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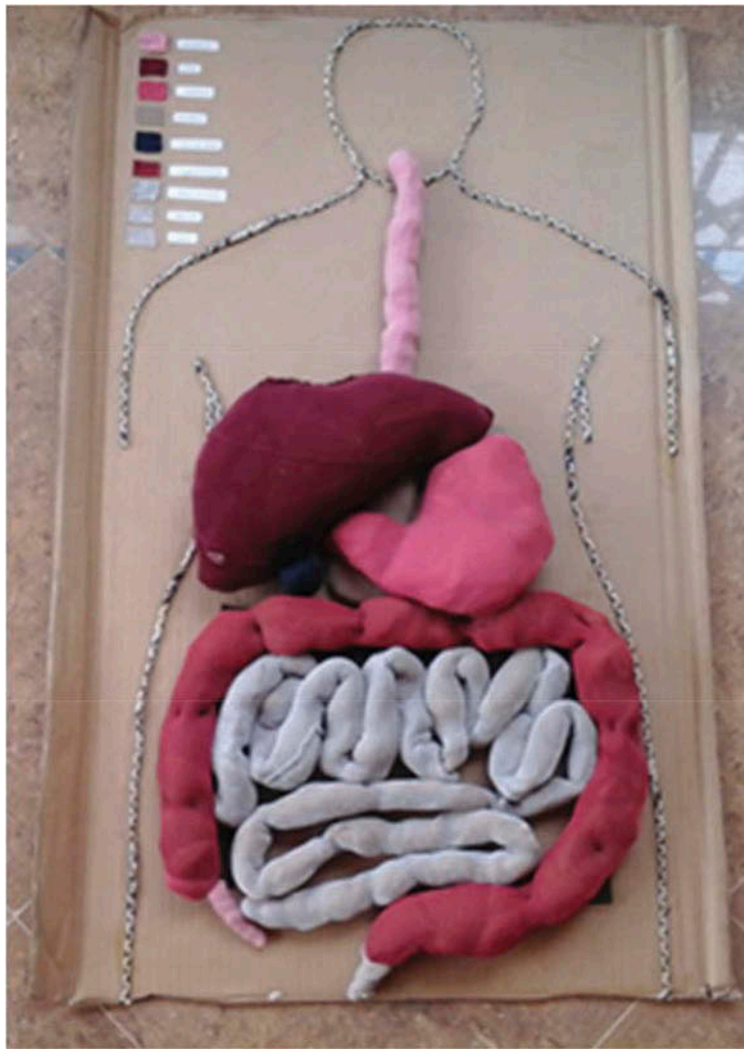

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Making primary school science education more practical through appropriate interactive instructional resources: A case study of Ghana

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Abstract: This instructional resource production project explored low cost and waste materials for developing practical and interactive resources for teaching science at the basic school level. Developing countries, including Ghana, are not able to provide teachers with instructional resources for teaching and learning due to financial constraints. Science in particular is a subject that pupils and students in Ghana generally do not perform well both at the basic and senior high levels which is evident from the end of level examinations over the years. The study used exploratory and descriptive approaches under qualitative research. Convenience sampling was used to select low cost and waste materials to work with, and observation was used to collect data from the production process. The research found that waste materials can be used safely to develop appropriate and useful instructional resources that are very practical for teaching and learning of science lessons. This research projects to science teachers that they can freely turn collected waste and low-cost materials into useful resources for effective lessons.

Rita Yeboah

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PUBLIC INTEREST STATEMENT

In Ghana and in most developing countries, teachers mostly "talk to teach" because of lack of instructional resources. This research therefore explored how low cost and waste materials can be used to develop practical and interactive instructional resources for teaching and learning of science at the basic school level. Paper and plastic wastes, second-hand clothes, plant sticks, glue, paint, Velcro, thread and needles were selected to work with. The outcome of the exploration showed that waste and low-cost materials can be used to create very practical and appropriate resources for learning. This implies that teachers and schools in developing countries like Ghana who are not provided with instructional resources by governments can turn waste and low-cost materials into useful resources for teaching and learning.

Subjects: Development Studies; Environment; Social Work; Urban Studies; Social Sciences; Education; Arts

Keywords: Primary school; science; interactive instructional resources; education

1. Introduction

Science is a subject that needs to be taught using very practical and appropriate instructional resources, but many educational systems in developing countries may not be privileged to be provided with all the practical science resources teachers need to use in teaching and learning for better understanding and to whip up student's interest in science. Nonetheless, as the educational paradigm shifts towards more engaging instructional approaches, one such proposition is engaging in low-cost science practicals, designed and run using very cheap readily available resources. Learning science should not only involve memorisation and reasoning but also performing activities and developing skills. The PEN-GAST workshop held in Ghana in 2014 for science teachers demonstrated that cost cannot always inhibit science in action. Teachers can take advantage of common low-cost materials to give school science a new twist. This will go a long way to contribute to raising competent innovators and problem solvers of the future (The Gamelian World, 2014).

The study is guided by the following research questions:

(1) How can practical and interactive instructional resources be developed from low cost and waste materials for teaching and learning of science?

(2) What are the challenges in using low cost and waste materials to develop practical and interactive instructional resources for teaching science?

2. Teaching and learning of science at the basic level in Ghana

Science is commonly viewed as a process of obtaining knowledge through experimentation and observation. This means that scientific knowledge is generated through extensive interaction of learners with the physical and natural world. It appears that the role of the teacher, therefore, is to provide students with the requisite tools to embark on this journey of discovery, filled with adventure, curiosity and wonder. Once interest is stimulated and maintained with appropriate practical instructional resources, the students can grasp and assimilate the content of science easily (The Gamelian World, 2014). Yet in Ghana, especially at the basic school level, lack of basic laboratory materials and equipment interfere with the ideal of teaching science using a hands-on approach. Without proper practicals or demos, students find it more challenging to understand topics taught in class. This may partly be responsible for the general poor performance of basic school pupils in their end-of-studies examinations in science. Handelsman et al. (2004) note that some teachers are intimidated by the challenge of learning new instructional strategies and therefore resist any change in their instructions. Wieman (2008) expresses that for science education to achieve its purpose in any country, teachers must develop their instructions with all the rigour and standard as scientists conduct scientific research. Consequently, science teachers are expected to create an environment conducive for students' active questioning and identification of issues and answers by employing appropriate instructional strategies (Dass & Yager, 2009).

3. Rationale for teaching natural and integrated science in basic schools in Ghana

Science and technology form the basis for inventions, for manufacturing and for simple logical thinking and action. This means that scientific and technological literacy is necessary for all individuals, especially in developing countries which have to move faster in the attempt to raise the standard of living of their people. Natural science is a fusion of the major branches of science. 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 (Teaching Syllabus for Natural and Integrated Science in Ghana, 2007, p. ii).

4. General aims (Teaching Syllabus for Natural and Integrated Science in Ghana, 2007, p. ii)

The syllabus is designed to help the pupil to:

(1) develop the spirit of curiosity, creativity and critical thinking.
(2) develop skills, habits of mind and attitudes necessary for scientific inquiry.
(3) develop the spirit of curiosity for investigating and understanding their environment
(4) communicate scientific ideas effectively
(5) use scientific concepts for explaining their own lives and the world around them.
(6) live a healthy quality life.
(7) treat all resources of the world with humane and responsible attitude.
(8) show concern and understanding of the interdependence of all living things and the Earth on which they live
(9) design activities for exploring and applying scientific ideas and concepts

5. Scope of content

The topics in the syllabus have been carefully selected to introduce the pupil to the enquiry processes of science as well as to basic ideas in science. The topics cover the basic science disciplines, agriculture, health, industry and Basic electronics. For successful study of Natural Science at this level, the pupil should have good observational skills and communication skills. The syllabus has been structured to cover five sections or themes: Diversity of matter, Cycles, Systems, Energy and Interactions of matter (Teaching Syllabus for Natural and Integrated Science in Ghana, 2007, pp. ii-iii). Tables 1 and 2 shows the structure and organisation of the lower and upper primary science syllabus in Ghana.

Table 1. Structure and organisation of the lower primary science syllabus in Ghana

	PRIMARY 1	PRIMARY 2	PRIMARY 3
DIVERSITY OF MATTER	Unit 1: Living and non-living things Unit 2: Measurement (length, mass, volume and time)	Unit 1: Leaving things(Plants/Animals) Unit 2: Water Unit 3: Air Unit 4: Rocks Unit 5: Measurement	Unit 1: Soil Unit 2: Feeding in Plants Unit 3: Feeding in Animals Unit 4: States of Matter Unit 5: Measurement of Time.
CYCLES	Unit 1: Sun and Earth Unit 2: Day and Night	Unit 1: Weather conditions	Unit 1: Seasons
SYSTEMS	Unit 1: Simple Electronic components	Unit 1: The Human Body Unit 2: Parts of a Plant	Unit 1: Sense organs
ENERGY	Unit 1: Sunlight Unit 2: Food	Unit 1: Hot and Cold Unit 2: Sound	Unit 1: Waves Unit 2: Building Simple Electronic circuit
INTERACTIONS OF MATTER	Unit 1: Personal Hygiene Unit 2: Simple machines	Unit 1: Personal Hygiene Unit 2: Sanitation Unit 3: Simple machines (Pulleys & Inclined planes) Unit 4: Simple Electronic circuit	Unit 1: Personal Hygiene Unit 2: Water pollution Unit 3: Water purification

Source: Teaching Syllabus for Natural Science in Ghana (2007).

Table 2. Structure and organisation of the upper primary science syllabus in Ghana

THEMES	PRIMARY 4	PRIMARY 5	PRIMARY 6
DIVERSITY OF MATTER	Unit 1: Groups of Plants Unit 2: Groups of Animals Unit 3: Metals and non-metals Unit 4: Rusting Unit 5: Measurement of temperature	Unit 1: Parts of flowers and their functions Unit 2: Measurement	Unit 1: Fruits and Seeds Unit 2: Air Unit 3: States of Matter Unit 4: Measurement of Time.
CYCLES	Unit 1: Ventilation	Unit 1: Water Cycle	Unit 1: Life cycles of Okro and Maize plant Unit 2: Life cycles of the mosquito
SYSTEMS	Unit 1: The Solar system	Unit 1: The Human Body systems	Unit 1: The digestive system of Humans Unit 2: Simple Electrical Circuit
ENERGY	Unit 1: Sources of Energy	Unit 1: Forms of Energy Unit 2: Conversion of Energy Unit 3: Change of State of Matter Unit 4: Basic Electronics	Unit 1: Respiration Unit 2: Heat Unit 3: Electrical Circuit Unit 4: Basic Electronic circuit

Source: Teaching Syllabus for Integrated Science in Ghana (2007).

6. Challenges in teaching science

According to Adu-Gyamfi (2013), students' lack of interest in science is as a result of the less practical nature of learning school science as well as teaching and learning of science which has basically become the transfer of knowledge from science teachers and from textbooks to students. Adu-Gyamfi (2014), in his study into challenges of science teaching at the basic level, revealed that, amongst all the teachers he interviewed, there was a general indication that science teaching at the basic level was challenged in the area of science materials and equipment. The science materials and equipment were said to be unavailable and where they were available, they were insufficient for effective and efficient science teaching and learning. Rocard, Csermely, Jorde, Lenzen, and Wallberg-Henriksson (2007), as cited in Agudzeamegah (2014), opine 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 report by The Organisation for Economic Co-operation and Development (2006) on Evolution of Student Interest in Science and Technology identified the following challenges with science education: a) The discomforting circumstances of some primary school teachers that are asked to teach subjects in which they lack enough self-confidence and knowledge; b) 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 memorising rather than on understanding; c) Furthermore, burdensome workloads that leave little time for meaningful experiments are reported. Another report from "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). Anderman, Sinatra, and Gray (2012) purport that science teachers' decisions about instructional practices and the strategies used in teaching and learning science are crucial to influence students' interest and attitude in pursuing any science related subject or course.

7. Using interactive instructional resources for teaching and learning of science

Instructional resources are aids to teaching and learning. They are items that help to raise teaching and learning from verbalization to practical making learning real and meaningful to learners (Okobia, 2011). This implies that they help to make concepts, abstracts and ideas concrete

in the teaching and learning process (Olawale, 2013). According to Yildirim (2008), instructional resources act as supporting elements which make teaching and learning easy, lively, interesting, enrich the education and teaching setting, facilitate learning, simplify and clarify knowledge that is put across to learners. They cover all physical means a teacher might use to implement instruction and facilitate learners' achievement of instructional objectives (Scanlan, 2003). Instructional resources are important in the teaching and learning of any subject in the school curriculum.

Teaching and learning experiences that involve the learner actively in concrete examples are retained longer than abstract experiences. Educationists agree that instructional resources bring about improvement in the teaching and learning process as well as permit teachers and students to interact and control their learning environment for better results (Olawale, 2013). The utilisation of instructional resources enables the teacher to explain abstract concepts practically to attract and sustain the attention of learners to comprehend easily with what they are taught (Thompson, 2001). Instructional resources serve as a means of extending the horizon of teachers and providing them with rich sources for procuring communicative materials for teaching and learning (Olawale, 2013; Saglam, 2011). Usage of instructional resources helps to overcome the limitations of time, space and size for students to understand things that are too small or too big, or too slow or too fast. Again, the use of instructional resources breaks language barriers, saves time, helps teachers to use different teaching and learning methods and enables students grasp concepts more effectively and faster (Olawale, 2013).

Igbo and Omeje (2014) study showed that the performance of learners improves when teachers utilise teacher-made instructional resources in teaching to help the learners comprehend easily with what they are taught. Another study by Nwike and Onyejegbu (2013) revealed that secondary school students who were taught with instructional resources in agricultural science at Orumba South Local Government area performed better in their academics than those that were taught without instructional resources. Again, Oladejo, Olosunde, Ojebisi, and Isola (2011) revealed that students in schools that used adequate instructional resources performed far better than the students in schools who did not use adequate resources in Ogun State in Nigeria. According to Rececе and Walker (2001), the use of instructional resources enhances students' learning and there is a link between poor learning and low performance with the failure to use instructional resources in the teaching and learning process.

8. Theoretical foundation of the research

The study is grounded on two theories of teaching and learning, namely, Dale's Cone of Experience and Multiple Intelligences. Dale's Cone of Experience summarises Dale's classification for the different learning experiences. The Cone of Experience explains that after two weeks of learning, people generally remember 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they hear and see, 70% of what they say and write, and 90% of what they do as they perform a task (Molenda, 2003). Figure 1 illustrates the Cone of Experience. This shows that the more learners are made to use their senses of sight, hearing, touch, smell and movement in learning activities, they retain more of what they learn and when less of the senses are used, learners retain little of what is learnt (Anderson, n.d.). Dale's theory is appropriate for the research because it provides teachers with instructional methods and strategies, which when used will make the teaching and learning process more practical for learners. Thus, the use of interactive resources by science teachers will help students understand and retain more of what they are taught than just talking to teach them.

9. Multiple intelligences

Gardner's Multiple Intelligences reveal different academic strengths of individuals and honours alternative ways of learning. This theory reminds teachers to consider the different ways students learn in the teaching and learning process instead of focusing on only linguistic and logical-mathematical intelligence (Fierros, 2004). The implementation of this theory in education helps to address students' different intelligences and to provide them with learning experiences that can lead to better learning opportunities (Fierros, 2004). This theory admits that there are different learning styles in every classroom so teaching and learning must be varied to include all students (see Figure 2 for an illustration of the Multiple Intelligences theory).

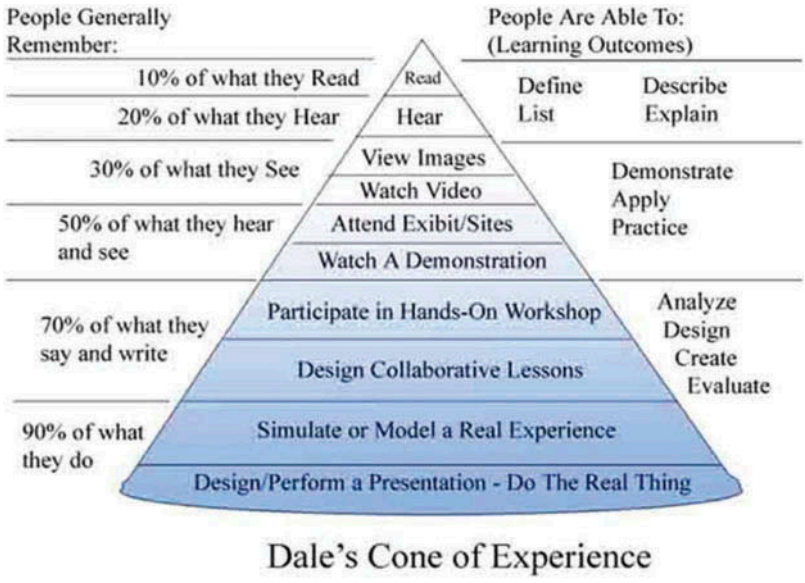

Figure 1. The cone of experience by Edgar Dale.

Source: by Bilash (2011).

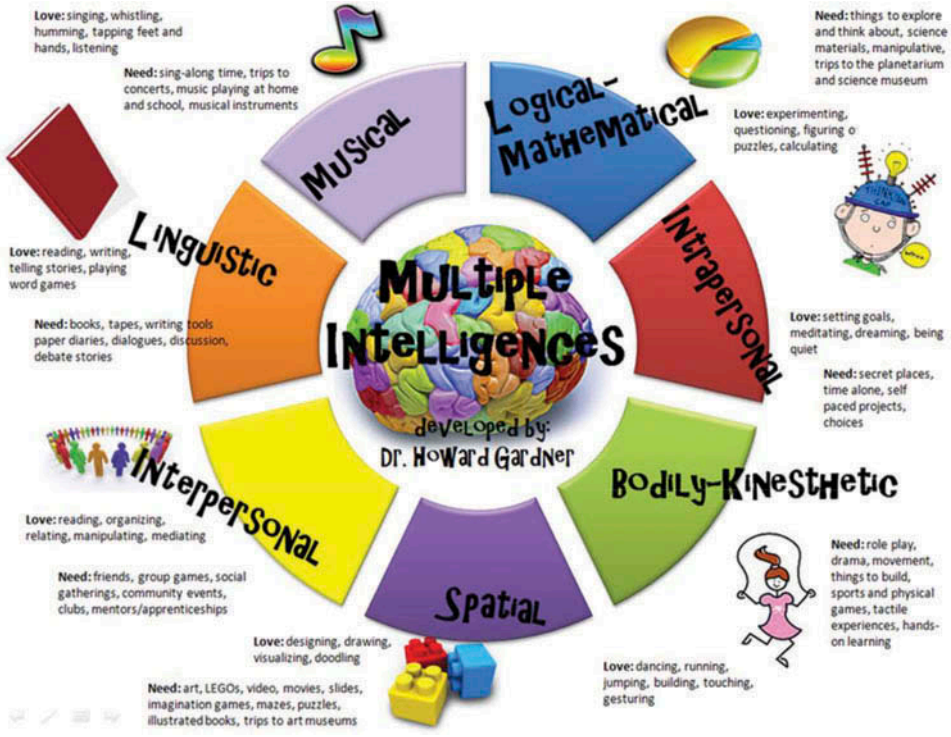

Figure 2. An illustration of the multiple intelligences theory by Howard Gardner.

Source: by onlinelearningtips.com

10. Methodology

This instructional resource production project used the case study approach of exploratory and descriptive methods under qualitative research to conduct the study. Exploratory research was used to explore the step-by-step processes for developing the instructional resources from solid waste and low-cost materials. The descriptive method was used to present and analyse the qualities of the resources that were produced. The population for the study considered all generated solid

waste and low-cost materials from which convenience sampling was used to select paper and plastic wastes, second-hand clothes, plant sticks, glue, paint, Velcro, thread and needle to work with. In Ghana, the waste materials can be collected for free in the environment, from offices, printing presses and refrigerator repair shops. These waste materials were used because they are commonly available in Ghana and they do not pose any harmful effects to both teachers and students as instructional resources.

The science syllabus for primary school is made up of five sections, namely, Diversity of matter, Cycles, Systems, Energy and Interactions of matter. Six topics were taken from two sections thus Diversity of matter and Systems to develop resources for teaching the topics. The topics included: The digestive system of humans, Parts of a flower, The germination of seeds, The solar system and Measurement of Time. Observation was used to collect data on the production process during and after the exploratory exercise.

11. Presentation of the developed instructional resources

11.1. The digestive system of humans

This very attractive, colourful and durable resource provides accurate visual representation of the various organs in humans for digestion. This was developed by first drawing the digestive system on the box paper and the organs were sewn using second-hand clothes and stuffed with soft foam to make them three-dimensional. The sewn organs were then fixed on the box paper using Velcro; this means that the organs are not permanently stacked to the box paper, so they can be removed and fixed back. This can be used by teachers to teach interactive lessons. This easy-to-construct and dismantle approach to the developed resources can foster and sustain the interest of all categories of pupils at the basic level. Figure 3 shows the resource.

11.2. Parts of a flower

As shown in Figure 4, the developed instructional resource for teaching the parts of a flower has aesthetic appeal, can clearly communicate the parts, foster and sustain interest in lessons at the basic level. This was developed by carving the stigma, style, ovule, ovary, pedicel and receptacle out of the hard insulation foam found in refrigerators. The petal and sepal were cut out from a box paper and painted. The filament and anther were made with plant sticks and soft foam.

11.3. Measurement of time

This resource is simple and very practical for teaching and learning of how to tell time. It looks attractive, very durable and is not bulky to move around. The resource conveyed the intended elements of a clock very explicitly. The resource was developed using box paper. The numbers for telling the time are not permanently fixed so they can be removed to indicate different times. Figure 5 shows the resource.

11.4. Stages of seed germination

Produced out of box paper, hard insulation foam from refrigerators, plant sticks and sand, the resource gives a vivid illustration of the stages plants go through to germinate. This resource can help teachers to give life to a seed germination lesson for effective and better understanding. Figure 6 shows the resource.

11.5. The solar system

This resource provides accurate visual representations of the various solar systems. All the planets and the labelling are not permanently fixed so they can be removed and fixed back to induce interactive teaching and learning. The resource was developed using box paper and the hard insulation foam. Figure 7 shows the resource.

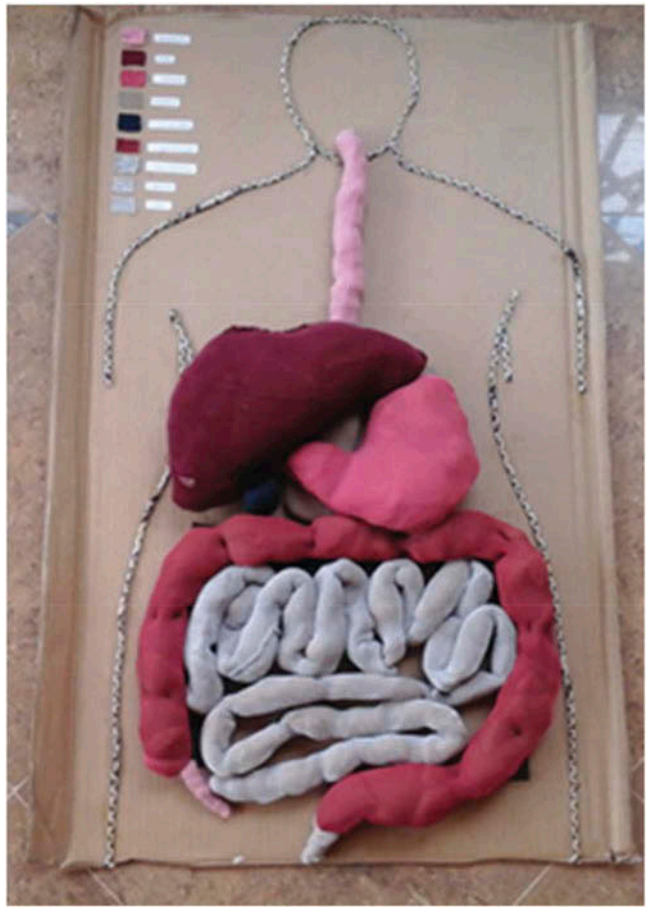

Figure 3. The digestive system of humans.

Figure 4. Parts of a flower.

Figure 5. Resource for measurement of time.

Figure 6. Stages of seed germination.

Figure 7. The solar system.

12. Discussion of results

12.1. The developed instructional resources from the exploratory work

The materials explored for producing the sample instructional resources for teaching and learning of science at the Basic school level were easy to work with, and the sample instructional resources can be used for teaching practical and interactive science lessons. The physical features of instructional resources are a very important factor in their selection and use. Physical features like attractiveness, durability, size, weight, clarity of the resources, easy handling and storage of resources must be considered in the selection of instructional resources (Alobo, 2010). With regards to this, the methods and conditions of use of the developed resources were not complex so teachers will not struggle to use them for teaching and learning. The developed resources could all be used without or in the absence of electricity; this will be very good for developing countries as most developing countries do not have constant electricity supply and some rural areas even do not have electricity supply as is the case in Ghana. The instructional resources were attractive, so they can be used to catch and sustain the attention of learners during teaching and learning. The materials used to create the resources ensured that the resources were durable and can last for a long time to sustain effective delivery of science at the Basic school level. Also, as a result of the materials used, the resources can be carried easily by teachers from class to class for teaching and learning and they can be viewed clearly in the classroom because of their sizes.

Furthermore, Alobo (2010) recommends for teachers to use materials from their local communities for teaching and learning instead of materials from other areas. In line with this recommendation, the solid waste and low-cost materials used to create the resources were locally generated, hence the resources are culturally appropriate. Also, the resources are very affordable because they are made of solid waste and low-cost materials that can be used at little or no cost for teaching and learning. According to Osei-Sarfo (2013), Ghana Education Service calls on teachers to improvise instructional resources from locally available materials to make their lessons effective. Here, using solid waste and low-cost materials will ensure that teachers will be able to improvise without spending a lot of money. With this approach, science teachers and schools in developing countries will not have to wait for the government to provide learning resources if they improvise with solid waste and low-cost materials.

12.2. Challenges faced in developing the instructional resources

There were some challenges in creating the resources, but they had limited effects on the successful production of the instructional resources. For instance, in creating the instructional resources for teaching "The digestive system", some of the Velcro glued on the box paper to stick the organs on got removed after some time. They were re-fixed by applying glue on the box paper and allowing the glue to dry very well before sticking the Velcro onto the box paper to take the organs. With the instructional resources for teaching "Parts of the Flower", some of the filaments got broken after some time since they were made using plant sticks. This can be re-fixed easily by glueing the anther onto a waste metal string to prevent any breakage. This suggests that teachers can easily repair the resources if they encounter such problems as they use them to teach. The solid waste and low-cost materials and the procedures followed in developing the instructional resources did not create any safety threat in the development of the resources. This will ensure that they can be used in the classroom safely without posing any harmful effects to both teachers and pupils.

12.3. The outcome of the exploratory work and implications on basic school science education in developing countries

This exploratory work indicates that solid waste and low-cost materials can be safely used to create useful and interactive instructional resources for teaching science. Based on this outcome, it is clear that if teachers and College of Education students are trained practically to use collected materials to create practical and interactive instructional resources, they will not have to teach without appropriate instructional resources or wait for governments to supply them with such resources which in most cases are never provided especially in developing countries. Alobo (2010)

confirms this by explaining that most of the time, the best instructional resources to be used are not available to teachers due to financial constraints. When faced with this situation there will be the need for every teacher to avail himself or herself to learn and acquire the skills for improvisation of appropriate instructional resources using available local materials. One problem with improvisation is the lack of adequate professional training of teachers in the effective use of local resources for teaching (Oladejo et al., 2011). Consequently, Oladejo et al. (2011) stresses the need for definite well-planned training programmes in teaching and learning resources improvisation for teachers. Such in-service programmes should include regular meaningful workshops on improvisation techniques for teachers to improve and update their competencies in instructional resource development. As Levlin et al. (2010) have explained that the more knowledgeable people are about something, the more likely they will practise it and feel satisfied with their actions. In this regard, if teachers and student-teachers are trained well to develop interactive resources from solid waste and low-cost materials, they will practise it. As teachers practise using solid waste and low-cost materials to develop instructional resources, they will help enhance the quality of teaching and learning in Ghana as learners will have the opportunity to be taught with practical and interactive resources that explain concepts easily for better understanding.

The use of practical and interactive instructional resources in teaching science will increase the pupils' enthusiasm to learn as instructional resources assume the role as supporting elements to concretize the knowledge or facts an instruction tries to put across. Yildirim (2008) expresses that students prefer teaching methods supported with instructional resources to traditional methods of just talking to teach. Learning resources help to increase learners' motivation to learn, reduce boredom in the classroom and make the teaching learning process more systematic (Ruis, Muhyidin, & Waluyo, 2009). Arousing such interest in learners in lessons in any discipline through the use of instructional resources can be achieved only by the ability of teachers to learn to use low cost and collected materials to create the appropriate resources they need. The use of interactive instructional resources will enable teachers to involve learners to participate in topics taught by using the resources as reference to illustrate their thoughts and ideas (Igbo & Omeje, 2014). This corroborates with Edgar Dale's Cone of Learning Experience (Bilash, 2011) which points out that the more practical a lesson is, the better the chance that many students can learn from it.

Teaching and learning of science without concrete instructional resources will make a lesson very theoretical and abstract which will make it very difficult for teachers to clearly explain concepts for Primary school pupils to understand. In this atmosphere, teachers would have to talk a lot in their effort to explain concepts, processes and techniques but sometimes, their efforts do not yield the required results, which is to make the learners comprehend what they are taught (Yeboah, 2016). Young learners at the basic school level in particular usually lack the ability to assimilate concepts abstractly, making it imperative for their teachers to adopt the use of interactive instructional resources for their lessons (Adeyemo, 2010; Aina, 2013).

12.4. Conclusion

The research indicates that solid waste and collected materials can be safely used to create appropriate interactive instructional resources for teaching science. Based on this, if very practical measures are put in place to train school teachers and College of Education students to create their own interactive resources from collected materials they will have resources to use in teaching and learning of any subject in school. Here, teaching and learning with instructional resources offer latitude for shaping lessons to students' interests and needs, thereby enhancing the potential of these teaching strategies to be realised in the classroom (Igbo & Omeje, 2014). Simply put, the primary purpose of instructional resources is to make teaching and learning more effective and also facilitate it (Benson & Odera, 2013; Saglam, 2011; Alobo, 2010; Scanlan, 2003).

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Correction
This article has been republished with minor changes. These changes do not impact the academic content of the article.

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