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THE USE OF ALUMINIUM SOLID WASTE AS AN ALTERNATIVE MATERIAL FOR CASTING IN SCULPTURE: THE CASE OF NKAWIE SENIOR HIGH TECHNICAL SCHOOL, GHANA

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Abstract
Casting is important for the mass production of designs and therefore plays a critical role in sculpture and other forms of art. Nevertheless, the application of many new and innovative machineries and conventional materials during practical sessions in the teaching and learning of metal casting raises the cost load on students coupled with some unfriendly orthodox materials which contain harmful compounds and are detrimental to human health. The purpose of this study is to explore solid waste aluminium for metal casting in sculpture. Non-biodegradable materials with aluminium in them were collected from restaurants and pubs, gutters, landfills, funeral and party grounds, and aluminium window and frame producers in the Atwima Nwabiagya Municipality in Nkawie district. Solid waste aluminium identified were sorted, shredded, and washed to make it ready for melting and poured into a mother mould for final casting. Beverage cans with brand names such as Malt, Coca-Cola, Sprite, Adonko Next Level, Milo, and others, including waste aluminium chips, waste aluminium window frames and doors, and waste aluminium from fufu pounding machines, are part of the significant ones recognised to produce a sizable amount of molten metal for casting. This study made use of quantitative-quasi-experiment, case study and action research methods. Focus group interviews, personal observation of the solid waste aluminium materials were employed for metal casting. These materials were recycled and used by art students and teachers for teaching and learning sculpture as well as their project work. In each stage of the study, experiential learning was found to be the most effective method of problem-solving. Based on the evidence gathered in this study, the most valuable outcomes are group learning through association and cooperative problem-solving. This study has demonstrated that when students actively engage in this learning process, they learn more effectively. Plaster mould casting has been shown to be feasible in the classroom without the need for lost wax method of casting. There is no need to manufacture vents or gating systems. Identifying alternative materials by teachers and students at all levels of sculpture learning must be prioritized. With the continuing divergence in aesthetic responsiveness, creativity, and sustainable development, sculpture teachers and sculptors must turn to solid-waste aluminium as an alternative medium for teaching, learning, and producing artwork.

Keywords: *Biodegradable and Non-Biodegradable Materials, Casting, Plaster Mould, Solid Waste.*

INTRODUCTION

In Ghana, waste disposal has become a serious problem. The amount of waste produced harms the environment. Ghana seems not to have a lasting solution to proper waste disposal. This is seen in the amount of waste that has engulfed our cities, towns, and villages. People throw away waste that ends up in landfills, gutters, and water bodies, which could damage human health and the environment. You walk down the street of Kumasi, Kejetia, and you are greeted by the stench of solid waste. As you walk in many markets in Atwima Nwabiagya Municipality after the market closes, you see heaps of waste. Scraps are dumped at various sites in Ghana, which raises concerns about environmental pollution.

In Ghana, aluminium window frame producers are abundant everywhere. The majority of people who put up buildings have resorted to using aluminium as door and window frames and it is sometimes used in the roofing systems. These manufacturers generate more aluminium waste from small cuttings and chips, which can be collected and used as a casting material in the classroom to facilitate teaching and learning of sculpture. Another area where aluminium waste is generated is the introduction of Fufu pounding machines, which are gradually replacing the traditional mortar and pestle method of pounding which most Ghanaians have patronised and is now in operation everywhere. Some parts of the Fufu pounding machine are made of aluminium. After the Fufu pounding machine outlives its lifespan, it becomes scrap and is thrown away or sold to scrap dealers. Aluminium is also used in the production of beverage and drink cans with brand names like Malta Guinness, such as Guinness, Fanta, Coca Cola, Sprite, Adonko Next Level and Nestle Milo. These materials prove the sustainability of aluminium solid waste material as an alternative sculpture material for metal casting.

Uyamk et al. (2011) argue that waste materials could be anything that could be preserved in time without losing its features; everything that is thrown away after use at home, or something that is natural or factory-made suitable for sanitary conditions. Waste is divided into different categories, namely: industrial and domestic. They are generated every day and everywhere and are classified into biodegradable and non-biodegradable. The degradable ones are organic in nature, like food, paper, and textile materials, whereas the non-biodegradable ones are plastic, metal, glass, bones, and the like (Olotah, 2019).

Congdon (2000) believes that "art teachers should teach their students to make art from discarded objects, but not necessarily because it does anything to the environment," and that "lesson can go beyond the 'I saved an egg carton' notion if students are taught about the many layered meanings that recycling can have for artists and viewers" (p. 12). He argues that in teaching and learning of art, the lesson can be linked to culture, spirituality, heritage, transformation, the fluidity of life, the roots of creativity as well as aesthetics concerns (Congdon, 2000).

According to Yeboah et al. (2016) "when waste materials are used in teaching and learning, it will help educate learners on the fact that waste materials can be recycled to create useful items instead of disposing of it to pollute the environment" (p. 57). Lessons become more practical, interactive, interesting, and real to students when appropriate instructional materials are used for teaching and learning (Yeboah et al., 2016).

Casting materials are very expensive and hard to obtain because most of the materials are not made in Ghana but imported. This challenge compels teachers to teach metal casting theoretically at the SHS level. SHS graduates are expected to learn skills such as carving, modelling, casting, assemblage, and construction (Opoku-Bonsu et al., 2017). Without practical activities, students can never acquire the requisite skills in the methods of sculpture production as posited by Opoku-Bonsu et al. (2017).

Olumorin et al. (2010) stated that factories that manufacture instructional materials for teaching art-based subjects are mostly very difficult to comeby. Because traditional art suppliers are mostly limited, making new objects from things that are no longer usable in their created state has roots in both modern and everyday life.

Agyei et al. (2020) point out that sculptors in Ghana limit their sculpture production to materials like clay, plaster of Paris, cement, and so on. The use of aluminium in the production of sculptures is not a common practice among sculptors in Ghana. The challenge of the sculpture teacher and student being unable to find a suitable metal casting material might stem from the fact that they do not see more aluminium sculptures in their immediate surroundings. By experiencing aluminium sculptures, they could ignite their thinking faculty to come up with innovative ways of finding alternative materials to undertake practical activities involving metal casting.

The study sought to answer the following questions:

1. What are the readily available solid waste aluminium materials and methods that can be used for casting with students at NSHST?
2. What are the processes involved in experimenting with the various solid waste aluminium to produce miniature sculptures with students at NSHST?
3. How can product concepts or designs be developed from the solid waste aluminium materials for casting in sculpture with students at NSHST?

LITERATURE REVIEW

Aluminium in Ghana

The basic material for making aluminum, bauxite, was discovered in Ghana in 1921, but mining operations didn't start there until after World War II (Dickson and Benneh, 1995, as cited by Nyarko and Bruijn, 2019). At Awaso, mining started in 1943. More bauxite deposits were discovered in the Eastern Region of Ghana in the 1960s at Mpraeso and Kibi.

The raw material used for the manufacturing of alumina is referred to as bauxite, which is further refined to aluminium. Kibi, Awaso, Mt. Ejuamena, and Nyinahin are the primary bauxite deposits in Ghana. Since 1942, Ghana has been producing and exporting bauxite to Europe from the Awaso mine, which has over 554 million metric tons of bauxite (Gawu et al., 2012).

With the growth of mining bauxite, reducing bauxite into alumina, smelting alumina into aluminum, and processing aluminum into intermediate and consumer products, the VALCO Smelter was established in Tema, Ghana. In 1967, VALCO began manufacturing aluminum ingots using imported alumina from Jamaica. It was planned that by 1977, VALCO will stop importing alumina and switch to using alumina produced on-site.

Ghana's industrialization, according to Dr. Kwame Nkrumah, the nation's first president, was based on the availability of affordable and dependable electricity. Dr. Nkrumah (1961) told the national assembly, or parliament, that the volta river project at

Akosombo, which would generate hydroelectric power, would act as a catalyst in turning Ghana's agrarian economy into an industrial one, benefiting not only Ghana but also the industrialization of all of Africa (Nyarko & Bruijn, 2019).

In order to specifically supply electricity to the Volta Aluminium Company (VALCO) aluminum smelter located in the recently established coastal industrial enclave of Tema, the Akosombo dam was built in 1965. This was to be connected back to the construction of a refinery that would process nearby bauxite reserves and supply the smelter. However, the construction of the necessary middle chain refinery never happened under any of the governments that came into power after Nkrumah was overthrown in 1966, which prevented Ghana from fully utilizing the potential of her bauxite resources for inclusive growth and development (Acheampong & Mensah, 2018).

With its estimated 900 million metric tonnes of bauxite reserves, especially at Awaso, Nyinahin, and Kyebi, Ghana has been examining the possibility of developing an integrated bauxite and aluminum business since the 1960s.

Secondary Aluminium

In Ghana, scrap metal is seen in commercial, industrial, household, and demolition companies and in junkyards, landfills, fitting shops, and metal work yards (Donkor, 2018). As described by Andrews and Gikunoo (2011) sources of raw materials for non-ferrous casting in Ghana are obtained from the Volta River Authority (VRA) and aluminium dealers.

When aluminium is recycled, secondary aluminium is created as the process of primary supply of aluminium scrap (Widyantoro et al., 2019). Aluminium is remelted in furnaces as part of the secondary aluminium production process. The following techniques are used to sort the aluminium scraps:

1. Magnetic separation to eliminate iron-containing compounds.
2. Rubber, foam, and plastic are removed by air separation.
3. Using Eddy's current separation to pick out aluminium.
4. Separating materials using dense media to determine density.
5. Manual sorting by hand.
6. Utilizing hot crushing to distinguish wrought from cast items (Brough and Jouhara, 2020).

Foundrymen select metal scrap according to their prior knowledge and measure it by visual inspection before charging it into the furnace (Andrews and Gikunoo, 2011). The scrap aluminium is sorted through identification and grouped based on weight and colour. According to Siyanbola et al. (2012) who described the indigenous casting industry in Nigeria, the primary raw material for indigenous aluminium casting is refined aluminium metal obtained from leftover aluminium goods and household utensils. They assert that the scraps are melted in earthen furnaces and locally fabricated crucibles using firewood or palm kernel shells for fuel. Molten aluminium is then poured into mud or clay moulds to form the desired products (Siyanbola et al., 2012). Alabi and Adeoluwa (2020) also said that pot manufacturers in impoverished nations rely on aluminium products such as shattered spoons, Figures, old aluminium pots, cans, and other used and discarded containers that they collect from the streets, gutters, and trash bins. The aforementioned information attests to the facts about the source of secondary aluminium and how it is processed into new products. It also confirms the reliability of aluminium scrap as an alternative casting material to be used in the classroom setting.

Aluminium sculptors

Seung Mo Park

Seung Mo Park was born in Korea in 1969. He is a sculptor who makes incredibly complex metallic sculptures by twisting aluminium wire into human forms (Noorata, 2013). The artist forms his art piece, which he titles "human series", using aluminium wire. The artist carefully portrays the realistic wrinkles of crumpled fabrics (Meamar, 2017). The Brooklyn-based artist begins his artworks by starting with fibreglass casting, after which he covers the cast work with aluminium wires that recreate the human form made in fibreglass (Anon., 2013). His pieces are made up of tightly wrapped layers of aluminium wire on top of fibreglass forms. Seung Mo Park creates exceptional sculptures out of tightly wrapped aluminium wire on fiberglass forms. In producing his "Human" forms, the artist meticulously pays attention to details, from the bone structure and curves of the human bodies to the complex folds of the hair and wrinkles of draped clothing. See Figure 2.11(a and b)

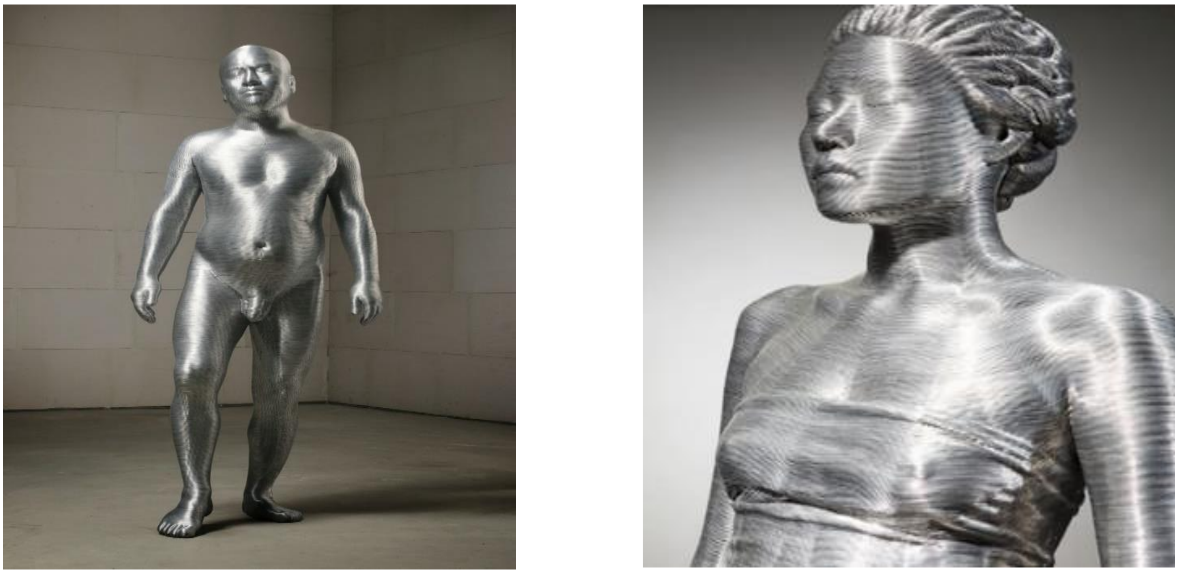

***Figure** 2.11(a and b) Aluminium Wire, Fibreglass, Lifecasting _ 34.5 x 93.5 x 48 cm 2013 HADA Contemporary*

***Source:** Seung Mo Park negsy1.wixsite.com*

Pouring Molten Aluminium into Anthills

Anthill Art is a remarkable technique that depicts the fascinating mystery of ants in sculpture form. To make the intricate sculptures, an anonymous American artist pours molten aluminium into the entrance of an anthill, fills the tunnels and chambers with the boiling liquid, and excavates the dirt (Hosmer,2013). Figure 2.13 (a and b) depicts cast aluminium from Anthill.

Palladino (2013) describes the process employed by the anthill artist as follows: the artist pours molten aluminium into the anthill and allows it to harden. After the aluminium solidifies, the sculpture is dug and washed with water to get rid of the dirt and filth, and the aftermath of the final piece depicts the stunning twists and turns that make up an ant colony. In his quest to study the architecture of ant colonies and their nests, Walter Tschinkel, an entomologist, and myrmecologist, came up with a way to record their three-dimensional underground chambers. He pours 1200F molten aluminium into the hill and then unearths the hardened cast. Nakaya says, “You can see that there is a lot of traffic near the surface. The shaft is like a ribbon, a wide tunnel like a superhighway. The more traffic it has, the wider it is.” This sculpture combines science with art (Nakaya, n.d.). Tschinkel (2010) indicates that “Nest architecture produced by wasps and bees is studied through the making of casts to create a perfect replica. The scientist melts aluminium in a crucible and then pours it into the nests in full. The cast is excavated in less than 5 minutes. He says, "The clear advantage of aluminium is that it is light and strong, creating a cast that is not broken.” (p. 11) An example of aluminium cast as a scientific study is shown in Figure 2.12.

Greby and Muller (2016) also wrote about an artist named David Gatlin and the way he gets rid of ant nests and produces intricate art by pouring 1,400-degree molten aluminium into the anthill. The artist allows the metal to dry to create beautiful sculptures (See Figure 2.13).

The researcher is fascinated by the philosophy that underpins anthill casts by artists and scientists at large. Their work has shown that aluminium is a potential casting material and has an advantage over other metals due to its availability and ease of collection in the environment. In comparison to other metals, aluminium is the most convenient metal, which melts at a low temperature and cools within 5 minutes (Tschinkel, 2010).

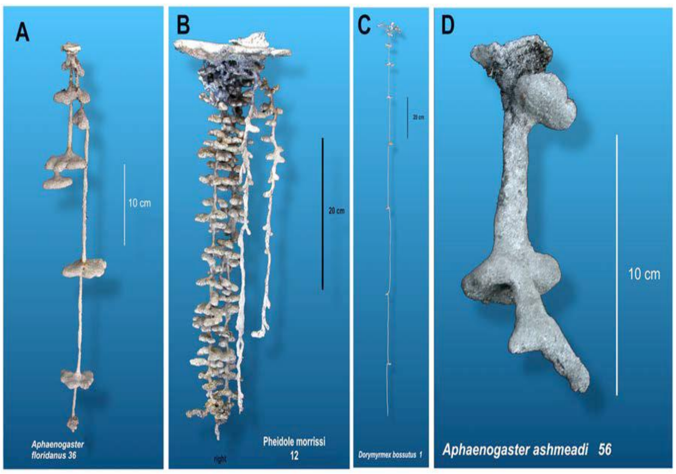

***Figure 2**.12 Casting of Waste Aluminium from Anthill*
***Source:** Tschinkel W. R. 2010*

Figure 2.13 *(a) Anthill Sculptures*
Source: Hosmer, 2013

El Anatsui

El Anatsui was born in the Ghanaian town of Anyako in 1944. He studied art at the Kwame Nkrumah University of Science and Technology's Art College in Kumasi. After graduating in 1975. He started teaching in Nsukka, Nigeria. He was a sculpture professor for over four decades.

Anatsui is well-known for his large-scale sculptures made of thousands of folded and crumpled aluminium bottle caps sourced from recycling stations and bound together with copper wire. His pieces are intricately crafted but malleable. His works of art incorporate indigenous Adinkra symbols as well as other Ghanaian motifs.

He has received international attention for his iconic "bottle-top installations," which are large-scale assemblages of aluminium pieces transformed into cloth-like wall sculptures that can draw connections between consumption, waste, and the environment (Anon., n.d.). Figure 2.14 shows how Anatsui uses the aluminium tops of bottles, seals, and labels by twisting and fabrication with copper wire. The aluminium waste bottle tops are meticulously fashioned together to create a cloth-like sculpture.

Figure *2.14 Adinkra Sasa, 2003. Aluminium and Copper wire, fabric*
Source: https://africa.si.edu/exhibits/gawu/artworks.html

Some Ghanaian Local Aluminium Cast Cookware

Aluminium cookware is specifically designed for cooking and storing items in Ghana. They consist of a mortar and pestle, a pot, a pan, a grinder, a ladle, and a spoon. This cookware is made from waste aluminium cans and aluminium ingots (Ansah et al., 2020).

They are designed to hold water, food, and to serve food during meals. They are used by Ghanaians in both urban and rural areas. In most Ghanaians' kitchens, larger utensils made of aluminum scrap are used to prepare 'Banku' and other foods. Figures 2.14 (a and b) show locally cast aluminium utensils made through the sand casting process.

According to Rogers (2020) the sand casting method is primarily used to produce solid castings in aluminium that can be welded or riveted to complete the final product. The following are the steps and results of the artisanal scrap aluminum sand-casting technique:

1. Aluminum scrap melting in a furnace.
2. A sand-filled pot pattern set with a wooden modular.
3. A sand-filled two-part split drag.
4. A sand core with the flask mould separated.
5. The finished aluminum cast product.
6. Fettling.

Figure *2.15 (a) Aluminium Grinder*
Source: *Ansah et al., 2020*

Figure *2.15 (b) Aluminium Pan*
Source: *Ansah et al., 2020*

METHOD

The researchers adopted quantitative research approaches which provided a numerical and text data for the study. Quasi-experimental, descriptive, action and project-based methods were employed for the study. Quasi-experimental helped the researchers to experiment solid waste aluminium with the correct method of casting as a sculpture material. Action research was used because Action research, according to Mohajan (2018) is a methodical inquiry carried out by educators to gather and analyse data that would help them realize and improve their practice. The researchers employed descriptive research to help them observe and describe the processes and results of the experiments conducted on solid waste aluminium as alternative casting material. Nassaji (2015) explained that descriptive research design involves a naturalistic data, the goal is to describe a phenomenon and its characteristics. Project-based learning is a type of instructional management that places a strong emphasis on learners' real-world experiences. This helps them develop their problem-solving skills, their capacity for creative thinking at work, and their understanding of how to plan their work using the scientific method (Nilsook et al., 2021). Project based research enabled the researchers to provide the requisite tools and guide participants to plan and execute sculpture works in solid waste aluminium. The procedural steps in this research include observation, interviews, reflection, creation, and analysis.

The total population of students in the department of Visual Arts were 269. However, the study participants who were conveniently selected for the project included 40 students in the visual arts department in Nkawie Senior High School (Technical), Ghana. The final products were evaluated by stakeholders in the sculpture discipline, namely teachers and students.

RESULTS AND DISCUSSION

Identification, Sorting and Gathering of Aluminium Solid Waste Materials

The first objective of the work was to explore different types of solid waste aluminium material with the correct method for casting. Samples of solid aluminium were gathered from restaurants, pubs, drinking bars, gutters, landfills, aluminium windows and frame manufacturers, and funeral grounds in Atwima Nwabiagya Municipality, Nkawie. This method was applied to facilitate easy identification of the solid waste aluminium in the environment. Before the collection of the waste aluminium, the researcher went to aluminium casters and scrap dealers, who gave examples of solid waste materials that have about ninety percent (90%) aluminium in them, which are used for making cooking utensils and other household products. (See Figure 3.1).

Figure *3.1 Researcher Interviewing Metal Casters (Krofofrom)*
Source*: Field Study, 2022*

The researchers visited aluminium scrap dealers and metal casters to discuss how to collect and gather solid waste aluminium from the environment. The scrap dealers gave the researchers a fruitful insight into the identification of waste aluminium. Gathering and collecting scraps is their mainstay. This has given them in-depth knowledge and experience in collecting appropriate waste aluminium. They were asked to list different items that are made with aluminium to enable the researchers and students to collect them with ease.

***Figure** 3.4: Sampled Fanta, Malt, Next Level, Milo, Sprite, Lucozade, Aluminium Chips and Window Frame.*
***Source**: Field Study, 2022*

(A) The first solid waste aluminium that were identified for the research was beverage cans. The cans come in different forms and brands, namely, Fanta, Adonko Next Level, Coca Cola. Malt, Guinness, and Sprite. The average weight of the can is approximately 14.9 grams. They are produced by a mechanical cold forming method by pressing a flat from a stiff cold rolled sheet. The sheet consists of about 1% manganese and 1% magnesium. Beverage cans are predominately used for packaging food and beverages such as Milk, Milo, and drinks. Waste aluminium beverage cans are mostly found at funeral grounds, entertainment venues, in gutters and landfills, and occasionally in Atwima Nwabiagya Municipal localities. Most of the beverage cans were collected by students and the researchers. Sometimes restaurant owners collect money before allowing students to gather the waste beverage cans. This is because they are sold to scrap dealers who travel from various restaurants to collect them. Figure 3.4 shows a photograph of different waste beverage cans. The beverage cans were sorted by their brand names by the students.

***Figure** 3.5(a) Students Washing and Drying the Sorted Solid Waste Aluminium*
Source: Field Study, 2022

(B) The second solid waste aluminium recovered was from a discarded fufu pounding machine. The waste material is used as a pestle in fufu pounding machines that are used in many homes in Atwima Nwabiagya Municipal. The material was retrieved from a discarded fufu pounding machine. Figure 3.7 (a and b) depict solid waste aluminium recovered from the fufu pounding machine by the researcher and students to be used for the study.


***Figure** 3.7(b) Waste Aluminium Recovered from Fufu Pounding Machine*
***Source:** Field Study, 2022*

(**C**) The third material recovered from the environment was waste aluminium doors and frames. The researchers, together with the students, went to aluminium door and frame producers to collect aluminium waste for the study. The aluminium producers sell the waste aluminium to scrap dealers after trimming. The researchers and students were able to procure these items for free because the students told them the materials were going to be used for their project work. Figure 3.8 (a and b) shows a photograph of waste aluminium recovered from aluminium frame and door producers. Figure 3.9 depicts students cutting the solid waste aluminium into pieces to make it ready and facilitate easy melting.

***Figure** 3.8 Waste Aluminium Recovered from Aluminium Door Frame Producers*
Source: Field Study, 2022

(**D**) The fourth solid waste aluminium was chaff from the trimmings of aluminium door producers. Aluminium chips from window and door frame manufacturers are shown in

Figure 3.10 (a and b). The researchers and students went to different aluminium frame producers to procure the waste from their production. Most of the manufacturers were hesitating to give out the waste chips. They sold the waste chips at a cheaper price upon telling them that it was going to be used as a material for students' practical. The researchers paid sixty Ghana Cedis for half bag of aluminium chips from an aluminium window manufacturer at Nkawie.

Figure *3.10(b) Aluminium Chips from Aluminium Window and Door Frame Manufacturers*
Source: *Field Study, 2022*

Developing Concept Designs in Miniature Using Relief and in-the-Round Sculpture.

The models were made in clay and wax by the students and the researcher. In applying the experiential learning style, students were tasked with developing concept designs using Adinkra symbols, Akan traditional stools, electrical devices, and animals. The researchers, together with the students, used printable pictures from the internet as a reference material to model and cast the designs.

Figure *3.31 Pouring Wax into Wooden Mould*
Source: *Field Study, 2022*

***Figure** 3. 32 Making Wax into Sheets*
***Source:** Field Study, 2022*

***Figure** 3.34(c) Students Making Designs*
***Source:** Field Study, 2022*


a


B


c


d


E


f

Figure *3.38(a-m) Wax Models of Adinkra Symbols*
Source*: Field Study, 2022*

Figure *3.39 (a-g) Wax Models of Animals*


a


B


c


d


E


f

Source*: Field Study, 2022*

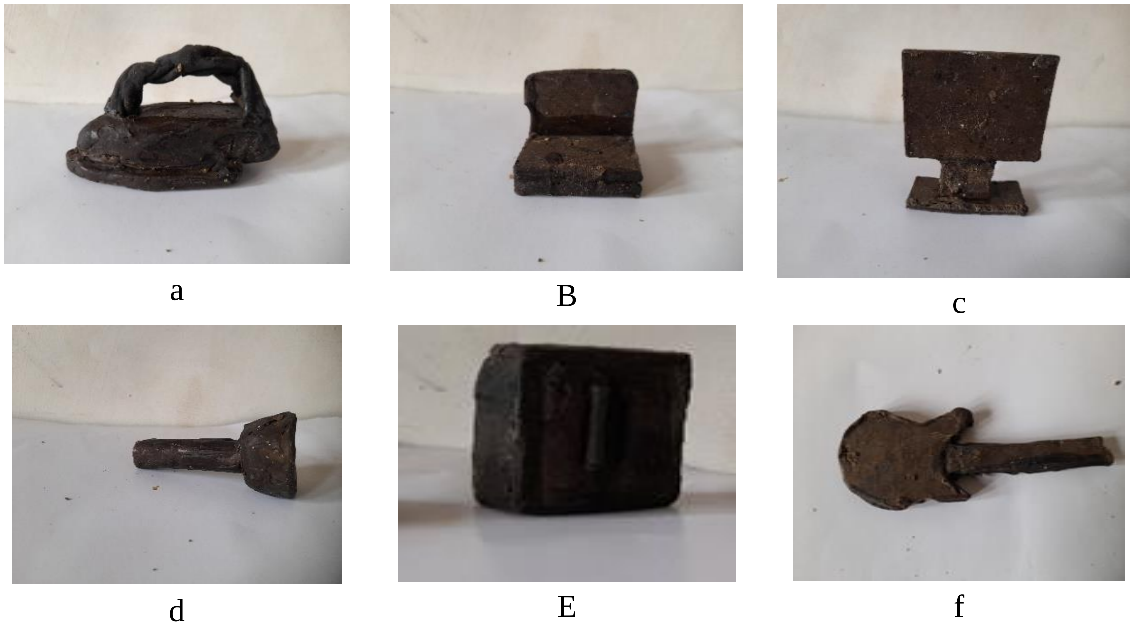

Figure *3.40 Wax Models of Electrical Devices*
Source*: Field Study, 2022*

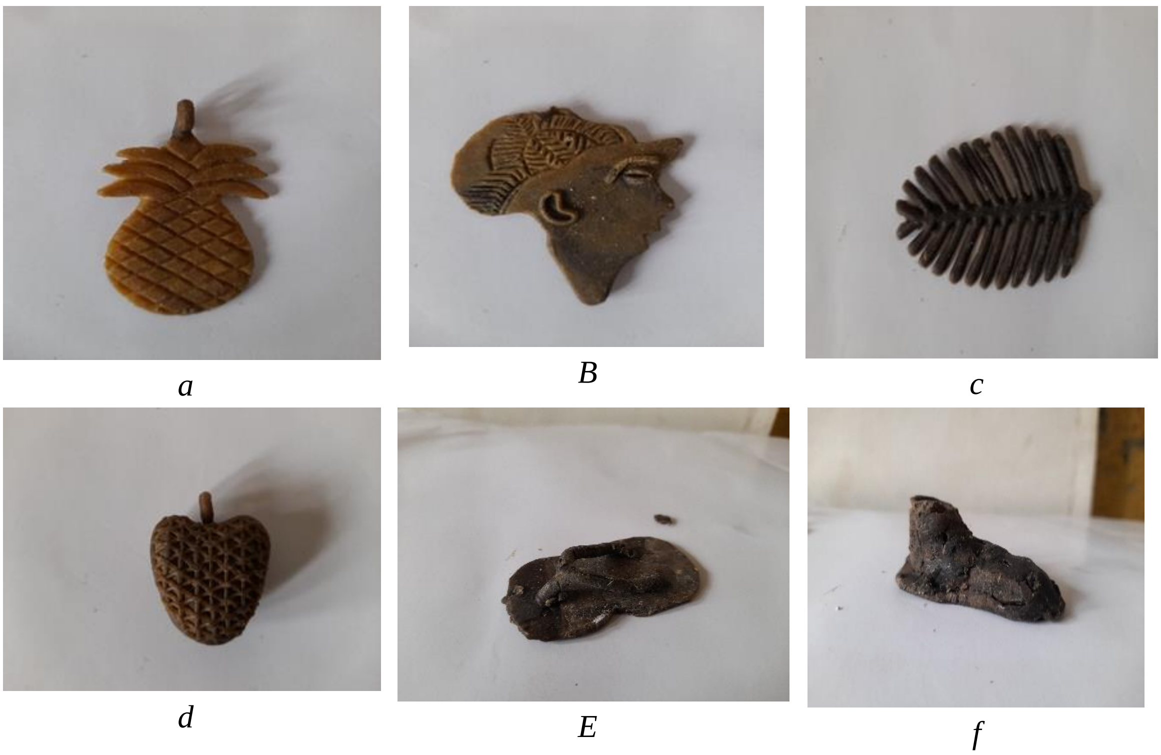

Figure *3.41 (a-g) Wax Models from other Concept Designs*
Source*: Field Study, 2022*

***Figure** 3.44 Students Spruing the Wax Pattern*
***Source**: Field Study, 2022*

***Figure** 3.45(a-d) Students Making the Mother Mould*
***Source**: Field Study, 2022*

Figure 3.46 shows the researchers and students preparing the furnace for the melting of the metal and dewaxing. The mother mould was put into the fire furnace to melt the wax to make the core ready for the casting to occur. See Figure 3.47(a and b). Figure 3.48 (a and b) depicts participants putting the waste aluminium into the crucible to be melted. The molten metal was poured into the mother mould and allowed to cool off for about ten minutes. See Figure. 3.49(a and b). The mould was chiseled to remove the final cast. See Figure. 3.50

Figure *3.46 Preparing the Fire Furnace*
Source*: Field Study, 2022*

Figure *3.47(a and b) Students Dewaxing*
Source: *Field Study, 2022*

Figure *3.48 (a and b) Students Melting the Solid Waste Aluminium*
Source *(Field Study, 2022)*

***Figure** 3.49 (a and b) Pouring the Molten Metal into Plaster Mould*
***Source**: Field Study, 2022*

***Figure** 3.50 Breaking the Mould*
***Source:** Field Study, 2022*

***Figure** 4.14 (a and b) Cast Work from Animals*
***Source**: Field Study, 2022*


a


b


c


d


e


f

g *h*

***Figure** 4.16 (a-h) Cast work from adinkra symbols*
***Source:** Field Study, 2022*

a b

c d

***Figure** 4.17 (a-d) Cast Work from other Designs*
***Source:** Field study, 2022*

Observations from the Concept Designs

To create their models, students were able to select from any design concept. The students use of their past knowledge to carry out the designs and how some chose direct wax modelling while others worked with clay models before manufacturing moulds was fascinating. To develop their final project, students gained knowledge through exchanging ideas with other group members. Participants sought advice from their co-workers because they had already gone through the casting procedure. Plaster mould casting was used to create most of the finished items. The study found that using this technique when working with tiny sculptures is relatively cost-effective.

Ormston et al. (2014) assert that human beings actively produce knowledge rather than passively consume it. This claim is supported by the fact that the students created sculptures based on their personal experiences after going through the process of gathering, sorting, modelling, and casting with the solid waste aluminium materials. To create small sculptures, students actively interacted with the materials and tools. The lifetime activity of project-based learning fills the void between theoretical and experiential learning. This study demonstrates that when students actively engage in the learning process, they learn more effectively.

***Figure** 4.1 Final Cast of Head of an Elephant from Solid Waste Aluminium Chips*
Source: Field Study, 2022

***Figure** 4.2 Final Cast of Head of a Rhinoceros from Solid Waste Aluminium Chips*
Source: Field Study, 2022

***Figure** 4.3 Final Cast of Head of a Rat from Solid Waste Aluminium Chips*
Source: Field Study, 2022

Observation of Solid Waste Aluminium Chips Casting

The final cast is aesthetically pleasing. When the work is observed from a distance, it looks very rough, but when felt with the palm, it is very smooth. The work should be used for both indoors and outdoors because they look strong. After pouring the mixture into the mould, the cast takes about fifteen minutes to set. The cast work can be finished by sandpapering. Figures 4.1, 4.2 and 4.3 show how the cast work selects approximately 99% of the details. Cast works made of aluminium chips pair well with silicon reinforced plaster moulds. With this type of mould, you will get complete details.

***Figur**e 4.10 Cast Work from Beverage Cans (Torso)*
***Source**: Field Study, 2022*

Observation of Beverage Cans

Figure 4.10 shows the cast work's deformities, which are signs of problems with the dewaxing process, which was improperly executed and left some wax in the mother mould. Compared to other aluminium waste materials, the cast work made from beverages is more susceptible to surface damage. The cast piece appeared to be in excellent condition with numerous pinholes. To produce a successful cast piece, the molten metal was supported by the plaster mould. The gas and cavities in the discarded aluminium produced surface voids. The molten metal's solidification and contraction caused the spaces.

***Figure** 4.11 Cast Work from Fufu Pounding Machine (Elephant)*
***Source**: Field Study,2022*

Observation of Cast Work from Waste Aluminium from Fufu Pounding Machine

The melting took a longer period. The surface of the metal produced little scums during melting. About ninety-nine percent of the molten metal was recovered for the casting. The cast piece appears solid. The molten metal depicted the design of the mould effortlessly with little damages on the cast surface. The melting took about 30 minutes before ready for pouring into the mould.

***Figure** 4.12 Cast Work from Aluminium Window and Frame Producers (Portrait)*
***Source**: Field Study,2022*

Observation

When applying this technique in a school context, safety steps must be taken to prevent casualties. Without using the standard lost wax casting method, an aluminium casting can be made immediately from a plaster mould. To avoid explosions and surface pinholes, refrain from pouring overheated molten metal into plaster moulds. Allow the metal to cool at the slowest possible rate before pouring. The heat shock caused by encountering the molten waste aluminium could not harm the investment material (POP). The mother mould was covered in layers until the necessary strength was reached to prevent it from fracturing and cracking during casting. Under tightly regulated humidity and temperature conditions, each layer was given time to dry and cure.

When applying the technique in a classroom context, casting with miniatures is more practical and affordable than casting massive objects. The warm casting process is highly difficult since it requires students to utilize tools and equipment that are difficult to find and understand.

Main findings

In connection with the objective one of the studies, the researchers identified different solid waste aluminium and the appropriate casting method. The study uncovered that there were a lot of different solid waste aluminium materials that are found in the environment which people throw away and end up choking gutters and degrading the environment. These materials can be harnessed and turned into useful sculpture materials for casting in Senior High Schools in Ghana.

Four solid waste aluminium cans were discovered within the research area. The materials that were identified were solid waste aluminium chips, waste aluminium from fufu pounding machines, waste aluminium from window and frame producers, and waste from beverage cans.

The solid waste aluminium chips were collected from shops that produced aluminium doors and frames. The waste aluminium from fufu pounding machines was recovered from a discarded fufu pounding machine by the operator of the machine at Nkawie. The beverage cans were also collected from restaurants, pubs, funeral grounds, gutters, and landfills, and with the help of the students. The last material, waste aluminium from door and frame producers, was obtained from the shops of aluminium door and frame manufacturers. The four solid waste aluminium materials were easily found in the environment since they are mainly used for packaging purposes, for building and construction, and for making cookware. These materials are less expensive to collect and use as a casting material as compared to the traditional medium.

The second goal was to create miniature in-the-round and relief cast works out of the identified solid waste aluminium. The researchers found out that beverage cans were very easy to procure and used for casting. Turning the material into molten metal was done with minimal effort. After pouring the molten metal into the mother mould, the cast cooled off within ten minutes with a smooth finish. The process was simplified by using aluminium chips, as the cast pieces dried in fifteen minutes, resulting in a finely cast product.

Plaster mould casting has proven to be feasible in the classroom without going through the process of lost wax casting. There is no need to produce vents and gating systems, which are very tedious and cumbersome and take a longer period to manufacture.

The third objective was to develop product concepts or designs using solid waste aluminium material for casting. Concerning this objective, students were guided to create designs from the waste material using adinkra symbols, animals, Akan stools, electrical devices, and other designs.

CONCLUSIONS

Solid waste aluminium thrown away is very detrimental to the environment, but these materials can be used as alternative materials in art production, especially sculpture. The study shows that waste material can assume a new life by introducing it to sculpture students to produce their cast works. By encouraging the use of throwaway materials, students become aware of the sustainable use of sculpture materials. Students will also become very innovative and creative by finding fewer and fewer materials in their immediate environment to manufacture their project work. The study revealed that beverage cans, waste aluminium chips, waste aluminium from fufu pounding machines, and door and frame producers are easily accessible and recyclable, which can be used as an alternative sculpture material for metal casting in Senior High Schools in Ghana. The identified solid waste aluminium works well with the already existing casting techniques.

The solid waste aluminium material is seen everywhere in the environment and can easily be procured and used by students and teachers at large. Identifying alternative materials by teachers and students at all levels of teaching and learning of sculpture must be utmost.

The findings from the study and the results testify that the solid waste aluminium materials that were discovered worked perfectly during the casting process. The cire perdue method of casting as observed by the researchers is very painstaking and requires great experience which the researchers recommend should be used by experienced teachers with great care and attention. The researchers advocate the use of direct plaster mould casting to be used in the classroom setting by teachers and students. This method requires little effort and cost efficient. On the other hand, the warm casting process is also durable and sustainable to be used in the classroom. However, acquisition of binders like resin will pose a challenge because they are not locally produced.

Finding tools and equipment for the casting process also pose minimal challenge. The researchers together with the casting artisans procured crucible from used fridge motor cylinder, and a local blower produced by a local electrician. Teachers can build their own fire furnace in their schools by contacting casting artisans for their expertise.

The most common and available material, according to the literature review, was aluminium, although casting with it in a classroom environment was exceedingly difficult and demanding. Based on the study, students should have prior experience with tools, materials, and equipment, as well as metal casting techniques.

The study also showed that group solutions were the best method for resolving issues at each stage of the project. The most useful outcome of this study is cooperative problem solving and group learning through association.

The researchers conclude that there are abundant recyclable materials in our environment which can be turned into useful art products to help lessen students' workload on procuring materials to carry out their practical activities. Students, upon completing school, can create useful products from these recyclable materials as a livelihood.

Unemployment will be reduced as students find innovative ways to manufacture functional objects from identified recyclable materials.

REFERENCES

Acheampong, T. & Mensah, K. A., 2018. Towards an Integrated Bauxite and Aluminium Industry in Ghana. *Researchgate*, pp. 1-19.

Agyei, I. K., Bediako, O. O. & Adom, D., 2020. Metal Welding Sculptural Portraiture for the Historical Remembrance of Political Figure in Ghana: The Case of Osagyefo Dr. Kwame Nkrumah. *Global Journal of Human-Social Science,* 20(19), pp. 1-14.

Alabi, O. A. & Adeoluwa, Y. M., 2020. Production, Usage and Potential Public Health Effect of Aluminum Cooking Ware. *Annals of Science and Technology,* 5(1), pp. 20-30.

Andrews, A. & Gikunoo, E., 2011. Small Scale Foundries in Ghana:The Challenge. *Leonardo Electronic Journal of Practices and Technologies,* Issue 19, pp. 1-12.

Anon., 2013. *Cool Things.* [Online] Available at: https://www.coolthings.com/seung-mo-parks-art/ [Accessed 4 June 2022].

Anon., n.d. *Castle Fine Art.* [Online] Available at: https://www.castlefineart.com/blog/the-works-of-sculptor-lorenzo-quinn [Accessed 27 March 2022].

Ansah, B., agyeman, k. K., Quaye, H. A. & Clement, F. A., 2020. Ghanaian Local Aluminum Cast Utensil Forms for Fountain Production. *International Journal of Innovative Science and Research Technology,* 5(6), pp. 1333-1345.

Brough, D. & Jouhara, H., 2020. The aluminium industry: A review on state-of-the-art technologies,environmental impacts and possibilities for waste heat recovery. *International Journal of Thermofluids,* 01(02), pp. 1-39.

Congdon, K. G., 2000. Beyond the egg carton Alligator: To Recycle is to Recall and Restore. *Art Education,* 53(6), pp. 6-12.

Donkor, E. K., 2018. Downside of Scrap Metal Art: Some Unknown Hazards Associated with the Practicing Sculptor. *AFRICA DEVELOPMENT AND RESOURCES RESEARCH INSTITUTE (ADRRI) JOURNAL,* 27(9(4)), pp. 47-59.

Gawu, S., Amissah, E. & Kuma, J., 2012. The Proposed Alumina Industry and How to Mitigate Against the Red Mud Footprint in Ghana. *Journal of Urban and Environmental Engineering,* 06(02), pp. 48-56.

Greby, J. & Mueller, C., 2016. *Businessinsider.* [Online] Available at: https://www.businessinsider.com/pouring-molten-metal-into-anthills-creates-some-crazy-art-2016-5?r=US&IR=T [Accessed 10 July 2022].

Meamar, T., 2017. *Artpeople.* [Online] Available at: https://artpeople.net/2017/03/aluminum-wire-sculptures-by-seung-mo-park/#:~:text=Brooklyn-based%20Korean%20sculptor%20Seung%20Mo%20Park%20creates%20%E2%80%9Chuman,is%20about%20the%20placement%20of%20each%20wire%20strand. [Accessed 4 June 2022].

Mohajan, H., 2018. Qualitative Research Methodology in Social Sciences and Related Subjects. *Journal of Economic Development, Environment and People,*, 7(1), pp. 23-48.

Nakaya, R., n.d. *The Kids Should See This.* [Online] Available at: https://thekidshouldseethis.com/post/64867440889 [Accessed 10 July 2022].

Nassaji, H., 2015. Qualitative and descriptive research: Data type versus data analysis. *Journal of Language Teaching and Research,* 19(2), pp. 129-132.

Nilsook, P., Chatwattana, P. & Seechaliao, T., 2021. The Project- Based Learning Management Process for Vocational and Technical Education. *Higher Education Studies,* 11(02), pp. 01-10.

Noorata, P., 2013. *My Modern Met.* [Online] Available at: https://mymodernmet.com/seung-mo-park-human-wire-sculptures/ [Accessed 15 March 2021].

Nyarko, D. A. & Bruijn, E. J. d., 2019. *THE COMPETITIVENESS OF GHANA'S ALUMINIUM INDUSTRY.* [Online] Available at: https://www.zbw.eu/econis-archiv/bitstream/11159/397979/1/EBP076102777_0.pdf [Accessed 09 09 2023].

Olotah, A. N., 2019. Production of Sculpture Using Waste Materials; a Tool for Addressing Environmental Degradation in Onitsha, Anambra State Nigeria. *Awka Journal of Fine and Applied Arts,* 06(02), pp. 131-151.

Olumorin, C. O., A. Yussif, U. A. A. & Jekayinfa, A. A., 2010. Development of Instructional Materials from Local resources for Art-Based Courses. *Asian Journal of Information Technology,* 9(2), pp. 107-110.

Opoku-Bonsu, K., Jectey-Nyarko, M., Donkor, E. E. & Anim, F. A., 2017. Rethinking Materiality in Pre-Tertiary Studio Art Education in Ghana. *Journal of Arts and Humanities,* 06(12), pp. 7-20.

Ormston, R., Spencer, L., Barnard, M. & Snape, D., 2014. The foundations of Qualitative Research. In: J. Ritchie, J. Lewis, C. M. Nicholls & R. Ormston, eds. *Qualitative Research Practice.* London: SAGE Publications Ltd, pp. 1-25.

Palladino, V., 2013. *The Verge.* [Online] Available at: https://www.theverge.com/2013/12/13/5207824/anthill-art-molten-aluminum [Accessed 10 July 2022].

Rogers, L. R., 2020. *Encyclopedia Britannica.* [Online] Available at: https://www.britannica.com/art/sculpture [Accessed 11 February 2022].

Siyanbola, W. O., Egbetokun, A.A., Oluseyi, I., Olamade, O., Aderemi, H. O., & Sanni, M., 2012. Indigenous Technologies and Innovation in Nigeria:Opportunities for SMEs. *American Journal of Industrial and Business Management,* Issue 2, pp. 64-75.

Tschinkel, W. R., 2010. Methods for Casting Subterranean Nests. *Journal of Insect Science,* 10(88), pp. 1-17.

Uyamk, O., Ersoy, M. A., Kandir, A., Can-Ysar, M., & Inal, G., 2011. New Explorations With Waste Materials in Early Childhood Education. *US-China Education Review,* pp. 111-118.

Widyantoro, Dhaneswara, D.,Fatriansyah, J. F., Firmansyah, M. R., & Prasetyo, Y., 2019. Removal of Oxide Inclusions in Aluminium Scrap Casting Process with Sodium based Fluxes. *MATEC Web of Conferences 269*, pp. 1-5.

Yeboah, R., Asante, E. A. & Opoku-asare, N. A., 2016. Teaching Interactive Art Lessons with Recycled waste Materials as Instructional Resources. *Journal of education and Practice*, 7(14), pp. 38-59.