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Integrating Child Art as a Pedagogical Strategy for Teaching Science, Technology, Engineering and Mathematics at Early Childhood Development Level in Bulawayo Central District, Zimbabwe

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ABSTRACT: *As knowledge regarding human development and learning continues evolving due to the global influences it has created an undeniable opportunity in researching on contemporary educational practice. Science, Technology, Engineering and Mathematics (STEM) is influencing educational practice from basic to tertiary education. This study acknowledges that teachers are essential and direct agents to supporting early STEM learning. Thus, this study is predominately a qualitative research approach with an interpretive epistemological and constructivist ontological perspective. Data was collected through semi-structured interviews from ten purposively sampled Early Childhood Development (ECD) teacher participants and formal analysis of 30 child art production (visual analysis of artefacts). The study affirmed that, art practice at ECD is a compatible strategy for early STEM learning. It was found that ECD learners' attitudes are receptive of art practice as a constructivist approach. The results revealed that teachers used learner development checklists and child art as a tool to measure learner development and progress in STEM. The findings of the study established that teachers and learners encountered challenges such as limited teaching and learning resources, lack of expertise among some teachers, parental interference and content overload. Despite the indicated challenges, the study concluded that the integration of child art as a pedagogical strategy enhanced imparting of STEM skills among learners at ECD level. The study recommended that the Ministry of Primary and Secondary Education should capacitate ECD teachers through professional development programmes that focus on ECD STEM learning and teaching.*

KEY WORDS: competence-based curriculum, continuous assessment, child art, early childhood development (ECD), science, technology, engineering and mathematics (STEM).

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INTRODUCTION

The introduction of the Competence-based Curriculum (CBC) in Zimbabwe meant a shift on the general aims and objectives of Early Childhood Education (ECD) system as stipulated in the Curriculum Framework for Primary and Secondary Education, 2015-2022. The transformation meant changes in the way learners were taught and assessed. The move was also from an academic oriented curriculum to one that is skills-based. In the updated curriculum, early childhood teachers play a key role in assessment through designing and implementing continuous assessment tasks in all learning areas. The Ministry of Primary and Secondary Education (2015) notes that, Zimbabwe's involvement in a new world-wide economy is premised on a system of education with a Science, Technology, Engineering and Mathematics (STEM) bias. Therefore, Zimbabwean learners need an early foundation in literacy and numeracy at the same time being exposed to the essential concepts of science and technology (Country Liaison Report, Early Childhood, 2017). In that respect, edvoiceviii, (2015) acknowledges that research in ECD indicates that early years mark the beginning of science talent. In addition, children are born with this innate sense of wonder. Thus, in order to make sense of their place in the world, children begin their lives already demonstrating the skills of a scientist through observing and questioning the environment. As a result, the ECD learners' achievement and conceptual understanding of science would be adversely affected if they are not given an early exposure to science instruction (Ong, Ayob, Ibrahim, Adnan, Shariff, & Mohd 2016).

It is important to note that if any two of the four disciplines mentioned above are intentionally emphasised then an activity can be considered STEM (Milford & Tippett 2015). Accordingly, for learners to be productive citizens, STEM education should empower them with the most important skills needed. Such skills include: taking initiative and being enterprising; oral and written communication skills; critical thinking and problem-solving; agility and adaptability; collaboration and leading with influence; and capability to access and analyse information. Hence, providing these skills prepares learners to actively participate and contribute expressively towards economies of the future (edvoiceviii, 2015; Ministry of Primary and Secondary Education, 2015). According to Transforming the Workforce for Children Birth Through Age 8, (2015) research reveals that a lot has been noticed cognitively, socially, and emotionally in young children including infants which scientists and education professionals did not previously know. They further explain that, children in their early years, start to learn about the world in sophisticated ways that are not always mirrored in their noticeable behaviour. Furthermore, it is noted that young learners' learning and development which are both rapid and cumulative, continue to lay a foundation for later learning. Hence, it is essential to explore how the selected participants integrate child art as a pedagogical strategy for teaching STEM at ECD level.

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Background

This study acknowledges that teachers are essential in supporting early STEM learning. Nevertheless, studies indicate that a lot of early childhood teachers have limited expertise to teach STEM concepts to young children in developmentally suitable ways. Literature indicates that some of the ECD teachers are inadequately prepared in significant STEM knowledge, and pedagogical approaches that support acquisition of that knowledge. Additionally, it has been observed that the teachers do not have access to professional development prospects in STEM and high-quality resources that can support all learners accomplish standards-based STEM learning outcomes in a speedily varying educational landscape (edvoiceviii, 2015; Ong et al 2016; Chen & Tippett, 2022). With regard to teacher preparation and professional development, Brenneman, Stevenson-Boyd and Frede (2009) and Bustamante, Greenfield and Nayfeld, (2018) posit that several kindergarten teachers find it difficult to teach Mathematics and Science concepts. The authors go on to argue that pre-service training programmes should offer chances for integrating Mathematics and Science into teaching practice. In-service professional development should be designed in a way that allows teachers to explore deeply the content and pedagogy of STEM learning instead of just one-day workshops. In addition, a lot of adults, as well as teachers, undervalue what young learners are able to learn, and for that reason, might not make available lots of chances for learners to realise numbers, patterns, and relationships, or to intermingle with the scientific phenomena or practices that set the stage for later STEM learning (Pasnik & Hupert, 2016). Ong, et al., (2016) and Bustamante, Greenfield and Nayfeld, (2018) observe that, although Science and Mathematics are included in the kindergarten, primary and secondary curricular, these subjects are not clearly taught in the early childhood curriculum. More so, it has been observed that in pre-school classrooms suitable approaches for implementing STEM teaching remains not known. Furthermore, scholars mention that if curiosity and enthusiasm for Science among learners is not fostered in the early grades, these aspects may continually diminish. Such attenuation of curiosity in Science will result in learners either developing interest in another discipline instead of STEM, or losing the aspiration to pursue an advanced course in Science (Pasnik & Hupert, 2016; Ong, et al., 2016). Moreover, research on STEM funding appears to be skewed toward older learners (McClure, Guernsey, Clements, Bales, Nichols, Kendall-Taylor & Levin, 2017).

Thus, due to lack of adequate funding in ECD, Milford and Tippett (2015) argue that there is limited information about how a STEM curriculum in the early years classroom may best be implemented. In addition, the tools for collecting data precisely crafted for early childhood STEM are inadequate. In the wake of the Competence-based Curriculum (CBC), Early Childhood Education needs to position itself to new insights into learning and teaching of STEM.

Linked with the above, it is important to comprehend CBC requirements in order to meaningfully improve early Science and Technology learning. For example, teachers, researchers, and policy makers who devote time in early learning situations see these encounters played out on a daily basis and realise that they are all held to a single driving need to afford high-quality early learning

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experiences to every child. Pasnik and Hupert (2016) acknowledge that teachers should generate spaces where learners can experience STEM in arts, reading, and in the community. This includes exposing all learners to the concepts, vocabulary, and experiences that go along with robust and developmentally applicable to STEM undertakings and preparing their educators to support this endeavour.

In this study the researchers observed that a lot of childhood art in different communities that could be useful for STEM learning is lost or goes undocumented for various reasons. Hitherto, all children are born artists and can easily record events artistically, thus, every child is born with creative potential (Menzer, 2015). Previous studies have shown that in a majority of cases children prefer to draw their experiences rather than writing it down or report orally. Proponents for child art and psychology like Lowenfeld (1957), claim that young children are explorers of their environment, that is, environment filled with unusual things, first experiences, and tentative explanations. Drawings can be regarded as the reflections of mental images on papers. As a language and mode of communication, art provides children the chance to play with ideas and make conclusions about themselves and their experiences, aspirations to be heard and understood by the surrounding people (Menzer, 2015; Oguz, 2010). In this regard, researchers have noted that there are a lot of scientific and technological experiences that children are exposed to in their childhood.

In line with the background, this study found it most appealing and appropriate to pursue childhood art practice as a pedagogical strategy for teaching STEM. More so, as a data collection device for ECD in Science and Technology. The focus was on forms of art that express the author's imaginative skill and emotional power but not necessarily intended to be appreciated for their beauty. As Chen and Tippett, (2022) highlight, the fundamental feature of early childhood STEM education is not the responses acquired but the chances for learners to discover concepts and conduct inquiries of their ideas. The common problems in children's daily lives are a source of STEM teaching content. The knowledge on how a child develops and learns, together with cognitive development, specific content knowledge and skills, general learning competencies, socioemotional development, and physical development and health is critical for adults with professional responsibilities for young learners (Transforming the Workforce for Children Birth Through Age 8, 2015). Curiosity and enthusiasm for science among children might persistently reduce if not nurtured in the early grades. Accordingly, important research questions emerged from this scenario:

- How is STEM education effectively implemented in early childhood learning environments?
- How is childhood art practice integrated as a pedagogical strategy for early childhood STEM learning?
- What are the challenges encountered by teachers and learners in integrating child art in STEM learning at Early Childhood Development level?

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LITERATURE REVIEW

Child Art and STEM Learning

According to Bretton (2021) in children's minds, chairs turn out to be horses, sofas turn into race cars, ladders become spaceships, and this is an indicator that children are masters of the make believe. Based on the work of Partnership for 21st Century Learning and National Research Council of America Bybee (2013) proposes a STEM skill set that consists of complex communication skills and self-development, adaptability, systems thinking, and non-routine problem solving skills. The extant literature put forward that through STEM education practices that use real world contexts and present learners with authentic problems or projects to work upon, the stated proficiencies are well developed (Hefty, 2015; Kelley, Brenner, & Pieper, 2010; Redmond, Thomas & High, 2011). Children stop or quit the role of being learners when they feel uncomfortable, under pressure or distracted. Such practices by teachers result in boredom, feeling confused and losing focus. However, through engagement, child art can be a source of inspiration to liking of STEM subjects as both of these abhor the traditional learning practises. The aim to provide child art activities to ECD learners does not focus on training artists but, to offer opportunities for self-discovery and self-discipline. This helps learners to relate to their environment as integrated healthy individuals. Thus, the issue of child art is critical as it supports the development of a learner in numerous ways, for instance, broadening their cognitive, social, problem solving and personal competencies, together with their physical, verbal and emotional development, hence, it becomes an important building block in the early years of learning (Danko-McGhee & Slutsky, 2007). In view of this, child art supports manifold means of knowing and learning that are innate in the exceptional nature of each learner. Therefore, child art offers opportunities for learners to develop creativity, imagination, and flexible thinking and enables them to communicate, represent, and express their thoughts, feelings, and perceptions (Cinquemani & Kraehe, 2020). Accordingly, it was critical for the researchers to probe how childhood art was integrated as a pedagogical strategy for early childhood STEM learning.

Early Childhood STEM Uptake

Globally, there is rather pervasive low uptake of science-based subjects (Ong et al, 2016). This is because there are obstacles to STEM learning for young learners which are more complex, subtle, and persistent than decision makers currently realise (McClure et al 2017). According to Pasnik and Hupert, (2016) several questions are raised concerning how best to transform the existing trend of early STEM learning. Such questions include:

- How will early learning teachers be prepared to teach STEM topics in developmentally appropriate ways?
- What kind of resources should be accessed by teachers?
- What role should parents and other family members play in supporting the STEM engagement of young children?

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Regrettably, it is all too easy to lose sight of the natural curiosity piping from young children in this educational climate's push toward standardisation and a one-size-fits-all curriculum (edvoiceviii, 2015). Furthermore, suitable approaches for implementing STEM teaching in ECD classrooms continue to be not known (Chen & Tippett, 2022). Still, teachers encounter low self-confidence, anxiety, and gendered assumptions about STEM topics, and these aspects might be transferred to their learners (McClure et al 2017). However, Mathwasa and Sibanda (2021) acknowledge that teachers in the early learning years should be competent, confident, more flexible, and skilled, when teaching ECD learners since they have the ability to positively change and transform the lives of learners.

In Zimbabwe, capacity building of current practising teachers is necessary to reinforce foundation in ECD philosophy, teaching methods and approaches. Besides, the ECD facilities, infrastructure and equipment in schools are not appropriate for ECD learners (Country Liaison Report, Early Childhood, 2017). Similarly, there is underrepresentation of Science and Engineering instruction at ECD classrooms in the United States, especially, in programmes designed for learners from low-income families. Likewise, the programmes designed to prepare teachers fall short of capacitating pre-school teachers to teach STEM content. Accordingly, the ECD teachers have developed a feeling of being intimidated and under-preparedness to teach science, and sometimes, they self-select into Early Childhood specifically to avoid it (Bustamante, Greenfield & Nayfeld, 2018).

In overcoming such decline, it is advisable that all ECD learners should be exposed early to STEM opportunities and be given chances to participate in inquiry-based learning. In the same way, research-based STEM preparation should be made available for general education including elementary teachers in the area of pre-service training and professional development (Ong et al, 2016). Notwithstanding, the presence of learning standards and improved curricular attention to Mathematics and Science, there is a tendency of not putting much emphasis in preparation of teachers or in-service professional development programmes. It is evident that pre-school teachers are reluctant to promote Mathematics and Science learning (Brenneman, Stevenson-Boyd & Frede, 2009). Hence, the important elements to consider in pre-service and in-service training are that they should be substantive, interconnected, and ongoing, and concepts taught should contain STEM content, child developmental learning progressions in STEM, and well-modelled, and practiced pedagogy (McClure et al 2017). A suitable science curriculum at ECD level should encourage and motivate learners to enable mastery of basic skills considering their intellectual capability. Instead of just teaching, teachers are expected to assist learners in their learning by exposing them to experiences known to benefit young learners. In this regard, through inquiry-based learning in the classroom, the science proneness among learners could be nurtured (Ong, et al 2016; Pasnik and Hupert, 2016). Learners might be reinvigorated to be insightful, imaginative, and creative when they are directed by well-informed, considerate individuals who permit them freedom to express ideas, feelings, and imaginations in a manner suitable to their level of development and ability (Martin, 2001). As a result, the researchers realised that there is literature

dearth in the problem understudy and found it prudent to conduct this study guided by the stated research questions.

MATERIALS AND METHODS

This study is predominately a qualitative research approach guided by interpretive epistemological and constructivist ontological perspective (Creswell, 2012). This was done through prolonged participatory qualitative strategies, engagements and the use of multiple data sources from institutions for triangulation. The proponents for qualitative constructivist-interpretive paradigm according to Creswell (2013), argue that learning what people make of the world around them, how people interpret what they encounter, and how they assign meanings and values to events or objects is the fundamental principle of understanding in research. In this regard, qualitative data were collected through semi-structured interviews from purposively sampled ten ECD A and ECD B, teacher participants from selected schools. This data helped to bring out broad trends that reflect on the integration of child art as a pedagogical strategy for teaching STEM at ECD level. It was also important to go beyond interviews and document analysis so as to verify data and improve credibility and trustworthiness. More qualitative data were collected through formal analysis of child art production (visual analysis of artefacts). By taking this standpoint the researchers presumed that social phenomena and the meaning of it are subject to the influence of social actors which are produced and constantly changed by social interaction (Thornburg & Chapman, 2014; Creswell, 2012, 2013). Ethical issues such as informed consent, confidentiality and protection from harm were considered when conducting the study. To conceal identity, the teacher participants were coded as ECDT1-10.

Results

The teaching experience of ECD teachers in the study ranged from two terms to 10 years. The sample included recently qualified teachers who were familiar with new models of teaching and learning and those who were educated in the old system but have vast experience. Besides the subject specialists, the majority of the teachers taught Science, Technology and Mathematics. Engineering as a learning area was not popular amongst all the teachers in the study. The teachers indicated that engineering concepts are implied in the syllabus and not directly specified.

Learners' uptake of STEM Learning Areas

STEM learning is misconceived by many people, for example, it is regarded as suitable for learners in upper classes, young learners should be taught other concepts first, it is only essential for those learners who outshine in these disciplines, that STEM subjects and other learning areas should be taught distinctly (McClure, et al., 2017). Given this background the study sought to establish ECD learners' uptake of STEM learning areas. There was a mixed reaction on the uptake of STEM by ECD learners with the majority ranging from average to above average. Only a few teacher participants considered the uptake to be below normal especially in the rural areas.

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Motivation of ECD learners in integrating Child Art during STEM Lessons

The study sought to establish how teachers motivated their learners as they integrate child art during STEM lessons. The participant responses are captured verbatim below:

> *I use of drawings related to the STEM lessons in the syllabus e.g. human body*. (ECDT1)
> *Teachers use rhymes related to the topics; learners memorise rhymes e.g. parts of the computers*. They also draw the named parts of a computer, e.g. mouse. (ECDT 2)
> *As ECD teachers we use realia e.g. concrete objects; use of media depends on the topic, e.g. counters are used for Mathematics concepts. They also draw the counters and match numbers* (ECDT 3)
> *Use of attractive media motivates learners.* (ECDT 4)
> *I display learners' art work and this motivates them. I also use Scratchy or Blocky games; laptops to watch videos; learners associate with cartoons they see on TV.* (ECDT5)
> *Learners are given stickers in the form of stars when they excel and they become excited.* (ECDT6)
> *With ECD learners, I use learner centred methods which motivate learners as they actively participate in learning. The activities include drawing, colouring and many others.* (ECDT7)
> *ECD learners learn better through play, we also expose them to radio lessons and learners are motivated.* (ECDT 8)
> *ECD learners are motivated when teachers use captivating lessons; learners want to manipulate objects.* (ECDT 9)

The participants' responses suggest that ECD learners are motivated by actively participating in STEM activities during lessons. These activities involve drawing, matching, colouring, reciting rhymes, playing games related to STEM concepts, and manipulating toy laptops to watch videos. In addition, the study found that use of realia, stickers in the form of stars, learner centred methods and captivating lessons motivate learners during STEM instructional delivery. The findings of this study are in line with the views of authorities that learner motivation in the classroom is promoted by three major considerations about the tasks and conditions learners confront: the nature of the learner and his or her expectations of success; and the nature of the learning environment and the extent to which it emphasises learning goals and provides support and the nature of the task and its value to the learner (Darling-Hammond, 2020). In the same vein, mastery motivational climates are based on three tenets associated with young learners. Therefore, the type of goal orientation a learner adopts can be influenced by the climate created by the teacher (Rudisill & Johnson, 2018).

Learning and Teaching Strategies used in Integrating Child Art during ECD STEM lessons

The study sought to establish the preferred methods of learning and teaching in integration of child art during ECD STEM lessons. It emerged from the findings the teaching and learning strategies

employed by teachers during ECD STEM lessons included games, demonstration, experimentation, role play, group work and discovery learning. For instance, the participants gave the following views:

> *We use various strategies which include experimentation, games, including computer games,* use of videos and educative cartoons, *puzzles, e.g. Subtraction games to motivate the learners.* (ECDT1)
> *The strategies used are teacher centred methods, for example, demonstrations because leaners are too young to do the experiments on their own. Learners will express themselves through art work and this reinforces the concepts taught.* (ECDT2)
> *We also use role play, learners learn through practicing and doing, they will then draw or do painting illustrating the characters in role play*. (ECDT3)
> *I use demonstrations, some learners are not aware of skills so they can imitate, learn by doing repetitive tasks.* (ECDT5)
> *We use discovery learning; art work activities, learner centred methods; group work discussions, these strategies help learners understand when they interact and an opportunity to explore.* (ECDT6)

The results of the study indicated that ECD teachers used varied teaching and learning strategies in integrating child art during ECD lessons. The strategies involved allowing learners to manipulate objects giving them opportunity to explore using objects, art work activities, discovery learning, collaborative learning, leaner centred methods, use of games, including computer games, use of videos and educative cartoons, puzzles to encourage critical thinking, role playing, experimentation to develop problem solving skills and demonstration. The results of this study are consistent with the observation that in Early Childhood, science and engineering are naturally happening, appealing, and goal-directed hands-on, minds-on, collaborative activities where learners plan and carry out inquiries or solve problems instead of memorising facts. Learners, though, cannot only go so far on their own, hence, the role of the adult becomes critical for learners' effective science and engineering learning (Bustamante, Greenfield & Nayfeld, 2018). The strategies mentioned above are related to inquiry-based approaches. Research points to growing confirmation that inquiry-based learning promotes critical-thinking, problem-solving, and meaningful ways to co-construct knowledge at all levels of education (edvoiceviii, 2015). However, learners have individual desires and trajectories that necessitate discerned instruction and supports to facilitate optimum growth in confidence, competence and motivation (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2020). By using instructional feedback and reinforcing behaviour, the teacher sets the motivational climate (either teacher-directed or learner-directed) (Rudisill & Johnson, 2018). The results of the study are also consistent with Grant's (2023) view that student engagement and provision of personalised learning experiences are enhanced through technology which has the potential to revolutionise ECD. Traditional teaching methods and making ECD more accessible and engaging can be complemented through use of interactive learning platforms, educational apps, and virtual reality tools.

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Teachers' understanding of Child Art

The teacher participants in the study generally understood child art as; drawings, communication and expression. They had this to say:

> *Child Art is the drawings created by the learners to represent their experiences. Leaners do drawings, paintings, traditional dances and songs.* (ECDT1)
> *I understand Child Art as the way children communicate through drawing.* (ECDT2)
> *Through Child Art, children express themselves, especially, feelings through scribbling or drawing.* (ECDT3)
> *Child Art is where learners are given freedom to draw* (ECDT4)
> *Child Art refers to the manner in which a child expresses him/herself in a unique way that they understand; any diagram is correct it is how they perceive the world.* (ECDT10)

It came out from the study that the teacher participants had an understanding of the concept of child art. The results of the study indicated that teacher participants revealed that child art entails communicative drawings that depict learners' experiences and feelings. The findings also suggest that child art like most child behaviour, is direct and unrestricted. A young child does not critique his work he paints freely and with pleasure, enjoying the fine and gross motor experience of moving paint over paper and watching lines, shapes and colours come to life. The freedom of choice, thought and feeling are provided through art when it puts a child in the 'driver's seat' and at the same time providing freedom (Kelly, 2004). Art is a dominant tool that gives learners the capability to express their thoughts and emotions long before they can entirely express themselves with words, refer to figure 1. The achievement of present learning outcomes and also enabling behaviours and attitudes that will support future learning in infants, toddlers and young children is influenced by engaging in and with different arts during early childhood (Vecchi, 2010). Therefore, the creativity of learners forms a critical part of the various range of human expression (Bretton, 2021).

Child Art activities for STEM Lessons

The study sought to establish the integration of child art with STEM lessons to enhance creativity, imagination and aesthetic expression. The participant responses are captured verbatim below:

> *The child art activities include modelling using clay or play dough.* (ECDT2)
> *Painting e.g. for topics like water; when learning about colour are some of the child art activities done during STEM lessons.* (ECDT3)
> *During STEM lessons, learners do child art activities such as cutting of pictures for example of computer hardware.* (ECDT4)
> *Construction and pattern making for motor skills are some of the activities that learners do during STEM lessons.* (ECDT5)

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The findings of the study revealed that child art activities done during STEM lessons comprised modelling using clay or play dough, painting, cutting of pictures, construction and pattern making. It was also found that the stated child art activities were related to concepts taught during STEM lessons. This is also indicated in Figure 2 for STEM topics expressed in art. However, some participants indicated that time was inadequate to cover most of STEM concepts using child art activities. The findings are commensurate with the researchers' confirmation that children are natural learners and innately seek to learn things that matter in their immediate everyday world (Darling-Hammond, et al, 2020). The designing of activities should fascinate and attract learners' attention (Rudisill & Johnson, 2018).

Assessment of learner progress in integrating Child Art in STEM Learning

The researchers sought to establish how ECD teachers assessed their learners' progress in integrating child art in STEM learning. The following are responses from participants:

> *I assess learners' progress through observing the objects learners create.* (ECDT1)
> *Learners are assessed through workbooks with drawings which are marked as the learner progresses.* (ECDT2)
> *We use Structured developmental checklist to assess the acquisition of content or if learners have grasped concepts or not. We also test the skill and tick appropriately.* (ECDT3)
> *I also check whether learners are innovative by using the information that they would have learnt, e.g. types of drawings, shapes, girls draw women and boys draw cars.* (ECDT4)
> *I assess them through tests (concepts, skills, performance) and physical assessment.* (ECDT5)
> *Assessment is done when learners are able to draw human figures e.g. drawing a person with a head and legs; with time they should add head, feet, ears, hair in their drawings etc.* (ECDT6)
> *We assess learners through assessment worksheets. We check if learners are able to identify and differentiate, for example, between mother and father. We also give them homework, for example, cutting and pasting using ICT tools. However, some parents do work for their children.* (ECDT10)

The study established that teachers use various types of assessment tools to assess learners' progress in STEM concepts. These assessment tools are composed of observation, workbooks with drawings, structured developmental checklist, drawings, assessment worksheets and homework on use of ICT tools among others. The results of this study are in agreement with Shepard's (1998) view that in order to be able to demonstrate learners' abilities, methods of assessment should recognise that learners need familiar contexts. Abstract paper-and-pencil tasks might make it difficult for young learners to demonstrate their knowledge. Shepard further acknowledges that assessment information should inform teachers what each learner is capable of doing and readiness

to learn next. Assessment data can be collected through direct observation of learners during natural activities. The methods include: asking questions either orally or in writing; looking at drawings and samples of work or asking informed adults about the child. Thus, observation is the most appropriate method for younger learners. The findings of this study further confirm what has been observed by Yun, Melnick, and Wechsler, (2021) when they state that the early learning assessments of high-quality should be well-matched with goals and practices that support learner-centred learning environs that promote diversity, active learning, and authentic experiences.

Analysis of Child Art work in STEM Learning

The researchers also analysed and decoded 30 child art pieces of work. The art activities were done either as school work or homework for STEM activities. The four levels of formal analysis, namely, description, analysis, interpretation and judgement were followed.

Description: All art work had titles such as; My teacher, My family, Our school and so on. For example:

Fig 1: Project titles

The work was done in pencil drawing or colour using crayons. They are all original based on the learner's understanding of the instructions and in preferred media of presentation. The learners explored the creative aspects of problem solving, logical and imaginative dimensions of their thinking on the given title.

Analysis: All art work represented STEM subject matter related to the topics that the learners were being taught. For example:

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Fig 1: Environment and Human Science topics

The work was produced according to the learner's own understanding and interpretation of the subject matter. For example, to visualise scientific concepts, human body, shelter, environment, plant and animal life, human science and many others. The visual representations can aid comprehension and reinforce understanding of STEM concepts.

Interpretation: The art work represents the learners' experience, understanding and expression of the subject matter. For example:

Fig 3: Design concepts

The work represents STEM concepts such as; technology, engineering, design to mention a few. Learners incorporated artistic elements into their drawings to enhance their design thinking skills.

Judgement: The art work fulfils the outcome demands of specific topics, concepts and subject matter being taught. For example:

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Fig 4: Objects and Human being

From the visual analysis of the art work it can be deduced that the approach helps learners make connections between art and scientific inquiry. Art was used as a starting point for scientific investigations. The findings are in line with literature observation that teachers can thoughtfully assess the strengths and needs of learners if high-quality assessment is practiced (Yun, Melnick, & Wechsler, 2021). The results of the study also confirm Grant's (2023) view that high-quality ECD programmes provide a motivating setting that supports learners in development of cognitive skills essential for achievement in school and later in life. These programmes often integrate attractive activities that encourage creativity, problem-solving and critical thinking. Additionally, the programmes offer a designed curriculum that introduces learners to foundational concepts in Mathematics, Science, and Language arts.

ECD learners' Challenges in Integrating Child Art in STEM Learning

The study established that the challenges encountered by the learners in integrating child art in STEM learning were related to limited learning resources, teacher's expertise, parental interference, concentration span of learners and content overload. The following were some of the responses:

> *There is too much content to cope with. Some concepts are difficult for the learners e.g. different states of water; they fail to concentrate* (ECDT1)
> *Some learners from under privileged families have limited exposure to technology such as computers, TVs and smart phones, they cannot operate phones and computers.* (ECDT2)
> *In some cases, parents do the work for their children at home instead of letting the child do it for themselves independently, being only guided by their parent.* (ECDT3)
> *Lack of resources such as art work materials, educational toys, e.g. lap top toys. Again, the teacher uses personal laptop; learners learn from imagination or pictures instead of real objects, e.g. computer hardware.* (ECDT4)
> *There is one computer lab at the school that is shared by all learners from grade 1 to 7; ECD classes are not given a chance to use the computer lab since ICT is not examinable. ECD learners have limited time to use the computer lab, for example, once or twice per*

> *term. Some teachers think it is not necessary for ECD classes to be exposed to use of computers and school administration is reluctant to solve the problem.* (ECDT10)
> *The other challenge is that some school furniture is unsuitable for ECD leaners; there is consistent power cut, therefore, it affects the use of computers; no internet in the computer laboratory, it demotivates learners. Science apparatus are not being used in science lessons.* (ECDT5)
> *Another challenge is that ECD learners cannot concentrate for too long, hence, the teacher has to engage learners in a variety of exciting activities. This, sometimes is time consuming.* (ECDT6)

The results of the study revealed that ECD learners encountered varied challenges which encompass inadequate learning resources such as art work materials and educational toys, content overload, parents doing homework for learners instead of guiding the learners, consistent power cuts which hinders the use of computers and other electronic devices, limited internet facilities to access some of learning materials, for example, videos and educative cartoons, unsuitable school furniture and learners' limited concentration span. The findings of this study are in agreement with literature observations that teaching in ECD centres is hampered by inadequate learning resources and facilities which are not appropriate for ECD learning environs. The facilities not suitable for ECD learners encompass classrooms which are not well ventilated, inappropriate furniture, unsafe water, unsuitable play area and toilet facilities (Ngumbi, 2022). Ngumbi, further confirms that while some ECD learners come from families with adequate technology gadgets and internet, others come from families with no smart phones, leave alone computers and internet connectivity. The results of this study are also in line with Grant's (2023) view that children might enter school unprepared, lagging behind their peers in crucial skills such as language acquisition, problem-solving, and logical thinking if they are not exposed early to enriching learning experiences. Grant, adds that children who are brought up in underprivileged families might be not able to participate in activities stimulating their cognitive abilities because of challenges in accessing quality early ECD programmes. These stimulating activities include collaborative storytelling, educational games or hands-on experiments. For that reason, such children may have difficulties in grasping complex concepts and to keep up with their classmates as their cognitive development may be stunted.

Teachers' Challenges in integrating Child Art in STEM teaching

The participants were asked to highlight the challenges that were experienced by ECD teachers in integrating child art in STEM teaching. The responses indicated that ECD teachers encountered numerous challenges. Some of the participants' responses are presented below:

> *Many teachers lack expertise and skills in content delivery and this makes it difficult for such teachers to integrate child art in STEM teaching and learning.* (ECDT1)

> *Language barrier e.g. some teachers are finding it difficult to communicate with ECD learners in their local language and the teachers end up communicating with learners in English instead of local language understood by learners.* (ECDT2)
> *Some concepts are also difficult for some teachers.* (ECDT3)
> *The main challenges include inadequate resources; shortage of materials, e.g. art work materials and ICT gadgets; no computers, also teachers are demotivated because of poor remuneration.* (ECDT7)
> *In ICT, teachers have a phobia for technology and change; ICT is not taken seriously; some think it is a waste of time* (ECDT8)
> *There is a problem of high enrolment, that is, teacher-learner ratio is too high for ECD classes. The classrooms are overcrowded.* (ECDT9)

Besides the generic challenges faced by ECD teachers in integrating child art in STEM teaching as noted in the literature review, this study identified lack of expertise and skills in content delivery, high teacher-learner ratio which results in overcrowded classrooms and limited teaching and learning resources as major impediments. The findings of this study are commensurate with Grant's (2023) observation that a lot of teachers do not have access to extensive training programmes that prepare them with requisite knowledge and skills on how to effectively teach ECD learners. Grant adds that high learner-teacher ratio is one of the main constraints in urban early childhood education. Congested classrooms result in a less effective learning environment since teachers will be having difficulties in providing individualised teaching to learners. Limited access to resources and support systems crucial for a child's development may be caused by high poverty rates in urban areas.

Improving the quality in integrating Child Art in STEM learning at ECD level

As knowledge regarding human development and learning has grown at a rapid pace, the opportunity to shape more effective educational practices has also increased. It was imperative for the study to enquire from participants how the quality in integrating child art in STEM could be improved. The participants gave various responses and some of them are captured below:

> *The ECD teachers need in-service training and workshops to equip them with skills while the administrators need refresher courses to run ECD school as they disregard their importance.* (ECDT9 and 4)
> *The teachers should be trained on how to use ICT gadgets in integrating child art in STEM learning. The number of computer laboratories should be increased and administrators should understand the importance of ECD learning. Government should avail funds for STEM learning to be successful implemented at ECD level.* (ECDT3)
> *The school administration/head should provide teaching and learning resources for ECD learners, and provide adequate infrastructure for ECD learners, with suitable furniture and equipment to teach STEM concepts.* (ECDT4)

> *Learners need motivation; school level competitions; teachers should be more creative and use various teaching strategies that will encourage learner participation.* (ECDT6)
> *The schools should avail more resources for teaching STEM learning areas at ECD level and ECD teachers should be provided with adequate teaching and learning materials such as science equipment.* (ECDT2)
> *ECD learners require adequate learning materials for their success in STEM learning and schools should provide teachers with resources such as laptops and ECD infrastructure.* (ECDT1)
> *ECD teacher specialist should teach at that level not general teachers and learners should do homework on their own.* (ECDT8)

The findings of this study suggest that in order to improve the quality in integrating child art in STEM learning, there is need for in-service training for ECD teachers to equip them with required competencies to teach ECD learners, provision of learning and teaching resources, appropriate infrastructure and facilities and involvement of stakeholders. The results of this study are consistent with Grant's (2023) view that devoting in professional development for ECD teachers is important to keep them well-informed of the modern teaching methodologies, best practices and research. Professional development learning prospects will capacitate teachers to deliver high-quality and developmentally suitable instruction. Grant further affirms that partnerships between schools and community resources in improving urban Early Childhood Education have also demonstrated to be effective. Likewise, improving infrastructure is crucial in creating safe and exciting learning environs. Improvement on facilities, providing materials suitable for the age of the learners, and making sure appropriate sanitation are all important aspects of improving the quality of ECD. By devoting in infrastructure, learners can access well-resourced classrooms and outdoor spaces that stimulate creativity, exploration and physical development.

Conclusion and Recommendations

The study focused on integrating child art as a pedagogical strategy for teaching Science, Technology, Engineering and Mathematics at ECD level. The study revealed that ECD learners' activities involved drawing and painting STEM related concepts according to their own interpretation and understanding, an indication of child art as a pedagogical strategy. Child art enabled ECD learners to enhance their creative talent and develop artistic and problem solving skills, the same skills that are required in STEM. ECD teachers in the study used learner development checklists and child art as tools to measure progress in STEM learning. By using child art, teachers accessed important information from the learners regarding the learners' mastery of STEM concepts. The study indicated that ECD teachers and learners experienced quite a number of challenges in integrating child art in STEM learning. These encompassed inadequate teaching and learning resources, lack of expertise and skills in content delivery and high teacher-learner ratio which resulted in overcrowded classrooms among others. Notwithstanding the challenges encountered in integrating child art in STEM learning, the study concluded that child art was an

essential pedagogical strategy in STEM learning at ECD level. There is evidence from the study that the schools understudy made an effort to integrate child art in STEM learning. The study recommended that the Ministry of Primary and Secondary Education should empower ECD teachers through professional development programmes that focus on ECD STEM teaching and learning. The schools should also provide teaching and learning resources, appropriate infrastructure and facilities for ECD learners and involve stakeholders to improve on quality of STEM teaching and learning at ECD level.

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