DEVELOPING THREE-DIMENSIONAL INSTRUCTIONAL MATERIALS FROM LOCALLY AVAILABLE RESOURCES FOR SCIENCE EDUCATION IN PRIMARY SCHOOLS, GHANA

By

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Philosophy in Art Education and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

The use of instructional materials and its impact on the teaching and learning process in primary schools have been highly expounded on as well as the adverse effects of the nonuse of these aids. In situations where there is non-use or insufficient materials, research has suggested improvisation of instructional materials from resources that are available in the immediate environment for teaching and learning purposes by teachers and instructors. This study delved into the use of locally available resources and how they can be used to develop three-dimensional instructional materials for Science education in the Weweso M/A Primary School. The research being qualitative was descriptive and experimental in orientation; it adopted observation and interview as data gathering instruments to identify and describe existing instructional materials used in the selected school, what materials they are made of, how they are used for teaching and learning, the shortcomings associated with their use as well as their impact on pupils‟ learning. It also enabled the description of the developed prototypes on teaching and learning of Science. Convenience and purposive sampling techniques were adopted; sampling 155 respondents–150 pupils, 4 teachers and 1 head teacher. The study identified locally available resource materials and developed them into three-dimensional models to teach topics that teachers had tagged as difficult to teach with or without the available instructional materials. The developed prototypes were tested in various classes to ascertain their effect on the teaching and learning of Science and the effect on pupils‟ demeanour in the classroom. The study identified that the use of the models made it possible for teachers to finish topics within the allotted periods and had

enough time to assess pupils. The lessons were enhanced with pupils demonstrating understanding since concepts were no longer being taught theoretically and abstractly but practically demonstrated. Pupils‟ participation in the classroom was greatly affected with pupils who had been spectators in the classroom participating fully in lessons. The usual noisy environment during lessons was highly curbed because pupils‟ attention was sustained

during lessons.

DEDICATION

I dedicate this project to the Almighty God for His mercy and faithfulness towards me; „for the Lord is good and His mercy endures forever."

To my parents Torgbi Klu Agudzeamegah II and Mrs. Beatrice Klu Agudzeamegah.

To my best friend Fred, and the Biblical Baptist Family of Atonsu, Kumasi.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE INTRODUCTION

1.1 Background to the Study

Science education at the primary and secondary levels of schooling is an essential component and at the heart of both economic growth and social development. There is an international consensus that a solid science education system in the school years is an indispensable requirement to having an economy based on knowledge and innovation (Gluckman, 2011). Science education, according to Curriculum Research and Development Division (2007), will equip young people with the necessary process skills and attitudes that will provide a strong foundation for further study in science at the upper levels of education and beyond. It will also provide children with the interest and inclination toward the pursuit of scientific work.

Undoubtedly, the role of science in modern society is shifting, being very different from that of a generation ago. More progressively, the challenges facing communities today, be it at the global level such as dealing with climate change or at the local level such as environmental degradation, among others, all depend on science. There is not a difficulty distressing humanity which does not have science and technology associated with finding a suitable solution (Gluckman, 2011). This means that scientific and technological literacy is crucial for all individuals, especially in developing countries which have to move faster in their effort to elevate the standard of living of their populace (CRDD, 2007).

Gluckman (2011) further explains that there are three other associated objectives of science education for all young people during their compulsory school years. That is, primarily, all children need to have a practical knowledge at some level of how things function; not in detail but with adequate understanding to appreciate the technological setting in which they exist and work, the environmental complexities of the world they live in, and the way the biological world, including their own bodies, function.

According to the European Commission (2007), in recent years many studies have highlighted a disturbing decline in young people‟s interest for key science studies and mathematics despite the numerous projects and actions that are being implemented to turn round this trend. Except more efficient actions are taken, innovation capability and the quality of research will also decline. Moreover, among the general population, the acquirement of skills that are becoming necessary in all walks of life, in a society increasingly reliant on the use of knowledge, is also under increasing danger. The European Commission continues that the origins of the declining interest among young people for science studies are found largely in the way science is taught in schools.

Teaching and Learning Research Programme (TLRP, 2006:6) has propounded that "unless school science explicitly engages with the enthusiasms and concerns of the many groupings that make up today‟s students, they will lose their interest". Therefore, enhancing the impact and quality of science education is vital to ensuring that the global community can meet the growing set of challenges facing the world today, whether climate change, food security, disease reduction, or industrial innovation

(www.nature.com).

1.2 Statement of the Problem

According to the Government of Ghana (2003) as cited in Ameyaw-Akumfi (2004), it is estimated that less than 15% of Ghanaians of ages 15years and above are scientifically literate. Factors that have contributed to this state of affairs include the following:

- insufficient resource allotment to the teaching and learning of Science and Mathematics at all levels of education, leading to poorly equipped laboratories and workshops.

- utilization of „uncreative and outmoded methods of teaching and learning‟ in schools such as learning by rote memorization, the chalk and talk approach, textbook dependent and examination-oriented teaching as well as lack of science practicals in most schools; and even where they are done they are fashioned in cook book manner to confirm known answers.
- most primary and junior high school teachers are inadequately prepared to teach science and mathematics.
- postgraduate research in science, technology and mathematics which should form the basis for developing the capacity for innovation and change is very low.

Maduabum (1991) as cited in Aina (2011) states that primary education is the bedrock of educational continuum and it requires a solid foundation in science. According to Maduabum, Science must be made real to pupils in primary schools through appropriate teaching methods, use of good instructional materials and improvisation where it is indispensable. As reported by Olumorin (2009) as cited in Olumorin, Yusuf, Ajidagba and Jekayinfa (2010), mentions that in the absence of original materials for use in teaching and learning, other types and forms of instructional materials can be applied. Abimbola (1999) as cited in Aina (2011) also explains that the prime purpose of using supportive materials in the teaching and learning process is to make teaching more effective and facilitate learning. Aroghene, Ekwevugbe and Okandeji (2012) assert that inadequate use of instructional materials in our primary schools may be responsible for the crises in the schools due to which some pupils do not comprehend various concepts; this has incapacitated them from meeting the society's developmental requirements.

Teachers, especially those in primary education, should therefore be encouraged to use as many instructional materials as possible to set an environment which is stimulative and conducive to learning, and in which pupils can be easily guided through the discovery of knowledge on their own (Chamunorwa, 2010). Also, Abolade and Olumorin (2004) as cited in Olumorin et al., (2010) have reported that most of the factory produced instructional materials for teaching are usually scarce to come by and where they are within reach, they are usually very expensive to buy.

Preliminary investigations emanating from school observation for courses ATE 714 Principles and Practice of Education and ATE 734 Production Techniques, enabled visits to four primary schools in the Kumasi Metropolis to observe the use of instructional materials. The observation confirmed points raised by available literature on instructional materials usage with such concerns as follows:

- Inadequacy of instructional materials for teaching science.
- Schools endowed with resources bemoaned the huge sums of money spent on instructional materials such as imported charts, some real objects and interactive videotapes and the painstaking experience of maintaining them in good condition.
- School heads confirmed decline in the performance of students in Science over the past years especially with reference to BECE results due to the lack of interest of pupils in the Science subject, a problem which may start from the lower primary level of education.
- Some teachers pointed out that the imported instructional materials they use such as charts and posters are based on foreign concepts which make it difficult for some children to relate to ideas being discussed in the classroom.

The preliminary investigations also brought to light how handicapped most of the instructional materials, basically charts or posters or textbooks, which were predominantly two-dimensional in nature, were, in assisting effective teaching and learning of science. The two-dimensionality of these materials only enabled hanging and fixing on classroom walls; this, wore the materials easily because of their constant exposure and handling, and did not allow interactivity, inhibiting active participation as a result and not encouraging whole class involvement.

Aina (2011) however, states that it will amount to wasteful exercise if a teacher decides to use materials that are not readily available or too costly to purchase, as a result, the idea of improvisation has to be employed to substitute for conventional instructional materials. The abundance of recyclable and non-recyclable materials resulting from indiscriminate littering which poses numerous health hazards to both inhabitants and the environment and the availability of cheap local materials, makes it possible for such materials to be put to good use to produce appropriate teaching and learning materials for teaching science at primary schools at least cost. The researcher therefore with experience and knowledge gathered from course ATE Principles and Practice of Education, into classroom instruction and effective teaching and learning approaches sought to investigate the existing instructional materials used for science education and explore through detailed examination and systematic inquiry into locally available resources and develop appropriate three-dimensional instructional materials for teaching and learning of Science with skills acquired from course ATE 734 Production Techniques in 3-D Art, for lower primary pupils at Weweso M/A Primary School to enhance their performance and enthusiasm for Science.

1.3 Objectives of the Study

1. To find out and describe existing instructional materials used for teaching and learning of Science at Weweso M/A Primary School in the Kumasi Metropolis.

2. To identify locally available resources and develop them into three-dimensional instructional materials that are appropriate for teaching and learning Science at Weweso M/A Primary School in the Kumasi Metropolis.

3. To pre-test the developed three-dimensional instructional materials on the teaching and learning of Science at Weweso M/A Primary School in the Kumasi Metropolis.

1.4 Research Questions

1. What instructional materials are used for teaching and learning Science at Weweso M/A Primary School in the Kumasi Metropolis?
2. What are the locally available resources that can be developed into threedimensional instructional materials for teaching and learning of Science at Weweso M/A Primary School in the Kumasi Metropolis?
3. How can three-dimensional instructional materials impact on teaching and learning of Science at Weweso M/A Primary School in the Kumasi Metropolis?

1.5 Delimitation

The study was limited to the development of three-dimensional models from locally available resources such as leather, wood remnants, plastic, textile materials and others, for teaching and learning Science at Weweso M/A Lower Primary School in the Kumasi Metropolis, Ashanti Region of Ghana.

1.6 Importance of the Study

1. The report will be of importance to teachers and pupils since the developed instructional materials will help teachers acquire effective instructional materials for pupils" better understanding of science topics at the primary schools.
2. The study will be beneficial to all teachers and educators in identifying simple available resources and using them to prepare instructional materials for pupils to achieve effective teaching and learning of Science in primary schools.

3. The study will benefit Primary schools to encourage recycling as an option for advancing education through the production of instructional materials at a minimal cost. Therefore, the Ghana Education Service can revise the syllabus on Science to incorporate the use of locally available resources as instructional media to achieve high academic success at the primary schools.
4. The research will be of importance to artists who want to explore locally available resources identified and documented in this thesis and use them in further research.
5. Last but not the least, this research will be a source of reference material for teachers, educators, students, artists, stakeholders and the general public.

1.7 Definition of Terms

- **Instructional materials**: These are educational materials that are used in the classroom to support specific teaching and learning objectives. Instructional materials and the term Teaching and Learning Materials (TLMs) are used interchangeably.
- **Locally available resources**: They are materials found in the environment that are either natural or artificial and are easy to come by.
- **Recyclable materials**: These refer to waste materials that have been identified as reusable but are yet to be processed, and are sometimes thrown away.
- **Prototypes**: These are the proposed and developed instructional materials for teaching and learning selected science topics in the study.
- **Basic Education**: The first nine years of schooling in the Ghanaian Educational system; that is, six years primary schooling and three years Junior High School (JHS).

- **Classroom environment**: The general situation in the classroom that promotes teaching and learning.

1.8 Abbreviations

- IM – Instructional Materials
- TLM – Teaching and Learning Material
- GES – Ghana Education Service
- MoE – Ministry of Education
- JHS – Junior High School
- CRDD – Curriculum Research and Development Division
- LED – Light Emitting Diode
- NCCA – National Commission for Curriculum and Assessment
- OECD – Organisation for Economic Co-operation and Development

1.9 Arrangement of the rest of the Text

Chapter Two provides theoretical and empirical review on science education, teaching and learning and teaching and learning materials in general. Chapter Three includes the methodology adopted for the research and presentation of findings as well as the production processes in developing three-dimensional instructional materials for teaching and learning science. Chapter Four deals with the discussion of main findings and testing of proposed and developed instructional materials for teaching and learning of science.

Chapter Five entails summary, conclusions and recommendations of the study.

CHAPTER TWO REVIEW OF RELATED LITERATURE

2.1 Primary Education in Ghana

Education in Ghana is centrally administered under the purview of the Ministry of Education (MoE), which is responsible for the formulation of educational objectives at the national level. This ministry oversees the Ghana Education Service (GES), which is responsible for pre-tertiary levels of education (Hutchison, n.d.).

Dosoo (1996) as cited in Boafo-Agyemang (2010) states that primary school education is the most essential form of formal education a nation provides for its citizens. The Ladbel Education and Health Organization (2013) explains that the educational system in Ghana is made up of six years of primary schooling, three years of Junior High School (which forms nine years of basic education) followed by three years of Senior High school education. This constitutes twelve years of pre-tertiary education. This process which starts from the official school-going age of six years and ends at entering into tertiary institution thereby ensures a sound foundation for the socio-economic development of the nation (Boafo-Agyemang, 2010).

For the first three years, teaching may be entirely in English or may integrate English and local languages. The majority of teachers are certified, having graduated from three-year Teacher Training Colleges. Children are taught to read in English, and all textbooks are in English (Keteku, 1999) except for those used for teaching and learning various Ghanaian languages.

The Ladbel Education and Health Organization (2013) propounds that primary education being the foundation of the education system has the following objectives:

- numeracy and literacy i.e. the ability to count, use numbers, read, write and communicate effectively

- laying the foundation for inquiry and creativity
- development of sound moral attitudes and a healthy appreciation of Ghana"s cultural heritage and identity
- development of the ability to adapt constructively to a changing environment
- laying the foundation for the development of manipulative and life skills that will prepare the individual pupils to function effectively to their own advantage as well as that of their community
- inculcating good citizenship education as a basis for effective participation in national development.

The Basic Education Curriculum proposes the learning areas as Ghanaian Language, English language Skills, Basic Mathematical Skills, Natural Science and Religious and Moral Education. Also Music and Dance, Physical Education and Creative Arts, comprising arts and crafts, are non-examinable and are to be taught practically and demonstratively. Social Studies and Environmental Studies are to be integrated thematically and incorporated in the various language materials (Ghana Education Service, 2012). That is to say that the goal of primary school education in Ghana is to lay a general foundation of knowledge and skills for use in the second cycle schools and therefore, the curriculum at the primary level stresses reading, writing and Basic Arithmetic, Integrated Science, Creative Arts, Civic Education as well as being creative since it begins from the formative years of every school going child.

2.2 Good Teaching

„Teaching is a complex and multidimensional process that requires deep knowledge and understanding in a wide range of areas and the ability to synthesize, integrate, and apply this knowledge in different situations, under varying conditions, and with a wide diversity of groups and individuals‟ (Hollins, 2011:395). Farrant (1996) asserts that teaching and learning are opposite sides of the same coin, for a lesson is not taught until it has been learned. Therefore teaching is a process that facilitates learning. This involves creating an environment to facilitate learning and motivating learners to have interest in what is being transmitted to them (Tamakloe, Amedahe & Atta, 2005), implying that what the pupils see, hear and do in the classroom is what the teacher provides for them, and what the pupils are ready and able to learn. Therefore, Bruner (1994) maintains that the goal of teaching is to make possible learning experiences and arouse critical thinking skills and not simply to transmit knowledge. Good teaching as defined by Boafo-Agyemang (2010) addresses learners‟ needs and abilities. It is a pleasant experience and at the same time keeps up the interest of pupils in the teaching and learning process. According to Dewar (2002), all good teaching starts with specific, clear and measurable goals and objectives. Goals are those general statements of outcomes whiles objectives are how the goals are to be reached. Good teaching is therefore identified to involve a process of facilitating learning rather than being the simple impartation of knowledge to the learner from the teacher.

This means teachers can smoothen the progress of learning by creating situations that allow pupils to pursue their interests keenly, observing pupils as they learn and expanding opportunity for pupils to learn (Huze, 2011). Therefore, Farrant (1996) postulates the following as characteristics of good teaching:

- The teacher structures his teaching by being sensitive to the abilities, interests and needs of his pupils.
- The teacher adequately acquaints with the curriculum by being thoroughly familiar with what he is required to teach, helping his pupils to make sense of their world,

encouraging creative abilities of pupils and helping children to develop emotionally and socially through their feeling of being valued.

- The teacher ensures resources are readily available inside and outside the school and that resources can be easily handled.

This implies that teaching can be defined as a purposeful and predetermined systematic attempt to induce learning in an individual by collective effort of both the learner and the teacher to result in a change in behaviour and accumulation of values and skills that otherwise cannot be related to physical maturity or growth. Therefore good teaching takes into consideration all variables involved in the teaching and learning process, such as the learner and resources; and how these variables can be effectively organized to make learning more meaningful to all categories of learners, less stressful and have greater impact.

2.3 Teaching Methods

It is beneficial that teachers become skilled at using a variety of teaching methods in order to satisfy the range of learning needs and requirements that are present within most class environments (Campbell, Farrows and Riley, n.d.). Also Kizlik (2013) explains that teaching methods are mainly descriptions of the learning objective-oriented activities and flow of information between teachers and students. The choice of teaching method(s) to be used depend(s) largely on the information or skill that is being taught, and it may also be influenced by the aptitude and zeal of learners. It is important that all teachers within all environments are aware of the advantages and disadvantages of all methodologies currently being utilized in the classrooms. This awareness will then enable instructors to structure learning occurrence to meet the needs of all persons while satisfying the requirements of the curriculum and upholding student safety.

Teaching methods include lecturing, discussion, demonstrations, practicals, experiments, note-giving, role playing, questioning, brainstorming, seminars and group work. Other methods include problem solving, inquiry centered learning, field work, discovery learning, Dalton and project-based (Wikipedia.org).

- **Lecturing**: In this method, teaching is usually characterized by one way communication; information or ideas are normally passed on to students orally while they listen. Adu-Yeboah (2008) asserts that lecturing is the most frequently used method of instruction that has dominated formal education over the years. Bligh (2002) asserts that the purpose of the lecture is to clarify information to a large group in a short period of time. Ideas or concepts are presented by the teacher while students listen and take down notes.
- **Discussion**: This is a method which can be used with the entire class or in small groups to review information, illuminate ideas or solve problems. It is conducted as a period of oral comments, questions and answers led by the teacher in which class members actively participate (Huze, 2011). Discussion has been described by Brookfield (1995) as both inclusionary and participatory because everyone has some useful contribution to make to the educational effort and because it claims to be successful with actively involving learners.
- **Demonstrations**: In demonstrations, an activity is performed so that learners can observe how it is done in order to help prepare learners to transfer theory to practical application; the teacher shows a skill while students watch. To carry out a demonstration effectively, the intended activity must be carefully planned, kept simple and thorough enough to meet the objectives of the lesson. Demonstrations may be augmented with other visuals and learners are given the opportunity to practice what they have watched. This teaching method helps visual learners,

enhances self-confidence, provides opportunity for targeted questions and answers and allows attention to be focused on specific details rather than general concepts (Teacher and Educational Development, n.d.).

- **Brainstorming**: Brainstorming is a process for generating multiple ideas or options in which judgment is suspended until a maximum number of ideas have been generated. Options are then typically analyzed, a best solution identified and a plan of action developed. Students are usually asked to throw out as many ideas as possible in a short time either in groups or whole class, while someone often writes the ideas down. Brainstorming actively involves learners in higher levels of thinking, promotes peer learning, critical thinking and creates synergy. It also helps groups reach consensus. But brainstorming requires that learners discipline their inputs to the discussion. Brainstorming may also not be effective with large groups (www.siartc.org; TED, n.d).
- **Role Play**: According to Kizlik (2013), role playing introduces problem under study dramatically and provides opportunity for students to assume roles of others and thus value another point of view allowing for discovery of solutions and providing occasion to practice skills. Teacher and Educational Development (n.d) adds that role playing dynamically involves members adding diversity, authenticity, and specificity to the learning experience. It also develops problemsolving and verbal expression skills providing practice to build skills for realworld relevance and when actual experiences are not readily available. Role playing provides teacher with prompt feedback about the learner‟s understanding and capacity to apply theories.
- **Project-based**: Project-based learning is the use of in-depth and rigorous classroom projects to facilitate learning and assess student competence. It is an instructional method that provides students with complex tasks based on challenging questions

or problems that involve the students' problem solving, decision making, investigative skills, and reflection that includes teacher facilitation, but not direction. It is also focused on questions that drive students to encounter the central concepts and principles of a subject in a hands-on method. It allows students to develop valuable research skills as students engage in design, problem solving, decision making and investigative activities (Buck Institute for Education, 2013).

The variety of teaching methods imply that a teacher has options to choose from but essentially, the selected methods of instruction should build on a foundation of pupils‟ previous knowledge, ensuring that the choice of teaching method encourages children to learn by doing, ensures learning develops from useful experience and experimentation, effective use of instructional aids, and creates a conducive learning environment in the classroom. The choice of teaching method must also stimulate appreciation as well as cognitive growth and help varying groups of pupils to get the most proficient learning out of all lessons.

2.4 Learning

Although learning proves to be a complex concept to define, the various learning theorists have come up with varying positions concerning the nature of learning. Knight (1998:8) defines learning as „the process that produces the capability of exhibiting new or changed human behaviour, provided that the new behaviour or behaviour change cannot be explained on the basis of some other process or experience such as aging or fatigue‟. This definition aligns with Farrant‟s (1996:107) idea which states that "learning is the process by which we acquire and retain attitudes, knowledge, understanding, skills and capabilities that cannot be attributed to inherited behaviour patterns or physical growth". Numale and Buku (2009) also explain that learning is obtaining new knowledge, behaviour, skills, values, preferences or understanding to aid a person to realize his or her academic, vocational, social and personal ambition.

Ramey and Ramey (2010) as cited in Boafo-Agyemang (2010) add that learning occurs in informal, everyday contexts as well as in structured learning situations. It involves associations or relationships between and among elements such as objects, representations of objects, actions, feelings, abstract ideas and concepts, the kinds of learning environments teachers create, quality of instruction, prior knowledge of students and background of learners.

It is therefore evident that learning refers to a determined activity that increases the capacity and willingness of individuals or groups to acquire and productively apply new knowledge and skills to grow and mature. Again, learning adapts successfully to changes and challenges, that is, learning should aim at helping individuals and groups to develop the intellectual, personal and social resources that will enable them to participate as active citizens, contribute to economic development and flourish as individuals in a diverse and changing society.

2.4.1 Domains of Learning

Humans are lifetime learners; that is from birth we learn and absorb what we have just learned into what we previously know. Learning can be categorized into the domains of concept knowledge, how we view ourselves as learners and the skills we need to engage in the activities.

As early as 1956, Educational Psychologist Benjamin Bloom (serc.carleton.edu) divided what and how we learn into three separate domains of learning as:

1. **Cognitive Domain -** This domain includes content knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts and

concepts that serve developing intellectual abilities and skills. There are six major categories, starting from the simplest behaviour (recalling facts) to the most complex of Evaluation (serc.carleton.edu).

2. **Affective Domain** – This deals with feelings and values and therefore influences our attitudes and personalities (Farrant, 1996). It includes feelings, values, appreciation, enthusiasms, motivations and attitudes (serc.carleton.edu).

3. **Psychomotor Domain**- The psychomotor domain of learning includes physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution (serc.carleton.edu).

It can therefore be deduced that for learning to be effective, all three domains have to be present. Teachers or instructors need to understand the different learning domains well in order to support their students with the appropriate resources to sustain their interest and enthusiasm as well as address learners" needs to attain the highest level of performance.

2.5 Learning through Direct Experience

Learning through direct experience, according to www.naturalcuriosity.ca (2013), is a process that engages students in direct and active interactions with objects or phenomena in the immediate environment, usually through the use of one or more senses (seeing, feeling, hearing, smelling, tasting and intuition). Learning through direct experience is crucial to successful learning across all phases of life, from infancy through to the senior adult years. Learners thrive from the learning environment or in classrooms through practical and hands-on experience. Learning from direct experiences is important to allow students to witness, observe and describe concepts based on their own interactions and first-hand knowledge of a shared experience with others in the community (Gabrielson & Hsi, 2012). Direct experience is necessary to gain understanding, create, change or refine a mental representation when students have little or misconstrued knowledge of a certain topic (intime.uni.edu, 2001).

Learning through direct experience is also referred to as experiential learning. Experiential learning shifts from textbooks as the fundamental or exclusive storehouse of knowledge and involves a constant exchange between students‟ immediate experiences and their individual reflections in order to re-examine previously held ideas and influence future experiences and behaviour. It also seeks to transform experience into newly formed knowledge (www.naturalcuriosity.ca, 2013). McGill and Beaty (1995) as cited in Dunn (2002:2) state that Kolb proposed a four-stage learning process with a model that is often referred to as „experiential learning‟.

The experiential learning theory is a holistic viewpoint that combines experience, perception, cognition and behaviour (www.learning-theories.com). Kolb believed that "learning is a process whereby knowledge is created through the transformation of experience" (Kolb, 1984:38). As explained by www.learning-theories.com, the four-stage learning cycle shows how experience is translated through reflection into concepts, which in turn are used as guides for active experimentation and the choice of new experiences. The cycle has the following stages:

i. First stage – *Concrete Experience*: this is where a learner actively experiences an activity such as fieldwork or laboratory exercise.

ii. Second stage – *Reflective Observation*: this is when a learner consciously reflects on the experience.

iii. Third stage – *Abstract Conceptualization*: this is where the leaner attempts to mentally formulate a model or theory based on what is observed. iv. Fourth Stage

– *Active Experimentation*: this is where the learner attempts to plan how to test a theory or plans for a forthcoming experience.

The process can begin at any of the stages but it must follow each other in the sequence and it is continuous. That is, there is no limit to the number of cycles that can be made in a learning situation. This theory asserts that without reflection we would simply continue to repeat our mistakes (Dunn, 2002). Fig. 1 shows a diagram of the cycle.

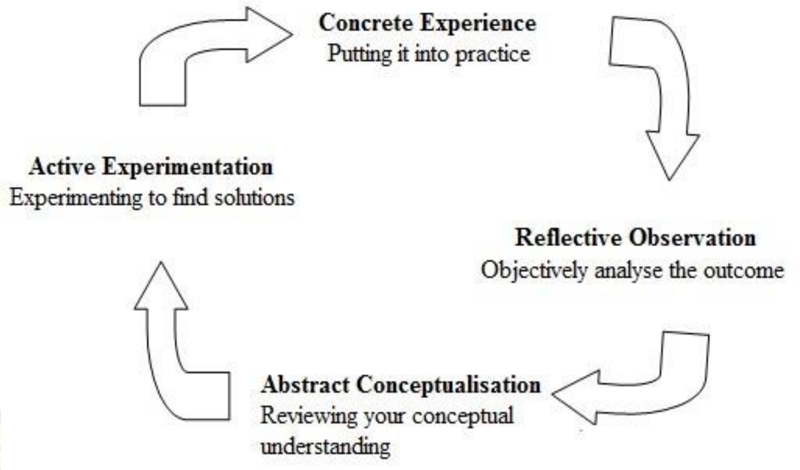


Fig. 2.1: Kolb‟s Cycle of Experiential Learning

Source: www.naturalcuriosity.com

In totality, learning through direct experience supports learning through the senses of touch, sight, hearing, feeling and taste that promotes better understanding, retention and recollection of information. Learning can be administered better in an environment where learners can interact with real objects, explore their potentials and deduce facts about them without necessarily being told, and draw objective conclusions about what they learn so that they understand issues better; the memory of the lesson lasts longer. OpokuAsare (2000) who comments on the significance of learning through physical objects and situations, mentions studies of various philosophers of early times such as Rousseau, Herbart, Pestalozzi, Froebel and Comenius whose specialty with child education emphasized how important it is for children to learn through their senses to make a topic under discussion more understandable.

The implication is that pupils will keep in mind what they see better than what they hear only and that more and better learning results from experiences gained through as many of the senses as possible. This confirms Edgar Dale‟s theory of the Cone of Experience (www2.education.ualberta.ca) which breaks down into percentages how much a learner learns using various senses or a combination with other activities. Figure 2 is a diagram of the Cone of experience.

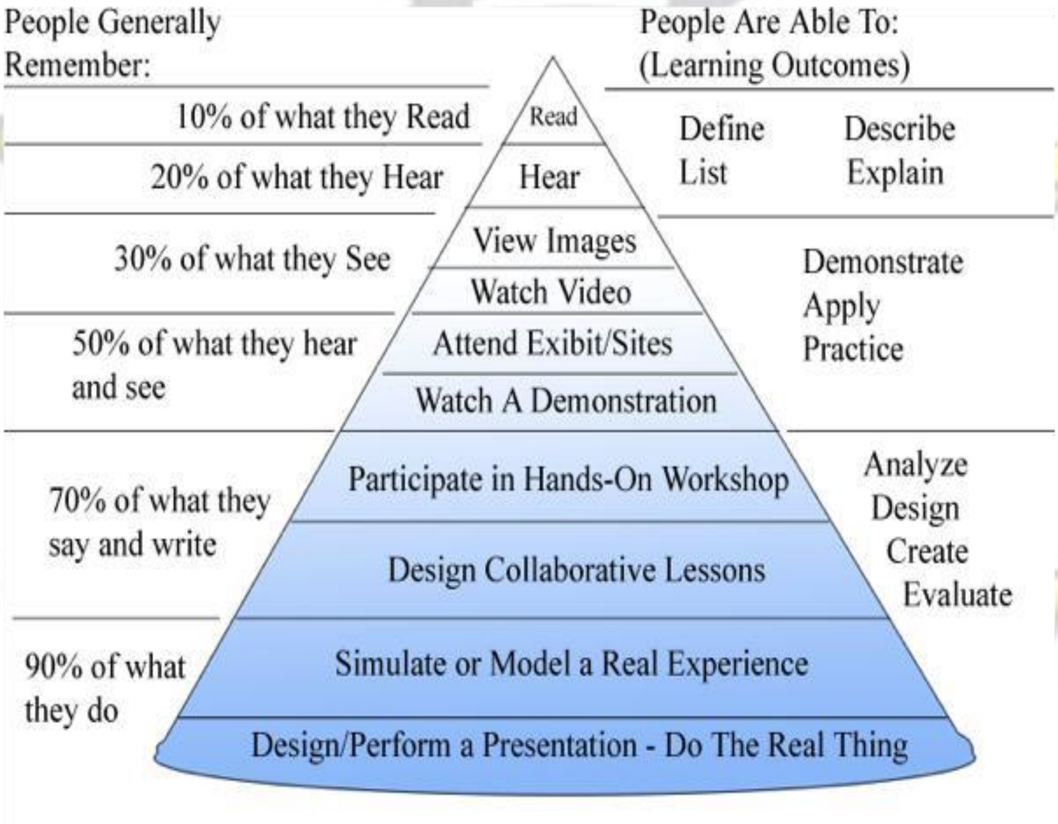


Fig. 2.2: Dale‟s Cone of Experience

Source: teacherworld.com

Reading from the bottom up, Fig. 2 shows that 90% of what students learn is remembered when they do the real activity or imitate a real experience, and 70% of what they learn is maintained when they have taken part in hands – on activity by saying and doing. As the senses of sight and hearing are utilized through actions such as watching a demonstration in class and attending educational trips or exhibitions, 50% of what learners see and hear is retained. But making use of the senses by themselves individually such as sight, hearing or reading yield very low results and so students learn 30%, 20% and 10% respectively. This stresses how important it is for children to be involved in demonstrative and hands-on activities in the classroom in order to achieve maximum understanding and retention of what is learned for effective learning. To this effect, Anang (2011) states that the teaching of Science is made more effective when there is the use of real objects, role play and improvisation or illustrations.

2.6 Active Learning

Active learning is a process whereby students engage in activities, such as reading, writing, discussion, or problem solving that promote analysis, synthesis, and evaluation of class content (Centre for Research on Learning and Teaching, 2013). Adler (1982) as cited in Bonwell (2000), states that all genuine learning is active, not passive. It is a process of discovery in which the core agent is the learner, not the teacher. Learners learn what they care about and remember what they understand. Learning is not an observer activity; students do not learn much just by sitting in class listening to teachers, memorizing pre-packaged assignments and spitting out answers. Students must talk about what they are learning, write about it, relate it to past experiences and apply it to their daily lives. Learners must also make what they learn part of themselves (Ericksen, 1982; Chickering & Gamson, 1987 as cited in Bonwell, 2000). Www1.umn.edu (2008) adds

that students and their learning needs are at the centre of active learning.

There are several teaching strategies that can be employed to actively engage students in the learning process, which includes group discussions, problem solving, case studies, role plays, journal writing and structured learning groups. The benefits of using such activities include improved critical thinking skills, improved retention and transfer of new information, increased motivation and enhanced interpersonal skills. Using active learning does not mean the abandonment of lecture format, but it does take class time.

Lecturers or tutors who use active learning pause frequently during the period to give students a few minutes to work with the information they have been provided. For some lecture-based classes, using active learning may be a bit more challenging because of class size or room limitations such as fixed seating; therefore, breaking students into groups under these circumstances may not be possible, but other strategies such as individual writing or paired activities are quite possible and this leads to good results (www1.umn.edu, 2008).

Bonwell (2000) summarizes active learning as involving learners in doing things, and thinking about the things they are doing. This suggests that in active learning, learners are involved more than in passive listening. That is, they are engaged in activities such as reading, discussing, writing and others placing greater emphasis on developing student skills and less emphasis on transmission of information. The exploration of attitudes and values is stressed and learner motivation is increased especially for adult learners. There is usually immediate feedback from instructors and so learners are involved more in analysis, synthesis and evaluation.

2.7 Science Education

"Science encompasses knowledge and understanding of the biological and physical aspects of the world and the processes through which such knowledge and understanding are developed" (National Commission for Curriculum and Assessment, 1999:6). Children construct, modify and develop broad range of scientific concepts and ideas through science education. Science education builds up children‟s knowledge and understanding of their physical bodies and the world in which they live. It involves children in actively building the understanding of concepts in their own way (NCCA, 1999). The development of children‟s ideas is central to science education. Young children come to science activities with ideas that they have formed from previous experiences. They use these ideas to make sense of the things that happen around them. These ideas tend to be limited to concrete, observable features and may be inconsistent with the formal theories of conventional science. With the focus of science education on helping children to modify their ideas and to develop more scientific understandings as well as planning, it is essential to consider the children‟s ideas as the starting points for science activities and education.

The teaching of Science at the primary level involves the creation of two types of understanding: conceptual understanding and procedural understanding. Children‟s conceptual understanding is concerned with the development of scientific knowledge and with their deepening understanding of fundamental scientific ideas; knowledge of the scientific process is sometimes referred to as procedural understanding (NCCA, 1999). Working scientifically involves children in observation, questioning, discussion, prediction, analysis, exploration, investigation and experimentation, while the knowledge and skills they acquire may be applied in designing and making tasks. Thus, science education equips children to live in a world that is increasingly scientifically and technologically oriented. This is why it is absolutely necessary to use real objects and illustrations or improvise during Science lessons to avoid ambiguity and confusion. This is confirmed by the Structure and Content of Education (MoE, 1974) as cited in Agbadzi (2009) which states that, teaching as an activity can be done effectively when there is the use of teaching-learning materials such as wall charts, chalkboard illustrations, diagrams or photographs. Wiredu (2008) as cited in Anang (2011) therefore suggests that teachers make use of diagrams, charts, making of models and drawings in order to make science topics meaningful to the students.

2.7.1 Challenges in Science Education

Wagner and Benavente-McEnery (2006) opine that Science Education is often under attack from many quarters today. Many lament its cost ineffectiveness in light of standardized tests while post-modernists critique the idea there are ever any truths to seek. Others also charge that science education leaves students with little sense of what science is really all about. The idea that science is an academic adventure, full of excitement, mystery and tentativeness is seemingly lost. Teaching and Learning Research Programme (2006) states that there is general concern about the outcomes of Science education at school. In the United Kingdom for example, representatives of industry say that more high-grade scientists, technicians and engineers are needed if the country is to compete successfully in technology-intensive worldwide markets. Whatever career intentions may be, far less young people do much Science at school once it is no longer compulsory. Results are fewer applications for Science degrees, and this reduces the supply of Science graduates. Just as significantly, the number of young people entering non-graduate occupations involving Science or technology is reduced, leading to skills shortages in many sectors.

The problem is even worse when looked at from a gender perspective, that is, girls are less interested in Science education than boys; hence, women choose fewer academic studies in Math, Science and Technology (MST). In fact, at the European level, girls account only for 31% of MST graduates (Rocard et al., 2007). Rocard et al. (2007) state that the reasons why young people do not develop interest for Science are complex, however, there is firm evidence that indicates a connection between attitudes towards

Science and the way Science is taught. A recently issued report by the Organisation for Economic Co-operation and Development (OECD, 2006) on „Evolution of Student Interest in Science and Technology Studies" identified some causes as:

- The discomforting circumstances of some primary school teachers that are asked to teach subjects in which they lack enough self-confidence and knowledge.
- The traditional „chalk and talk" methods with which teachers are more comfortable are often chosen and avoid inquiry-based methods that necessitate them to have deeper integrated Science understanding. The focus therefore becomes memorizing rather than on understanding;
- Furthermore, burdensome workloads that leave little time for meaningful experiments are reported.

Another report „Europe Needs More Scientists" adds that science subjects are often taught in a much too abstract way. It explains that "It is abstract because it is trying to put forward fundamental ideas, most of which were developed in the 19th century, without sufficient experimental, observational and interpretational background and without showing sufficient understanding of their implications" (Rocard et al., 2007:8).

2.7.2 Science Education in Ghana

Hutchison (n.d.) states that science education has always been a part of the Ghanaian culture. It included both the formal and informal forms of education that were present prior to the advent of modern education. Modern education in Ghana came with the advent of European missionary and mercantile enterprises, and has largely become the vehicle for social upward mobility. Generally education and science education for that matter are serious issues for all Ghanaians.

The significance attached to science education has been a yardstick to the continuous presence of the science subject at all levels of the Ghanaian education system.

The Ghanaian science curriculum follows the "spiral approach", which treats the same themes at different times and in greater depths within each educational level; Natural science at the primary level and integrated science for the Junior High School pupils. This is a generalist, survey course, which exposes the children to the universe. At this stage, the students get the basic exposure to scientific ideas; learn about the history of science and the basic scientific vocabulary at this level.

- **Rationale for Teaching Natural Science at the Lower Primary School**

According to the Curriculum Research and Development Division (CRDD, 2007), Natural Science is a fusion of the major branches of science (Chemistry, Physics, Biology). Its study at the basic education level will equip the young person with the necessary process skills and attitudes that will provide a strong foundation for further study in science at the upper primary level and beyond. It will also provide the young person with the interest and inclination toward the pursuit of scientific work.

- **General Aims of the Natural Science Syllabus**

The syllabus is designed to help pupils to develop the spirit of curiosity, creativity and critical thinking; develop skills, habits of mind and attitudes necessary for scientific inquiry as well as developing the spirit of curiosity for investigating and understanding their environment. It also seeks to help pupils to communicate scientific ideas effectively and use scientific concepts for explaining their own lives and the world around them in order to live a healthy quality life and treat all resources of the world with humane and responsible attitude. Furthermore, the syllabus is to help pupils to show concern and understanding of the interdependence of all living things and the Earth on which they live and design activities for exploring and applying scientific ideas and concepts (CRDD, 2007).

- **Scope and Organisation of the Syllabus**

The topics in the Natural Science syllabus have been carefully selected to introduce pupils to the enquiry processes of science as well as to basic ideas in science. The topics cover basic science disciplines, agriculture, health, industry and basic electronics. The syllabus is structured to cover each of the three years of Primary 1 to 3. Each year‟s work has been grouped under five sections or themes (Diversity of matter, Cycles, Systems, Energy and Interactions of matter). Each of these themes has been related to everyday experiences of the child, and to commonly observed phenomena in the child‟s environment. The main aim is to enable pupils appreciate the links between different scientific topics and thus help them to integrate scientific ideas in dealing with phenomena. The sections/themes cover a core of concepts which provide broad based understanding of the environment upon which the foundation for further study could be built. The feature of Spiral Approach, adopted in the syllabus is characterised by revisiting concepts and skills at different levels with increasing degrees of depth at each stage. The spiral approach has the benefit of matching scientific concepts and skills to pupils‟ cognitive development; therefore pupils are helped to build a gradual mastery of scientific skills. The titles of the sections are the same for each class level. However, the knowledge, understanding as well as the activities and range of process skills presented have been extended at the different class levels (CRDD, 2007). Appendix E shows the structure and organisation of the syllabus.

2.7.3 Challenges in Science Education in Ghana

Science is poorly served in schools, with many schools lacking well-equipped laboratories and workshops. Results in public examinations, while improving, demonstrate poor performance in mathematics and science with pass rates of 59% and 51% respectively in the 2000 Senior Secondary School Certificate Examination (MoE,

2003). Personal communication with Professor Allotey as cited in Ameyaw-Akumfi (2004) also revealed that, results of the 2002 SSSCE indicated that over 40% failed core mathematics, elective mathematics and physics and over 60% failed to get a Grade D in all the pure science subjects. The situation becomes even more alarming when students with grade E"s are added to the failures since most universities do not accept grade E. Ghana cannot build a strong science and technology base with such results.

According to Ameyaw-Akumfi (2004), science education has not achieved its primary purpose of improving the social, cultural and economic conditions of the country. But Ghana"s participation in the global knowledge system depends on the development of a strong science and technology knowledge base which is currently the currency for economic and social transformation of nations. Ameyaw-Akumfi continues to say that many factors have contributed to this state of affairs resulting in the government of Ghana"s estimation in 2003 that less than 15% of Ghanaians of ages fifteen years and above were scientifically literate. He mentions the following factors as responsible for this state:

- Inadequate resource allocation to science and mathematics teaching and learning at all levels of education, leading to poorly equipped laboratories and workshops.
- Inadequate government commitment to the development of science and technology.
- Poorly-developed science and technology innovation system resulting in the lack of interaction among the different agencies connected with science and technology.
- Use of uncreative and outmoded methods of teaching and learning in the schools e.g. chalk and talk approach, textbook dependent, examination-oriented teaching learning by rote memorization (chew-pour-pass-forget), lack of science practical in

most schools and even where they are done they are designed in cook book manner to confirm known answers.

- Non-utilization of community resources in science teaching and learning and decontextualised curricula.
- Inadequate number of teachers of mathematics, technology and science
- Unmotivated teachers.
- Most primary and junior secondary school teachers are ill-prepared to teach science and mathematics.
- Post graduate research in science, technology and mathematics which should form the basis for developing the capacity for innovation and change is very low. Also studies by Anamuah-Mensah and Asabere-Ameyaw (n.d) in basic schools in Ghana, on trends in international mathematics and science studies showed that:
- The overall performance of Ghanaian students in science tests are very low; the overall average score of 255 placed Ghana at 45th position, while the International average was 474.
- The average percentage correct on all science test items for each participating Ghanaian student was 19%.
- There was a very large variation in science abilities among the students with some scoring as low as 52 and others scoring as high as 450.
- Pupils‟ weakest content area was in physics.
- Students performed well at the factual knowledge level instead of the conceptual understanding and reasoning and analysis levels.

The studies highlighted the following weakness in the way Science and Mathematics were taught in basic schools in Ghana:

- There was no provision made in the curricula for teaching children with different abilities.
- Students were taught by teachers who were not specialists in Science or Maths.
- Teaching was dominated by demonstration and lecture.
- Students spent considerable time on homework but the nature of home-work did not seem to improve their achievement.

With reference to pre-service teacher preparation, the following weaknesses were identified to affect Science and Mathematics education in Ghana. That is, there were low emphasis given to subject matter content during pre-service, disconnection between theory and practical application and the teaching of science and mathematics at the primary level is conducted in English which is not the mother tongue but a foreign medium of instruction.

Unfortunately, most teachers in the primary school come from a background in the humanities and are ill-prepared for the progressively more complex questions about science that primary school children might throw at them. If teachers are not able to answer children‟s questions at primary school with confidence and zeal, then children‟s confidence, enthusiasm and spirit of enquiry can be lost (Gluckman, 2011).

Ameyaw-Akumfi therefore suggests that quality teachers and quality teaching are the single most important determinant of a good science education. The success of Ghana‟s students in science education and the progress of the nation will depend on quality science teaching which ensures the development of the innate capacities of all students. Quality teaching builds a strong foundation in basic sciences and leads also to the acquisition of better research skills. The country needs to attract, train and retain a new breed of teachers with skills required in nurturing scientific inquiry and understanding and developing innovative capacity in the youth. Such teachers must be knowledgeable, enthusiastic, dedicated, creative, and reflect on their teaching and students outcomes and must be ready to utilize community resources and new technologies in their work.

The foundation for the learning of science is laid in primary schools; therefore science must be given greater emphasis at the primary school level. Teachers in primary schools should be given effective training and support to enable them to provide exciting and fulfilling teaching and learning of science to strengthen science teaching and learning in primary schools. A select group of primary science specialist teachers can be created to provide support, mentor and guide other primary teachers in schools in science teaching. Teacher education programmes should allow opportunities for primary teacher trainees to specialize in science and not generalist teaching only. Primary teachers with weak skills in science should be given support to upgrade their knowledge and skills. It therefore becomes necessary to make certain that within every primary school there are resources and experts able to assist teachers less confident in providing that sense of scientific enquiry and scientific enthusiasm to young minds (Ameyaw-Akumfi, 2004; Gluckman, 2011).

Basically children in the primary school are fascinated by the world around them. They have a spirit of enquiry and an eagerness for life that needs to be encouraged in every way. Therefore, teachers and all stakeholders involved should seek and work hard to encourage and sustain that scientific curiosity, understanding, critical thinking and enthusiasm in children to want to know more. This may be achieved when especially primary school teachers are adequately trained in the fundamentals of science to give them a better understanding of scientific concepts and confidence in handling the topics well.

2.8 Instructional Materials

In order to facilitate effective teaching and learning, it is important for the teacher to implement a resource or a technology which will be able to address the needs of all learners irrespective of learner‟s background, intelligence level and academic need. Various aids known as instructional materials may be employed to help a teacher to effectively deliver a subject or lesson to the understanding of all learners (Chamunorwa, 2010).

Broadly, the term instructional materials as stated by Lewis **(**2013) refer to a range of educational materials that teachers use in the classroom to support specific learning objectives. Olumorin, Yusuf and Ajidagba (2012) add that they are those materials that help the teachers to teach with ease and the learners to learn without stress. Ministry of Education (1974) as cited in Agbadzi (2009) states that the use of teaching and learning materials is very important at all levels of pre-university education. According to Olumorin, et al. (2012), IMs appeal to the senses of seeing, touching, smelling, feeling and hearing. On the other hand, they are used by teachers to convey and put emphasis on information, arouse interest and ease the learning process (Rius, Muhyidin & Waluyo, 2009).

In recent times, there have been many other terms used alongside or otherwise interchangeably with instructional materials but bearing the same idea. Some of these include Instructional Media, Teaching and Learning Aids (TLA), Teaching and Learning Materials (TLMs), Educational Media (EM) and Instructional Resources (IRs). For the purpose of this study, the terms would be used interchangeably and only refers to the classroom education context.

- **Types of Instructional Materials**

Instructional media encompasses all the materials and physical means an instructor might use to implement instruction and facilitate students' achievement of instructional objectives. This may include traditional materials such as chalkboards, handouts, charts, slides, overheads, real objects and videotape or film, as well as newer materials and methods such as computers, DVDs, CD-ROMs, the Internet and interactive video conferencing (Unmgrc.unm.edu, 2009). Florano (2011) categorizes instructional media into text media, audio media, visual media, motion media, people media, manipulative media and multimedia. These different aids are the basic components in teaching and learning at all levels of education especially pre-schools and primary schools. These instructional materials help children to understand what is being taught when they see and handle the objects themselves (Shankar, 1980; as cited in Anini, 2011).

Fianu (1999) as cited in Boafo-Agyemang (2010) also postulates that IMs are either visual or audio-visual. According to him, materials that are considered visual are those which teachers use to make visual impressions on the learner during the lesson for effective understanding of what is taught. They include projected, non-projected, printed and others such as objects or relia, three-dimensional objects that are produced through locally sourced materials, program instruction, instruction package among others (Olumorin, et al., 2012). Audio-visual materials are anything seen and heard which together with the teacher"s voice add to the effectiveness of instruction or teaching (Rius et al., 2009). An alphabet book, alphabet chart, calendar, chart, easy reader, flash card, flip chart, poster, sentence building cards, sentence building grid, syllable wheel, word building cards, word slide are all examples of IMs (Leus, 2002).

- **Advantages of Instructional Materials**

According to Jekayinfa (n.d.) the selection of materials which are related to the basic contents of a lesson, helps in-depth understanding of such a lesson by the students in that they make the lesson attractive to them, thereby arresting their attention and thus, motivating them to learn. Similarly, good instructional materials are those that require the minimum of intervention by the teacher. Nikky (2010) mentions that some advantages of using IMs are that they supplement in verbal instructions, make learning permanent, provide variety, helpful in attracting attention of the students and save time and energy.

IMs also encourage healthy classroom interaction, help the teacher to create situations for learning for beginners and are helpful in creating positive environment for discipline. They also assist in meeting individual differences as well as providing speech training to the pupils. Olumorin et al. (2012) add that IMs can be used to teach large classes, are cheaper to produce and encourage class participation.

IMs can be purchased or made by teachers or schools. Richards (2012) asserts that teachers or institutions preparing their own IMs hold certain advantages. These include:

- Relevance of materials to learners‟ and institutional needs that reflect local content, issues and concerns.
- It also develops expertise among staff, giving them a greater understanding of the characteristics of effective materials.
- The reputation of the institution or teacher is enhanced by demonstrating commitment to providing materials specifically for their students.
- Finally, flexibility of materials produced as they can be revised or adapted as needed, giving materials greater flexibility than the imported IMs and commercial course books.

Potential disadvantages include cost; because quality IMs requires time as well as resources to produce. Materials development is a specialized skill and not all teachers are capable of producing good materials, therefore, teacher-made materials will not normally have the same standard of design and production as commercial materials.

Olumorin et al. (2012) however, emphasize that some of the factory produced or imported IMs have also been discovered to be concept-based on foreign ideas and culture. A locally produced chart will reflect objects that can easily be seen in the child‟s environment depending on where the child resides or his background.

- **Criteria for Selection of Instructional Materials**

As much as IMs are crucial for effective teaching and learning, care has to be taken by the teacher or school when choosing these materials. The choice of IMs should fulfil the aims and objectives of a lesson to be taught since an aid used in one lesson might not relay the same message when used in another lesson. This implies that there are specific roles that each IM plays in the teaching and learning process. Therefore IMs if not properly chosen might mislead pupils instead of promoting understanding of a lesson being taught. There is therefore the need for teachers to acquire various materials to satisfy the objectives of different lessons to be taught, understand their roles and more importantly get training on how to use them.

According to Leus (2002), the following criteria should guide a teacher or school in their selection of IMs. These include: Appropriateness, Authenticity, Interest, Organization, Balance and Cost. Farrant (1996:169) also explains that „good educational media are those that require the minimum of intervention by the teacher. Good instructional material needs little or no explanations, stimulate ideas, demand an active response from the learner, must be appropriate to the maturity and culture of the user as well as be flexible in use‟. They should also provide enjoyment and be strongly made and wear well.

This means that in the selection of IMs for instruction, consideration should be given to the mutuality of the material to be used by both learners and teachers as a study resource. For instance, IMs for science should provide a main source of science content, present specific views about the nature of scientific practices, and how scientific knowledge is developed. This is because IMs can serve as a major influence on how science should be taught by teachers. IMs should help to produce instruction that actively engage students in the learning process and encourage the inclusion of hands-on engagement with daily occurrences laying emphasis on student responsibility since these are more likely to increase conceptual understanding; hence, a good IM should fulfil these.

2.9 Instructional Materials from Local Resources

Locally sourced instructional materials can be categorized based on their mode of production. These divisions, as adapted from Ogunmilade (1984) as cited in Olumorin, et al. (2012) are: (i) Models and ready-made materials (packages), (ii) Local materials made by experts in visual resources and (iii) Self made (inexpensive) materials. Fig. 3 below shows the categorization of locally sourced instructional materials based on their mode of production as adapted from Ogunmilade (1984) as cited in Olumorin, et al. (2012).

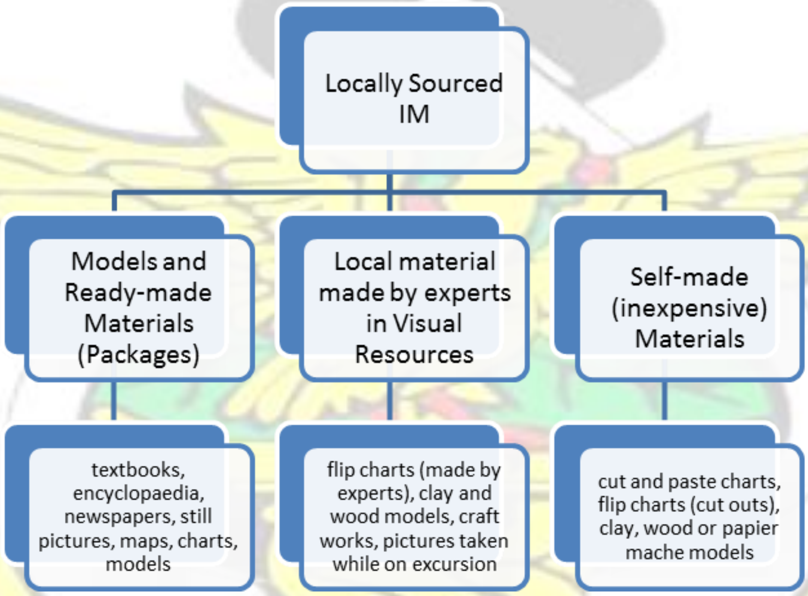


Fig. 2.3: Categorization of IMs based on mode of production

Source: Olumorin, Yusuf and Ajidagba (2012)

Various studies have been done by experts in IMs development using local materials. Such studies highlighted the need to rely on what is available in the immediate environment of schools and teachers to produce their own resource materials for classroom instruction. Abban (1982) advocated the use of locally available materials such as cigarette boxes,

raffia, carton papers, waste fabric, metal scrap, bamboo and coconut for use in various art and craft projects in Ghanaian schools. It was emphasized by Abban that the materials should be available in the environment and teachers and students should be well acquainted with them. Abban"s work highlighted the necessity of incorporating locally available resources in the classroom and how these materials can be used to enhance teaching and learning. Some of these materials were used to produce artworks like furniture (from cigarette boxes), drinking cups (bamboo), flutes (bamboo), sandals
(raffia), office stationary holder (coconut shell), toy cars (metal scrap), door mats
(coconut fibre) and so on. Based on Ogunmilade"s categorization, Abban"s work can be classified as self-made materials.

Adwetewa-Badu (1992) incorporated puppetry in basic education in the teaching of language and literacy using local materials such as cotton fabrics, old socks, old newspapers, bottle-like plastic containers, straw, raffia, wood shavings, corn tassel, leather, bamboo, egg cartons, coconut fibre, cane, and others. His works encouraged the collaborative effort of both teachers and pupils in producing models for teaching and learning; and can be classified as self-made according to Ogunmilade"s categorization. He explained that the collection and use of „odds and ends" (that is, local materials) and a variety of materials is vital to help children identify with, and explore their environment.

Also, Anini (2011) produced instructional materials from local leather for pre-school education. The successful completion of Anini"s work identified local leather as a viable local resource for the production of instructional materials. Anini"s work, according to Ogunmilade"s categorizations, can be classified as local materials made by experts in visual resources. Gabrielson and Hsi (2012) as science educators worked hand-in-hand with local teachers in Timon-Leste to use locally-rooted materials as resources and design principles for the successful development of Science and Mathematics curricular and IMs for use in community schools. Locally-rooted materials such as certain palm leaves indigenous to Timon-Leste communities, bamboo, chicken feet (found in every Timorese home) and local Timorese baskets were used as instructional resource materials.

This means that local materials are indeed very viable resources in the production of IMs at all levels of education and more especially in primary schools. But in order to efficiently produce instructional materials from local resources, sufficient basic skills are needed by teachers. This acquisition of skills can be made possible by constantly practising and observing professionals. Teachers also must have the knowledge of basic design principles and be familiar with the materials in their environment in order to utilize them in the classroom to support instruction.

2.10 Instructional Design Models

Instructional design models present users with a way of understanding an otherwise incomprehensible problem. Instructional design models provide structure and meaning to instructional design problems, allowing designers to discuss design tasks with an appearance of conscious understanding. Envisaging a problem and breaking it down into discrete and manageable units is achieved with the help of models; and the importance of a specific model is determined within the context of use. Like any other instrument, a model assumes a specific intention of its user. A model is judged by how it arbitrates the designer's intention, how well it can share a work load, and how efficiently it moves focus away from itself to the aim of the design activity (Ryder, 2012).

There are many different models in use today for solving instructional design problems. Some of these models have been named after the model designers or the purpose they served. Examples include ADDIE (Analyse, Design, Develop, Implement and Evaluate), Dick and Carey Model, Merrill‟s First Principle of Instruction, Kemp‟s Instructional Design Model, Gagne‟s Nine Events of Training Evaluation, Cathy Moore‟s Action Mapping. Others include Backward Design/Assessment-Driven Design, Organizational Elements Model, Transactional Distance, Elaboration Theory and Instructional Design Systems (www.instructionaldesign.org). For the purpose of this study, focus will be on the Backward Design.

Instructional models can also be adopted and modified to suit the use of the designer; as adopted by Reiser, et al. (2003) who modified the backward design into their own assessment-driven design process (refer to Figure 4). The idea of Backward Design comes from Wiggins and McTighe (2001) and proposes that „learning experiences should be planned with the final assessment in mind. It starts with the end, the desired results (goals or standards), and then derives the curriculum from the evidence of learning (performances) called for by the standard and the teaching needed to equip students to perform' (Wiggins & McTighe, 2001). There are three stages to backward design:

i. Stage 1: Identify Desired Results ii. Stage 2: Determine Acceptable Evidence of Learning and iii. Stage 3: Design Learning Experiences and Instruction (instructionaldesign.org).

In this research also, the backward design model was adopted and modified into the „Objective-Driven Approach‟ to suit the purpose of the research.

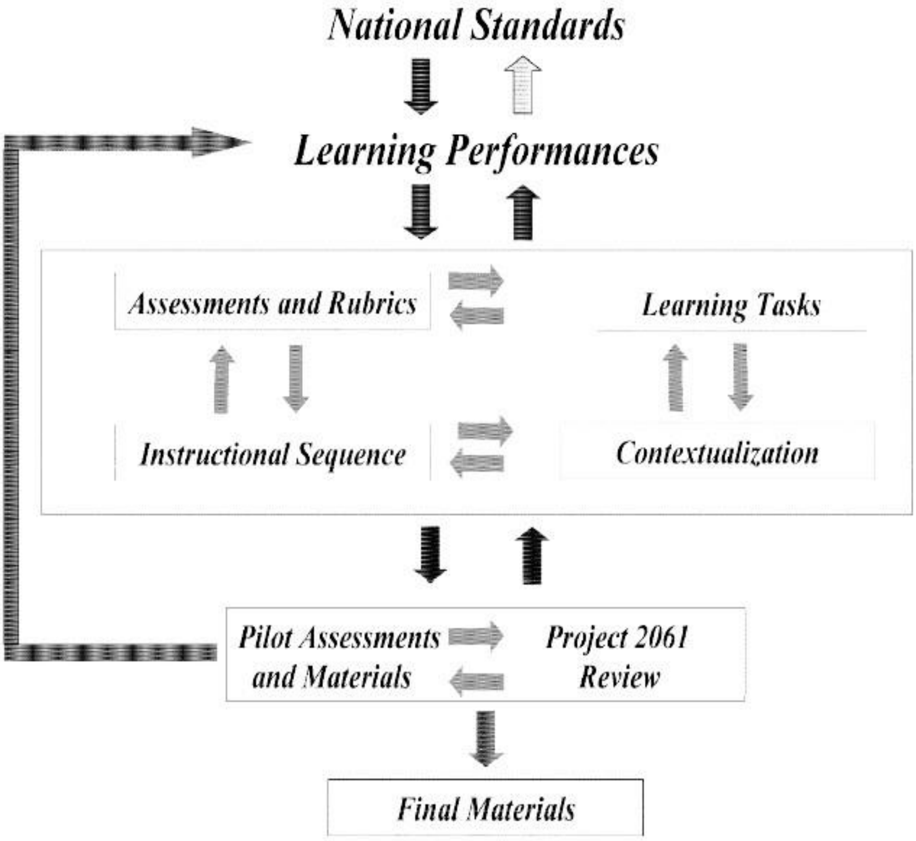


Fig. 2.4: Assessment-Driven Design Process *Source: Reiser et al. (2003).*

CHAPTER THREE METHODOLOGY

3.1 Research Design

The qualitative research design was adopted for this study. Qualitative research is "a holistic approach that involves discovery" (Williams, 2007:3). According to Denzin and Lincoln (2000) as cited in Ospina (2003:3), qualitative research involves an interpretive and naturalistic approach that allows "qualitative researchers study things in their natural settings, attempting to make sense of or to interpret phenomena in terms of the meanings people bring to them". Qualitative research as one of the main research paradigms is concerned with the opinions, feelings and experiences of individuals which are used to produce subjective data. It describes social phenomena as they occur naturally and attempts not to manipulate situations under study; situations are just understood and described from the participant‟s viewpoint (Hancock, 2002). In the view of Leedy

(2002:133), a researcher “cannot afford to skim across the surface” of a problem being researched into since he must get to the bottom of issues and investigate to have a complete understanding of the phenomenon being studied; qualitative research method provides that opportunity. Rubin and Babbie (2001) also state that qualitative research has the ability to provide comprehensive viewpoint that results in a deeper understanding.

Some advantages of qualitative research, according to Hancock (2002), are that it describes social phenomena as they occur naturally. This means qualitative research offers a unique and rich approach to understanding what, how and why of events in relation to a particular setting. Osuala (2005) also postulates that qualitative research method enables the researcher to gain new insights, develop new concepts and discover problems that exist within the phenomenon.

However, some weaknesses associated with qualitative research are that data is collected through direct encounters such as interviews or observations and so it is time consuming; and large samples cannot be worked with due to the intensive and time consuming nature of data collection.

- **Reasons for Adopting the Qualitative Research**

In view of the fact that this study does not concern itself with statistical procedures of investigation, it was appropriate to adopt the qualitative research approach since it provides the chance to study in-depth available instructional materials and how they are used in the selected school. Again, it enabled the researcher to identify the materials the instructional materials are made of, how they are used by teachers and pupils‟ response to their use in the classroom for the teaching and learning of Science at Weweso M/A Primary School.

The researcher employed this approach since the situations studied were based in their natural settings, which is Weweso M/A Primary, particularly the classroom environment. Qualitative data gathered were analysed to produce a meaningful picture of the state and usage of IMs in the selected primary school for science education.

3.1.1 Research Methods

The researcher employed the Descriptive and Experimental research approaches of qualitative research and made use of observation and unstructured interviews as instruments for data collection. The descriptive research approach offers researchers the opportunity to obtain information concerning the current status of phenomena to describe what exists with respect to variables or conditions in a situation (Key, 1997). Descriptive research is also defined by Shuttleworth (2008) as a scientific method which involves observing and describing the behaviour of a subject without influencing it in any way.

The descriptive research method afforded the researcher opportunity to give a detailed account of IMs available in the selected school, the materials they are made of and their uses in the teaching and learning of Science.

The experimental research method was also used for data collection for the study. Experimental research is the systematic and scientific approach to research in which the researcher influences one or more variables, and controls and measures any change in other variables (Blakstad, 2008). Also Key (1997) explains that it is an attempt by a researcher to maintain control over all factors that may affect the result of an experiment; in doing this, the researcher attempts to determine or predict what may occur. The experimental method provided the researcher the opportunity to test identified local resources as well as observe the use of the produced three-dimensional models and how they affect the teaching and learning of Science at Weweso M/A Lower Primary School.

3.2 Population

Anhwere (2013) defines a population as the entire aggregation of study groups that satisfy a designated set of criteria. This implies that whatever the basic unit, the population always involves the total aggregation of elements in which the researcher is interested. The population for the study was two head teachers, 12 teachers and 360 pupils (30 pupils per class) in the primary department of Weweso M/A Primary School in the Kumasi Metropolis. Therefore, the population for the study was 2 + 12 + 360 = 374.

3.2.1 Target Population

A target population for a study, according to Hayes (2011), is the entire population in which the researcher is interested and to which he or she would like to generalize the results of a study. Since the population was clearly unreachable, a portion of the population was chosen for the study. Therefore, the target population for the study was made up of two headteachers, 6 teachers and 180 pupils (30 pupils per class) in the Lower Primary department of Weweso M/A Primary School. That is, the target population was 2

+ 6 + 180 = 188.

3.2.2 Accessible Population

Hayes (2011) states that accessible population is the population of subjects available for a particular study; usually a non-random selection from the target population and it is from the accessible population that researchers draw their samples. The accessible population for the study included one head teacher, 4 teachers and 150 pupils who were available and willing to participate in the research and this summed up to 155. Therefore the accessible population for the study was 1 + 4 + 150 = 155.

3.2.3 Sample and Sampling

Sampling, according to Osuala (2005), is taking a portion of the population as a representation of the total population. Sampling can also be described as depending on a cross-section of a target population to perform an experiment or an observational study. This is because it is usually not possible to study an entire population. Ruane (2005) therefore explains that samples offer a practical solution to the daunting task of studying entire populations. Samples are used to "stand in" for a larger population. In this sense, samples can be very efficient devices which allow researchers to look at the "few" in order to know about the many.

3.2.4 Sampling Design

The sampling design adopted for the study affects the extent to which the results can be generalized. In this study the convenience and purposive sampling techniques were employed. According to Lucas (2012), in convenience sampling members of the population are chosen based on their relative ease of access; and Hayes (2011) adds that selection is based on the most readily available persons as subjects in a study. The convenience sampling was used in selecting the primary school for the study since it assured the proximity of the researcher to the school and this saved the researcher time from travelling too far for data collection.

Oliver (2006) explains that purposive sampling is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher based upon a variety of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research. The purposive sampling technique was adopted to select teachers, head teachers and pupils because they possessed knowledge and information on IMs used in the school which was needed for the study. Therefore, the sample size for the study was 155 which is 100% of the accessible population and 82.4% of the target population.

3.3 Data Collection Instruments

In accordance with the research approach, the study adopted interview and observation as means of collecting data for the study.

3.3.1 Observation as a Tool for Gathering Data

Observation involves descriptions of activities, behaviours, actions, dialogue, interpersonal interactions, organisation or community processes or any other aspect of observable human experience. The data gathered from observations consist of detailed descriptions of the environment within which the observation was made (Lemanski & Overton, 2011). According to Asare-Forjour (2009), direct observation of behaviour is an essential means of evaluating the works of schools and teachers. In the field of education, observation comes handy to critically determine a teacher"s teaching skills and assessment of practical skills. It answers specific research questions and provides full documentation of observations by recordings and complete field notes (Ruane, 2005).

Conversely, a disadvantage with this data collection technique is that observers may have their own focus and may interpret significant events in their own way, which can lead to imposing their own interpretations on what is observed. These result in the failure to understand what an activity means for those who are involved (Bell, 2005).

- **Justification for Choosing Observation as the Research Tool**

Observation was used to gain insight into the teaching and learning of science in the lower primary department of Weweso M/A Primary School. Classroom teaching of Science, that is, the topics taught and their objectives**,** the types of IMs available in the school for science education and their use by teachers as well as pupils‟ response to the IMs and their impact on pupils‟ understanding of abstract science topics taught them were observed. During this study, there was the possibility of missing out on important occurrences because permission was not granted for video or audio recordings, hence not every detail could be recorded.

The observation was done in two phases: a total of six weeks of classroom teaching was intended to be observed but eight weeks was spent due to various setbacks from the school such as cancellation of scheduled lessons due to interruptions in the academic calendar and rescheduling of lessons because teachers were absent from school. Three weeks of teaching and learning of Science were observed in the first term and five weeks in the second term of the school‟s academic calendar. Written descriptions and photographs were techniques used to document data. Observation was done with the help of an observation checklist (See Appendix D).

- **Designing an Observation Checklist**

A less structured checklist was designed to guide data collection through direct observation. The checklist enabled the researcher to note down the appropriate observed actions by the teachers and pupils in the selected classes. The checklist was guided by what information answers the research questions, why the information were needed by the researcher, what purposes the information will serve and how the information will be used by the researcher.

A total of 30 questions made up the two observation checklists that sought information on instructional materials used in teaching Science in the selected school. The designed checklists were vetted with the help of colleagues from the Department of General Art Studies for the necessary corrections to be effected before it was submitted to the research supervisor for final vetting and approval. The observation checklists were piloted to ensure that they were error – free and would be appropriate for the data being sought.

3.3.2 Interviews as a Tool for Gathering Data

Interviews refer to personal exchange of information between an interviewer and an interviewee. Good interviews seek to make the dialogue a comfortable, conversational one (Ruane, 2005). According to Lemanski and Overton (2011) interviews consist of open-ended questions and probes produce in-depth responses about people‟s experiences, perceptions, opinions, feelings and knowledge. Data includes word for word quotations and enough content to be interpretable. Ruane (2005) adds that of all the data collection instruments available in search for information, the interview strikes many as the single best device for promoting understanding and getting at the truth. Interviews may be structured, semi-structured or unstructured.

Unstructured interviews were used to seek answers to specific questions pertinent to the teaching and learning of Science from school head and teachers adopting the face-to-face approach. It was also an essential approach for the researcher to verify information gathered through observation. Both school head and teachers were interviewed on science education in the primary school, instructional materials and their views on incorporating instructional materials for teaching Science at the lower primary level. A conversational approach to interviewing was adopted by the researcher to ensure that teachers were comfortable in participating and willing to share information freely as explained by Hancock (2002) who states that „qualitative interviews should be fairly informal.‟ An interview guide was however, used to streamline the various discussions.

- **Designing Interview Guide**

Two sets of interview guides were prepared for two sets of interviews; one for school head and the other for teachers. The guides focused on the teaching and learning of Science and the instructional materials used in the school. This assisted the researcher to validate the issues observed with the teaching and learning of Science in the school. The first and second guides were for teachers and head teacher and had 13 and 10 questions each. To ensure the validity of the interview guides, copies were given to colleagues to vet before submitting them to the supervisor for final vetting to make the interview guides as objective as possible. Prior notice was given to the respondents to help them to prepare for the interview and to eliminate unnecessary stress on interviewees but they were still uncomfortable, therefore a conversational approach was adopted.

- **Conducting the Interviews**

The first interview was carried out with four lower primary teachers. This was conducted after the first two weeks of observation which formed the preliminary study for the research. The second interview took place between the researcher and a head teacher.

Appointments were booked after interview guides were designed and copies submitted at the convenience of the interviewees. The researcher was punctual to all dates and scheduled times and recordings were in the form of written descriptions.

- **Difficulties Encountered during the Interviews**

Due to ethical considerations, interviewees did not allow tape or video recording of responses and opinions shared. A major challenge was keeping up with recording of statements from interviewees since not all comments could be captured through writings. Sometimes questions had to be repeated to make sure that the recorded answers were correct.

3.4 Types of Data

The two types of data that were gathered for this research were primary and secondary data. Primary data collected included field notes from observing classroom teaching and learning of Science and interviews with teachers and school head at Weweso M/A Lower Primary School. Secondary data was gathered from books, journals, online documents, published and unpublished thesis, school records and other documents that related directly to Science education and the development and use of IMs at the primary school level.

3.5 Data Collection Process

A letter from the Department of General Art Studies was presented to the head teachers and teachers of the school explaining the purpose of the research. Permission sought and approved by the head teachers and teachers enabled the research to commence with observation sessions in the school. The researcher then visited the school on the approved dates and times for the scheduled observations in the four out of the six lower primary classes on how Science was taught to and learnt by pupils as well as the resources available for Science education and how they are used to improve the understanding of challenging topics to pupils at the lower primary level.

The observations were undertaken every Monday, Wednesday and Thursday of the approved weeks and each session lasted a full period of forty minutes. The times for the observations differed depending on whether the schedule of the stream of the school to be observed was in the morning or afternoon as the school run a shift system. Three weeks of the months of November and December 2013 were used for the first term during the initial observation and five weeks from January to March 2014 that was in the second term of the school"s academic calendar constituted the follow-up observation. The first three weeks was used for the preliminary study which involved testing the Observation Checklist 1 (Appendix C) which was made up of 14 questions to survey the school situation to identify what pertains in the school with regards to Science education. The second observation which was used for the follow-up observation was based on Observation Checklist II (Appendix D) and consisted of 16 questions intended to collect data needed to guide the design of an intervention to resolve any identified shortcomings in the instructional materials found in use during the preliminary study. Results of observation and interviews carried out are presented in Chapter 4.

The balanced participant observation strategy was adopted during the classroom observation since it enabled the researcher to get involved in the activities in the classrooms and also place herself in the position of a spectator to watch what was going on.

- **Limitations in Undertaking the Observation**

Lack of co-operation on the part of some teachers made it difficult for the researcher to obtain the required data for the study. Some teachers changed topics and repeated lessons purposely to impress or cover flaws in previous lessons. Other teachers did not want their teaching observed and refused the researcher because they believed the data collected could be used against them. Also, because teachers were aware that they were being observed, some were very careful in the way they went about their activities in the classroom. Teachers who had not adequately prepared for class refused to have their lessons observed on those days by giving various excuses and requesting reschedules.

3.6 Activities Undertaken for Objective One

Objective one was to find out and describe existing instructional materials used for teaching and learning Science at Weweso M/A Primary School in the Kumasi Metropolis.

3.6.1 Observation of Lessons on the Topic "Measurement of Time"

The lessons for this topic were observed in Primary One and Two classes of the morning shift. The number of pupils present for the lessons was 41 and 37 respectively. The topic was under the theme Diversity of matter. The specific objectives, according to the syllabus were that the pupils should be able to tell the time on an analogue or digital clock for Primary One and Primary Two pupils should be able to measure the time of events and design and make an analogue clock.

- **Observation Made in Primary One (P1) Classroom**

The teacher in Primary One introduced the topic by asking pupils questions on what activities were done with time and how time is measured. The concept of the clock was introduced using an illustration on the chalkboard (refer to Plate 3.1). To help pupils in identifying clock hands and their movement, a wall clock from the head teacher"s office was brought into the classroom. After explaining how the clock hands worked and how to read the time by hour and minutes, pupils were given textbooks from which notes on the passage of time and some activities that can be done in time were explained by the teacher. The pupils found it quite easy telling time by the hour but had a lot of difficulty telling by the minutes. An exercise was then copied from the textbooks into pupils" books where they were to draw clocks from the textbooks and tell the time the hands on the clock showed. The pupils were generally quiet through most of the lesson because the teacher went through the aisle with a cane in hand as a form of discipline constantly calling out names of pupils to get their attention. But there was consistent movement and fidgeting at the back of the class causing distraction. This was clearly because pupils seated at the back where the researcher was could not see what teacher was demonstrating.

- **Observation Made in Primary Two (P2) Classroom**

The lesson in Primary Two utilized a chalkboard illustration and illustrations found in the textbook. The teacher introduced the topic with a chalkboard illustration of an analogue clock and asked pupils to tell various times by the hour which most pupils were able to do with ease, after reminding pupils that the topic was a continuation of what they learnt in their previous class. She then went straight to introducing time in quarters and halves, attempting to help pupils to tell the time using the minute hands on the illustrated clock. Pupils were called to attempt to tell the times illustrated on the board but many failed to get the questions right. After a few more tries, some pupils got the answers right. Because the lesson was the last period to end the morning shift, the time was short for oral or written assessment therefore pupils were asked to illustrate clocks from textbooks into their exercise books and tell the times on the clocks as assignment. Pupils were confused looking at their faces and body language, and the classroom was noisy with pupils constantly moving about, playing games and fidgeting throughout the lesson.

Plate 3.1: Teacher using wall clock and chalk illustration to teach “Time” in P1.

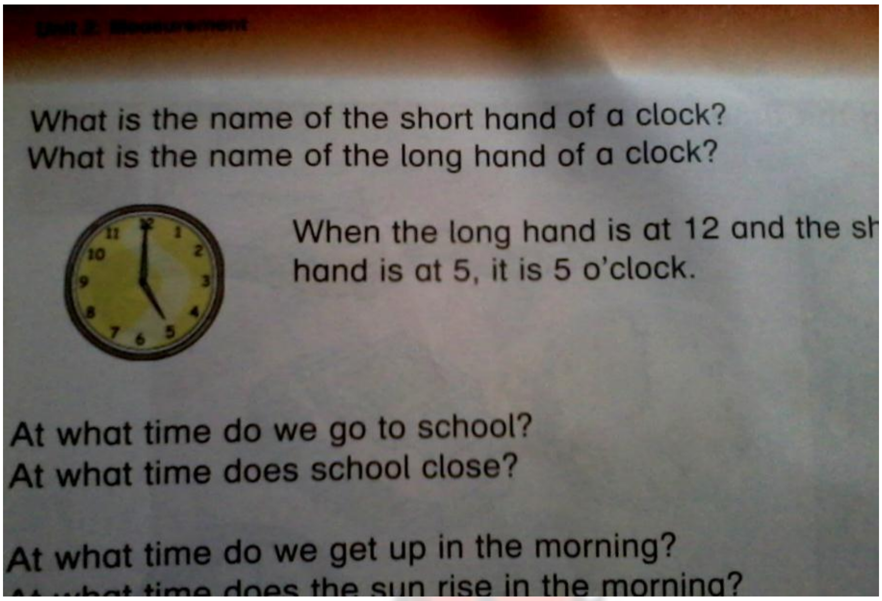

What is the name of the short hand of a clock?
What is the name of the long hand of a clock?
When the long hand is at 12 and the sh
hand is at 5, it is 5 o'clock.
At what time do we go to school?
At what time does school close?
At what time do we get up in the morning?
At what time does the sun rise in the morning?

Plate 3.2: Textbook illustration for teaching "Measurement of Time" in P1.

Plate 3.3: Teaching of "Time" with chalkboard illustration in P2.

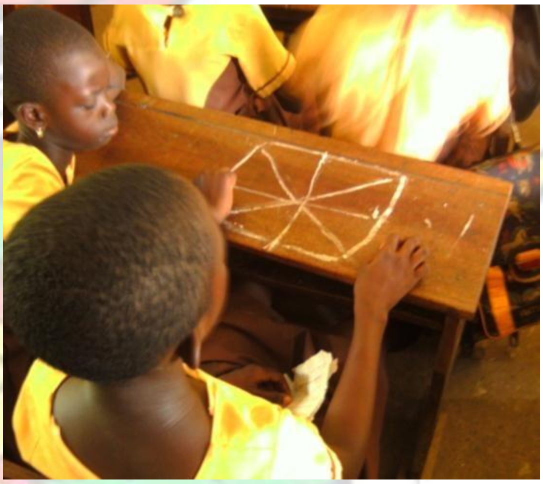


Plate 3.4: Pupils in P2 distracted during lesson on "Measurement".

3.6.2 Observation of Lessons on "Building a Simple Electronic Circuit"

Classes observed for this topic were Primary One in the afternoon shift and Primary Three in the morning shift. The numbers of pupils present for each lesson were 41 and 47. The topic was under the theme Energy and the specific objectives are that pupils in Primary One should be able to tell what makes electronic gadgets (toys) work and pupils in Primary

Three should be able to use simple electronic circuit to convert electrical energy into light energy or sound energy.

- **Observation Made in Primary One (P1) Classroom**

The teacher in Primary One introduced topic in class by asking pupils about what happened at night when there was darkness and how they could see. Responses from pupils mentioned various types of lighting such as torches, lamps and generators. The teacher used these examples to explain that electricity outcomes could be in the form of light or sound and asked pupils to mention various objects that used forms of electric energy from their textbooks. The teacher then used a lamp with batteries to explain that electric energy could be transformed into light energy or sound energy as used in radios
(Plate 3.5). Teacher also used a switch on the classroom wall to mention a switch as part of a circuit and how it is used to turn on or off light. The general atmosphere in the classroom was calm. After the lesson there was no time for written exercise because pupils had to go on break so a few oral questions were asked.

- **Observation Made in Primary Three (P3) Classroom**

The lesson in Primary Three was introduced as pupils were asked to mention various objects that used forms of electric energy. After examples were given, the teacher refreshed their memories on what a circuit was as pupils learnt in primary two. Pupils could not remember the names of the parts of the circuit therefore the teacher listed the parts on the board and referred pupils to their textbooks where there was a labelled diagram of a simple electronic circuit. Pupils repeated the names of the parts of the circuit after the teacher, as she attempted to explain the functions of the parts and mentioned that the electric energy could be converted to light energy as seen in light bulbs or sound energy as heard from microphones and speakers. Pupils were then asked to copy the diagram and label the parts into their exercise books as a form of assessment. Pupils were quiet in class as the teacher used a cane often but lesson was not consistent as the teacher was constantly called out of the class to attend to some administrative duties in the absence of the head teacher since she was an Assistant Head Teacher. During the periods that the teacher was out pupils talked loudly and paid no attention to the textbooks they had or keywords listed on the board.

Plate 3.5: Teacher using lamp and batteries to show how electronic gadgets work to P1 pupils.

3.6.3 Observation of Lessons on "How Plants Produce their Young Ones (Reproduction)"

The lesson for this topic was observed in Primary Two of the morning shift with 37 pupils present in class. The specific objectives for the topics are that pupils should be able to mention ways by which plants make their babies (young ones) and demonstrate ways by which baby plants (young) are produced from seeds and it fell under the theme Diversity of Matter. The teacher introduced the topic to pupils by asking them what they saw on the school compound. When pupils mentioned various plants, the teacher asked if they knew how those plants came to being. Some examples of plants were mentioned by pupils and they were asked to turn to their textbooks. The teacher mentioned various ways by which plants could be grown including the use of seeds. The teacher then used a diagrammatic representation of the germination process (Plate 3.6) in the textbook to show how a seed could grow into a young plant. Throughout the lesson the class was noisy as pupils kept moving about, talking to peers and flipping over the pages of their textbooks. The teacher did not look very comfortable with the topic and kept fumbling and jumping over key points. Attempts to demonstrate the germination process by a practical activity, which was done by planting seeds in empty cans according to the teacher proved unsuccessful due to disruption by the shift system and churches activities on the school premises. The cans containing the planted seeds were usually poured out or thrown away when the classrooms were swept.

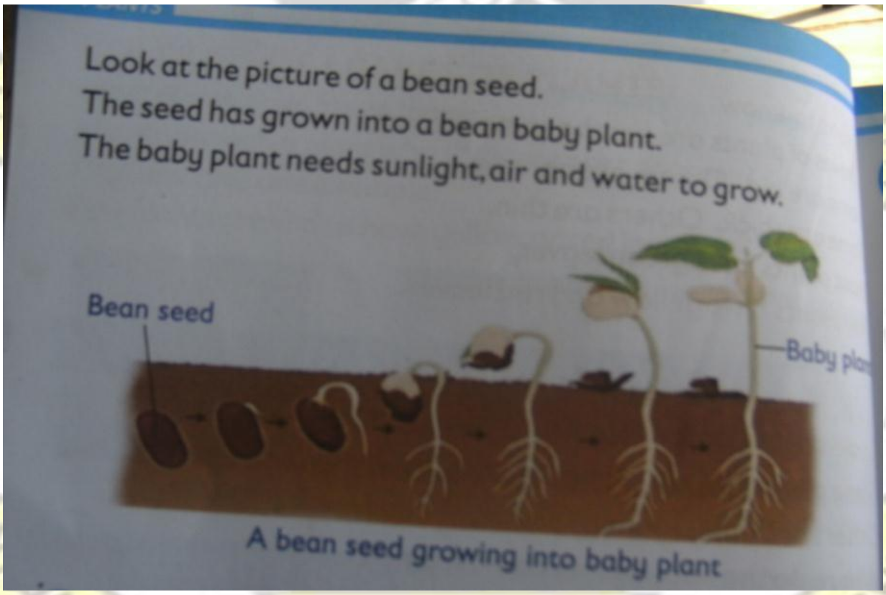


Plate 3.6: Textbook diagram of Germination Process for teaching in P2.

3.6.4 Observation of Lesson on "Waves"

The topic is limited to Primary Three classes and falls under the theme Energy. According to the syllabus, pupils should be able to create waves and explain that waves carry energy. The last observation on „Waves" could not be done because no lesson was taught on the topic for researcher to observe. But teachers stated that they relied on the textbook illustrations to explain the topic to pupils.

In summary, the IMs identified through the observations for teaching and learning the different topics in Science at the lower primary department at Weweso M/A Primary School included chalkboard illustrations, real objects, textbooks and Charts (that is, Selfmade or Purchased).

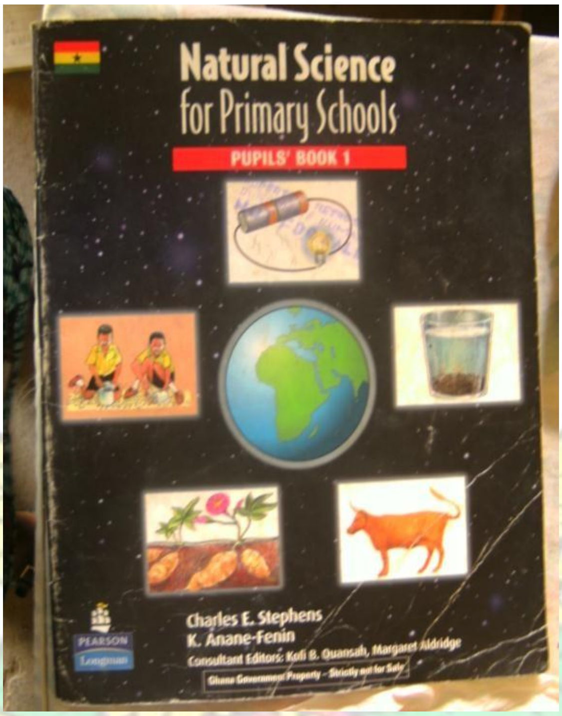
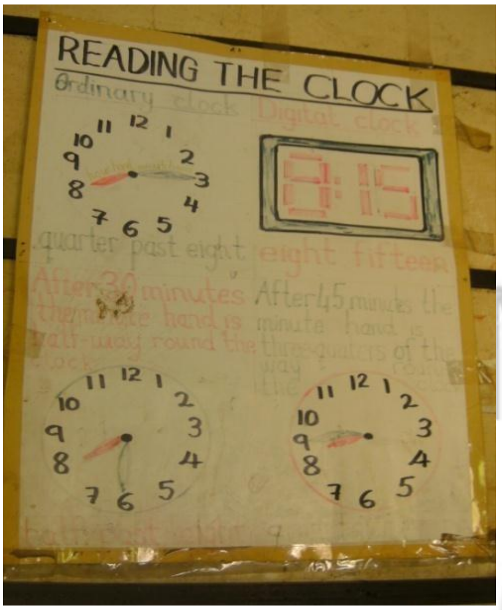


Plate 3.7: Textbook for teaching Natural Science in P1.



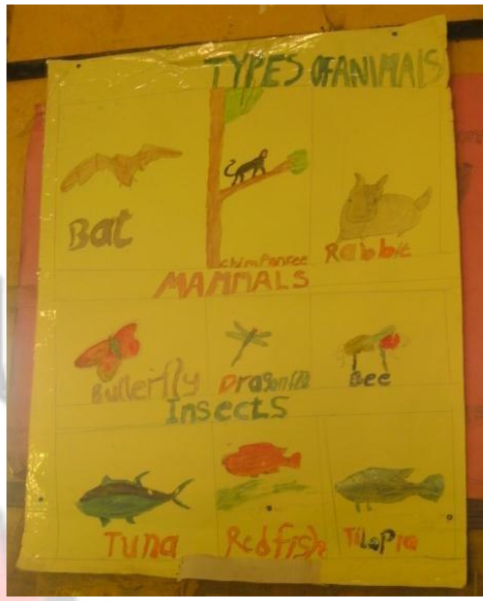


Plate 3.8: A chart for teaching "Time" in P3.

Plate 3.9: A Chart for teaching "Living things" in P2.

3.6.5 Interviews with Teachers and a Head teacher at Weweso M/A Lower Primary School

Four teachers and a head teacher took part in the interviews. Some demographics included their age ranges and years of experience in teaching at the lower primary department in particular. The ages of teachers ranged from 30 years to above 54 years.

The teacher with the least experience in teaching had been in the lower primary class for 5 years; the rest had 23, 29 and 35 years of teaching experience. Two teachers had Bachelor"s degree in Education and the others had Diploma in Basic Education. Charts, real objects, textbooks and chalkboard illustrations were confirmed as the IMs available for teaching and learning Science. They mentioned that charts were usually purchased by the school or made by teachers and posted on the classroom walls. They were usually detailed illustrations, writings or simple outline drawings. The school provided some basic materials such as paper and felt pens or markers. Occasionally charts were also provided by the Ministry of Education (MoE) through the Ghana Education Service (GES). Textbooks, chalk and exercise books were supplied by MoE through GES usually at the beginning of the academic year. Occasionally items like crayons and charts are supplied but they are usually inadequate; for instance for the academic year within the research period, only seven (7) packets of crayon were supplied to the school. Real objects used in the classroom are usually brought to class by the teacher or by the pupils. Chalk illustrations are sometimes made by teachers or where the teacher cannot draw, help is usually sought from pupils in upper classes who had the ability to draw well. Sometimes, others were commissioned to do the illustrations and this leads to the problem of poor presentation on charts (see plate 3.9).

Teachers explained that the IMs available were helpful in the classroom but were inadequate and not always sufficient with enough basic information. They also stated that the textbooks were modelled after the syllabus and so it provided opportunity to follow the syllabus. But because materials are mostly paper, especially charts and textbooks, IMs wore off very easily after handling them for a short period of time. Moreover, apart from a few charts posted on the classroom wall, all IMs were returned to the head teacher‟s office or put away in cupboards after the lessons were over. They could not be put up or left in the classroom for pupils to refer to or interact with because of the shift system. Last but not the least, teachers explained that sometimes, pupils could not identify items in books or link the ideas to their environment since they are based on foreign ideas.

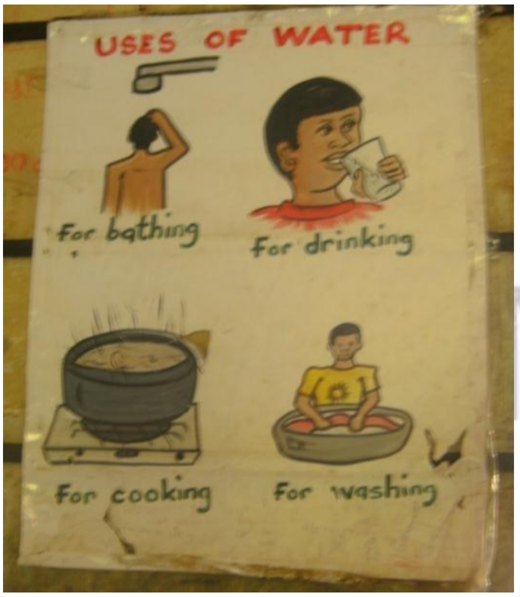


Plate 3.10: Chart for teaching "Uses of Water" in P3.

Plate 3.11: Chart showing "Protected and Unprotected food" in P3.

The teachers added that during lessons pupils responded positively to the IMs. Pupils sometimes participated in lessons, demonstrated some understanding by answering questions correctly and to some extent pay attention in class. Punishment and rewards such as claps were used as mechanisms for keeping the class under control and sustaining pupils" interest during lessons.

The teachers stated the following topics were very abstract to teach without the help of IMs. The topics included: Measurement of Time, Waves, How Plants Produce their Young (Reproduction), States of Matter, Water Purification, Seasons, Feeding in Plants, Water Pollution and Building a Simple Electronic Circuit. They added that the following topics were difficult to teach even with the available IMs in the school; Measurement, Waves, How Plants Produce their Young (Reproduction) and Building a Simple Electronic Circuit. The teachers further added that reasons why the named topics were difficult to teach even with the existing IMs included the fact that IMs available were not sufficient with basic information; not all topics to be taught had IMs to aid effective teaching and the school has no science laboratory to perform most of the practicals needed to ensure better understanding by pupils. Again, non-performance of practical activities due to short school hours as a result of the shift system, as well as religious groups that hold their meetings in the classrooms oftentimes throw out activity materials as they tidy the classrooms, are other reasons. They also stated that generalist teachers lacked in-depth knowledge, love and interest to teach the science subject to pupils to comprehend. Last but not the least, practical activities were destroyed by the shift classes and some other times activities were not performed because materials were not available.

3.7 Activities Undertaken for Objective Two

Objective two sought to identify locally available resources and develop them into threedimensional instructional materials that are appropriate for teaching and learning Science at Weweso M/A Primary School in the Kumasi Metropolis.

3.7.1 Design Principles for Development of IMs

The Ministry of Education and the Ghana Education Service strongly advocate for the use or incorporation of locally available materials in the classroom. Teachers and schools are encouraged to look to their environments for resources that are readily available to them and incorporate them in their instruction and other learning activities. This is seen visibly in the various syllabi all across the different levels of education where activities spelt out in the curriculum encourages the use of both natural and artificial objects from the environment.

In supporting this very important effort to encourage local materials in the classroom to enhance teaching and learning in Ghanaian primary schools, consideration was given to the choice of materials for the production of the three-dimensional models. The design principle adopted by the researcher for this project was the principle of sustainability, hence the use of locally available resources. These materials are readily reached either in the environment freely or available for purchase on the local markets. The availability of the materials employed makes the produced models reproducible. Also, various experts have been consulted in order to produce the most appropriate IMs to be used at the primary school. This is in line with Gabrielson and Hsi (2012:215) who state that „sustainability as a design principle addresses concurrently the environmental sustainability of the materials used, and the economic sustainability of materials acquisition, available non-monetary resources and the willingness of the community to contribute resources to education‟. This principle is consistent with ideas found in education for sustainability and sustainable development.

Based on Ogunmilade‟s categorization, the produced three-dimensional IMs can be classified as local materials made by experts in visual resources.

3.7.2 Locally Available Materials Identified for Prototype Production

Before materials used for the IMs were settled on, a series of experimentations were done with various materials to ascertain the most suitable ones that would give the best effect, represent the ideas appropriately and safe for use for the target group which is lower primary school pupils.

Identified local materials have been grouped into natural and artificial or recyclable materials. The natural materials considered were local leather, calabash and wood remnants, whereas artificial (recyclable) materials included plastic waste, metal scrap, textile materials, paper, waste paper products and used electronic components.

During the experimentations of the different materials in order to choose the most suitable for the proposed IMs for teaching and learning science at the lower primary level, continuous testing of materials yielded the rejection of some until the desired ones considering their characteristics were appropriate alternatives. Materials perceived to have certain qualities chanced upon when tested did not yield the expected results. For instance, the clock was first attempted in strawboard but the result was a wobbly unstable figure with falling hands that could not bear its own weight.

An attempt was made at the germination processes in textile materials with strawboard used as the support base, but the effect was also not satisfactory. The case for housing the modelled figures for the germination process were also identified not as solid as needed to bear the weight of the complete model, so the case was rebuilt with larger frames of PVC trunking. Moreover, the IM for wave which was originally made as a single frame was found to be very bulky and difficult to move around and, so some modifications were made to allow for folding using hinges.

Also, during the preparation of digits for the clock, the plastic glaze used in coating the cut-out figures reacted differently from what was observed in earlier experimentations.
The glaze which was supposed to start drying after sixty seconds started drying within the first twenty seconds; therefore the solution had to be poured in very small amounts and applied one after the other to the cut-out digits.

Plate 3.12: Attempted model of the clock in strawboard and plastic for teaching

"Measurement of Time"

Plate 3.13: Experimentation on the Germination case using textile waste and strawboard

- **Reasons for Using the Identified Materials by the Researcher**

Choice of local materials was guided by various empirical studies and further experimentation. The reasons for employing these materials are;

Leather – According to Anini (2011), leather in terms of properties, is versatile, durable, pliable and can be dyed in various colours to attract children, since they are highly curious and are easily attracted to bright colours. Since leather is light in weight, its usage for making instructional materials will help reduce weight, promote durability of teaching and learning materials and also avoid or reduce the high cost of imported materials such as charts, plastic and electronically operated teaching and learning aids.

Calabash – Calabash is a versatile plant that can be put to various uses; from religious to domestic as well as decorative purposes. Calabashes can be decorated by several different techniques in different colours or their original warm yellow colour maintained (Oziogu, 2012). Calabashes are cheap, light in weight and easy to handle, which makes it ideal for use in various purposes (Odugbemi, 2008).

Wood remnants – using materials leftover from workshops aim to specialize in sustainable design (Recyclart, 2009). Wood remnants can be recycled (as biomass fuel, wood chips or animal bedding), reused or disposed. Reusing wood remnants is very cost effective and reduces drastically landfill waste (woodremnants.co.uk). Cut outs from wood can add the missing element to any demonstration or project (Smith, 2014).

Recyclable materials – According to Kurz (2014), the best way to recycle something is to reuse it, either in its original state or in a project. Using recyclable items can save money when used in place of store-bought materials. School projects provide multiple opportunities to demonstrate the usefulness of recyclable items.

3.8 Execution of Prototype Three-Dimensional IMs for Teaching Science to Lower Primary Pupils at Weweso M/A Primary School

The execution of the prototype three-dimensional IMs covers steps in the design and production of proposed prototypes for "difficult-to-teach" topics in science at the lower primary level of education. The design framework, criteria for developing prototypes and the production process are discussed.

3.8.1 Design Frameworks for Developing IMs

In designing the IMs, the researcher adopted what is referred to by Wiggins and McTighe (2000) as backwards design, also termed as assessment-driven design. The central idea was to identify learning objectives and use the objectives to guide all phases of curriculum and activity design in alignment with the target or specific objectives. The researcher in this case adopted this approach with some modification. The expected learning experiences were identified and used as a basis to design IMs that would aid the teacher in satisfying the specific objectives of the topic as outlined in the syllabus more easily. The observations done in the school assisted the researcher to identify shortcomings with the available IMs and adjustments made to suit the classroom situation and the skills of the teachers. The modified framework is named the Objective-Driven Approach.

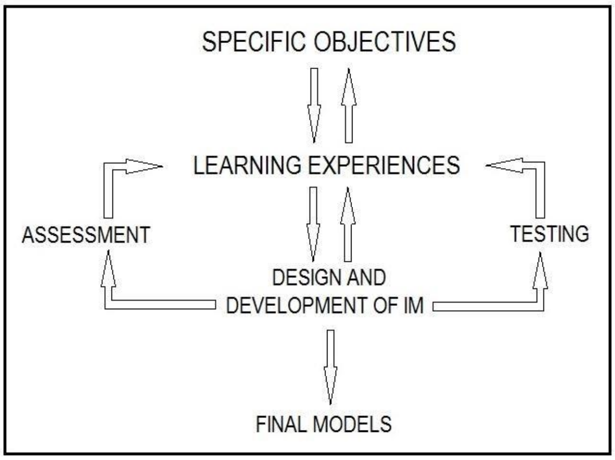


Fig. 3.1: Modified framework for developing IMs named “Objective-Driven Approach”

3.8.2 Criteria for Designing Prototype IMs for Science Education

In designing IMs, a key consideration is the target group. The needs and the varied interests, abilities, socio-economic backgrounds and maturity levels of the students should be served. Physical materials employed should be appropriate for the category of learners

(Library Media Services, 2012).

Also, the size of the IM should be carefully planned in order to serve its purposes. Rongalerios (2009) mentions that it is extremely essential that an IM is big enough to be seen by even the farthest learners in a classroom. In cases where text is involved the font size and font style to be used should be considered carefully; therefore, it should be bold and legible.

Additionally, suitability is another principle that should inform the development of IMs for teaching science at the lower primary level of education. A major criterion in IM development is its educational suitability for the intended purpose; taking into consideration the intellectual content of the material such as the scope, arrangement, organization, relevance and timeliness of information is crucial (Library Media Services, 2012). Nikky (2010) adds that IMs should be informative, simple, accurate and realize learning objectives.

Furthermore the colour scheme should play a major role in creating IMs for lower primary school pupils since learners are more interested in materials which are colourful and beautiful. Children especially are mostly attracted to bright colours, because it easily attracts their attention and facilitate the learning process (Rongalerios, 2009).

Again, the interactive nature of IMs is pertinent when satisfying children‟s learning needs. Interactivity is one of the most important factors in the design and development of effective IMs (Milheim, 1996). Learners wish to handle materials to arouse their curiosity and allow them to manipulate in order to evaluate how they can learn through the materials on their own.

Another principle to take note is the portability of the developed IMs, especially at the basic level of education. IMs must be easy for all to handle and carry, so that it is more convenient to move around. IMs should not be too heavy or big and should not occupy too much space in the classroom (Anini, 2011; Rongalerios, 2009).

More importantly, safety cannot be overlooked in developing IMs for children at the lower primary level. Children are curious, playful, exploitative, manipulative hence safety measures should be ensured when designing instructional materials for such group. Materials used should be child-friendly and non-hazardous to their health (Anini, 2011).

Last but not the least; durability is of prime importance to IM development especially for young learners. IMs should be resistant to children‟s pressure when using them during teaching and learning. The IMs should have the ability to survive in the hands of learners from wear and tear, scratching, discolouration and dirt (Anini, 2011).

3.8.3 Production Process of Prototype IMs

The production process of prototype IMs includes a physical description of the prototypes, tools and materials used in their production as well as the steps involved in producing prototypes. Before the production of all four designs, samples were first attempted to see the outcome and how changes could be made to suit its intended purposes for teaching and learning some science topics in the lower primary level.

a) Design and Development of Prototype IM for Teaching "Measurement of Time"

The prototype is a simple spherical clock made in leather and mounted on plywood covered with a layer of foam and a sheet of greybaft. The clock has an accompanying rack which has pockets to contain numbers representing hours, minutes and activity cards. The clock shows both digital and analogue clock interfaces and both clock and rack can be hanged up. The prototype IM has been named "Fun and Learn Clock".

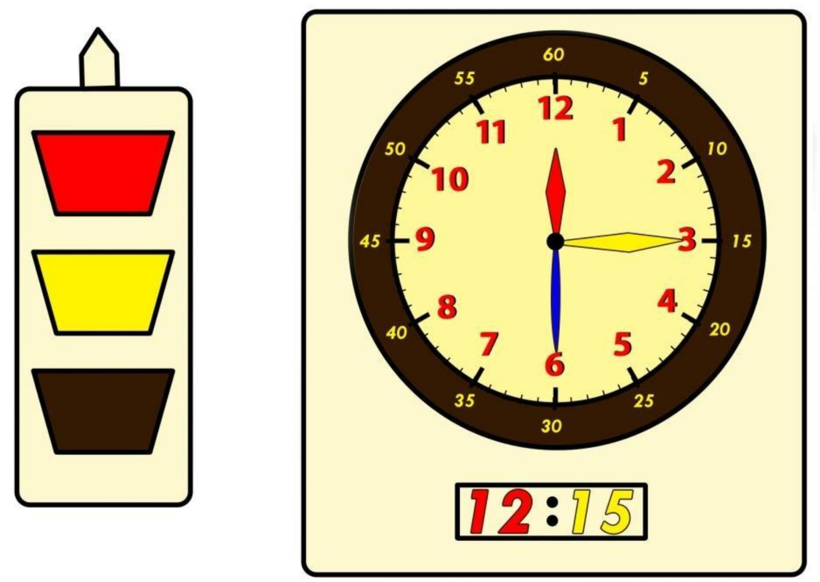


Fig. 3.2: Designed "Fun and Learn Clock" with number rack for teaching "Measurement"

- **Tools and Materials for the Development of the IMs**

Tools and materials for the production of the clock were work table, local leather, strawboard, plywood, adhesive, scissors, tape measure, empty glass bottle, pencil, rule, bowl, sanding block and utility knife. Others include PVC trunking, rivets, pair of compass, protractor, thumb pins, acrylic paint, foam, greybaft and sticky paper tile.

- **Processes Involved in Developing Clock for Teaching "Measurement of Time"**

The first step in this process was the preparation of leather material. The local leathers used were vegetable tanned leathers made by indigenous tanners who follow crude production methods such as the use of acids and alkalis. These are applied to treat the local leather to make them clean, more refined and safe for the intended purpose of producing IMs (K. Asubonteng, Personal Communication, April, 2014); therefore the leather had to undergo secondary treatment. The secondary treatment enhances the leather and these treatments begun with sanding with a sanding block (60 grit sand paper) which helped to remove excess flesh and loose fibres at the back of the leather to attain a velvet feel. The sanded leather was soaked in a bowl of clean water and washed to remove dust. The edges of the hydrated and softened leather sheets were pulled taut continuously around the perimeter systematically and tacked using thumb pins with the grain side of the leather up on a board of ½ inch plywood. This was to remove all wrinkled and folded areas and increased the surface area of the leather as well; enhancing economic cutting value. Leather was dried by exposing it to shade drying which conditioned the moisture content of the leather through evaporation. Last but not the least, the leather was burnished by rubbing grain side with hard surface bottle to introduce lustre or sheen and achieve flatness adequately as well as smoothness.

Plate 3.14: Sanding a sheet of leather

Plate 3.15: Burnishing of leather

After this, two discs of 20 inches and 14 inches were marked and cut out of the strawboard to serve as the outer and inner circles of the clock respectively. Two 1.5cm rings were also cut for both inner and outer disc to reinforce and build the clock surface. The cut-out discs were used to trace the clock size onto the flesh side of the leather which was then cut with a pair of scissors. The rings were fixed onto the cut out 20 and 14 inches discs to give the disc a relief form for the clock surface. A wet rag was used to give an even and consistent flatness as joining of leather to clock support was being done. This prevented air bubbles from getting trapped between the leather and clock reinforcement. To ensure a very firm hold, the grain surface of the leather-covered outer disc was sanded before fixing the inner disc on top. The two discs were joined with adhesive. With the help of a ruler, pencil, protractor and a pair of compass, the divisions of the clock were made on the leather covered inner circle. The marking were projected onto the outer circle using a rule. Rivets were used to demarcate the numbering, secure the leather onto its reinforcement as well as add beauty to the work. Big rivets were used for the minute markings and smaller rivets for the second markings. Dimensions of 6, 7.5 and 8.5 inches were marked and cut out from a piece of plastic to represent the hour, second and minute hands respectively. The cut-out templates were filed to make edges smooth, remove excess materials and then coloured to match the numbering on the clock.

Clock hands were fixed onto the surface of the clock with a rivet.

Plate 3.16: Cut out disc and ring

Plate 3.17: Divisions for numbering on the clock surface

Plate 3.18: Cutting clock hands in a pair of scissors

Plate 3.19: Finished clock hands plastic with

Two sets of numbering were done; the first set represents the hour and minute figures on the clock. The hour figures were made larger than the minute figures and made to match the colour of the hour hand and minutes to correspond to the minute hand. This was done to ensure easy identification by pupils. The second set of numbers to be used as digits for interactive activities with the clock were cut from strawboard, painted and fixed onto the clock interface to serve as activity digits. Pieces of velcro were fixed at the back of the activity digits to allow for fixing on the space provided for digital clock. The colours used for the activity numbers are made to match the clock hands. The complete clock was then mounted on 25 by 30 inches plywood, padded with foam and a sheet of greybaft to complement the colour of the khaki leather. A piece of synthetic material was sewn as the handle, which was fixed to the back of the plywood with epoxy and fastened with half inch nails. A sheet of carpet sticker was used to cover the back to give a neat finish.

The section for the digital clock was then made from velcro, pieces of black coloured strawboard cut into two discs to represent the colon and pieces of red and yellow fabric.

The velcro are cut and fixed beneath the analogue clock using adhesive and hour digits were separated from the minute digits using the colon. Pieces of red and yellow fabric are used to demarcate the hour and minute sections respectively.

A rack with pockets was then made from waste fabrics and a piece of greybaft to hold activity numbers and flash cards.

Plate 3.20: Cut and painted digits

Plate 3.21: Activity digits with fixed velcro

Plate 3.22: Clock rack to hold activity numbers and cards

Plate 3.23: Complete "Fun and Learn Clock" for teaching "Measurement of Time"

b) Design and Development of Prototype IM for Teaching "Building a Simple Electronic Circuit"

The IM is a simple electronic circuit showing the parts such as a battery, a switch, an LED and conductors serving as the connecting insulated wires. The circuit is built on a formica board and supported by calabash discs serving as stands. The „Interactive Circuit Board" as the IM is named comes packed in a bag, with compartments where the removable components are kept.

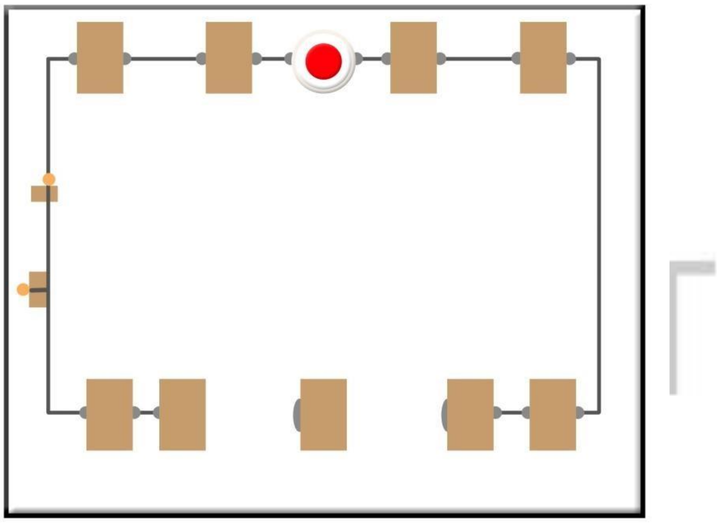


Fig. 3.3: Designed “Interactive Circuit Board” for teaching “Building a Simple Electronic Circuit”

- **Tools and Materials**

Tools and materials used were formica board, wood remnants, aluminium rod, plastic bottle cap, adhesives, calabash, LED bulbs, cast iron plates, hammer and saw. Others were steel rule, digital metre, scissors, pliers, nose mask, soldering iron, lead, pencil, nails and plastic beads.

- **Processes Involved in Developing Circuit for Teaching “Building a Simple Electronic Circuit”**

Schematic diagram of the proposed circuit was drawn on the formica board showing locations of various components with a pencil. Measurements of the wood pieces serving as component holders of circuit, aluminium rods serving as conductors, switch and LED holder were marked. Marked out measurements on wood, aluminium rod and grooves for holding cast iron pieces were cut using a hacksaw and pliers and they were sanded and filed to remove rough and sharp edges that may cause injury; and smoothened to make projections even to achieve better finishing.

Cut wood pieces serving as components for building circuit were then coated with a layer of varnish which served as preservative and set to dry. Pieces of cast iron as conductors were fixed in grooves except for the battery holders and openings created at both ends of the cast iron pieces served as holders for conductors. Styrofoam and metal discs were cut and used as a cushion for the dry cells that served as a battery.

At this stage, prepared components were fixed onto the surface of the formica board after the schematic diagram was drawn on the surface. Components were now fixed in their respective positions with adhesive after the spots have been sanded slowly so that it holds better; and held firmly in place with half inch nails. Aluminium rods serving as conductors were cut and tips bent with pliers to fit into the eyes created in the holders. Then, switch was made from pieces of aluminium rod and wood and held in place with epoxy and tacking nails. The switch was fashioned in such a way that it could be opened and closed to depict an open or closed circuit.

LED was made from insecticide cap, copper wire, aluminium rod, inner tube of a pen, epoxy and an LED bulb. Copper wire was wound around two aluminium rods that have been shaped into LED stands and soldered to the wires that would be connecting the holder of the LED to the legs of the LED. The insecticide cap was used to cover the soldered area where LED would be fixed and help as one piece by filling the empty areas in the cap with epoxy making sure it does not block the holes to receive the LED. Rough edges of fixed components, LED and conductors were filed smooth to avoid any sharp edges that might cause injury to the pupils.

Plastic beads were then fixed on the tips of the components serving as the switch to be a handle and also avoid possible injury because of sharp edges. With all components complete, calabash discs as stands for the IM were prepared by cutting out discs, sanding and coating with varnish. The back of the model was then covered with a sheet of sticky paper tiles cutting out the spots that would hold the stands. Calabash discs were fixed to the back of the model using adhesive.

Components in wood were covered with the sticky paper tile, aluminium rods serving as conductors and styrofoam cushion were painted with a layer of silver oil paint leaving only contact surfaces. The LED legs were also coloured red and black to depict the negative and the positive respectively.

Plate 3.24: Wood components with cast iron pieces

Plate 3.25: Battery components with cushion

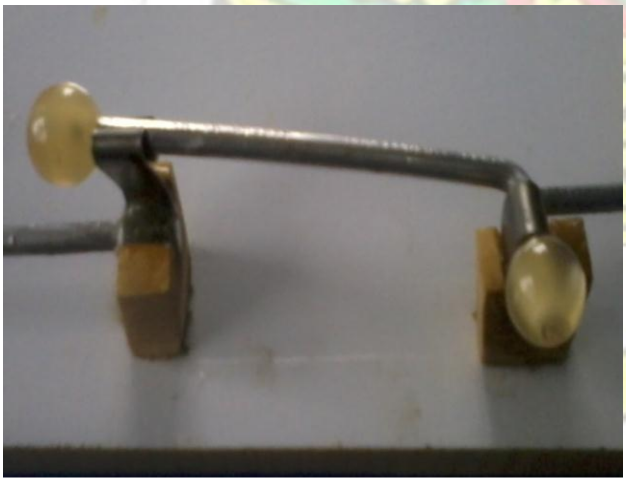


Plate 3.26: Plastic beads fixed on switch

Plate 3.27: Finished LED

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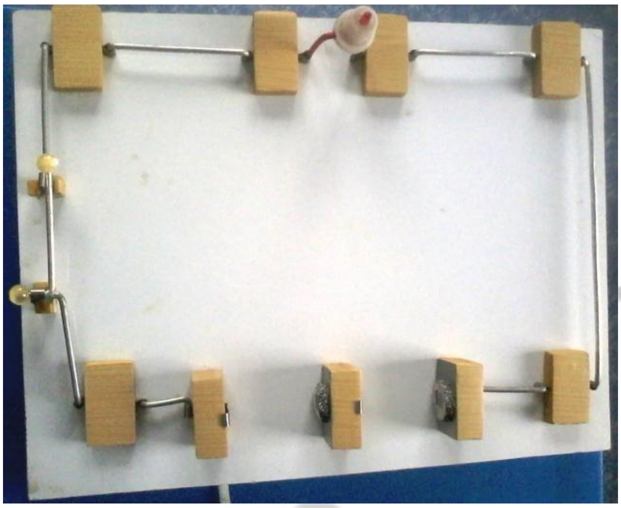

Plate 3.28: Developed "Interactive Circuit Board" for teaching "Building a Simple Electronic Circuit"

c) Design and Development of Prototype IM for Teaching "How Plants Produce their Young Ones"

The IM demonstrates a seven step procedure of the growth process of a bean seed from planting until it germinates into a young plant. The IM is encased in a box with transparent covering so that the modelled figures can be seen from the outside without touching. The IM is named the „Germination Case".

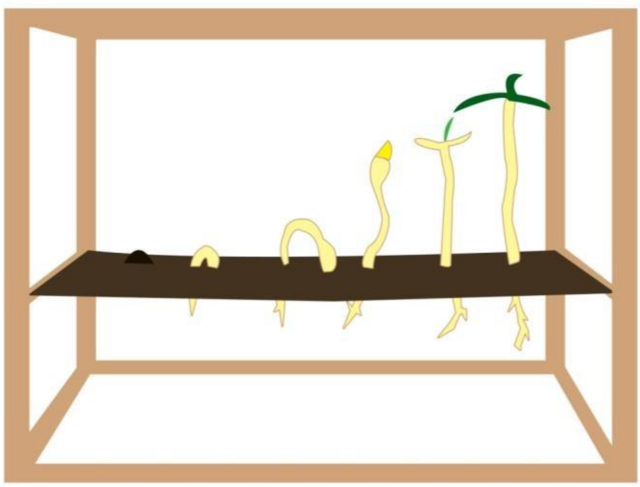

Fig. 3.4: "Germination Case" for teaching "How Plants Produce their Young Ones"

- **Tools and Materials**

Laminating film, waste paper, glue, plywood, PVC trunking, acrylic paint, paint brushes, sand, mortar and pestle were the tools and materials that were employed for the production of the Germination Case.

- **Processes Involved in Developing IM for Teaching "How Plants Produce their Young Ones"**

Pulp was made from soaked and pounded waste papers and it was spread out to dry completely in the sun to avoid decomposition because of the organic nature of paper. Locations for moulding the figures for the model were marked on 1/8 inch plywood of 7 by 20 inches. Holes were made in the marked spots for the supporting wires to pass through. Modelling started with mixing of the dry pulp with white glue, and molding into the desired shapes. Various components after they were modelled were set out to dry in the sun. The stems were supported with pieces of copper wire to make them strong and upright. After drying, rough surfaces were smoothened with sand paper. Components were then fixed in their respective spots marked out on the plywood with the help of white glue and super glue. Root hairs were made from strands of nylon cord and stiffened with glue, and fixed on the roots. Parts such as the leaves were cut from waste fabric and artificial flowers, and glued onto the stems. Finished model was given some time to dry and then given a prime coat. The model was then painted to give it a lively outlook.

In order to demonstrate the breaking of the ground by the seed, sand was used on the surface of the plywood serving as a support to represent the soil. This was done by applying glue on the plywood and covering it with fine sieved sand. A case to hold the model was then built from pieces of PVC trunking and laminating film.

Plate 3.29: Modelling of individual figures

Plate 3.30: Modelled figures on support

Plate 3.31: Modelled and painted figures

Plate 3.32: Buttom view of IM

Plate 3.33: Complete "Germination Case" for teaching "How Plants Produce their Young Ones"

d) Design and Development of Prototype IM for Teaching "Waves"

The IM is made from a wooden frame, a steel plate, a cord and metal tin and demonstrates that wave has shape, sound and carries energy. The wooden frame can be folded into two for easy transportation and less space to occupy. The IM has the shape of a wave printed on the frame surface to show the shape of a wave. The model is named the „Shape Energy Sound (SES) Demonstrator‟.

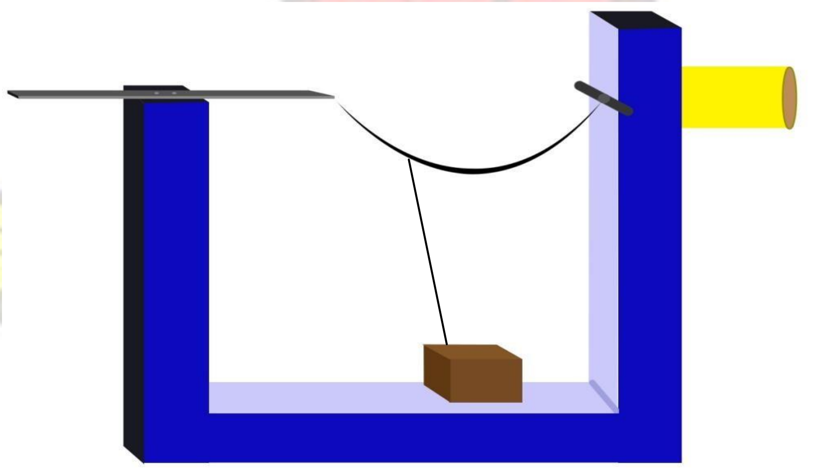

Fig. 3.5: Designed "SES Demonstrator" for teaching „Waves‟

- **Tools and Materials**

Tools and materials for producing this model included a hammer, pliers, screws, calibrated rule, pencil, tape measure, wood, square, cord, nails, empty can, cork and hinges.

- **Processes Involved in Developing "SES Demonstrator" for Teaching "Waves"**

Two L-shaped wood pieces of 4 inches wide were ordered from the local carpenter. The heights of the two pieces are 8 and 10 inches respectively. A hole of about half an inch diameter was drilled into the ten inch piece at the eighth inch mark, so that the hole was levelled with the eighth inch height of the other wood piece. The two pieces were then joined with two hinges so that they could be folded into two to form a single unit. Two ½ inch nails were fixed right beneath the drilled hole on the inner face of the piece with the hole; this was to serve as holder for the stopper. The two pieces which was now a single frame was then primed and finished with white paint on the inside and blue on the outside. An empty tin to serve as a sound amplifier was also coated with yellow oil paint.

A wavy line to demonstrate the shape of a wave was then printed on the inner surface of the frame by stencilling. Pieces of aluminium rod were also cut to be used as handle and stopper for the model. A hole was drilled through the tin to fall in line with the hole on the frame piece. The painted tin was then screwed onto the outer face of the frame piece so that the hole in the tin fell in line with the hole in the frame piece. The cut aluminium pieces were passed through the holes made on the side of the tin to serve as a handle; another piece was passed through the nails fixed on the inner face to serve as the stopper. To avoid both metal pieces from sliding out, pieces of plastic straw were cut and glued at the tips. The square to be fixed on the frame piece was drilled at the tip to hold the cord and the square was screwed firmly onto the wood.

A length of cord was then tied to the square by passing through the hole made at the tip of the square, and passing the other end of cord through the hole in the wood and fastening onto the metal handle through the tin. The tied knots on both sides were strengthened by applying drops of glue on the knots.

Plate 3.34: L-shapes joined with hinges

Plate 3.35: Amplifier with handle and stopper

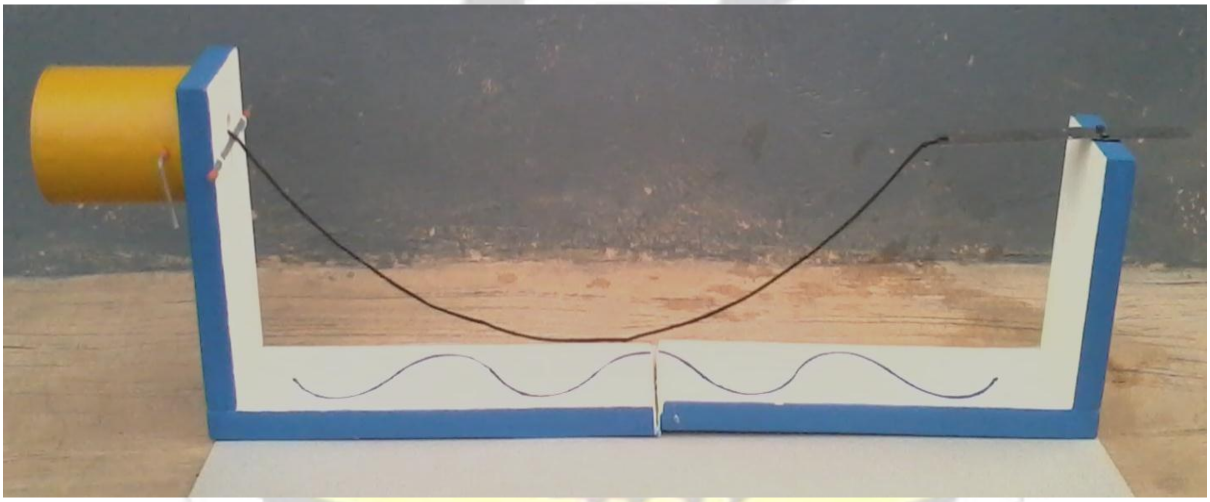

Plate 3.36: A front view of finished IM for teaching "Wave"

Plate 3.37: Developed "SES Demonstrator" for teaching "Wave" with weight attached

3.9 Challenges Encountered During Execution of Prototype IMs for Science Education

The researcher encountered some challenges while undertaking the production of the models. Because various experts were consulted on some of the materials, production and appropriate techniques, times scheduled for the development of the IMs had to be at the convenience of their busy schedules; some of which caused some delay in the production period.

CHAPTER FOUR PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Profile of Weweso M/A Primary School

Weweso M/A Primary is a government school in the Amangoase community, about five hundred metres away from the KNUST campus. The school is by the main Kumasi-Ejisu highway to Accra. The "Wewe" River flows on the border separating the school compound from the KNUST staff quarters. The school was built in the 1950"s to cater for the educational needs of the wards of junior staff members of the university but it is now open to all members of the communities in the area. The school has an open compound with lots of shade trees that serves as a playground and places of convenience for teachers and pupils, as well as a tap for pipe borne water. There are no toys or playground materials visible on the school compound. The school starts from kindergarten to the junior high level; the primary section runs a shift system (that is, morning and afternoon classes) because of the large number of pupils and has two head teachers while the junior high operates a regular morning system with one head. The morning shift starts from 7:30am to 12:00pm, whiles the afternoon session operates between 12:30pm and 5:00pm from Monday to Friday.

4.2 a) Strengths and Weaknesses Observed with the Use of Existing IMs for Teaching "Measurement of Time"

- *Strengths*

The IMs adopted for the lesson, helped the teacher to introduce the topic to the class as in the case of the chalk illustration. The pupils were able to visualize a clock from the wall clock presented. The textbook also provided notes and sample exercises for assessment of pupils.

- *Weaknesses*

The available IMs such as the textbook did not provide sufficient basic information on the topic; this prevented IMs from satisfying a basic criterion by Nikky (2010) who states that IMs should be informative, accurate and realize learning objectives. Also the size of both the wall clock and chalk illustration was not appropriate for the class size, impeding visibility and allowing pupils at the back to lose focus thereby and fidgeted. This scenario confirms what Rongalerios (2009) said that it is extremely essential that an IM is big enough to be seen by even the farthest learners in a classroom and that font size and font style should be bold and legible. The already made clock prevented pupils from interactive activities by handling and manipulating the clock themselves to explore how it worked and be engaged in the process and this denied pupils from participating actively in learning. The colours used in the wall clock were not attractive to arrest pupils" attention, hence, they were distracted and as a result much learning was not achieved. This falls in line with the findings of Rongalerios (2009) who mentions that children especially are mostly attracted to bright colours, because it easily attracts their attention and facilitate the learning process. It could not be overlooked that the IMs did not fully engage pupils throughout the lessons and even with all the aids available, the teachers still had difficulty explaining to the understanding of pupils how to tell time by the minutes.

b) Strengths and Weaknesses of the Available IMs for Teaching "Building a Simple Electronic Circuit"

- *Strengths*

The IMs employed by the teacher, that is, the battery lamp, a classroom switch and textbook collectively helped to sustain pupils‟ attention during the lesson. The lamp as used in Primary One aided the children in seeing how a lamp could utilize the electric energy from the battery to function and give light; and the switch helped the children to identify a part of a circuit and how it could be turned on or off to give or take produced light energy. Again, the textbook used in Primary Two provided a visual of the parts of a simple electronic circuit for pupils to see.

- *Weaknesses*

Although the teacher in Primary One used the IMs to support the lesson, pupils were not directly engaged in any hands-on activities involving the lamp, switch or textbook employed by the teacher; therefore interactivity was hindered as pupils were only engaged visually. As Opoku-Asare (2000) emphasizes, it is of great significance for children to learn through their senses to make a topic under discussion more understandable than in the non-use of their senses, that is, the more senses engaged in the learning process, the higher the retention.

The textbook employed for the lesson in Primary Two did not afford pupils the opportunity to explore and or identify the parts of a circuit as expected of them to know at their level, therefore they did not have a practical demonstration of how electric energy could be converted to light or sound energy consequently the teacher did not know how to explain this concept to the understanding of pupils or give a practical demonstration.

The difficulty of pupils applying related previous knowledge stresses how important it is for children to be involved in demonstrative and hands-on activities in the classroom in other to achieve maximum understanding, retention and effective learning. To this effect, IMs for science teaching should provide some hands-on activities for pupils and be a good reminder of previous knowledge so that lessons do not seem abstract (Anang, 2011).

c) Strengths and Weaknesses of the Available IMs for Teaching "How Plants Produce their Young Ones"

- Strengths

The textbook which was the IM used for the lesson provided a diagrammatic representation of the germination process for pupils to see.

- Weaknesses

The IM used for the lesson which was the textbooks did not provide any tangible experience for pupils to engage in active learning. Interactivity with the IM was limited because pupils could not explore with the materials to fully understand how seeds germinate. As a result, the claim by Bonwell (2000) that active learning involves learners doing things and thinking about the things they are doing, hence leading to the discovery of knowledge, was missing.

Also, learning as an observer activity in which pupils do not learn much by sitting in class listening to teachers and memorizing pre-packaged assignments and spitting out answers (Chickering & Gamson, 1987; as cited in Bonwell, 2000) was evident in this lesson as all pupils did was to watch the teacher and the diagram provided in their textbook. Furthermore, the understanding that learning can be administered better in an environment where learners can interact with real objects, explore their potentials and deduce facts about them without necessarily being told, so that they understand issues better and as a result the memory of the lesson lasts longer, was absent from the lesson. As a result, the pupils made a lot of noise and some flipped the pages of their textbooks to view other pages, which was a distraction and disrupted the lesson. The above situation can be avoided if IM is appropriate, interesting enough to capture pupils‟ attention, stimulate ideas and demand active response from learners (Leus, 2002; Farrant, 1996).

The challenge for the teacher was how to demonstrate to the understanding of pupils the step by step process of the growth process from seed to a young plant. Obviously, the textbook was not effective as it did not help the teacher to create conducive situations for learning and discipline (Nikky, 2010).

Because the textbook did not assist the teacher by supplementing verbal instruction, hence not satisfying the advantage of requiring minimum intervention by the teacher as mentioned by Farrant (1996), she lost confidence during the session and started fumbling resulting in her jumping over salient points in the lesson.

Three out of the four topics mentioned as difficult to teach are fundamental topics in Physics. With teachers having difficulty teaching these topics and particular attention not given to them, it authenticates Anamuah-Mensah and Asabere-Ameyaw‟s conclusion on studies carried out in basic schools in Ghana that, pupils‟ weakest content area in science is Physics. Also since lessons are not well supported with appropriate IMs to facilitate better understanding and retention of knowledge, it becomes easier for pupils and teachers to prejudice the science subject as abstract and difficult to understand and teach.

4.3 Activities Undertaken for Objective Three

Objective three was to pre-test the developed three-dimensional instructional materials on the teaching and learning of Science at the selected school.

The developed “Fun and learn Clock”, “Interactive Circuit Board”, “SES Demonstrator” and “Germination Case” were initially introduced to the teachers, and they were taught how the prototypes were to be used to teach the various topics. Since they had basic concepts of the topics, understanding the usage of the IMs was easy for them. The produced IMs were tested in the school to ascertain their suitability and effectiveness for and enhancement of science education.

4.3.1 Testing of “Fun and Learn Clock” for Teaching “Measurement of Time”

The clock was tested with Primary One and Two pupils at Weweso M/A school. In both instances, teachers first introduced the topic to the class with chalkboard illustration before introducing the intervention to the class. The clock has bold brightly coloured numbers and visible clock hands to enhance visibility and easy identification. It has an accompanying rack which has pockets to contain numbers representing hours, minutes and activity cards that ask pupils to do practical activities with the clock. The clock‟s digital and analogue interfaces allowed opportunities for various engaging activities to be performed. Both clock and rack can be hanged up so that even the farthest pupils in the class can view clearly. Pupils interacted with the clock by manipulating the clock hands, fixing and removing of digits on the digital clock and participating in various activities that the teacher would instruct.

Again, the analogue and digital clock faces, made it easy for pupils to identify with two types of clocks used to measure time. Pupils also moved various clock hands to tell time on the analogue clock and then fixed numbers on the digital interface to tell time on the digital clock. Since the seconds and minutes numbering were visible on the clock, it became very easy for pupils to tell the time by the minutes as against the previous lessons where they could not. Pupils therefore interacted with the IM by manipulating the clock hands, fixing and removing of digits on the digital clock among other activities and these facilitated experiential learning as discussed by Opoku-Asare (2000). This means that the proposed IM satisfied the purpose of suitability by presenting appropriate intellectual content and being relevant to the lesson (Library Media Services, 2012). Also in helping pupils to know the various clock interfaces the IM was informative and helped in realizing learning objectives (Nikky, 2010). The bold and brightly coloured numbers and visible clock hands enhanced visibility and easy identification; this made it easy for pupils sitting at the back to see clearly and follow what the teacher was demonstrating with. Pupils picked cards and numbers from the pockets to do practical activities with the clock as directed by the teacher. The clock helped pupils in Primary One to identify the types of clocks and how to tell time, that is both hourly and by the minutes, by the handson activities they undertook and performed excellently during lesson. Primary Two pupils learnt to tell time on both clock faces by the minutes and quarterly as well as measuring the duration of event which could not be achieved in previous lessons as a result satisfying the objectives. Assessment of pupils was done orally for pupils in Primary One and pupils in Primary Two were asked to draw the clock in their books and attempt a paper clock as assignment.

The introduction of the intervention resulted in an exciting shout through the class like a shockwave. Pupils‟ excited screams could be heard far from the class and this attracted the attention of pupils from other classes. As teacher used the IM to explain the topic, nods, smiles and excitement could be seen on the faces of almost all pupils. Pupils were happy to come up and do various activities with the model. As teacher started questioning, hands shot up in the air even from pupils who were not previously participating in the class. Those who fumbled were helped by their peers or the teacher.

Teaching then became fun and exciting. Teachers‟ comments after the lesson were: “Wow, I have never seen my class so lively and full of participation” and “today, my children really enjoyed the lesson.” Other remarks expressed by the teachers were “The TLM has made it very easy to explain the topic; I didn‟t have to talk so much for them to understand” and “even the quiet ones are talking in class today.” Some curious pupils from other classes were peeping through the window to see what had caused the excitement in the classes where testing were done.

Plate 4.1: A teacher demonstrating with the developed IM during lesson on “Measurement” in Primary Two

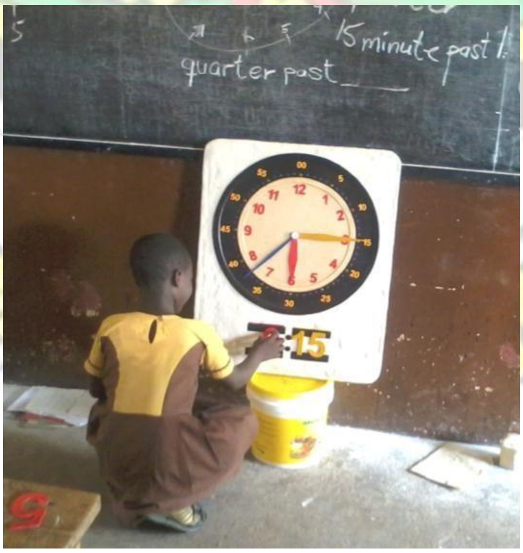

Plate 4.2: A pupil in Primary Two telling time with “Fun and learn Clock”

4.3.2 Testing of Prototype IM for Teaching "Building a Simple Electronic Circuit"

The IM was tested in Primary One and Three. The teachers after introducing the topic set up the model on a table in front of the class where individual parts are fitted into their respective positions. When all parts have been well arranged, the LED bulb turns on when the switch is closed. If any part is out of place or the switch is opened, the circuit is not complete therefore the light would not be turned on. The lighting of the bulb is the indication of a complete and well arranged circuit.

Because the parts of the circuit are removable, the individual parts were taken apart and their names and functions explained to the pupils. They were then assembled by teachers to explain that all parts were needed to achieve a complete circuit. This was also used to explain a closed and open circuit. The pupils were taught that the lighting of the LED was an indication of a complete and well arranged circuit; therefore, pupils were drawn to what they were being taught as the bulb came on. Moreover, since the switch was selfmade, it was possible for pupils to see how switches work and understand the principle behind closed and open switches. The painted legs of the LED made it easier for teachers to explain in which direction the electric energy was flowing and for pupils to identify the negative pole from the positive. Pupils were also taught to understand how the electric energy from the battery was converted to light energy. After teachers had taught by demonstrating with the IM, pupils answered oral questions correctly to show their understanding. They were organized into groups to interact with the model.

In Primary One, pupils in their groups had a hands-on activity by exploring the parts of the IM to increase their knowledge and understanding of the circuit board. When a group fixed all parts correctly, the LED lighted when the circuit was closed. Pupils worked together to make sure all parts were correctly fixed. There were excited uproars in the classroom with group members who had the assigned tasks correct. By their interaction with the IM pupils learnt how electronic gadgets used the batteries inside them to generate energy for the gadgets to work as outlined in the syllabus; satisfying an extremely essential criterion as appropriate for target group and sufficient with intellectual content hence suitable for teaching at that level (Library Media services, 2012).

In Primary Three, it was evident that pupils had comprehended how the electric energy was converted to light energy seeing all the circuit parts, taking apart the parts and reassembling them; as a result experiencing first-hand the creation of light energy from electric energy. Teachers admitted that the involvement of pupils in activities kept the class lively and pupils who did not participate in class activities were fully engaged by volunteering to perform an activity; causing his peers to clap and cheer him on. Interested pupils from other classes were attracted and curious, hence questions were asked after the lesson was over. The teacher who was the Assistant Head teacher did not leave the class to attend to administrative tasks; instead, meetings were rescheduled so as to complete activities with her pupils. The IM arrested the curiosity and attention of pupils since there were many competitive discussions as to who could get all the parts right. This means that the IM promoted good teaching as explained by Tamakloe et al. (2005) who said that good teaching involved creating an environment to facilitate learning and motivate learners to have interest in what was being transmitted to them, since what they see, hear and do in the classroom is what the teacher provides for them.

Also, by making use of their senses in the hands-on activities during the lessons, pupils were engaged in experiential learning and the memory of the lesson would last longer. Furthermore, this model was easy for all to handle and carry and convenient to move around, that is, it was not too heavy or big and did not occupy too much space in the classroom. Last but not the least, although the IM was developed to generate some form of energy, it was child-friendly and safe for both pupils and teachers to use and did not cause any injury or harm.

Plate 4.3: A teacher demonstrating parts on the circuit board in Primary One

Plate 4.4: A group of pupils engaged in a hands-on activity with "Interactive Circuit Board" for teaching "Building a Simple Electronic Circuit" in Primary Three

Plate 4.5: Primary Three pupils‟ reaction after successful completion of assembling the circuit board

4.3.3 Testing Prototype IM for Teaching "Waves"

The IM was tested in only Primary Three classes of the morning and afternoon shift since the topic was limited to this level. The IM made from wooden frames, with a steel plate, a cord and metal tin, demonstrates that wave has shape, sound and carries energy. The wooden frames joined together with hinges such that the model can be folded into two for easy transportation and to occupy less space. The model has a wavy line printed on the frame surface to show the shape of a wave. This is based on conceptual data processing by Lindsay and Norman (1977) who state that „when you know what to look for, it is easier to see it.‟ Mathematically, the sound amplification is directly proportional to the volume of the container. Therefore Sound Amplification = K × Volume, K becomes a constant, and Volume becomes a variable.

The teachers first introduced topic to the pupils by asking them to mention examples of activities that produced or involved waves in and out of the classroom setting. The IM was then set up on a high table in front of the classes, as teachers demonstrated with the model. Pupils were taught that the printed wavy line on the IM is how the shape of a wave looked like. When called to answer questions almost all pupils in both classes raised their hands up with some pupils answering that they saw the shape of a snake whiles others saw a movement of the sea. Some pupils were asked to draw on the chalkboard and they could draw accurately what they perceived to be the shape of a wave. This meant that the printed wavy line on the IM had imprinted in their minds what they were to look for. Pupils came to the front in groups around the table to participate in how waves could produce sound. Some pupils were asked to regulate the handle of the model, others applied the pressure and others listened for the sound; those listening were asked to repeat the sound they heard from the amplifier. The teacher used the cord on the model to explain to pupils that it was serving as the medium for the wave to travel through just like the way every wave travelled through a medium, and the waves carried the sound through the cord to the amplifier. To show that waves carried energy, a weight was attached to the sagged cord on the IM and some pupils were asked to come and apply pressure on the metal plate; when the weight moved as the pressure was applied, pupils understood it well. This was evident in the answers they gave when questions were asked. The confidence, explicity and joy with which the teachers taught the lessons could not be overlooked; clear sign of their own understanding of the topic unlike previous times when they did not want to teach the topic. The versatility of the IM provided a means for them to exhaust all aspects of the topic including areas that they had not been able to cover in previous lessons. This implies that the IM satisfied the criterion of suitability and met the needs of the target group. Therefore, teaching was enhanced and learning was achieved in an exciting manner; confirming the point by Boafo Agyemang (2010) that good teaching is a pleasant experience and at the same time keeps up the interest of pupils in the teaching and learning process while addressing learners‟ needs and abilities. Teaching was not teacher-centered and pupils were involved in active learning through the practical activities that went on in the classroom.

Plate 4.6: A teacher demonstrating with the "SES Demonstrator" to teach "Waves" in Primary Three

Teachers‟ comments were; "I have never been able to finish this difficult topic within the period because pupils find it difficult to understand". "As a teacher I have never really understood this topic well because it was so abstract, therefore I did not understand it." "The IM captured the attention of my pupils throughout the lesson."

Plate 4.7: A pupil in Primary Three drawing the shape of a wave

4.3.4 Testing Prototype IM for Teaching „„„How Plants Produce their Young Ones"

The IM for the germination process was not used in a lesson because the topic had already been taught in the previous term; so teachers in all classes involved in the study used the model to demonstrate to pupils practically what had been taught theoretically. The IM demonstrates a seven step procedure of the growth process of a bean seed from planting until it germinates into a young plant. The model shows in steps what happens when a bean seed is put in the ground until it shoots out.

The support bearing the modelled seed and plants were taken out of the case for the pupils to get a closer look. The step by step growth process could be visibly seen by pupils; from the planted seed, to the breaking of ground, through the sprouting stage until the young plant grew. These were taught very thoroughly to ensure that pupils understood all the processes. Pupils also had the opportunity to study the root system of the growth process at every point. The IM refreshed pupils" memory since they could visualize what was taught in the textbook theoretically. Pupils paid keen attention and showed much interest during instruction as captured in plate 4.11. The IM helped teachers to explain comprehensively and pupils to understand clearly. This IM was effective in helping teachers to supplement the verbal instructions by creating situations for learning and making learning permanent as well as creating positive environment for discipline. Also the IM satisfied the advantage of requiring minimum intervention by the teacher as explained by Farrant (1996) who said that good educational media require the minimum of intervention by the teacher and needs little or no explanations as well as demands active response from learners. Pupils were allowed to touch the IM, feel the surface of the board covered with sand as the soil and identify with the stages involved in the growth process. Furthermore, the understanding that learning can be administered better in an environment where learners can interact with real objects and deduce facts about them without necessarily being told, so that they understand issues better and as a result the memory of the lesson lasts longer was now clearly visible in the lessons as pupils were actively engaged throughout the lessons. The prototype was portable and could be moved around without difficulty.

Plate 4.8: Teacher demonstrating with the "Germination Case" in Primary One

Plate 4.9: Primary Two teacher teaching with the "Germination Case"

Plate 4.10: Teacher in Primary Three teaching with the "Germination Case"

Plate 4.11: Pupils‟ demeanour during demonstration in Primary Three

4.4 Challenges Encountered During Testing Developed IMs

Class management was a difficulty since pupils out of excitement screamed on top of their voices causing teachers to stop the lessons to control the class. Testing was rescheduled during teaching Measurement and Circuit since pupils used most of the time to jubilate.

The short duration of school hours as a result of the shift school did not allow for adequate time for testing some of the IMs especially the afternoon shifts. For instance, in testing the model for teaching Wave, the afternoon shift lesson did not provide enough time to exhaust all aspects expected to be covered therefore, the topic was completed in an additional lesson.

CHAPTER FIVE SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Study

This research was determined to identify locally available resources and develop them into instructional materials for science education at the lower primary level using the Weweso M/A Primary School as a case study. The objectives guiding the research were to find out existing instructional materials used for science education, identify locally available resources and develop these resources into three-dimensional prototypes for enhancing science education in the school. The research was carried out qualitatively adopting the descriptive and experimental research methods and using observation and interviews as research instruments.

- **Main Findings**

The study identified charts, textbooks, some real objects and chalkboard illustrations as the instructional materials for teaching and learning Natural Science in the selected school. It was found out that the existing instructional materials did not adequately support the teaching and learning of science and this made it difficult for teachers to exhaust all areas of topics as the syllabus demands. This reduced the spirit of curiosity, creativity and critical thinking as clearly spelt out in the syllabus.

Pupils" attitude, conduct and response to science lessons indicated that they did not pay attention; hence, they lacked understanding and interest for the subject. It was evident that these negativities were as a result of the rote memorization and textbook approaches adopted for teaching with hardly any hands-on activities. This means that concepts were memorized by pupils without understanding them.

Some local resources, both natural and recyclable materials including local leather, wood remnants, calabash, textile waste, metal scrap, paper and others, were identified as well suited for the production of instructional materials after series of experimentations and used to develop three-dimensional prototypes for the teaching and learning of some science topics. The development of IMs was based on topics considered „difficult-toteach" by teachers. The developed IMs were tested in the primary school to identify the effectiveness or otherwise on the teaching and learning of science to lower primary pupils. The successful completion of IMs confirmed giving secondary life to waste and other materials (recycling) as a valuable resource for supporting science education at the primary level of education through the production of appropriate instructional materials.

The pre-testing of the developed prototype IMs ascertained the developed prototypes as appropriate and effective for the teaching and learning of science at the lower primary level of education. It also authenticated the importance of using aids in science lessons, and how interactive and hands-on activities positively impact and enhance classroom teaching and learning of science. With the introduction of the prototypes, teachers were able to confidently and comfortably tackle „difficult-to-teach" topics within the allotted periods and even had time to give some form of assessment to pupils. The threedimensionality of the prototypes made handling easy and fun, and pupils who did not previously participate in lessons all got involved in the classroom, answering questions correctly to demonstrate understanding of the topics.

The excitement and cheery disposition exhibited by pupils during lessons with the prototypes showed that, pupils were interested and willing to learn the science subject if the appropriate resources were available. This means that, that spirit of curiosity, critical thinking and enthusiasm for science can be aroused in primary school pupils if appropriate interventions are introduced in science classrooms.

5.2 Conclusions

The study, although done in one school only, paints a picture of Science education in Ghana not being interactive enough hence it is not inculcating the desired qualities that the syllabus intends to cultivate in pupils. The textbook-dependant approach to teaching and the lack of hands-on or interactive activities in science lessons is gradually quenching pupils‟ interest in science. This gives teachers the chance to skip topics that they perceive as difficult mainly because the teachers do not know any creative means of teaching the topics.

Without knowledge of local resources that are readily available even in school environments and the skill to convert them into instructional materials, that could be adapted for teaching to enable their pupils interact with science as a subject of study, science will continue to appear too difficult to teach and understand. The research also revealed that our immediate environment is endowed with various resources that can be a great resource for addressing schools‟ instructional resource needs in the country and also enable schools and their local communities to collaborate effectively in utilizing the tools and materials available in their local environs. Therefore identifying and giving second life to waste and other materials can be an asset in boosting science education in Ghanaian primary schools.

The introduction of appropriate and interactive instructional materials that allow pupils to engage in hands-on activities in the classroom during science lessons can be a way forward to reviving the interest of primary pupils in the science subject and a motivator to teachers by helping to make seemingly difficult topics and concepts easier to understand, teach and learn. Teachers can also benefit from these kinds of interventions when topics can be explained easier with effective aids and within the allotted periods.

Although instructional materials are indispensable in creating a thriving environment for effective teaching and learning, this research identified other factors that also affect teaching and learning in the classroom. In the selected school for example, variables such as classroom furniture, teachers‟ background knowledge of subject matter and teaching styles were identified to affect and sometimes hinder the creation of a conducive environment for learning science as well as play a significant role in the teaching and learning process.

5.3 Recommendations

The following recommendations can help resolve and improve conditions for science education in Ghanaian schools:

1. The Ghana Education Service (GES) can collaborate with qualified educational institutions that are responsible for training educators to hold exhibitions and training sessions for the display of instructional materials and technologies that can be adopted for effective classroom instruction. For instance, the Department of General Art Studies, KNUST can hold exhibition of course products and invite the Regional Office of the GES in Ashanti Region, teachers and schools to initiate collaboration and glean ideas for various subjects including science.
2. The use of local and recyclable materials as an alternative for acquiring basic IMs should be encouraged in schools especially the primary level. Teachers can liaise with their pupils to gather materials and work on basic IMs together; this involvement of both teachers and pupils will establish participatory spirit, and strengthen teachers and pupils‟ relationship.

3. Primary school teachers can utilize some known skill that they have acquired or learn some basic skills from known experts that will enable them to design and develop simple but effective aids to enhance pupils‟ knowledge and understanding of abstract science topics that they are taught at the lower primary level.
4. Colleges of Education should infuse more practical skills acquisition into the study of subjects to develop the skills needed for teachers to design and develop appropriate instructional materials for classroom instruction.
5. The School Based Inserts (SBI) and Cluster Based Inserts (CBI) usually organised for teachers every academic year by school administrations in collaboration with the sub-metros can help teachers with simple and creative means of adopting local resources into science lessons; and teachers should be encouraged to participate fully in these training sessions to make topics that are difficult to teach more understandable.
6. GES should intensify their monitoring activities to schools to ensure that teachers adopt the most suitable teaching practices in science education at the lower primary level in Ghana.
7. School premises should adhere to their core functions of teaching and learning and avoid religious groups on school premises especially if the activities of the groups interfere with academic work.
8. Further research could be conducted to find out the effect of abusive language on pupils and their academic performance, as well as trading activities teachers engage in during school hours and how they affect teaching and learning. Also, the seating arrangement adopted by teachers whereby pupils who are seen as brilliant are made to sit in front rows in the classroom whiles pupils perceived as weak or non-serious

are seated at the rear of the classrooms and its effect on pupils can be researched into.

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APPENDICES

APPENDIX A

INTERVIEW GUIDE FOR PRIMARY SCHOOL TEACHERS ON DEVELOPING THREE-DIMENSIONAL INSTRUCTIONAL MATERIALS FROM LOCALLY AVAILABLE RESOURCES FOR SCIENCE IN PRIMARY SCHOOL EDUCATION, ASHANTI REGION

PART I (a): INFORMATION ON THE SCHOOL

Name of School: …………………………………………………………………...

Location of School: …………………………………………………………………..

Category of School: (a) Government [ ] (b) Private [ ]

TEACHER"S BACKGROUND INFORMATION

i) Gender: (a) Male [ ] (b) Female [ ] **ii) Age:** (a) Below 30 [ ] (b) Between 30 and 34 years [ ]

(c) Between 35 and 39 years [ ] (c) Between 40 and 44 years [ ]

(d) Between 45 and 49 years [ ] (e) Between 50 and 54 years [ ]

(f) Above 54 years [ ]

iii) Teacher"s Qualification: (a) GCE "O" Levels [ ] (b) GCE "A" Levels [ ]

(c) Higher National Diploma (HND) [ ] (d) Diploma in Basic Education (DBE) [ ]

(f) Bachelor / Post-Graduate Degree [ ]

If others, please specify. ....

iv) Years of teaching experience:

(a) Between 1 and 5years [ ] (b) Between 6 and 10years [ ]

(c) Between 11 and 15years [ ] (d) 16years and above [ ]

v) Years of teaching at the Lower Primary School:

(a) Between 1 and 5years [ ] (b) Between 6 and 10years [ ]

(c) Between 11 and 15years [ ] (d) 16years and above [ ]

PART I (b): QUESTIONS

1. In which class do you teach Science in the Primary school?

(a) Primary One [ ] (b) Primary Two [ ] (c) Primary Three [ ]

2. In teaching Science, which teaching methods do you use?

(a) Lecture Method [ ] (b) Discussion Method [ ]

(c) Field trip Method [ ]   (d) Demonstration [ ]

□ If others, please specify …………………………………………..

3. Do you know Instructional Materials (IMs)?   (a) Yes [ ]   (b) No [ ]

4. Who provides IMs for your classroom for teaching Science?

   ....

5. a. Are the needed IMs available for use in the classroom? a) Yes □   b) No

   i. If **Yes** to Question 5, do you use the IMs in teaching your lessons?

   (a) Yes [ ]   (b) No [ ] ii. If Yes to above question, which type(s) of IMs do you employ for teaching

   Science to pupils?

   (a) Purchased   (b) Locally made   (c) Self-made

   ▪ If others, please specify. ....

   b. If **No** to Question 5, what alternatives do you employ to use as IMs for teaching Science? ....

6. What materials are the IMs that you use in your class made of? ....

7. i) Are the available IMs used appropriate for teaching Science at the primary School?   (a) Yes □   (b) No

   ii) Please state the reason(s) for your answer ....………………… 8. What IMs are available for students to learn privately or on their own?

   ………………………………………………………………………………………..

9. How do pupils in your class respond to the teaching of Science with IMs?

   (a) Pupils participate in class [ ]   (b) Pupils answer questions correctly [ ]

   (c) Pupils demonstrate understanding [ ]   (d) Pupils pay attention [ ]

   (e) Pupils fidget in the classroom [ ]   (f) Pupils sleep in the classroom [ ]

   (i) Please specify if others ………………………………….............………

10. Please kindly state why you think the above reason holds. …………………....

11. How do you sustain pupils‟ interest or get their attention in the classroom in the absence of IMs? ....……………………….........

12. a. Can you state topics which are difficult to teach in absence of IMs?

………………………………………………………………………..................

b. Please give your reason(s) for the above answer. ....…………....................

13. a. Are there other topics that are difficult to teach even with the use of IMs?

………………………………………………………………………..................

b. Please give your reason(s) for the above answer. ....

Thank You

APPENDIX B

INTERVIEW GUIDE FOR PRIMARY SCHOOL HEADTEACHERS ON DEVELOPING THREE-DIMENSIONAL INSTRUCTIONAL MATERIALS FROM LOCALLY AVAILABLE RESOURCES FOR SCIENCE IN PRIMARY SCHOOL EDUCATION, ASHANTI REGION

PART I (a): INFORMATION ON THE SCHOOL

Name of School: ……………………………………………………………..

Location of School: ………………………………………………………..

Category of School: (a) Government [ ] (b) Private [ ]

HEADTEACHER‟S BACKGROUND INFORMATION

i) Gender: (a) Male [ ] (b) Female [ ]

ii) Age: (a) Between 25 and 35years [ ] (b) Between 36 and 46years [ ]

(c) Between 47 and 55years [ ] (d) Between 56 and above [ ]

1. a. As school head what is your view on science education in Ghana, generally?

b. Your view on science education in primary schools? ....

2. As a public school, how is the teaching and learning of science administered in your school? ....

3. How do you recruit your science teachers and what are the qualifications required? ....

4. Do you employ Instructional Materials for the school‟s Science programme?

   Yes [ ] No [ ]

5. What kinds of IMs do you use as a school? ....

6. How does the school get its IMs? ....

7. How often are these IMs acquired? ....

8. a. Does the school upgrade its stock of IMs? (a) Yes [ ] (b) No [ ]

   - Specify any other answer...

   b. If Yes to Question 8, how does the school upgrade? ....

9. Averagely, how does the school invest in IMs for school‟s science programme?

   ....

10. Specifically, what does the administration do to improve Science education in the primary department? ....

APPENDIX C

OBSERVATION CHECKLIST I FOR DEVELOPING THREE-DIMENSIONAL INSTRUCTIONAL MATERIALS FROM LOCALLY AVAILABLE RESOURCES FOR SCIENCE IN PRIMARY SCHOOL EDUCATION, ASHANTI REGION

Name of School: …………………………………..…………………….……………...

Location of School: ………………………...…………………………….……..

Class: .... No. On roll: .... Date: ....

Steps for Observing the Teaching of Science

1. Topic being taught. ....……………………………
2. Objectives of the topic. ....………
3. Teaching strategy being used by the teacher.....................................……
4. IMs employed for the lesson. ....………………
5. Kind of IMs being used.

   i. Self - made ii. Purchased package iii. Locally made by visual experts
6. Materials used for the IMs. ....………..………
7. IMs relate to the topic being taught. i) Yes [ ] ii) No [ ]
8. Incorporation of the IMs into Science lesson by teacher. ……………….........
9. Pupils‟ response to the IM. ....……………………………………….............
10. IMs seem to promote understanding. i) Yes [ ] ii) No [ ]
11. IMs engage pupils in the class. ...………………………………………………
12. IMs distract pupils during lesson. i) Yes [ ] ii) No [ ]
13. Lesson was finished within allotted time. i) Yes [ ] ii) No [ ]
14. Form of assessment given to students. ....……………………………

APPENDIX D

OBSERVATION CHECKLIST II FOR DEVELOPING THREE-DIMENSIONAL INSTRUCTIONAL MATERIALS FROM LOCALLY AVAILABLE RESOURCES FOR SCIENCE IN PRIMARY SCHOOL EDUCATION, ASHANTI REGION

Name of School: …………………………………….………......

Location of School: ……………………………………………...

Class: .... No. On roll: .... Date: ....

Characteristics of Good Teaching

1. Do teachers make sure that pupils understand Science concepts taught?
2. Are teachers skilled in using the available IMs?
3. Are Science teachers always resourceful?
4. Do teachers assist pupils when teaching Science?
5. Do Science teachers boost pupils‟ interest by inspiring them?

Teaching Strategies Adopted

6. Are different methods of teaching combined to teach Science?
7. Are the teaching methods suitable for the topic?
8. Is Science taught using a hands-on activity?
9. Are teaching methods employed pupil-centred?

Pupils‟ Response to use of IMs in the Primary School

10. Are pupils interested in Science lessons?.............................…………………
11. Are pupils encouraged to learn Science? ………………………………………
12. Do pupils exhibit enthusiasm for Science? ....…………………
13. Are pupils attentive during the Science lessons? ....………………………….
14. Do pupils demonstrate comprehension of topics taught in Science without IMs? ....…………………………….............................………
15. Are topics taught with IMs understood by pupils? …………………

16. Do pupils answer correctly questions asked in class during Science lessons?

APPENDIX E