Journal of Arts & Humanities

Volume 08, Issue 03, 2019: 55-72
Article Received: 16-01-2019
Accepted: 23-03-2019
Available Online: 03-04-2019
ISSN: 2167-9045 (Print), 2167-9053 (Online)
DOI: http://dx.doi.org/10.18533/journal.v8i3.1574

Eggshell Powder as a Viable Sculpture Material: The Case of W.B.M Zion Senior High School, Koforidua, Ghana

Benjamin Deffor[1], Dr. Joe Adu-Agyem[2], Dr. Dorothy Akpene Amenuke[3], Kenneth Dam Sakoalia[4]

ABSTRACT

Sculpture is one of the subjects studied in second cycle and tertiary institutions in Ghana. Due to its relevance in the socio-economic development of the country, materials for production of sculpture are of much importance. In some Second Cycle institutions where Visual Art is studied, many of the materials for sculpture production are imported, expensive or inaccessible to students due to the inadequate funding in purchasing materials for studio work. This has restricted Visual Arts teachers and students with limited materials resulting in less and monotonous practical works, depriving students of mastering effectively, the skills in sculpture production. Eggshells from hatcheries, homes and fast food industries have been used for art for centuries across the world. But they have also been disposed of as waste materials that may cause environmental pollution in some places including Ghana. This study experiments with eggshell powder for sculpture production that will be of benefit to Visual Art teachers and students in skills development lessons and the enhancement of creative ideas. This study has identified eggshell powder as a viable sculpture material through quasi experiments conducted with selected binders to ascertain its potential for modeling and casting. The methodology involves preparation of the Eggshells, milling of shells into powder, laboratory test for chemical composition of the powder, mixing with variety of binders, sculpting and finishing. Although eggshell powder reacted differently to the various binders, the results show that eggshell powder is a suitable unconventional material for modeling and casting figures. Second Cycle and tertiary Institutions are therefore encouraged to use it as alternative sculpting material to enrich the practical session of the visual art programme.

Keywords: Binders, Eggshell Powder, Unconventional Materials, Visual Art Programme.

[1] Tutor, Department of Visual Arts, W.B.M Zion Senior High School, Post of Box 14, Old Tafo, E/R, Ghana. E-mail: benjamin_deffor@yahoo.com. Mobile number: 0549141307
[2] Senior Lecturer & Former HOD, Department of Educational innovations in Science and Technology, KNUST, Kumasi, Ghana. E-mail: kdsako@yahoo.com.
[3] Lecturer, Department of Painting and Sculpture, KNUST, Kumasi, Ghana. E-mail: drjaa2@yahoo.com
[4] Tutor& HOD, Department of Visual Arts, Salaga Senior High School, Ghana. E-mail: dorothyamenuke@gmail.com.

1. Introduction

Sculpture, one of the visual art subjects studied in second cycle and tertiary institutions in Ghana has been gaining more attention due to its relevance in the socio-economic development of the country. This has resulted in the exploration of creative ideas in the aspect of skills, materials and tools for artistic production. Conventional materials such as clay, cement and plaster of Paris have been the main materials used by sculpture teachers and students for modeling and casting of artifacts in most second cycle schools in the country. Students have to acquire these materials by themselves, for their practical studio experiences, and this has been difficult for many of them, since the materials are quite expensive. Students studying sculpture in W.B.M Zion Senior High School have developed more interest in practicing sculpture but the materials for their works have been limited to these conventional ones. The researchers find it necessary to identify alternative materials which could be less expensive, easily accessible and environmentally friendly. This has resulted in an enquiry into eggshells.

Eggshells are waste materials from hatcheries, homes and fast food industries (Phil et al., 2009) and are mostly disposed of and this sometimes contributes to environmental pollution. Challenges associated with disposal of eggshells in some countries include cost, availability of disposal sites, odour, flies and abrasiveness (Zhinong et al., 2005) in the case of large scale egg production. Although a waste material, Eggshells have several advantages and have been widely used. Eggshells are pulverized into powder, and have very fine particles which are useful in the aspect of health since it contains calcium. According to Jillee (2017) an eggshell is made of calcium carbonate, which is also the main ingredient in some antacids. Eggshell has about 750 – 800 mgs of calcium, according to Bhaumik et al., (2011). Eggshell powder has been developed for fluoride removal from aqueous solution. Chicken eggshell is an interesting alternative to the currently used products in supplementation of other natural sources of calcium for humans and animals. Higher solubility of calcium carbonate from chicken eggshells as compared to carbonate derived from oyster shells and the presence of valuable mineral components (strontium, barium) make them an excellent biomaterial for the production of new dietary supplements (Szeleszczuk *et al*., 2015). In addition, the conversion of calcium carbonate and calcium citrate results in a calcium salt with improved properties compared to calcium carbonate. Calcium citrate obtained from chicken eggshells is characterized by a suitable microbiological purity and includes valuable minerals in its composition (Dolińska *et al.,* 2011). The study of the kinetics of calcium release to the artificial gastric juice confirms that calcium is more rapidly released from the tablets containing calcium citrate derived from eggshells than from those with synthetic calcium carbonate.

Eggshells are ground, stockpiled and applied to farm fields. They have a value as a liming source and continue to react with the soil keeping the pH level high (Holmes et al., 2006). Eggshells are very useful in most part of the world. Barazesh et al., (2012) asserts that eggshell powder is useful in clay soil because it reduces the plasticity level in the soil. Eggshells have also been used for several artworks around the world. Among these are paintings, jewelries and sculpture. Works made from eggshells include mosaic art, egg carvings and egg paintings. Despite its usage for art around the world, its exploration in powder form and as alternative modeling and casting material has been under-explored for work in senior high schools in Ghana. Since most of the conventional materials are expensive for students to acquire Eggshells powder tends to be a possible alternative material for modeling and casting of figures, hence this research and experimentation. The researchers engaged students to have a feel of the materials in order to enable them construct more ideas and understand the use of eggshell powder in their sculpture productions; hence project base model was employed for teaching and learning processes with the use of the identified material (eggshell powder). According to Dewey (1959) students develop personal investment in the material if they engage in real, meaningful tasks and problems that emulate what experts do in real-world situations. Sculpture students in the above institution practically got themselves involved in experimenting with eggshell powder and selected binders and got more meaning and understanding of the materials being used, therefore this led students to come out with more creative works using eggshell powder as an unconventional material useful in sculpture productions.

Key reasons that necessitated experimenting with eggshell powder include:

1) Learners getting exposure with the use of eggshell powder in producing sculpture. This is to enhance their knowledge, skills, creativity and attitude towards the use of eggshell powder and its contribution to the development of art.

2) The study is to serve as an alternative material for future researchers in the field of art.

3) The study is to enable students to exhibit their creativity and expansion of the frontiers of knowledge in the field of Art.

2. Project based model

Project-based learning is an age old model of learning with its roots extending back to over a hundred years (Dewey, 1959). In this model of learning, Dewey believed that students would develop personal investment in the material if they engaged in real, meaningful tasks and problems that emulate what experts do in real-world situations. Many years after Dewey's declaration, project-based model of learning continued to be upheld. Dickinson et al., (1998) explained that project-based instruction is an authentic instructional model or strategy in which students' plan, implement, and evaluate projects that have real-world applications beyond the classroom. This idea was emphasized by Branford et al., (1999) when they wrote that project-based learning is a way of learning in which learners actively build knowledge as they explore the surrounding world, observe and interact with phenomena, take in new and old ideas, make connections between new and old ideas and discuss and interact with others. In project-based learning, students actively construct their knowledge by participating in real world activities similar to those that experts engage in, to solve problems and develop artifacts. Blumenfeld et al. (2000) similarly asserts that project-based model or learning allows students to learn by doing and applying ideas. Students engage in real world activities that are similar to the activities that adult professionals engage in. The project-based learning is a form of situated learning and it is based on the constructivist findings that students gain a deeper understanding of material when they actively construct their understanding by working with and using ideas in project-based learning (Blumenfeld et al., 2000).

3. Sculpture

Sculpture as an art form has various definitions that the definition is based on materials for productions, skills involved in expression of ideas, theme and concepts behind production of artifacts and finally the technique employed in making of objects. Sculpture which is a three dimensional art work involve making good use of material, tools, methods and space in expressing individual inborn abilities for solving societal issues. According to Gamble (1995) Sculpture is an art form that deals with using organic and inorganic materials to produce three dimensional figures with the aid of tools and equipment. Gamble's definition for sculpture is best appropriate for traditional sculpture since it is an art of solid form, as a solid form it has no movement and the main techniques employed is modeling and carving. The art of sculpture is no more restricted to traditional sculptural concepts, materials and methods but it can be in a form of abstract, kinetic and capable of movement. Today's sculpture can be assembled, glued, projected as well as constructed in a wide variety of ways (Judith, 2007).

Sculpture has been practiced since the prehistoric era and it is still practiced with different techniques and methods in terms of tools, skills and materials. Sculptures are usually presented either in the round (solid) or in the relief form. Sculpture as a three-dimensional work of art is meant to be viewed from more than one side; this means that sculpture works have depth, volume and mass. There are several techniques employed in sculpture such as carving, modeling, casting, assemblage and construction. Hempson (2012) proclaims that sculpture exists physically as three-dimensional spaces where these sculpture works are altered and realized by the limitation and structures of the materials of their production both from a visual and solid aspect.

Some of these sculptures are cast, but before casting is made possible, a mould is necessary which involves creative process. Most outdoor sculpture works are done using materials that are able to stand the test of time such as cement, wood, resin, fabrics etc. Some of these materials in which most are conventional materials are bonded for casting sculpture. In today's art, the materials for sculpture are no more stagnant but more unconventional materials are experimented with to add up to the conventional materials for practicing sculpture. Some of these materials can be used for only indoor sculptures due to bad environmental conditions.

4. Concept of mould making

The use of mould for casting figures have been in existence from the early stages in practicing sculptures across the world and in this 21st century, artist still use mould for several sculpture productions. The idea behind the usage of mould is to copy surface details of models to be converted into more permanent material. Sthapati (2002) asserts that mould making was done during the early stage of Art. In the prehistoric time, it was done, and the early Egyptians also used mould in their sculptural works. Hence the origins of moulding date back to prehistoric times. Mould making has been traditionally used in casting sculpture figures and materials for making a mould includes clay, plaster of Paris, silicon, cement, resin and hardener. Potters must have been the first to recognize the intriguing fact of forms that could reproduce exact impression of figures in wet clay which is the mould. Mould making in sculpture as a technique for casting refers to a hollow object into which a liquefied material is poured into it in order to copy the shape of the hollow object. There are several types of mould making in sculpture. Some of the mould are stone mould casting, clay mould casting, and metal mould casting. Mould can be either waste or permanent which are used in casting with several viable materials.

4.1 Types of mould

Mould making in sculpture is categorized into two main forms depending on the purpose for productions. According to Hempson (2012) there are two main forms of mould: these are permanent mould and waste mould. Moulds are made permanent depending on the material used for the mould picking. Hence, there are varieties of materials used for making permanent moulds but flexible rubbers are used often for permanent mould due to its nature of copying details and easy removal from the original model and the cast piece, Rubber products for mould making such as latex, polysulfide, polyurethanes, silicon etc. Waste mould is prepared for temporal uses. Usually, waste mould is destroyed after casting.

4.1.1 Clay mould casting

Clay mould is achieved by mixing clay and plant ash with water, therefore, clay is preferably used to cast thin-wall objects. Clay mould casting has been used a lot by the ancient Chinese for their bronze works. Also, Clay mould is mostly used for lost- wax casting technique (cire-perdue) for making jewelries. Clay and sand is also used for mould making in casting objects at some industries, this involves the use of machines that will aid in compression of clay and sand as a mould for casting. According to Bast (2013) the production of castings using clay bonded sand mould continues to be a very important method for manufactures and he asserts that the quality of clay-bonded sand mould is determined by parameters such as the specification of moulding machine, that is method and pressure of sand compaction, pressure time and the characteristics of moulding sand. The process of making a mould from clay and sand is to transfer the moulding sand from the free flowing state into the solid state by its compaction.

4.1.2 Silicon mould casting

The nature of silicon as a mould making material is more preferably than other mould materials since objects cast from silicon mould are perfect in terms of surface quality, detailing and special effects, therefore, silicon mould is a recommended material for making long lasting moulds. Silicon which is also known as polysiloxanes are polymers that include any inert, synthetic compound made up of repeating units of siloxane, which is a chain of alternating atoms, combined with hydrogen. This rubber-like material is used in sealants, adhesives etc. due to its heat resistance. Mouldmaking/casting involves covering the model one wants to copy in a material which can become permanent to be detached from it and keep its shape, so that a negative of the object can be used for casting. The most effective mouldmaking material is silicon rubber. This can be poured as liquid or applied in the form of a paste on the surface of the original object. Silicon rubber has the valuable property of not only of flexing easily, but returning to its original shape without distortion. Silicon rubber has the best release properties of all the mould rubbers. Due to high temperature resistance of silicon, it acts as the only mould rubber suitable for casting low melt alloys. Silicon has an advantage of not taking more time to solidify when used in mould making. The normal curing time for silicon is between 18-24 hours, but curing time may be reduced by using fast-acting catalyst (McCormick et al., 2018).

4.1.3 Plaster mould

Plaster of Paris has been very useful in mould making and casting in various art industries and institutions. Though, the material is expensive but settles very fast when used for mould. The material can be accelerated or retarded when working with it. Plaster of Paris is a white powder material obtained from gypsum and it soluble with water for casting. The additional materials that can be used to prevent plaster from cracking include magnesium oxide, terra alba. Also, lime or cement is used to control plaster. Plaster generates heat during its curing stage (Abidoye et al., 2010).

5. Modeling

Modeling as a technique in sculpture has been practiced from prehistoric era and also practiced by the Egyptians, Romans and the Greeks for their sculpture productions since it is a technique that enables artist to express their creativity by exercising their hands to create figures. This technique in sculpture is achieved by adding malleable materials such as clay, cement, plaster of Paris etc. bit by bit on a support such as armature to obtain a form. The hand is the commonest tools that sculptors use when modeling figures, especially when dealing with materials that are not harmful. Direct modeling involves using malleable materials to create sculptures by directly applying the modeling materials bit by bit in order to obtain a form. Materials used in modeling are organic and inorganic materials. These materials include clay, cement and Plaster of Paris etc. In modeling, a figure in the round, requires armature if the work is to be done in direct modeling (Sthapati, 2002).

Modeling in sculpture is not only to be done using the traditional methods and techniques but today's modeling is also digitalized. The introduction of computer to facilitate learning sculpture has made it possible in using tools and materials that has been programmed in the computer for modeling. Galyean (1991) proclaims that modeling technique for computer graphics is based on the notion of sculpting a solid material with a tool in which the technique involve building with materials bit by bit to get a form of an object. Materials used have the same features of materials used in traditional modeling and the process is similar to modeling with the hand.

6. Casting

Casting is one of the techniques in sculpture that involves creative skills and technicalities. Sculptors make replica of objects through casting from indigenous time to this contemporary era, many decorative objects been made are from casting. Casting therefore is the first step in manufacturing metallic component. Casting comes in several forms such as sand casting, metal casting, lost- wax casting etc. According to Hempson (2012) Casting is a technique employed in sculpture as a means of obtaining solidity of liquefied materials, therefore casting is a process of pouring liquefied material into a mould so that when it dries in the mould, the material will be solidified in order to copy the shape of the hollow object. Most sculpture figures are converted into permanent materials through casting. The technique involved in casting is, therefore, of much importance to the sculptor.

Reproduction of sculpture pieces is of much importance to the sculptor to aid in making copies of pieces that are often needed as gifts and for sale. This can be achieved through casting. A mould is the negative or hollow cavity produced around a sculpted piece for use in creating multiples of those pieces. A cast is referred to the positive or reproduction of the original piece of sculpture created by pouring casting materials such as brass, bronze, resin, plaster of Paris etc. into a pre-formed mould. There are several materials used for making mould to cast, and these materials are plasters (Gypsum), latex rubber, paste maker, gelatin and polymer among others.

7. Uses of eggshells in Ghana

The use of egg in Ghana have symbolic roles since there is a notion behind the use of egg that it is used to pacify and use for various rites and rituals, eggs are seen to be powerful and full of strength. Apart from the use of eggs, the shell which is largely disposed off as waste material in Ghana has several uses. Therefore, researchers in Ghana are making good use of disposed items in solving issues confronting the society since it is important to make good use of natural resources. The focus of a good national development is to look inward with the intent of mobilizing all-natural resources for economic

purposes (Adoglah et al., 2016). According to Adoglah (2016), eggshells are used in the building industry as a material to improve compressed laterite brick. Laterite bricks were produced with varying quantities of eggshells which comprised 0%, 10%, 20%, 30% and 40% by weight of laterite. Compressed laterite bricks showed improvements in all the tests conducted after the inclusion of the powdered eggshells. Powdered eggshells were deemed appropriate for improving the general characteristics for compressed bricks although the optimum quantity was attained at 30%, (Adoglah et al., 2016). The concept of utilizing eggshells to improve compressed laterite bricks tends not only to improve the engineering properties of the bricks but also reduce wastes and associated costs and lessen landfills. Strategically, this alternative use of eggshells could create substantial revenue for both potential recyclers and communities where poultry farming is their priority. The study was to explore the feasibility of utilizing powdered eggshells to improve the properties of compressed laterite bricks for masonry purposes. Shells are also used for mosaic art in various art institutions in Ghana; some industries also used the shells for cosmetic products since it is rich in calcium and other useful minerals.

8. Physical properties of eggshells

The shell of egg is oval in shape and also fragile but somehow it is seen to be strong since it prevents cracking in order to preserve the embryo until hatching in a natural environment. Ebubekir et al. (2008) confirms to this that the eggshell must be strong enough to prevent cracking in order to preserve the embryo. Therefore, studies on the physical properties of eggs have shown that normal chicken eggs have elliptical shape (Ebubekir et al., 2008). Hence, Eggshell varies in sizes and colours due to several factors concerning egg production in Poultry due to the genetic make-up, the feed intake, the age of the hen during the egg production cycle and environmental conditions such as temperature, aeration and among others (Nys et al., 2011). Eggs must be stored away from strong smelling food since it can cause it to have strong scent. Shell Quality of egg has approximately 2.3g of calcium in the shell, and a hen needs to consume around 4g of calcium per day to maintain good shell quality. The shell should be dry, clean and free of any cracks. Egg size is related to shell quality. Smaller eggs have stronger shells and larger eggs have weaker shells. As hens get older, their eggs get larger and as a result egg shell quality can decline. Weaker-shelled eggs will be more prone to cracking. Bacteria can also penetrate the shell and reduce egg quality, particularly when there are cracks. The colour of the shell is determined by the genetics of chicken and does not affect the quality of the egg. As a general rule of thumb, white feathered hens lay white eggs and brown feathered hens lay brown eggs. When hen ages, there is less intestinal calcium uptake which affects the thickness of an egg negatively but leads to increased egg size and decrease in production level (Rayan et al., 2010). Table 1 gives account on percentage contribution of egg components.

Table 1: Percentage contribution of egg components

Egg component	Contribution (%)
Whole liquid egg	86.72
Albumin (Egg White)	56.72
Egg Yolk	30.00
Eggshell	13.28

Source: Ikegwu et al. (2016)

9. Eggshell powder

Eggshells are normally milled into powder with the aid of electronic milling machine. Eggshell powder has been very useful for human consumption since it contains calcium which is not only the major component of bones and teeth but participates in the regulation of hormone secretion and activation, muscle contraction, neuronal conduction through ion channels, regulation of inflammatory processes, maintaining the permeability of cell membranes and many others (Dri et al., 2011). The eggshell primarily contains calcium, magnesium carbonate (lime) and protein. In many other countries, it is the accepted practice for eggshell to be dried and used as a source of calcium in animal feeds. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. Eggshell powder is therefore a pulverized of an outer crest of an egg into a fine-grained

powder with suitable proportion which is sieved for several uses. Bread with eggshell powder has been used in bakery to facilitate bread enrichment with calcium (Braduskiene et al., 2017). According to Shaafsma et al., (2000) chicken eggshell powder, due to its high calcium content and the presence of other microelements such as Fe, Se and controlled amounts of Pd, Cd and Al, has the potential of serving as a good human dietary calcium supplement. It serves as a dietary supplement, not only for the general population, but also for the elderly population and postmenopausal women.

9.1 Chemical composition in eggshell powder

Eggshells consist of chemical compositions due to an experiment that was conducted already by a group of researchers in Ghana. According to Adoglah et al., (2016) the Oxides present in the powdered eggshells were analyzed using the X-ray Fluorescence technique. This was done by mixing 4.0g of the ash sample homogenously with 0.9 grams of Hoechst wax in a mill before pressing with a hydraulic press at 15 tons to a 32mm pellet. Multi-element determinations from the prepared pellet were carried out using an energy-dispersive polarizing X-ray Fluorescence Spectrometer. Chemicals present in eggshell powder include Calcium Oxide (CaO), Sodium Dioxide (Na20), Magnesia Oxide (MgO), Silicon Dioxide (SiO_2), Aluminium (Al_2O_3), Chlorine (Cl), Potassium (K_2O), Sulphate (SO_3), Ferrous Oxide (Fe_2O_3). The researchers also tested for the chemical composition in eggshell powder as an experiment was conducted at the KNUST chemistry Laboratory and the result is coherent with Adoglah et al., (2016) findings.

10. Eggshell art

Mosaic art is oldest type of Art that is still very popular today, with seashells, eggshells and pebbles of all sizes being used to keep this skill alive. Eggshells are used for art works in several ways. Eggshell mosaic is an art form that is also known as mosaic art. This form of art work is mostly enjoyed by kids and reduces waste at the same time. Mosaic artist also uses a lot of it, the materials needed for this art works are eggshells, cardboard and glue. With the mosaic art, the eggshells are washed and allowed to dry. At times the egg shells are coloured by adding ¾ cup of water to a small bowl, which 1 teaspoon of white vinegar and 15 drops of food colour is added to the shells, which is allowed to soak in the dye for about 15 minutes, before it is placed on a paper towel to dry. Designs are drawn on a support, then the part of the design which will have a mosaic effect is glued, and the shells are used to cover the design. According to Falkenhagen (2000) eggshell mosaic can be applied to any rigid surface that contact cement will adhere to. Flat surfaces are more successful than curved surfaces, but eased corners and slight curves are very possible. The surfaces should be smooth, clean and free of dust. Wood makes an excellent substrate but should be sealed first; the surface of a rigid metal structure also works well. Eggshells are also used for art works in sculpture, eggshells are carved as a decorated object, Ron Cheruka is an artist who works mainly in eggshell carving and according to the artist he uses dental tools to carve eggshell into patterns. There is another sculpture work that was done by using eggshells to cover concrete sculpture. Eggshells can also be used to build figures by the aid of armature. Figures 1, 2, 3 and 4 are art works fashioned from eggshells.

Fig. 1: Mosaic Art, Artist (Anonymous), source: flickr.com, Fig. 2: Eggshell Sculpture, Artist (Kyle Bean)
Source: https://kylebean.co.uk/portfolio/whatcamefirst

11. Binders

Fig. 3: Eggshell Carving, Artist (Ron Cheruka), Source: https://fractalenlightenment.com
Fig. 4: Concreteness in shells, Artist (Benjamin Deffor), source: Photographed by Artist

Binders are very useful in making materials to adhere together when creating artifacts. Some liquid binders can dissolve materials from powdered to solid state, binders simply refer to Liquid substances that harden by a chemical process and binds fibers, filter powder and other particles added into it. Binders or Adhesives as a means of bondage has been used from prehistoric period in Art up to the 21st century but are in varieties depending on the material used for making an adhesive. From the earliest days, the materials used were cements, glues, gums, resins, pastes, adhesives and sealants, were interchangeably used. Keimel (2003) proclaims that new uses of adhesives have their origins in ancient times and asserts that insects, fish and birds know the art of producing mucous body fluids for gluing. He also declares that human beings adopt the techniques of many species by observing the natural phenomenon of sticky substances. That is when some natural materials fell on rocks heated by the sun; they softened and become sticky, and later hardened in the cool of the night. Binders can be naturally obtained like the latex from trees and others too are artificially prepared from plastics and other man-made materials.

11.1 Starch binders

Starch is the most common binder in tablet formulation and important sources include cassava tubers and this is confirmed by Chitedze et al., (2012) that starch was used as binders for 400 mg ibuprofen tablet. Cassava (Manihotesculenta) roots are largely cultivated in tropical countries, it has been earmarked as the crop that can spur rural industrial development and raise income for producers, processors and traders. Starch binders are mostly extracted from cassava. It is used to bind particles together; starch is a renewable and unlimited resource which is produced from grain or root crops. Cassava is converted chemically, physically and biologically into many useful products in making adhesives. Starch was cooked, following various stages;

Preparation stage (peeling and washing)
Rasping/ pulping/grating (starch washing)
Dewatering
Drying and finishing

11.1.1 Wheat flour starch

Wheat as a cereal crop for man consumption is also useful for preparing binder in holding particles together. Wheat flour is a powder made from the grinding of wheat and it varies depending on the gluten content whether low or high. According to Rattary (2017), whole wheat flour is flour ground from the whole grain without the bran being removed first. Semolina flour and durum flour is also another type of flour that is made from hard durum wheat with a high gluten content. It is usually used in making pasta, noodles, couscous and cereals. Graham flour is a coarsely ground whole wheat flour used to make crackers and used in baking. Wheat flour contains starch due to its gluten that makes it possible as a binding material. Starch in bread is due to its gluten level in the wheat flour. According to Alfaro (2017), wheat flour is the most common flour used in baking. There are different types of wheat flour and they are distinguished by the amount of gluten they contain. The gluten is the wheat natural

protein that gives baked goods their structure. Gluten develops and becomes elastic when dough is kneaded

11.1.2 White glue

White glue, known as polyvinyl acetate woodworking adhesive, is a bonding agent particularly suited for high strength, permanent bonding on wood and a variety of other porous materials. White glue serves as a multi-purpose binding agent for wood and porous substrates such as paper, cardboard, leather, fabric among others. White glue is water based, safe to use and non-flammable. It is also non-toxic as per U.S. Federal consumer product safety commission.

Taylor et al., (2003, p. 99) assert that "Polyvinyl acetate was used as a solvent-based adhesive in the 1930s, but was not of commercial importance until its introduction in the 1940s, as an emulsion adhesive used mainly to bond paper and wood". Today, in emulsion form as white glue, it is the most widely used thermoplastic adhesive worldwide. Vinyl acetate–ethylene (VAE) emulsion adhesives, with over 55% vinyl acetate content, were developed in the early 1950s but did not become of commercial importance in the United States until the mid-1960s.

11.2 Resin binders

Resin binder is preferably used for casting sculpture works since it is strong in binding particles and the weather does not have effect on its bondage. Resin referred to any natural or synthetic organic compound consisting of a non-crystalline or viscous liquid substance. Natural resins are typically fusible and flammable organic substances that are transparent or translucent and are yellowish to brown in colour. Resin is soluble in various organic liquids but not in water. Spurgeon (2016) asserts that Resin is a viscous (liquid or semi liquid) substance that reacts to certain conditions (usually heat). The reaction is polymerization, which is the formation of long molecular chains transforming the substance into a solid with adhesive properties during the transitioning. Superglue, fiberglass bonding compounds and epoxy glues are all examples of resins.

12. General work procedures and processes

Materials and tools used in the modeling, moulding, casting and finishing the project work include eggshells, eggshell powder, clay, Plaster of Paris, cassava, wheat flour, Polyvinyl acetate, Super Adesivo Adhesive, liquid polish, Silicon, Spatulas, Sandpapers, steel wire. Other materials were plastic containers and sieve

12.1 Acquisition and treatment of eggshells

The researchers and students in W.B.M Zion Senior High School collected eggshells from food vendors, homes, hatcheries and various landfills in Koforidua - Tafo. Acquiring eggshells was easy because consumption of egg in Ghana has increased and therefore there is pressure at various landfills which has led into environmental pollution. Adoglah et al., (2016) opine that eggshells vary in sizes and colour. Eggshells are brown to pale brown in colour and at times whitish. Eggshells comprises of residues and components that made the researchers to experiment with the material if there was possibilities of using it as a viable sculpture material.

The researchers treated the eggshells by washing them and pouring hot water on the shells to remove the residues in the shell that causes vermin. Eggshells were dried to be brittle for 3 hours to avoid

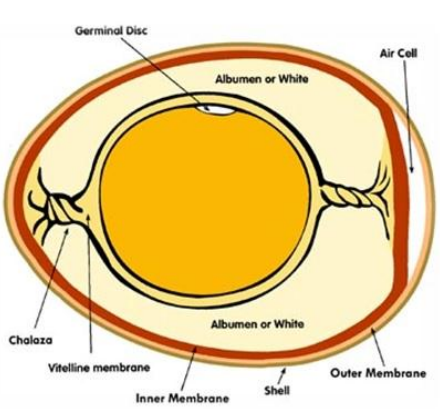

Figure 5 - Eggshells

odour and unwanted particles attached to the shells. Electronic milling machine was then used to convert eggshells into a powdery material with very fine particles. (See figure 6) Sample of eggshell powder was sent to Kwame Nkrumah University of Science and Technology chemistry laboratory to reveal the chemical compositions in the eggshell powder if it is useable without any negative effect when used with selected binders. The process of converting eggshells into powder was introduced to students. Results of the experimentation of eggshell powder is seen in Table 2

Table 2: Chemical compositions in eggshell powder

Oxides Present	Result
Calcium Oxide (CaO)	64.83%
Sodium Dioxide (Na2o)	1.48%
Silicon Dioxide (SiO2)	0.79%
Magnesia Oxide (MgO)	0.29%
Aluminium (Al2O3)	0.13%
Chlorine (Cl)	0.09%
Potassium (K2O)	0.08%
Sulphate (SO3)	0.06%
Ferrous Oxide (Fe2O3)	0.06%
% Retained in 425um	14.4%

Source: KNUST chemistry laboratory

Figure 6: Processing of shells into powder

12.1.1 Making sculpture figures using eggshell powder and selected binders

The first objective of the work was to experiment with eggshell powder and selected binders to serve as a viable material for modeling and casting in W.B.M Zion Senior High School. The researchers converted eggshells into powder for modeling and casting, the powdery material was experimented with selected binders such as white glue, cassava starch, wheat flour starch and super Adesivo adhesive. A study into the preparation of natural binders gave the researchers idea of how binders are prepared to hold particles. Clay was used to model figures and mould was prepared for casting to take place after the experimentation of the powdery material and the selected binders. Experimenting with eggshell powder and selected binders is seen in figure 7.

Figure 7: Modeling and casting with eggshell powder and selected binders
A: mixture of eggshell powder and selected binders, B: pouring mixture of eggshell powder and selected binders into a mould, C: mixture of eggshell powder and white glue, D: cast piece (Drummer)

The second objective was to introduce students of W.B.M Zion Senior High School to the process of making sculpture figures out of eggshell powder with selected binders. The researchers selected students based on their skills in modeling and casting and introduced to them the processes involved in using eggshell powder as a viable material for modeling and casting. The students had to be given a detailed explanation on what they were about to do and its relevance. The researchers grouped students and each group was to model and cast with eggshell powder and a selected binder. Group A, experimented with eggshell powder and cassava starch under the supervision of the researchers. Students were introduced to the preparation of starch binders by peeling and washing of cassava, rasping cassava, dewatering the grated cassava and using it to cook starch. Clay was used to model sculpture figure and silicon was used for the mould in order to cast the sculpture piece. Eggshell powder and cassava starch was mixed together and was poured into a mould to solidify. A detail in the mould was copied by using starch as a binder. It took three days for the cast piece to be separated from the mould. The process is seen in figure 8.

Figure 8: students modeling and casting with eggshell powder and cassava starch
A: Clay work, B: Silicon mould, C: mixture of eggshell powder and cassava starch, D: cast piece (Gyenyame symbol)

12.1.2 Results

It was found that the cassava starch could bind eggshell powder but it took longer period of time for the material to solidify. During the experimentation, eggshell powder and cassava were mixed with cassava starch. Because the cassava starch was viscous, it made the eggshell powder thicker and easy to be poured into the mould for casting. It took three days for the cast piece to be separated from the mould since cassava starch used in binding eggshell powder was slow to solidify. It was also observed that cassava starch should not be prepared to be thicker but rather semi-fluid to enable easy casting.

It was also observed that detailing of the mould was copied without much problems and the eggshell powder mixed with cassava starch was easily separated from the mould. Mixing cassava starch with eggshell powder did not affect its colour but the colour remained the same as pale brown. Also sanding of the cast piece was easily done since the cast piece was somehow fragile. Works done in eggshell powder and cassava starch must be handled with care. During the process of casting, the work was reinforced to avoid breakages; the first cast piece broke into pieces during separation of the mould and the second casting was reinforced with chicken wire to make it compact. The cast piece therefore must be kept in-door since water can easily dissolve it and affect its lifespan. During the experimentation, it was found that eggshell powder with cassava starch as a binder is weightless as compared to resin and white glue binders for casting.

12.2 Students were introduced to the process involved in working with Eggshell powder and Resin

Clay was used to model sculpture figure and plaster of Paris (P.o.P) was used to make a mould in order to cast the sculpture figure. The mould was laminated with grease oil. Eggshell powder and resin was mixed together and was poured into a mould in order to solidify. Details in the mould was copied by using resin in binding eggshell powder and it took less than 15 minutes for the cast piece to be separated from the mould. Students modeling and casting (see figure 9)

Figure 9: Casting with eggshell powder and resin
A: mixture of eggshell powder and resin for relief sculpture, B: silicon mould for casting, C: portrait, D: relief figure composition (unity)

12.2.1 Results

It was observed that when resin was mixed with the eggshell powder, it dissolved the powder material that makes it easy to be poured into a mould to cast the figures. It was also observed that eggshell powder mixed with resin and hardener generated heat when it was in the process to solidify. It took less than 15 minutes for the material to become solid. During the studies, it was observed that the cast piece was compact and could not easily be destroyed. Sculptures in figure 9, accidentally fell down but it was still intact.

During the practical session, while experimenting with eggshell powder and resin, it was noticed that water could not penetrate into the cast piece. Therefore, a Sample of a cast piece of eggshell powder and resin was placed in water for 72 hours and nothing happened to it. The cast piece was still compact. Therefore, a cast figure from eggshell powder and resin can be used for outdoor sculpture without being affected by the rains and vagaries of weather. It was found that sanding of the works is not different from sanding conventional materials such as wood, cement, plaster of Paris, etc.

12.3 Students were introduced to the process involved in working with Eggshell powder and polyvinyl acetate (white glue)

Armature was constructed for modeling human figure (the hunter) and mixture of eggshell powder and white glue was directly applied on the armature to build a form. Since the nature of the material was malleable, building of the human form was easily done. (See figure 10)

Figure 10: Direct modeling with eggshell powder and white glue as a binder
A: Armature for sculpture in the round (the hunter), B: Direct modeling with eggshell powder and white glue, C: The hunter

12.3.1 Results

During the direct modeling technique with eggshell powder mixed with white glue as a viable material for modeling, it was observed that the eggshell powder is pliable for modeling since there is plastic in it and it behaves like clay just that clay is highly plastic as compared to eggshell powder mixed with white glue, due to the plastic nature of the material. It became malleable which enables students to manipulate the material into forms and shapes for direct modeling. The eggshell powder and white glue as a binder transforms from a plastic stage into solid stage, (dry) within 10 to 20 minutes.

It was also observed that, if more glue is added to the eggshell powder for modeling, it takes longer period to dry and it becomes more compact and harder. Since the researchers employed direct modeling method with the material, more glue was added to the eggshell powder to retard it from quick

hardening. Due to this, it took more than 20 minutes for the material to become solid as applied on the Armature to build a form. It was also observed that the colour of the eggshell powder changed from pale brown to ash colour as mixed with the white glue as a binder. In the studies, it was observed that sculpture figure (the hunter) produced from eggshell powder and white glue as a binder could only be used for indoor works since the rains can affect the lifespan of the sculpture figure when placed outdoor. Works made are seen in figure 10, during the experimentation with the material, eggshell powder mixed with white glue was allowed to solidify and it was kept in cold water overnight to check if water gets in contact with it, it will still be in a solid state. The result was that the particles lost its binding and turned back into slurry.

In the modeling stage, modeling tools such as the wooden spatula was used for building a form as well as the hand in manipulating the material. It was observed that the eggshell powder and white glue binder had effect on the tools used for the modeling since the edges of the tools solidified and became difficult in cleaning them. During the modeling stage, it was easy to chip off the unwanted part of the material since it did not become extremely hard to carve out as compared to some conventional material like cement. It was also observed that eggshell powder mixed with white glue turned into solid and looked like kaolin. The students used sand paper to smoothen part of the work as a matter of getting a smooth surface, and it was observed that sanding of the works by hand was not difficult, because it looks like dried clay.

12.4 Students were introduced to the process involved in working with Eggshell powder and wheat flour starch

Clay was used to model sculpture figure (Gye-nyame) and plaster of Paris (P.o.P) was used to make a mould in order to cast the sculpture figure. Eggshell powder and wheat flour was mixed together and was poured into a mould in order to solidify. A detail in the mould was copied by using wheat flour to cast. (See figure 11)

Figure 11: Eggshell powder and wheat flour as a binder for casting
A: mixture of eggshell powder and wheat flour, B: casting process, C: Gye-nyame symbol, D: broken art piece (Gye-nyame symbol)

12.4.1 Results

During experimentation and observation, it was found out that wheat flour starch was slow in binding as compared to cassava starch. Though wheat flour starch contains gluten that makes it possible as a binding material in food but the result was not all that positive as it was experimented with eggshell powder. Eggshell powder was mixed with wheat flour starch to be slurry and it was poured into a mould made of silicon. The mould is a replica of the clay figure (Gye-nyame symbol). It took about a week for the cast figure to solidify but after three days the cast piece developed some cracks which later broke into pieces.

12.5 Students were introduced to the process involved in working with Eggshell powder and super Adesivo adhesive (Type 99)

Clay was used to model sculpture figure and silicon was used to make a mould in order to cast the sculpture figure. Eggshell powder and super Adesivo adhesive was mixed together and was poured

into a mould in order to solidify. Details in the mould were copied by using super Adesivo adhesive as a binding agent for eggshell powder. (See figure 12)

Figure 12: Eggshell powder and Super Adesivo Adhesive as a binder for casting
A: Super Adesivo Adhesive, B: casting process, C: Gye-nyame symbol, D: Finishing of Gye-nyame symbol

12.5.1 Results

Eggshell powder bonded with super Adesivo Adhesive came out successfully. During the experimentation, it was observed that super Adesivo Adhesive diluted eggshell powder which made it possible to be poured into a mould for casting to take place since the material can easily flow when diluted with the super Adesivo Adhesive. Eggshell powder mixed with Super Adesivo Adhesive results in the expansion of the material. It was also observed that it took a longer period of time for the material to harden. It took three days for the material to harden to enable separation of the mould. Eggshell powder mixed with Super Adesivo Adhesive which is a yellowish substance turned the eggshell powder into a pale yellow colour. During the observation, it was also recorded that, the cast figure was elastic due to the characteristics of the bonding material that is the Super Adesivo Adhesive. Since the material behaves like elastic, it was not able to break into pieces when the cast figure accidentally fell down. It was possible to apply colour to the figures in eggshell powder with Super Adesivo Adhesive as a means of surface finishing.

13. Presentation and discussion of findings

Observation of Eggshell, Eggshell powder and binders

The study revealed that eggshell powder could serve as an alternative modeling and casting material due to quasi-experimental conducted by the researchers, using the powdery material with selected binders. The binders that were workable with eggshell powder are Polyvinyl Acetate (white glue), Super Adesivo-Adhesive, Cassava Starch, Resin and Wheat Flour Starch. In the experimentation it was found that eggshells are in varieties, in terms of the size and colour. It was observed that the colour of eggshells ranges from white, brown and pale brown. It was discovered that eggshells become brittle when the shells are placed under the sun to dry and they were easy to break and attached to a membrane. The membranes attract vermin that causes the shells to have odour and causes environmental pollution. This tally with Adoglah (2016) findings that eggshells are largely discarded as waste materials. As observed and gathered from interviews held with students and food vendors, it was recorded that eggshell is easy to collect and are largely trash at various landfill sites. Majority of food vendors and students who were interviewed proclaimed that eggshells are waste materials. This confirms what Phil et al., (2009) documented that eggshell waste disposal contributes to environmental pollution. Challenges associated with disposal of eggshells include cost, availability of disposal sites, odor, flies and abrasiveness

From the studies, the researchers observed that eggshells can be stored for longer period if the membranes attached to the shells are removed and the shell is washed and dried. Eggshells are kept in a dry place without contact with any liquid. During the studies eggshell was kept in a sack for three (3) months without being destroyed by insects. As observed and gathered from the interview held with the students, eggshells are used for mosaic art and white glue is a common adhesive usually used to bind eggshells on wooden surfaces, in which the shell is coated with lacquer to make it glossy. It was also

observed that the eggshell is bumpy and grainy in texture and consists of tiny pores that make it semi-permeable for air and moisture to pass through its pores. The shells were placed in boiled water and due to the tiny pores; all the residues in the shells were removed. It is also recorded that not all types of binders can be used with eggshell powder for modeling and casting. During the experimentation, the researchers was able to discover binders that can hold the powdery material and the binders discovered were white glue, resin, cassava starch, wheat flour starch and super Adesivo adhesive. These materials were selected based on their bondage strength with eggshell powder. It was observed that eggshells are converted into a powdery material by boiling the shells for fifteen minutes before drying it and finally taking it for milling. The laboratory milling machine was used to convert the eggshells into powder. During the milling process, it was observed that the eggshells have to be further broken into bits to enable easy milling.

The powdered material observed was in fine particles. It was observed that the equipment used for converting eggshells into a powdery material was the same one used for milling corn, millet etc. The researchers gathered three sacks of eggshells for milling, but it was observed that eggshells reduced into half of a sack when it was converted into a powdery material. The colour of the shells changed into pale brown since the brown shells dominate more than the white shells. As observed and gathered from the interview held with the students, eggshell powder does not have strong odour and it smells like a boiled egg and the fine particles look the same as plaster of Paris but it has different characteristics as compared to plaster of Paris. Eggshell powder as observed is nontoxic, this tallies with Anton et al., (2006) findings that eggshells consist of Calcium carbonate which forms the major constituent of the eggshell, it is said that 91% of the total mass is made of calcium carbonate. The processed eggshells were turned into an excellent source of calcium. It is used as a dietary supplement in animal feeds, making toothpastes and orange juice. A sample of the material was sent to the Material Laboratory (KNUST) to test for its tensile strength and the chemical compositions in the powdery material. During the laboratory test, it was revealed that, eggshell powder does not have negative effect on the body and does not affect the internal organs of the human digestive system when inhaled. In the experimentation with binders, it was revealed that eggshell powder can be toxic depending on the binder used to bond the eggshell powder. Nontoxic binders do not have negative effect on eggshell powder when used in modeling and casting. During the milling process of the shells, it was observed that eggshell powder is easy to be inhaled due to the dusty nature of the material. The tunnel of the milling machine has to be covered with a sack to prevent dirt. During the direct modeling technique with eggshell powder mixed with white glue as a viable material for modeling, it was observed that the eggshell powder is pliable for modeling since there is plastic in it and it behaves like clay just that clay is highly plastic as compared to eggshell powder mixed with white glue, due to the plastic nature of the material. It became malleable which enables students to manipulate the material into forms and shapes for direct modeling. The eggshell powder and white glue as a binder transforms from a plastic stage into solid stage, (dry) in 10 minutes to 20 minutes. It was also observed that, if more glue is added to the eggshell powder for modeling, it takes longer period to dry and it becomes more compact and harder. Since the researchers employed direct modeling method with the material, more glue was added to the eggshell powder to retard it from quick hardening. Due to this, it took more than 20 minutes for the material to become solid as applied on the Armature to build a form. It was also observed that the colour of the eggshell powder changed from pale brown to ash colour as mixed with the white glue as a binder. In the studies, it was observed that sculpture figures produced from eggshell powder and white glue as a binder could be used for indoor works since the rains can affect the lifespan of the sculpture figures when placed outdoor.

During the experimentation with the material, eggshell powder mixed with white glue was allowed to solidify and it was kept in cold water overnight to check if water gets in contact with it, it will still be in a solid state. The result that came out was that the particles lost its binding and turned into slurry. In the modeling stage, modeling tools such as the wooden spatula was used for building a form as well as the hand in manipulating the material. It was observed that the eggshell powder and white glue binder have effect on the tools used for the modeling since the edges of the tools solidified and became difficult in cleaning it. During the modeling stage, it was easy to chip off the unwanted part of the material since it does not become extremely hard to carve out as compared to some conventional material like cement. It was also observed that eggshell powder mixed with white glue turned into solid and looked like kaolin. The students used sand paper to smoothen part of the work as a matter of getting a smooth

surface, and it was observed that sanding of the works by hand was not difficult, because it looks like dried clay. It was observed that when resin was mixed with the eggshell powder, it dissolved the powder material that makes it easy to be poured into a mould to cast the figure. It was also observed that eggshell powder mixed with resin and hardener generated heat when it was in the process to solidify. It took less than 15 minutes for the material to become solid.

During the studies, it was observed that the cast piece was compact and cannot easily be destroyed. Though it incidentally fell down, it was still intact. During the practical session, while experimenting with eggshell powder and resin, it was noticed that water could not penetrate into the cast piece. Therefore, a Sample of a cast piece of eggshell powder and resin was placed in water for 24 hours and nothing happened to it. The cast piece was still compact. Therefore, a cast figure from eggshell powder and resin can be used for outdoor sculpture without being affected by the rains and vagaries of weather. It was found that sanding of the works is not different from sanding conventional materials such as wood, cement, plaster of Paris, etc.

Eggshell powder bonded with super Adesivo Adhesive came out successfully. During the experimentation, it was observed that super Adesivo Adhesive dilute eggshell powder which makes it possible to be poured into a mould for casting to take place since the material can easily be in a liquid state when diluted with the super Adesivo Adhesive. Eggshell powder mixed with Super Adesivo Adhesive resulted in the expansion of the material. It was also observed that it takes a longer period of time for the material to become harden. It took about three days for the material to harden to enable separation of the mould. Eggshell powder mixed with Super Adesivo Adhesive which is a yellowish substance turned the eggshell powder into a pale yellow colour. During the observation, it was also recorded that, the cast figure (Gye-nyame) was elastic due to the characteristics of the bonding material that is the Super Adesivo Adhesive. Since the material behaves like elastic, it was not able to break into pieces when the cast figure accidentally fell down. It was possible to apply colour to the figures in eggshell powder with Super Adesivo Adhesive as a means of surface finishing

14. Conclusion

Conventional materials are commonly used for practicing sculpture in several art institutions in Ghana and there is the need to seek and explore materials in our natural settings as a means of making useful ideas out of them. Though unconventional materials are used in several ways in practicing sculpture, there is still the need of experimenting with more materials to be used in sculpture since without viable materials there would not be a feasible sculpture product in most of our Art institutions.

The future outlook for expansions in terms of materials for practicing sculpture, eggshells are environmentally friendly and exploring it as a viable material in Art will lead to reduction of the cost in modeling and casting. In terms of health it is safe to model and cast with eggshell powder since it is not poisonous as most of the conventional materials in the market. Cassava starch is a vegetable matter that contains carbohydrates; it is biodegradable, cheap and easy to use. This implies that there is no need to always rely on conventional materials. Also, there is much value in eggshell powder when used for sculpture pieces in the sense that it generates more profits as compared to conventional materials. Since Eggshells can easily be collected from various sites in Ghana and can be processed into powder and well packaged for artists /student artists to use for their modeling and cast works. Eggshell powder does not easily expire as compared to most of the conventional materials such as Plaster of Paris, cement etc. Eggshell powder is essentially a choice for students' miniature works. Exploring waste materials in the environment for modeling and casting is economical in operation. Therefore, eggshell powder can serve as an alternative material in practicing sculpture by using all the techniques involved in the production of sculpture such as direct modeling, casting and carving. Eggshell sculpture figures can be treated to have interesting finishing like how most conventional materials are treated by spraying, polishing etc. the study is significant for enriching Visual Arts education at the different levels; it is also relevant for developing creativity in non-formal educational settings

References

Abidoye, L.K and Bello, R.A (2010) Restoration of compressive strength of Recycled Gypsum Board Powder. Pacific Journal of Science and Technology. Available: www.researchgate.net

Alfaro, D. (2017). The Different Types of Wheat Flour, Available: www.thespruce.com, Retrieved August 20, 2017

Adoglah, F. Yalley, P and Arkoh, M. (2016). Improving compressed laterite bricks using powdered Eggshells. The international journal of Engineering and Science, Available: www.theijes.com, Retrieved April 14, 2017

Anton. M, Nau. F and Nys, Y (2006). Bioactive component and their potential uses. World poultry science journal, 62

Barazesh, A. Hamidreza. S, Mehdi. G and Moustafa. Y (2012). Laboratory Investigation of the Effect of Eggshell Powder on Plasticity Index in Clay and Expensive Soils. Available: www.pelagiaresearchlibrary.com, Retrieved June 8, 2017

Barrett, T. (2007) Teaching toward appreciation. In L. Bresler (ED. International Handbook of Research of Arts Education. New York, NY: Springer. Retrieved May 18, 2018 from http://www.Terrybarrettosu.com/pdfs/B_TeachTowApp_07.pdf

Bast, J. (2013) A New method for the measurement of flowability of green moulding sand,

Berkeley. W (2018) Types of Wheat Flour, University of California, Available: www.berkeleywellness.com, Retrieved February, 2018

Bhaumik, R. (2011) eggshell powder as an adsorbent for removal of fluoride from aqueous solution: equilibrium, kinetic and thermodynamic studies, world wide web, Available:http.//www.ejchem.net

Blumenfeld, C. Fredricks, J. and Alison, H (2000) Learning with peers: From small group cooperation to collaborative communities. Educational Researcher

Branford, J., Brown, A. L. and Cocking, R. R. (1999). How people learn: Brain, mind, experience and school. Washington, DC: National Academy Press.

Chitedze J., Monjerezi M., Saka K., Steenkamp J., (2012) Binding Effect of Cassava Starches on the Compression and Mechanical Properties of Ibuprofen Tablet. Journal of Applied and Pharmaceutical Science. Available: www.japsonline.com

Dewey, J. (1959). Dewey on education. New York: Teachers college press

Dickinson, K. Soukamneuth, S. Hanh, C. Amico, M. Perry, R. and Susan, P. (1998). providing educational services in the summer Youth Employment and Training Program. Washington DC. US Department of labor office of Policy & Research

Dolińska, B. Jelinska, M. Szulc-Musiol, B. and Ryszka, F. (2011) Uses of Eggshells as a Raw Material for Production of Calcium Preparations. Czech. Available: www.agriculturejournals.com

Dri N., Brun L., Di Loreto V., Lupo M., Rigalli A. (2011) Study of the composition of eggshell. A low cost calcium supplement. Bone. Available: https//google.com/patents/EP2780114a1?cl=un

Ebubekir (2008) Physical properties of Hen's Egg. Journal of food and animal science. Available: https://open.library.ubc.ca

Falkenhagen, D. (2000) Eggshell mosaic. Available: www.dianefalkenhagen.com. Retrieved September 17, 2017.

Galyean, A. (1991) Sculpting an interactive volumetric modeling technique. Massachusetts institute of technology, Cambridge. Retrieved February 27, 2019. Available: citeseerx.ist.psu.edu

Gamble, H. and Gamble, D. (1995). Document resume. Available: cyber.law.harvard.edu/digitaldiscovery/library

Gowsika. S, Sarankokila. K, Sargunan (2014) Experimental investigation of eggshell powder as partial replacement with cement in concrete

Hempson, J. (2012). Unseen sculptures 2014, Available: http://www.unseensculptures.com

Holmes, J. (2007). Uses of Ground Eggshells as a Lime Source. Iowa State Research Farm Progress Reports.

Ikegwu, T.M, Balogu, V.T, Balogu, D.O, Kolo, S.I, Babatunde, J. (2016) Physical Properties of Hen's Egg. Journal of food science.

Jillee, B. (2017). How to make eggshell calcium. Available: www.mamanatural.com. Retrieved July 20, 2017

Keimel, F. (2003). The history of adhesives. Available: www.adhesives.org/resources. Retrieved August 7, 2017

Keiren, N. (2016). Eggshell Art. Available: www.insteading.com. Retrieved July 18, 2017

Nys, Y., Guyot, N. (2011). Egg formation and chemistry. Sawston, Cambridge, UK. Woodhead publishing ltd. Available: https://open.library.ubc.ca

Phil, G. Zhihong, M. and Rodda, B (2009). High value product from hatchery waste. RIRDC Publications

Rattray, D. (2017). Cornmeal Bread. Available: www.thespruceeats.com. Retrieved September 6, 2017

Rayan, G.N., Galal, A., Faith, M.M and El-Attar A.H (2010) Impact of layer breeder flock age and Strain on mechanical and ultrastructural properties of eggshell in chicken. International journal of poultry Science

Shaafsma, A. Doormaal, J. Hofstede, G. and Pakan, I. (2000). Positive effects of a chicken eggshell powder. International Journal of Poultry Science

Spurgeon, H. (2016). Reactive and non-reactive binders. Available: www.researchgate.net. Retrieved April 19, 2017

Sthapati, V.G. (2002). Indian Sculpture and Iconography, Forms and Measurement Sri Aurobindo institute of research in social sciences

Szeleszczuk, L. (2015). Uses of eggshells that will really surprise you. Available: www.experthometips.com. Retrieved August 6, 2017

Taylor, C. Antonio, P. and Kashmiri, L. (2003). Handbook of Adhesive Technology, Marcel Dekker, Inc. New York, U.S.A. Available:www.dekker.com