging models are shared resource frameworks across a network of schools in close proximity to minimize the high cost implication.

g. **Lack of a STEM policy:** None of the sampled countries had established the policy on STEM education at the basic learning level. The priorities in STEM education at the primary schools in Africa were embedded within the national education sector plans, and most often they were not adequately articulated except for a few countries like Eswatini and Rwanda. This presents a challenge in designing programmes, resource mobilisation and resource allocation for the implementation of STEM programs. Given the multiple players in the STEM education space, a standalone policy is important to ensure coherence and harmonisation in the delivery of the STEM agenda.

h. **Alignment between content of curriculum and time allocation:** While the science and mathematics curriculum in most countries is clear in terms of the detailed content, specific objectives, activities to be carried out, and the type of skills, there is a challenge in the allocated time to deliver the curriculum. Consequently, teachers often rush through the delivery of lessons

irrespective of whether learners understand the concepts or not, leaving little room for adoption of innovative teaching and learning approaches such as group work and play because they are considered to consume more time than planned

i. **Language of instruction:** Except for a few countries where the local language was indicated as a language of instruction for instance, Hausa in Nigeria, and Kiswahili in Kenya, in all other countries the language of instruction was not native to the learners. In the case of Kenya and Nigeria, only a few schools indicated to use native language of instruction in combination with a foreign language mostly English. As noted earlier regarding the low reading skills among children in the region, the language of instruction is an additional barrier to understanding scientific and mathematics concepts. This arises from lack of equivalent scientific or mathematical terms in the learner's first language. The verbatim excerpt from the interview illustrating the language barrier in mathematics and science is shown below:

> ***Thales Theorem***
> *Personally, I remember when I was still at school my teacher asked me to explain the Thales theorem, but I couldn't because it was too complicated for me at the time, as I didn't understand the language. It was only later that I realized that this theorem was simple and easy to understand, especially if the teacher had asked me in my native language.*
> ***Senior education official***

j. **Lack of Key Performance Indicator:** Most of the countries lack a comprehensive monitoring and evaluation framework with specific indicators to track progress of the development of STEM education at the basic education level. Some countries have identified indicators of implemented programs, but are inadequate and there was no evidence during the interviews or document reviews that ministries of education are tracking programs in STEM education. A comprehensive monitoring and evaluation system, ensures that countries evaluate and document progress on the development of STEM education to support decision making on designing interventions and priority areas for resource allocation.

k. Furthermore, teachers and education officials at the sub-national geographies confirmed the barriers that emerged from the review of documents and interviews with senior education officials. The top three barriers identified by teachers were (a) inadequate resources and facilities, (b) inadequate funding of STEM education, and (c) poor conditions of service for teachers (

l.). Meanwhile, education identified the top three challenges to achievement of quality STEM education at the primary schools in Africa as (a) inadequate funding of STEM education, (b) inadequate resources and facilities, and (c) poor teacher pedagogical practices.

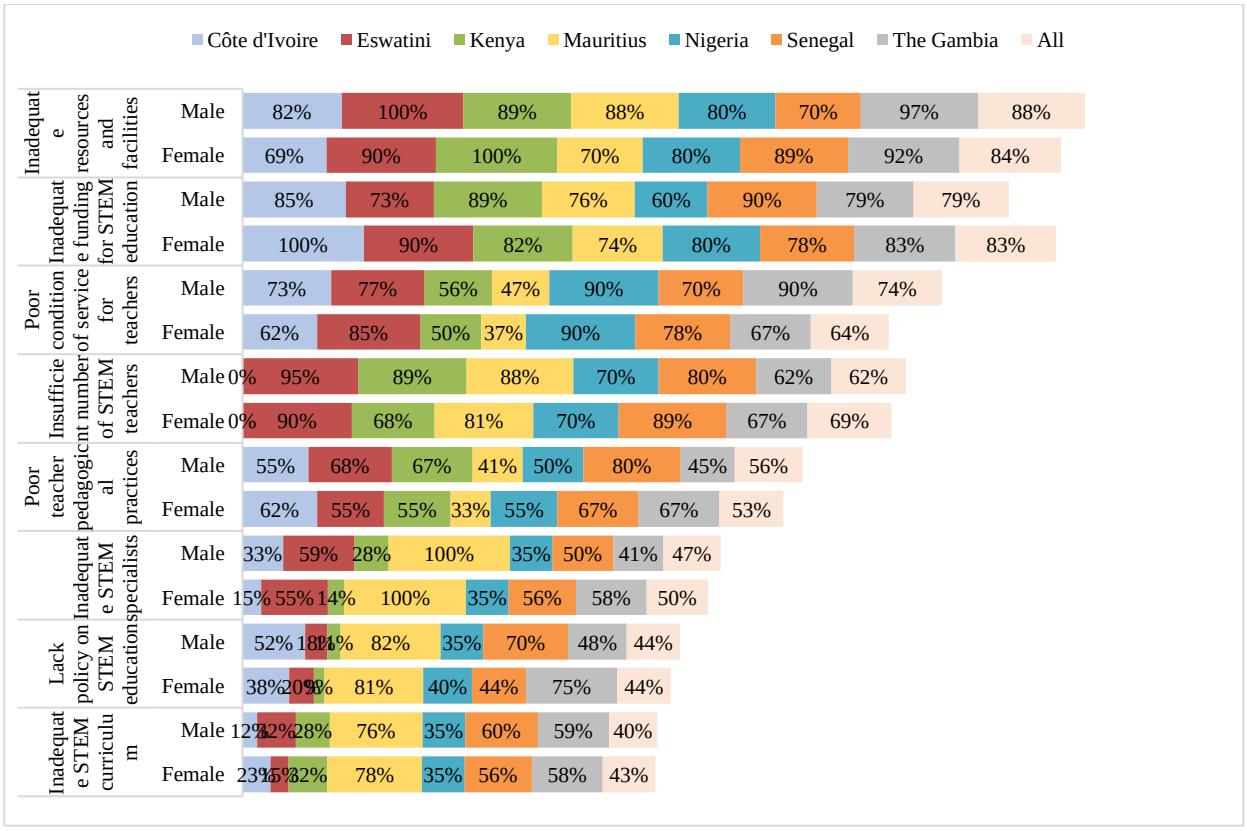


Figure 54: Barriers - teacher

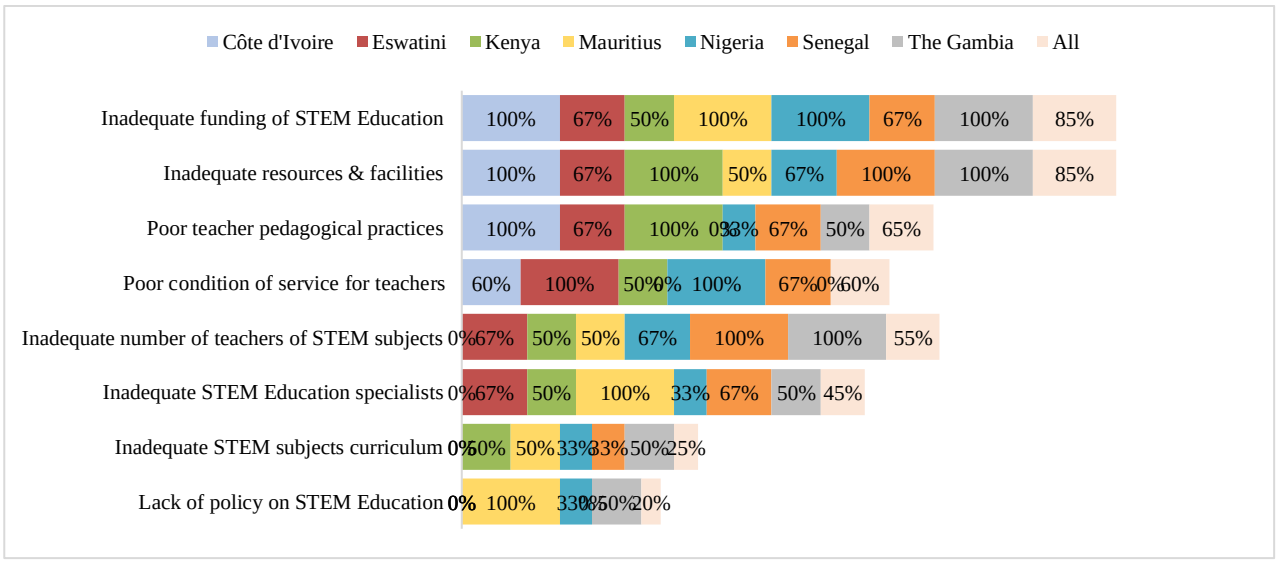


Figure 55: Barriers – Education official

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The following are the conclusions arising from this study.

5.1.1 Strengthening play-based STEM education

Overall, there is emerging global trend towards playful pedagogies in education particularly at the basic levels. In this study, there is consensus on the priority for play-based STEM education across the key stakeholders in Africa including education officials, school administrators, teachers, parents, and students who participated in this study. However, there is lack of clarity on how to articulate the priority areas across countries and even across stakeholders within the same country. Some of the countries have a detailed articulation of priorities with a bearing on play-based approaches and STEM education including the corresponding performance indicators for tracking progress in the education sector plans. Some were, however, brief or general in articulating priorities with a bearing on play-based STEM education. Furthermore, different terminologies were being used across the countries to characterise play-based STEM education that may cause misunderstanding and confusion. In most of the sample countries, there are initiatives focused on the play-based approaches at the primary schools, but they have not been fully integrated in the teaching and learning process. They are largely supported by development partners, and are localized in some regions within the countries. Additionally, several countries in the region have undertaken curriculum review or are in the process of reviewing or intending to undertake curriculum review towards the competency-based curriculum. This will demand the adoption of pedagogical practices that are congruent with competency-based curriculum and therefore present an opportunity for integration of play-based approaches in the education system. Meanwhile, the provision of resources and facilities for the implementation of STEM curriculum at the primary school level is a key priority of the education authorities in the region. While the governments are committing budgetary allocations for this component, there are partnerships with development partners either in the past or present, are providing resources and facilities including laboratories, equipment, and physical classrooms.

5.1.2 Understanding of play-based STEM education.

There were mixed views and understandings among the education stakeholders, regarding the meaning of play-based approaches in STEM education and their application at the primary school level. For instance, some of the senior education officials appeared skeptical about the role of play-based activities in the teaching and learning process while others acknowledged the potential of the approach in promoting learning STEM subjects. Senior education officials aware of the play-based approaches acknowledged that they were only being practiced at the pre-primary school level where

they are widely recognized and practiced. At least eight in ten teachers, school administrators and education officials at the sub-national levels demonstrated awareness of play-based approaches while at least five in ten had been trained on approaches with a bearing on play-based approaches. However, there were disparities across countries in terms of exposure to play-based approaches. Additionally, despite awareness and to some extent training on play-based approaches, the readiness to adopt the approaches was a challenge largely attributed to lack of guidelines and commitment from the education system to support integration of play-based approaches. Meanwhile, both students and parents were supportive of play-based approaches. Overall, the level of understanding of play-based approaches among the key stakeholders presents an opportunity for integrating and institutionalizing the delivery of STEM education in primary schools.

5.1.3 Initiatives focused on play-based STEM education at primary schools in Africa.

Several initiatives focused on improving the quality of education, including STEM education, at the primary school level are on-going in the region. A number of these are donor funded projects within and across countries, focused on promoting interactive and engaging teaching and learning through teacher professional development programmes coupled with student support with resources including online platforms and content for some of the projects. Additionally, there are ongoing initiatives at country level. For instance, teacher pedagogical boxes in some countries are stocked with contextualized teaching and learning materials to address the lack of conventional science laboratories. There are other initiatives voluntarily organized by science and mathematics teachers' subject associations at country level to promote student science fairs, clubs, and forums that create interest towards the subjects. Some programs structured and funded by governments in the region in partnership with donors include a range of initiatives, such as formalized in-service teachers' training, teacher coaching and mentoring support, and communities of practice where teachers either at school or cluster of schools meet regularly to address challenges in teaching while sharing best practices. Furthermore, at least nine in ten teachers were regularly participating in these initiatives. All the educators acknowledged that the initiatives have a positive impact on improving teaching and learning. The existing systems of teachers' support are potential avenues for integration and mainstreaming of play-based approaches in the delivery of STEM education at primary school level in Africa.

5.1.4 Enabler and barriers to integration of play-based STEM education in primary schools in Africa.

The key **enablers** to integration and mainstreaming of play-based approaches in the delivery of STEM education at the primary school level in Africa include:

a. **Level of awareness of and readiness for play-based approaches:** There is some level of awareness of and readiness for adoption of play-based approaches among key stakeholders including educators, parents, and learners in Africa. This presents an opportunity for integration and institutionalization of play-based approaches in the provision of STEM education at primary schools in Africa.

b. **Existing strategies in the education sector plans:** The education sector plans in several countries have identified strategies that are supportive of play-based approaches. While the interpretation and lack of implementation of these strategies may be a challenge, it also presents an opportunity and entry point towards integration and institutionalization of play-based approaches in the teaching and learning practices.

c. **On-going reforms in education in the regions:** There are on-going education reforms in several African countries including review of the education sector plans and national curriculum at the basic learning levels, which present an opportunity that could be leveraged as an entry point for integration and institutionalization of play-based approaches into the curriculum and education sector plans.

d. **On-going play-based and STEM education improvement initiatives:** There are currently on-going initiatives focused on play-based approaches and improvement of the quality of STEM education at the primary school level in several African Countries including in-service teachers training, school-based teacher coaching and mentoring support, and teacher communities of practice. These initiatives are potential avenues for integration and institutionalization of play-based approaches in the provision of STEM education at primary schools in Africa.

The key **barriers** follow under three categories: technical, institutional, and resources.

a. **Technical barriers:** include the low foundational skills in reading and numeracy for students in primary schools in Africa that impede the capacity for learning, coupled with a foreign language of instruction that creates an additional barrier to understanding scientific and mathematical concepts that have no equivalence in the learner's first language. Additionally, the inadequate number of and insufficiently qualified teachers further compounds the problem. Meanwhile, the heavy demand on teachers for delivery of an overloaded curriculum coupled with additional responsibilities in co-curricular and administrative duties leave them with little room for adoption of innovative pedagogical practices in the rush to cover the prescribed curriculum. Additionally,

learners' performance in STEM subjects at the basic learning level including primary schools is low, which reinforces the attitude among teachers, parents, and learners that these subjects are difficult. Furthermore, most of the countries lack a comprehensive monitoring and evaluation system with key indicators to track progress over time in the development of STEM education at the basic education level, including in primary schools. This presents a challenge not only in evaluating progress in STEM education but also in making decision on how to design effective programs and priotize areas for investment.

b. **Institutional:** the large class sizes at primary schools with an average of 73 learners per class across the countries and a high of 133 presents classroom management and pedagogical challenges that need to be considered when designing and implementing teacher professional development and school improvement programs in Africa. Furthermore, the situational analysis revealed that none of the sampled countries had a standalone policy on STEM education at the basic learning level, which was noted earlier as a challenge in designing programs, in mobilizing and in allocating resources for the implementation of STEM education programs.
c. **Resources:** The lack of resources and facilities for delivery of STEM subject curriculum at the primary schools in Africa was a constant theme in this study with nine in ten teachers identifying this as a key challenge. Very few public primary schools have established science laboratories and equipment for practical lessons in STEM subjects. Furthermore, there is inadequate funding for the implementation of the STEM curriculum yet investment in STEM education improvement interventions will require funding for staffing and infrastructure which were frequently mentioned to be inadequate in all the sample countries.

5.2 Recommendations

Based on the findings and conclusions in this study, several recommendations were made for integration of play-based STEM education at primary schools in Africa in the following sections.

5.2.1 Policy on play-based STEM education at basic learning level

The national education authorities need to develop and implement a policy on play-based STEM education at the primary school level with a focus on integration of play-based approaches in the teaching and learning of STEM education. This policy will lay the ground for structured engagement in the whole spectrum of delivery of quality STEM education, by informing strategies, mechanisms, resource mobilisation and funding models, structures, partnerships, collaboration, coordination, and quality assurance in the delivery of quality of STEM education at the basic education learning levels.

The policy should clearly articulate expected outcomes, and measurement, while ensuring harmonisation and coordination across multiple levels. The policy should further provide guidelines on how to support innovations generated by both teachers and students, including proprietary rights where necessary.

5.2.2 Mapping and sharing of play-based STEM education interventions.

Given the lack of an inventory of interventions on play-based STEM education in African countries, the government should conduct a mapping exercise of all existing interventions. The mapping should document; scale of operations, focus geographies, key strategies, timelines, reach, and impact, as well as funders. Using this information, the education authorities should establish a comprehensive database on existing interventions to be able to constantly assess whether the areas of need are being addressed as well as consolidation of emerging innovations and best practices. Furthermore, the education authorities should nurture a community of practice among the existing players in this area, and regularly convene forums for synthesis and dissemination of lessons learnt from the interventions. Through this process, a repository of contextual knowledge will be accumulated that will ensure relevance of interventions, harmonisation, and coordination of efforts in this critical sector. Finally, the ADEA ICQN-MSE should offer technical support in this exercise.

5.2.3 Resource mobilisation to fund play-based STEM education.

Given the potential for play-based approaches in improving the quality of STEM education at the primary school level, Education authorities in African countries should provide adequate funding to support accelerated integration and mainstreaming of play-based approaches for improved holistic learning outcomes.

5.2.4 Adequate staffing with STEM teachers at primary school

Currently, there are inadequate numbers of teachers at primary schools in the sample countries. Furthermore, the teachers were reported to be inadequately qualified to deliver the STEM curriculum at the primary school level. Additionally, teachers at the primary schools are not specialized. Therefore, primary schools should be staffed with adequate number of teachers while building their capacity through continuous professional development programmes. The potential to support teachers' subject specialisation, at least in the upper primary grades should be considered.

5.2.5 Strengthening continuous professional development and pre-service for teachers in STEM pedagogical content knowledge

A sustainable model for regular capacity building of STEM teachers of primary schools through different modalities should be implemented in each country. Already there are existing modalities including face-to-face training workshops, online courses, blended learning, communities of practice, and webinars that can be strengthened for delivery of the play-based STEM education agenda. These strategies should be articulated in the policy on STEM at the basic learning level to ensure that they are institutionalized. Meanwhile continuous research on play-based pedagogies in STEM should be mounted to generate insights on what is working and what is not.

5.2.6 School leadership training programmes on management of play-based STEM education

To ensure institutionalization and sustainability of school level play-based STEM initiatives, the school leadership including school head / directors, school boards of management or committees should be trained to secure their support in play-based STEM initiatives at the school level. This training could include resource mobilisations, benchmarks, standards for STEM education at primary schools, and monitoring quality of STEM education.

5.2.7 Improve terms and conditions of service for teachers

A recurring theme was the poor terms and conditions of service for teachers and therefore, strategies should be devised to attract people into the STEM teacher field, reduce teacher attrition, and improve commitment to delivery of the STEM curriculum. It was felt that teachers' salary and other conditions of service should be addressed. As part of these strategies, champion STEM teachers should be recognized to boost teacher motivation and commitment to improve quality of STEM education. An incentive system as part of the school STEM strategy could raise the profile of STEM education.

5.2.8 Provision of resources and facilities

Provision of resources and facilities was the most frequent recommendation as a way of achieving quality Play-Based STEM education. The resources and facilities that came up more frequently were classrooms, laboratories, laboratory equipment and chemicals, computers, textbooks, and internet connectivity. Therefore, the school leadership, parents, government, education authorities, and development partners should work collaboratively in provision of resources and facilities for STEM education.

5.2.9 Equipping of schools with adequate ICT infrastructure

There are indications that delivery of STEM curriculum could greatly benefit from integration of ICT in the pedagogy, and this was amplified in the advent of COVID19 pandemic where education authorities and individual schools explored opportunities of utilising ICT for continued learning of students while at home when in-person schools closed. Furthermore, several global and regional initiatives have emerged delivering STEM education at the basic learning levels in Africa through online platforms, while some are customized for offline access to content. Therefore, education authorities should continue to invest in ICT infrastructure including internet connectivity as a mode of curriculum delivery to ensure equitable access to quality STEM education at the primary schools in Africa.

5.2.10 Monitoring and Evaluation Framework for play-based STEM education

Drawing from the policy on STEM education at the basic learning levels, a framework for guiding quality assurance needs to be developed. This is an important tool that determines the quality aspects to be assessed, the benchmarks and standards for assessments, and the process of assessment. The set benchmarks and standards of performance, facilitate the assessment process and determine quality, and the use of feedback in decision making or constructive discourse on quality issues of STEM education. Quality assurance is diverse and context specific, the aspects of quality, standards of performance, benchmarks and target thresholds need to be clearly defined. As part of the monitoring and evaluation framework, countries in Africa need to develop and use Key Performance Indicators (KPIs) aligned with specific strategies or interventions for tracking progress of STEM education at the primary school. The indicators may be relevant at the national or school level, while others maybe cutting across the different levels of the education system.

5.2.11 Sensitisation programme for parents and communities on play-based STEM education

Parents have a critical role in the education of their children and are part of the solution to the delivery of quality STEM education at the primary school level. In this context, parents support the school in providing resources and facilities for STEM, participating in school forums for STEM such as science and technology fairs, and encouraging the children to pursue STEM subjects, and careers. The schools with support of education authorities need to mount regular sensitisation programs on awareness of STEM education for parents and communities in order to secure related support in terms of resources or motivation for the children, to create interest in STEM subjects and careers.

5.2.12 Science and Technology fairs and excursions

The STEM education interventions should include learner's exposure initiatives through educational opportunities to spark interest and develop a passion for the subjects. Several countries in Africa are running science fairs for students, either at individual school level, or in cluster of schools, nationally, or regionally and this ought to be sustained and improved.

REFERENCES

African Union. (2005). *Second Decade of Education for Africa (2006-2015) Plan of Action.* Addis Ababa: African Union.

African Union. (2015). *African Union Agenda 2063 Framework Document.* Addis Ababa: African Union.

African Union. (2015). *Continental Education Strategy for Africa 2016-2025.* Addis Ababa: African Union.

Ahmed, H. O. (2016). Strategic future direction for developing STEM education in higher education in Egypt as a driver of innovation econonmy. *Journal of Education and Practice, 7(8)*, 127-145.

Ali, E., Constantino, K. A., Hussain, A., & Akhtar, Z. (2018). The effects of play-based learning in early childhood development. *Journal of Evolution of Medical and Dental Sciences, 7(43)*, 6808-6811.

Arends, R. I. (2012). *Learning to Teach, 9th Edition.* New York: McGraw-Hill.

Asabere, A. A., & Mereka, D. K. (2009). Comparative analysis of performance of eighth graders from six African countries. *Mathematic connection volume 8*, 17-27.

Ayot, H. O., & Patel, M. M. (1992). *Instructinal Methods.* Nairobi: Educational Research Publications.

Basham, J. D., Israel, M., & Maynard, K. (2010). An ecological model of STEM education: Operationalizing STEM for All. *Journal of Special Education Technology, 25(3)*, 9-19.

Bleakley, A., & Carrigan, J. L. (1994). *Resource Based Learning Activities: Information Literacy for High School Students.* Chicago: American Library Association.

Bold, T., Filmer, D., Martin, G., Molina, E., Stacy, B., Rockmore, C., . . . Wane, W. (2017). Enrollment without Learning: Teacher Effort, Knowledge and Skill in Primary Schools in Africa. *Journal of Economics Perspectives*, 1-31.

Briggs, M., & Hansen, A. (2012). *Play-based learning in the pirmary school.* Thousands OAKS, California 91320: SAGE Publications Ltd.

Broemmel, A. D., Jordan, J., & Whitsett, B. M. (2016). *Learning to be a Teacher Leaders: A Framework for Assessment Planning and Instruction* . New York: Routledge: Francis and Taylor.

Bronfenbrenner, U. (1979). *The Ecology of Human Development: Experiments by Nature and Design.* Cambridge: Harvard University Press.

Buck Institute. (2020, December 22). *PBL Works.* Retrieved from Buck Institute for Education: https://www.pblworks.org/what-is-pbl

Carnegie Mellon University. (2020, November 9). *ww.cmu.edu.* Retrieved from STEM Education - Carnegie Mellon University: https://www.cmu.edu/gelfand/documents/stem-survey-report-cmu-iu1.pdf

CDC Harvard University. (2016). *Best Practices to Breakthrough Impacts.* Cambridge, MA: CDC Harvard University.

CEMASTEA. (2019). *Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) Strategic Plan 2020-2024.* Nairobi: CEMASTEA.

Darling-Hammond, L., Flook, L., Harvey, C. C., Baron, B., & Osher, D. (2020). Implications for education practice of the science of learning and development. *Applied Developmental Science 24(2)*, 97-140.

Engineering for Kids. (2020, November 12). *Why is STEM Education So Important?* Retrieved from Engineering for Kids: https://www.engineeringforkids.com/about/news/2016/february/why-is-stem-education-so-important-/

European Union. (2010). *Science, Technology and Innovation in Europe.* Luxembourg: European Union.

Ezekwesili, O. (2022, March 1). *Literacy Rates: Access alone has not guaranteed that children are learning in schools*. Retrieved from the africa report: https://www.theafricareport.com/180027/africa-access-alone-has-not-guaranteed-that-children-are-learning-in-schools-says-ezekwesili/

Fomunyam, K. G. (2020a). Introductory Chapter: Theorizing STEM Education in the Contemporary Society. In K. G. Fomunyam, *Theorizing STEM Education in the 21st Century* (pp. 1-5). London, United Kingdom: IntechOpen.

Formunyam, K. G. (2020). Massifying Stem Education in Africa. *International Journal of Engineering Research and Technology, 13(2)*, 253-260.

Freeman, B., Marginson, S., & Tytler, R. (2019). An International view of STEM education. In A. Shahin, & M. J. Mohr-Schroeder, *STEM Education 2.0* (pp. 350-363). Leiden, The Netherlands: Brill Publishers.

Gonzalez, H. B., & Kuenzi, J. J. (2012). *Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer.* Washington D.C.: Congressional Research Service.

Government of Japan. (2020, 12 10). *Cabinet Office, Government of Japan*. Retrieved from Science and Technology Administration in Japan: https://www8.cao.go.jp/cstp/english/about/administration.html

Hadani, H. S., & Rood, E. (2018). *The Roots of STEM Success: Changing Early Learning Experiences to Build Lifelong Thinking Skills.* San Diego, California: Center for Childhood Creativity.
Hanushek, A., & Woessmann, L. (2010). Education and Economic Growth. *International Encyclopedia of Education Volume 2*, 245-252.
Heritage, M. (2010). *Formative Assessment: Making It Happen in the Classroom.* Thousand Oaks, California 91320: Corwin.
Herr, J. (2001). *Creative Learning Activities for Young Children.* Albany, NY 12212-5015: Delmar Thompson Learning.
Hirsch, C., & Supple, D. B. (1996). *61 Cooperative Learning Activities in ESL*. Portland, Maine 04104-0658: J.Weston Walch.
Hirsh-Pasek, K., & Hadani, H. (2020). *A new path to education reform: Playful learning promotes 21st Century skills in schools and beyond.* Washington DC: Center for Universal Education, Brookings Institution.
Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K-12 contexts. *International Journal of STEM Education, 5(3)*, 32.
IBE-UNESCO. (2019). *Exploring STEM Competences for the 21st Century* . Paris: UNESCO.
Jackson, R. R. (2011). *How to Plan Rigorous Instruction: Mastering the Principles of Great Teaching.* Washington DC: Mindsteps.
Jamme, M. (2020, November 10). *World Economic Forum*. Retrieved from What STEM can do for Africa: https://www.weforum.org/agenda/2015/01/what-stem-can-do-for-africa/
Kahan, J. A., Cooper, D. A., & Bethea, K. A. (2013). The Role of Mathematics Teachers Content Knowledge in thier Teaching: A Framework for Research applied to a Study of Student Teachers. *Journal of Mathematics Teacher Education, 6:3*, 223-252.
Kattan, R. B. (2018, March 29). *Quality education for all: measuring progress in Francophone Africa*. Retrieved from The World Bank: http://blogs.worldbank.org/education/quality-education-all-measuring-progress-francophone-africa
Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM Education. *International Journal of STEM Education*, 1-11.
Kids of Excellence. (2016, October 3). *Understanding STEM in play-based curriculum*. Retrieved from Kids of Excellence: https://www.kidsofexcellence.com/news/understanding-stem
Kloser, M. J. (2014). Identifying a Core Set of Science Teaching Practices: A Delphi Expert Panel Approach. *Journal of Research in Science Teaching, 51(19)*, 1-13.
Koketso, L. P. (2015). STEM education in Botswana: understanding the gender disparity in enrolment and. *Unpublished Master Thesis, Concordia University, Montreal, Canada*, 1-103.
LaForce, M., Noble, E., King, H., Century, J., Blackwell, C., Holt, S., . . . Loo, S. (2016). The eight essential elements of inclusive of STEM HIgh Schools. *International Journal of STEM Education*, 1-11.
Li, Y., & Oliveira, H. (2015). Research on Classroom Practice. *The Proceedings of the 12th International Congress on Mathematical Education* (pp. 489-496). Seoul: SpringerLink.com.
Mansfield, J. W. (2020, November 9). *Researchgate.* Retrieved from https://www.researchgate.net/: https://www.researchgate.net/publication/276076320_The_Congressional_Science_Technology_Engineering_and_Mathematics_STEM_Education_Caucus_and_the_Congressional_Academic_Competition_History_and_Current_Practice
Margot, C. K., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education, 6(2)*, 1-16.
Marzano, R. J. (2005). *A Handbook for Classroom Instruction That Works.* Upper Saddle River, N.J: Pearson / Merrill Prenctice.
Matachi, A., & Kosaka, M. (2017). JICA's support to education in Africa in the last two decades: Focusing on mathematics and science education. *Journal of International Cooperation in Education, 19(2)*, 35-53.
Moore, D., Edwards Susan, Cutter-Mackenzie-Knowles, A., & Boyd, W. A. (2014). *Young Children's Play and Environmental Education in Early Childhood Education.* New York: Springer Cham Heidelberg.
Munna, A. S., & Kalam, M. A. (2021). Teaching and learning process to enhance teaching effectiveness: a literature review. *International Journal of Humanities and Innovation (IJHI) Volume 4(1)*, 1-4.
Nancino-Brown, R., Oke, F. E., & Brown, P. D. (1982). *Curriculum and Instruction: An Introduction to Methods of Teaching.* London: Macmillan.

National Science Foundation. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington D.C: The National Academies Press.
OECD. (2016). *Innovating for Education and Educating for Innovation.* Paris: OECD Publishing.
OECD-PISA. (2003). *Learners for Life; Student Approaches to Learning Results from PISA.* Paris: OECD.
Oers, B., & Duijkers, D. (2012). Teaching in a play-based curriculum: Theory, practice and evidence of developmental education for young children. *Curriculum Studies 45(4)*, 1-24.
Ohanyido, C. (2018, March 29). *The Pivotal Role of Education in Africa's Development*. Retrieved from Global Education Conference: http://www.globaleducationconference.com/profiles/blogs/the-pivotal-role-of-education-in-africa-s-development
Oliver, M. R., & Reschly, D. (2007). *Effective Classroom Management: Teacher Preparation and Professional Development.* Washington DC: National Comprehensive Center for Teacher Quality .
Ottevanger, W., Akker, J., & Feiter, L. (2007). *Developing Science, Mathematics,and ICT Education in Sub-Saharan Africa; Patterns and Promising Practices.* Washington DC: World Bank.
Parker, R., & Thomsen, B. S. (2019). *A study of playful integrated pedagogies that foster children's holistic skills development in the primary school classroom.* Billund, Denmark: LEGO Foundation.
Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning through play at school: A framework for policy and practice. *Frontiers in Education, 7*, 1-12.
Patricia, C. K. (1987). Teaching for Learning. *American Association for Higher Education (AAHE), Volume 39(8)*, 1-6.
Price, K. M., & Nelson, K. L. (2014). *Planning Effective Instruction: Diversity Responsvie Methods and Management.* Belmont, CA 94002-3098: Wadsworth Cengage Learning.
Roberts, T., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Cavalcanti, M., Schroeder, D. C., . . . Cremeans, C. (2018). Students' perceptions of STEM learning after participating in a summer informal learning experience. *International Journal of STEM Education, 5(35)*, 1-14.
Sharma, A. (2016). *Innovative Teaching by Creative Tools and Teacher's Role.* New Delhi: Educreation Publishing.
Singer, D. G., Golinkoff, R. M., & Hirsh-Pasek, K. (2006). *Play=Learning: How Play Motivates and Enhances Children's Cognitive and Social-Emotional Growth.* New York: Oxford University Press.
Stewart, E. B. (2000). *An ecological perspective of science and math academic achievement among African American students.* Ames: Iowa State University.
The Planet Earth Institute. (2016). Generation Science: Empowering Africa's Future Scientific Leaders. *ScienceAfrica UnConference* (pp. 1-9). London: The Planet Earth Institute.
Tuttle, H. G. (2009). *Formative Assesssment: Responding to Your Student.* New York: Eye on Education Inc.
U.S. Department of Commerce. (2020, November 12). Retrieved from STEM Jobs: 2017 Update: https://www.commerce.gov/sites/default/files/migrated/reports/stem-jobs-2017-update.pdf
UN Economic Commission for Africa. (2011). *Climate Change and Water Resources of Africa: Challenges, Opportunities and Impacts.* Addis Ababa: UNECA.
UNESCO. (2012a). *Mobile Learning for Teachers: Global Themes. UNESCO Working Paper Series on Mobile Learning.* Paris: UNESCO.
UNESCO. (2014). *EFA Global Monitoring Report: Teaching and Learning, Achieving Quality for All.* Paris: UNESCO.
UNESCO-UIS. (2006). *Teachers and Educational Quality: Monitoring Global Needs for 2015.* Monstreal: UNESCO Institute of Statistics.
UNICEF. (2018). *Learning through play - Strengthening learning through play in early childhood education programmes.* New York: UNICEF.
United Nations. (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development.* New York: United Nations.
United Nations. (2020, 12 10). *Science, Technology and Innovations (STI) and Culture for Sustainable Development and the MDGs*. Retrieved from United Nations Economic and Social Council: https://www.un.org/ecosoc/en/content/science-technology-and-innovation-sti-and-culture-sustainable-development-and-mdgs
Veiga, G., O'Connor, R. A., Neto, C., & Reiffe, C. J. (2020). Rough-and-tumble play and the regulation of aggresssion in preschoolers. *Early Childhood Development and Care*, 1-13.
Wanjiru, N. J. (2017, October 20). Factors Contributing to Poor Performance in Primary Schools in the Kenya Certificate of Primary Education (KCPE) in Gatundu Division, Gatundu District, Kiambu County, Kenya. Nairobi, Kiambu, Kenya. Retrieved from http://ir-library.ku.ac.ke/bitstream/handle/123456789/7035/Ngaruiya%20Joyce%20Wanjiru.pdf?sequence=3

Wenglinsky, H. (2001). *Teacher Classroom Practices and Student Performance: How Schools Can Make a Difference.* Princeton, NJ 08541: Education Testing Service.
White, D. W. (2014). What Is STEM Education and Why Is It Important? *Florida Association of Teacher Educators Journal, 1:14*, 1-9.
White, D. W. (2020, November 29). *What Is STEM Education and Why Is It Important?* Retrieved from STEM BEST PRACTICE: http://stembestpractice.com/what-is-stem-education-and-why-is-it-important/
World Bank. (2021, December 31). *The World Bank*. Retrieved from GDP growth (annual %) - Sub-Saharan Africa: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=ZG
World Bank. (2022a, December 14). *The World Bank in Africa*. Retrieved from The World Bank: https://www.worldbank.org/en/region/afr/overview
World Bank. (2022b, (n.d.) (n.d.)). *Population growth (annual %)*. Retrieved from The World Bank: https://data.worldbank.org/indicator/SP.POP.GROW?view=chart
World Bank. (2022c, (n.d.) (n.d.)). *Population ages 0-14 (% of total population)*. Retrieved from The World Bank: https://data.worldbank.org/indicator/SP.POP.0014.TO.ZS?view=chart
World Bank. (2022c, December 14). *The World Bank in Africa*. Retrieved from The World Bank: https://www.worldbank.org/en/region/afr/overview
World Bank. (2022d, (n.d.) (n.d.)). *The Work Bank*. Retrieved from World Bank Open Data: Indicators: https://data.worldbank.org/indicator
Wright, L. M. (2016). *How Does Play in Dramatic Play Centers Help Preschool Children Develop Oral Language and Literacy Skills?* Minneapolis, Minnesota: Walden University Scholar Works.
Zosh, J. M., Hopkins, E. J., Jensen, H., Liu, C., Neale, D., Hirsh-Pasek, K., . . . Whitebread, D. (2017). *Learning Through Play: A Review of the Evidence.* Billund, Denmark: LEGO Foundation.

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