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The Teaching of Science Process Skills in Early Childhood Development Classrooms

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Abstract There is a growing interest in the teaching of science in early childhood development (ECD) classrooms the world over. This has led to some countries crafting and implementing policies that ensure the teaching of science process skills. This study explored the teaching of science process skills in ECD classrooms of Zimbabwe through an interpretive multiple case study. Data were collected using semi-structured interviews, lesson observations, still photographs and field notes from four purposively selected ECD teachers. Findings show that the participants had knowledge of science process skills namely, communication, observation, measuring, comparing, classifying, predicting and inferring. The study found that science process skills were best taught using child-centred approaches such as explorations, play, experiments and guided discovery because such methodology encourages an active participation of learners. Effective teaching of science process skills in prepared science environments lays a foundation of acquiring scientific knowledge, content and skills in young learners. The study concluded that participants' knowledge and experience of teaching science process skills afforded them a strong foundation for developing science skills in ECD learners. Hence, there is a need for parents and school administrators to support teachers through resource mobilisation, provision and allocation. The study recommends the ECD teachers to teach science process skills as a way of perpetuating the nation's goal of introducing STEM subjects in ECD classes.

Keywords Early Childhood Development, ECD Classroom, ECD Teacher, Science Process Skills

1. Background and Literature

The teaching of science process skills has spurred a large body of research, with some scholars arguing that science education is imperative for young children because it assists them in understanding the world around them [1-5]. Most studies conducted in Africa support the view that a nation's capacity to innovate and develop in this modern world of technology depends on producing graduates with science skills [6-8]. In support of the above, [8-10] concurred that the teaching of science process skills to young children is crucial for developing and mastering the relevant and appropriate concepts and critical thinking skills needed in the twenty-first century. Although several studies have explored the significance of teaching science process skills to young learners, much uncertainty still exists on the knowledge of teachers on the basic science process skills that should be taught in early childhood development (ECD) classrooms. This indicates the need for teachers to extend their knowledge base on science process skills and understand the value of teaching science as a discipline in line with twenty-first century demands.

To ensure the teaching of science process skills in ECD

classrooms, some countries have crafted and implemented policies, such as the National Curriculum Statement and Curriculum and Assessment Policy Statement (CAPS) in South Africa [11,12] and the Guidance for Kindergarten Education in China (13). In Zimbabwe, the introduction of science, technology, engineering and mathematics (STEM) policy and the implementation of the new curriculum led to the advent of teaching science skills in ECD classes [4, 5, 14]. The existing policies in Zimbabwe include, among other policies, Statutory Instrument 106 of 2005, Secretary's Circular Number 14 of 2004, Director's Circular Number 12 of 2005 and Director's Circular Number 48 of 2007. It is evident that the policies were crafted some decades ago and are due for replacement. In light of the above, curriculum planners should design current policies that specifically guide teachers on the basic science process skills to be taught in ECD classrooms. Given this background, the study intends to (1) inform policymakers on the need to channel existing STEM funds towards the teaching of science from early childhood and (2) provide case study insights that may be useful in understanding the teaching of science process skills to young children.

1.1. The Teaching of Science in Early Childhood Classrooms

The teaching of science in ECD classrooms is substantiated by numerous studies and practices in many countries. In Kenya, pupils are taught science skills so that they will be able to describe, explain, predict, discuss and evaluate information with science content (17). On the same note, still in Kenya, science teaching in preschools is critical in equipping learners with science skills relevant for accelerating economic growth of the country (18). It is therefore imperative to note that science teaching enhances the development of scientific skills and learners becoming scientifically literate [4, 5, 17]. Similarly, in Nigeria, science as a subject is regarded as the cornerstone of industrial development and teaching science skills equipping young learners with scientific knowledge, content and skills relevant for the twenty-first century (19). While the teaching of science in ECD classrooms is undoubtedly important, it becomes very prudent to examine teachers' perceptions of the skills and to explore the science skills taught in ECD classrooms.

1.2. Science Process Skills Taught in Early Childhood Development Classrooms

Given the background of the importance of teaching science skills in ECD classrooms, and the value attached to it, (20) and (21) asserted that science process skills are central to the acquisition of scientific knowledge that is so critical in solving problems in society. The scientific knowledge and skills are mainly developed in learners through the teaching of science process skills (20). Science process skills refer to learners' cognitive activities that enable them to identify science evidence required in solving problems and making decisions (11). On the same note, (15) alluded that science process skills are ways or techniques that are used by people in order to study problems that they encounter during scientific enquiry. To this end, it is imperative to explore the science process skills that are taught in order to equip learners with problem-solving skills.

By considering science process skills as an important strategy and inseparable part of science education [13, 21] it becomes crucial to explore the basic science process skills that should be taught in ECD classes. These science process skills include: observing, comparing, classifying, measuring, communicating, inferring and predicting among others [8, 15]. From the foregoing, science process skills are not step-by-step skills but can be combined and taught in one lesson with the aid of age-appropriate learning materials during lessons.

1.2.1. Observing

Observation is the most fundamental science process skill that is acquired by learners when they learn about the world around them through the use of senses to gather first-hand information [15, 22]. The skill entails the senses of sight, touch, smell, taste and sound. In this regard, (8) posited that the skill enables learners to identify the similarities between objects and events. By giving learners opportunities to observe during science learning, they can explore their environment in order to construct meaning within their natural world [19, 22]. Few studies have been conducted on teachers' knowledge on the facilitation of observation skills in ECD learners. There is need to augment literature on teacher knowledge of science process skills by exposing teachers to different activities and practices that learners can be engaged in to learn about their environment through observation.

1.2.2. Inferring

Inferring is one of the most fundamental skills that should be taught to ECD learners. The skill involves explaining, making interpretations or drawing conclusions about a specific event based on observations and data (15). During science lessons, learners can infer when they use what they know to draw conclusions and figure out reasons for events that they do not witness. For example, learners can infer that the holes in a leaf resulted after parts of the leaf were eaten by insects. The learners' previous knowledge and experiences are very important when teaching the skill. Inferring also involves observations and making interpretations. From the above discussion, it is evident that skills are not taught in isolation but rather embedded in the activities that learners engage in.

1.2.3. Classifying

The process of classification involves grouping, sorting or serial ordering of concrete objects according to different

categories such as colour, shape, length, weight or size (15). For example, learners can sort groups of objects with common characteristics and place them in one set, for example red triangles, small pencils, heavy metal or light feathers. For the learners to sort or group objects, they should observe the similarities, differences and interrelationships between the objects (22) and build knowledge as they interact with different materials in prepared learning environments (19). To this end, (23) posited that the skill of classification is enabled by supportive learning environments created by the teachers in the ECD classrooms. Because of the value the classification skills bears in science, it becomes imperative to explore the existing learning environments in the ECD classrooms and how teachers use these environments to teach classification skills. The current article also sheds more light on the learning materials available in classrooms that will enable learners to classify objects according to various categories.

1.2.4. Measuring

Measuring is the quantification of a child's observations through standard and non-standard units (19). Standard units of measuring include pounds, degrees, seconds and minutes, whereas non-standards units include spans, jumps, feet, rocks or day events. For example, young children can measure the number of cups that can fill a bucket or measure their height using a string. Like observation and other science process skills, (4) asserts that measuring is a child-centred activity that also involves the use of senses by learners. In addition, (24) posited that engaging learners in informal scientific experiences such as measuring or observing during science teaching is vital because learners develop scientific concepts and skills. Recent reviews of literature on science teaching in ECD classrooms have suggested that ECD children are still numeracy illiterate and therefore measure using non-standard units of measurement [24-26]. Central to this study was to establish the science process skills taught by teachers during science lessons and to examine how measuring, as a science process skill, was being taught.

1.2.5. Communicating

Research on science teaching in ECD has adopted the view that communication can be verbal or non-verbal and is the ability by young children to describe a phenomenon to share their observations, findings or results (27). Non-verbal communication can be gestures, body positions or facial expressions and verbal communication is the use of words or vocal sounds. For example, learners can describe the weather using their language or after an exploration, learners can present their findings in pictures, or share what happens to salt when warm water is added to it. During experiments, young children speak to themselves, which (28) called private speech. The role of private speech is to guide children's thoughts and to assist them in accomplishing difficult practical tasks (28). Young children should be encouraged to describe their observations of material properties such as shape, colour, texture and others (19). The skill of communication seems to take centre stage among most of the activities done by learners during science lessons. The study explored the different ways used by learners to communicate their findings or results after experiments or activities during science lessons and how best the skill can be developed in learners.

1.2.6. Predicting

Children can use their imagination to predict what they think can happen in future based on connections in their everyday lives (19). Predictions, according to (15), are based on observations made from data collected and reasonable expectations and finding patterns and making connections. For example, children can listen to a story about cutting down trees and then predict what happens to the soil when rain comes. After the predictions, the children will observe the phenomenon they have made a prediction about and observe the actual results (15). It is important to note that prediction skills are significant for children learning reading, mathematics and science. Considering the emphasis of existing literature on teaching prediction skills to young learners, it becomes important therefore to explore various activities employed by teachers when teaching prediction skills.

2. Purpose

- The study contributes to the literature on the basic science process skills taught in early childhood development classrooms.
- The paper explores the value of teaching science process skills in early childhood development classrooms, guiding teachers on best strategies to develop them in young learners.
- The study findings inform policymakers and curriculum planners on the need to design policies that support the teaching of science process skills from early childhood.

3. Methods and Context

The aim of the study was to explore the teaching of science process skills in ECD classrooms. The study adopted an interpretive paradigm and multiple case study designs involving two schools in the Harare Metropolitan Province from which four ECD teachers were selected. Since the study explored an issue, an instrumental case study type was used (29). The design was chosen for allowing in-depth study of the science process skills taught by offering rich descriptions and explanations (30). Studying a small number of participants provided detailed, real data from the teaching experiences of ECD teachers

(31). Data from multiple cases are usually reliable and strong (32).

3.1. Study Participants

Four teachers (two from each school) were purposively sampled due to their relevance in the study (33). Purposive selection enabled us to focus on participants who possess the knowledge, expertise and experience regarding the phenomenon under study (30). Therefore, a homogeneous purposive sampling technique was used, whereby the participants belonged to a subgroup that had defining characteristics (34). The four female participants were qualified and each had more than five years of teaching experience in ECD classes and were able to communicate their thoughts and ideas appropriately (35). Science is one of the curriculum subjects taught in ECD classes and the curriculum emphasises that science concepts and skills should be taught in order to equip learners with lifelong skills Zimbabwe (14). In four of the classrooms visited, science lessons were taught as per timetable and the number of learners ranged between 33 and 49.

Pseudonyms were assigned to the participants in order to provide anonymity (30). Teachers Jane and Lisa belonged to School A and Teachers Mary and Susan belonged to School B. Participation of teachers and children was solely voluntary. Written consent for still photographs of children and their participation in the study was obtained from parents and it was explained that consent could be withdrawn at any time. All field notes were stored in a locked office cabinet accessible to us only.

3.2. Research Methods and Data Collection

Data were gathered through classroom observations captured as field notes, semi-structured interviews and still photographs of learners for a period of three months during science lessons. Each participant was observed and recorded five times teaching a science lesson. To keep a good record of events, the length of each activity was recorded. The activities that the learners participated in, whether in groups or individually, were recorded as field notes, paying special attention to the science process skills being taught.

Still photographs were captured when learners were engaged in activities assigned to them by the teacher. Photographing in research is regarded as an engaging and creative strategy for involving children in research (30; 35). A cell phone was used to capture important moments on camera during the course of the activities (30). The photographs or visual prompts assisted in recalling details of context during transcribing field notes and served as visual record of events (33). During each lesson observation, at least three photographs were taken.

The semi-structured interviews with participating ECD teachers were conducted to obtain first-hand information on the science process skills that they taught and how they taught them (36). Interviews are regarded as critical components for qualitative case studies (30) and this design permitted a cross-case analysis enabling views to be contrasted and compared (37). The semi-structured interviews were useful as they provided in-depth and insightful responses of the participants on how they prepared their classrooms in order to effectively teach science process skills (38). Before the interviews, the participants were briefed and reassured of their rights and responsibilities in the research (38). The interviews were conducted mostly after lessons had been observed.

3.3. Data Analysis

The qualitative data collected were analysed for content using the steps outlined by (39). The first step was to identify units of data that correspond to the research question. Once the units of data had been segregated according to the research questions, coding and category construction followed. The categories were named and counted. Finally, the categories were clustered into fewer groups (themes) in a way that makes meaning and is theoretical. Although the steps seem to be procedural, the process of data analysis was iterative to ensure that the categories were correct and refined. Tables 1 and 2 show excerpts extracted from the coding book, showing how the data from the interviews and observations were analysed, respectively.

Table 1. Excerpt from the interview code book

Identification of data responsive to research questions/themes	Description of code	Examples of data	Naming of categories
Defining of or giving meaning to science process skills	• Activities performed by learners during science learning • Content of science • Methods or approaches of teaching science • Competencies	• Assigning learners in groups to perform the activities • Content is learnt through social interaction • Competencies are learnt through active participation	• Methodology of teaching science process skills • Importance of teaching science
Science process skills taught	• Communicating • Classifying • Observing • Inferring • Grouping • Predicting	• Experiments • Explorations • Discussions • Observations • Guided discovery • Play	• Methodology of teaching science process skills • Science process skills taught in ECD classrooms

Table 2. Except from the observation field notes code book

Identification of data responsive to research questions/themes	Description of code	Examples of data	Naming of categories
Teaching of science process skills	• Group work • Pair work • Demonstrations • Explanations	• Sharing limited toys/learning materials • Asking questions • Discussions • Rushed activities/explanations	• Methods employed during teaching of science process skills
Science process skills taught	• Observations • Classification • Measurement • Grouping • Describing	• Insufficient learning resources • Learners scrambling for limited toys • Inadequate space for experiments	• Challenges or problems faced

4. Findings of the Study

The data analysis yielded three themes, namely: science process skills taught at ECD, methods used by teachers to teach science process skills, and challenges faced by teachers during the teaching and learning of science process skills. The findings of the study are presented under the three themes as follows.

4.1. Science Process Skills Taught at Early Childhood Development

The four ECD teachers who participated in the study could easily identify and teach science process skills and it should be noted that all had had five years of teaching experience. The teaching experience seemed to be sufficient to equip them in the teaching of science process skills. They mentioned measuring, observing, communicating, predicting, classifying, comparing, grouping and describing as science process skills taught in ECD classrooms. Teacher Jane had this to say: "The major aim of early childhood development is anchored on skill development. These are competencies that learners learn as they develop science concepts and scientific skills." This comment indicates that science process skills can be competencies that are learnt by learners during science lessons. Teacher Lisa said: "Skills like classifying, predicting, reading and describing are activities that learners engage in during science lessons."

Data from the interviews indicated that the participants possessed knowledge of science process skills and that they taught them during science lessons. The science process skills were taught daily as indicated on the timetable. The mathematics and science syllabus that participants used explained science process skills as lifelong skills that were meant to equip learners with scientific concepts. In each lesson, learners were exposed to more than two process skills. For example, in one of Teacher Lisa's lessons, learners observed that heavy objects sink in water and lighter objects float and they communicated their findings using their mother tongue.

Figure 1 is a photograph of learners in Teacher Susan's classroom sorting and classifying objects. It shows learners working together to complete a given challenging task. As they worked together, they communicated and shared play materials and ideas.

Teacher Mary facilitated an experiment for learners where they were asked to predict the number of cups that can fill a five-litre container. Learners were then asked to perform the actual measuring activity. They compared their results with the initial predictions. A lot of communication, active participation and sharing of knowledge and ideas were noted during the activity. In another activity, learners were given a chart with pictures

of different animals and were asked to identify them. Later, they classified the animals into domestic and wild animals. When they were classifying animals, they argued, asked questions and discussed. The process exposed them to developing other social skills such as interaction, cooperation and turn-taking, which are very important skills in science teaching and learning.

Participants identified the skills as activities or competencies that are learnt and acquired during science learning. The science process skills are not taught in isolation, but two or more can be taught in a single lesson. More importantly, the science process skills complement each other. For example, good communication of results or findings is a result of good observations during the experiment.

4.2. Methods Used by Teachers to Teach Science Process Skills

Participants indicated that there are various approaches to teaching science process skills. They responded that science process skills can be taught through experimentations, explorations, play and guided discovery. Group-work proved to be one of the best approaches to teaching science process skills. Learners were observed working together, collaborating ideas and discussing cooperatively. Teacher Susan commented: "During group-work, learners work together, share ideas and team up to solve problems. Their active engagement during group-work assists them to acquire new knowledge through sharing of information." Such comments seem to imply that group work as a teaching method is ideal for science process skills since it promotes teamwork, sharing of ideas and active engagement of learners.

In Teacher Lisa's classroom, we observed that through discovery learning, learners observed that substances such as salt, sugar and bicarbonate of soda can dissolve in water, whereas mealie meal and flour make a paste when mixed with water. In addition, during a measuring activity, learners also discovered that a bucket is bigger than a cup, and in a different activity, they found out that a magnet can attract metal objects. More importantly, through discovery learning, learners constructed new knowledge and created new ideas. Below is a photograph of learners in Teacher Jane's classroom working together to complete a task.

Figure 1. Learners sorting classifying and describing objects

Figure 2. Learners completing a task in a group

The participants hinted that they develop concepts in learners through play, science process skills not being an exception. One of the games that the learners played is known in their mother tongue as *mahumbwe* (playing house). As the learners played *mahumbwe*, they worked together and shared utensils. The participants said that play also improved learners' social skills, including cooperating, interacting, sharing and turn-taking, as well as physical skills such fine and gross motor skills. We observed a group of learners playing *mahumbwe* in Teacher Mary's classroom. They played a game of cooking food, thereby measuring the ingredients, communicating their actions, classifying or grouping the cooking utensils according to use and describing the materials they were using. The participants explained that play encourages learners to uses their senses.

Data gathered revealed that science process skills are best taught through experiments, exploration, play and discovery learning. The participants used these approaches because they enhance cooperative learning, sharing of information and ideas as well as constructing new knowledge. Through active engagement and collaboration during experiments and discovery learning, learners also developed social, fine and gross motor skills.

5. Discussion

The study explored the science process skills taught in ECD classrooms. The findings showed that the participating ECD teachers were qualified and experienced in and knowledgeable of science process skills that should be taught in ECD classes. Participants identified communicating, observing, predicting, measuring, classifying and describing as science process skills they taught during science lessons guided by the Mathematics and Science Syllabus. The participants referred to them as skills, activities, content or competencies taught during science lessons. In the same vein, research has also considered these as lifelong learning skills [8, 14, 21, 25].

These skills are science practices that are critical in ECD for the acquisition of scientific concepts and knowledge that are critical to young children in solving problems encountered in day-to-day life experiences or in future. The skills are developed as learners actively participate in hands-on practical activities solely prepared by the teacher in a prepared environment.

Participants agreed that they employed different approaches in teaching science process skills. They identified play, exploration, discussions, experimentation and guided discovery. (4) regarded these methods as child-centred methods. The methods place the child at the centre of learning and enhance active participation of learners, construction of knowledge and sharing of ideas in a prepared environment [4, 23]. Incorporating child-centred methods in the teaching of science process skills has been considered as a progressive way of teaching as this enhances children's involvement in the teaching process. This motion is supported by (40), who posited that child-centred approaches that include child-directed play and exploration are a form of developmentally appropriate practices designed by teachers for young children to learn and construct their knowledge.

6. Conclusion

We conclude that teachers' knowledge and experience of teaching science process skills place them in a very important position in terms of developing science process skills in ECD learners and perpetuating the nation's goal of introducing STEM subjects in ECD classes. The effective teaching of science process skills in ECD proves to be the foundation of acquiring scientific knowledge, content and skills that assist children in solving day-to-day problems. Pedagogically, the teaching of science process skills is a child-centred approach that promotes active participation by and knowledge construction in learners. This study is limited in that it involved only four participants from two schools in Harare Metropolitan Province. This may compromise generalisation of the study findings. Therefore, a further study involving rural schools and which is quantitative in nature is recommended to explore the science process skills that are being taught in ECD classes.

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