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Educating Students Living with Blindness and Visual Impairment: A Critical Inquiry into The Production Processes and Use of Innovativetactile Teaching and Learning Materials (TLMs) in the Akropong School for the Blind, Ghana

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ABSTRACT

The purpose of this design-based method in the qualitative research approach was to produce content and context-specific TLMs for Upper primary learners living with blindness and visual impairment at the Akropong School for the Blind in Ghana. This was followed up by post-project personal interviews with four teachers and six learners living with blindness and visual impairment in the study area. The study produced four tactile TLMs to enhance the teaching and learning of Integrated Science, Mathematics, and Social Studies. These were tactile TLMs on the Human Digestive System, the Geographical Map of Ghana, the Toddlers' Shapes Puzzle, and the Addition machine. The learners expressed great excitement while interacting with the tactile TLMs that were produced. The findings revealed that the learners living with blindness and visual impairment revealed that the tactile TLMs highly improved their learning interests and outcomes while impacting positively on their retention and recall capabilities of learned concepts. The study contends that the Ministry of Education and the various educational institutions in Ghana must prioritize the establishment of instructional resource centres where innovative TLMs could be produced especially for students with special educational needs to heighten their learning interests and outcomes.

Keywords: Educational needs; instructional resources; inclusivity; students living with blindness; visual impairment; Ghana.

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1. Introduction

Ensuring an inclusive and equitable quality education for every individual irrespective of their physical, psychological, and/or emotional development limitations is very crucial for ensuring the quality of life. This is reiterated in the United Nations Sustainable Development Goal 4 which focuses on quality education, 'Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all' (United Nations, 2015). Unfortunately, many learners face various forms of difficulties and limitations in education because of their physical growth development deficiencies. For instance, earners living with blindness or visual impairment have limitations in concept learning because they depend largely on other senses rather than the sense of sight in concept acquisition (Rahi & Cable, 2003). This category of learners largely depends on their sense of touch in acquiring information for the acquisition of learned concepts in the classroom (Kizilaslan, 2020). Their low vision or blindness requires that they are allowed to touch, handle and examine the parts of objects to be able to grasp the learned content (Smith, 1998). As such, they would need instructional materials that could provide them with tactile information for them to be able to have full access to the learned content (Downing & Chen, 2003). These instructional materials could consist of diagrams, schemes, pictures, embossed maps, and three-dimensional models of physical organs (Kizilaslan, 2020). Instructional resources are very important as they assist in increasing the understanding levels of students for various subjects that are taught (Lewis, 2019). They help students to visualize and get involved in practical activities to facilitate their learning process.

In Ghana, instructional resources are recognized but they are not fully utilized. Sadly, schools with students who have special needs such as the Akropong School for the Blind are not equipped with appropriate instructional resources for teaching certain subjects. It is based on this background that this study aimed at creating and producing tactile instructional resources for students with vision challenges in the institution.

1.1 Teaching and learning materials

Teaching and Learning Materials can highly be effective if the tenets, methods, and implementation of TLMs all provide inclusive education. This is in its attempt to give all students, regardless of their skills or special needs, equal access and opportunity (Kryszewska, 2017). Buslieta (2013) stated that it is impossible to picture a good lesson delivery without the usage of many current TLMs in today's teaching processes. According to Yildirim (2008), the best way to define the use of TLMs in teaching is as supplemental components that enhance the educational and instructional environment, promote learning, and specifically address the sense organs of the learner.

Although the language is still the most essential asset in a teacher's job. TLMs history cannot be traced to a particular person however, ancient civilizations came up with scientific experimentations and some theories that were used for making teaching and learning comfortable. Some TLMs used by ancient civilizations were tablets and abacus. The tablets were made of Greek Clay which had readable inscriptions on them as guidelines for the children to follow on how to read and write. The evolution of the abacus can be classified into three (3) ages; Ancient times, Middle Ages, and modern times. The Ancient times called it the Salams Tablet (300 BCE) and revised by the Romans which was then after called the Roman Hand-Abacus (300 CE). During the Middle Ages, the name was changed to Arabic numbers, the Japanese also had a style it went on and on. This led to the likes of Edgar Dale, who came up with the cone of experience, and Maria Tecla Montessori who come up with the scientific pedagogy named after her (Montessori), to develop theories that can facilitate teaching and learning, especially from the basic level of education. TLMs are in various forms and for every level of education. Thus, they fall under three (3) main classes namely; Audios, Visuals, and Audio-Visuals (Batton et al., 2015). Others also, classify TLMs under two main categories which are Modern and Traditional. The Modern TLMs are specifically made up of computers, projectors, tablets, and other electronic devices that we can think of whilst the traditional TLMs are made up of blackboards, chalks, textbooks et cetera. TLMs are strategic aspects for instructors in the planning and offering of relevant learning situations (Oni, 1992). In addition, the crucial role played by TLMs in boosting the quality of teaching, and learning and improving student performance is widely acknowledged (Smart and Jagannathan, 2018). In other words, the availability of Teaching and learning materials can also affect how well students do. The motivation and engagement of students can be increased by using materials that address their various learning demands. In addition, having TLMs that are pertinent to the curriculum and learning objectives will help ensure that students are well-prepared for their assessment. This is because the use of TLMs in lesson delivery helps to clarify ideas that the instructor could not explain without the use of TLMs, allowing students to learn more easily and favourably influencing their academic achievement. However, there is a knowledge gap created in the aspect of the design of TLMs for students with special needs and their effectiveness in their academic journey. TLMs are a crucial part of the educational process. The accessibility and caliber of these materials are important elements that affect how well education is provided. Students learning experiences and academic performances can be improved by using high-quality TLMs. Relevance, quality, accessibility, appropriateness, and the teacher's expertise are some of the aspects that affect how effective TLMs are. Hence, it is essential to guarantee that teaching and learning materials are current, of the highest caliber, readily available, and appropriate, and that teachers are skilled in their use.

2. Data and methodology

Design-Based Research (DBR) as a methodological approach in educational inquiry aims at developing products to solve identified problems in education (Brown, 1992; Joseph, 2004). Design-Based Research (DBR) is a four-phase process that includes designing, testing, evaluation, and reflection. A problem is identified which is often education-based. Then, instructional tools are designed as an intervention to solve the educational need identified. The developed instructional resource or material is tested in the real-world setting, herein the classroom to find out if it positively impacts the learning outcomes of learners (Scott et al., 2020). After a scholarly evaluation of the developed instructional materials, the strengths and limitations are noted. The limitations are revised progressively if necessary to heighten its purpose of creation (Collins et al., 2004). The reflection process critiques the implementation process and develops design principles. Since the process is cyclical, the four-phased process starts at that point to keep refining the developed instructional solution to heighten its benefits to the teaching and learning processes. These four procedural steps in Design-Based Research (DBR) were meticulously followed in the development and implementation of the teaching and learning materials to improve the learning outcomes of learners living with blindness and visual impairment.

The case study design was adopted to investigate how teaching and learning materials could be developed and used at the Akropong School for the Blind, Ghana. Four tutors and six students were purposively sampled based on their high interest in this study at its initial stages when the researchers discussed the study's purpose and relevance to the school. Personal interviews based on an interview guide designed in relation to the DBR and how the TLMs are produced and their impact on the teaching and learning processes at the Akropong School for the Blind, Ghana. The data garnered were analyzed using thematic data analysis. The tutors signed an informed consent form while the visually impaired and blind students gave oral consent to participate in the study. The study participants were assured that their privacy and views shared would be protected using pseudo-identity.

3. Results and discussion

3.1 Concept design

For this study, there were several TLMs produced, and therefore the designing phases for all the materials vary. They have been differentiated on that front for better knowledge. With the subject areas that are being tackled, these TLMs fall under these subject areas. Also, some of the TLMs of the various subjects have similar features and therefore undergo the same planning and production phase. The first TLMs that were produced were the Puzzles – these comprise the Human Digestive System, the Geographical Map of Ghana, and the Toddlers' Shapes Puzzle. These fall under Integrated Science, and Social Studies respectively. The materials, tools, and equipment that were used have been tabulated.

Table 1.
Lists of tools, materials, and equipment.

Tools	Materials	Equipment
Hammer	Wood	Sander (sanding machine)
Brush	White Glue (P. V. A)	Cross-cutting machine
Pencil	Sanding sealer	Router
Rule	Lacquer	Sprayer (spraying machine)
Carpenter's square	Thinner	Planer
Mallet	Water	Lathing machine
Drill bits	Acrylic paint	Drilling machine

3.2 Designing phase of the puzzle

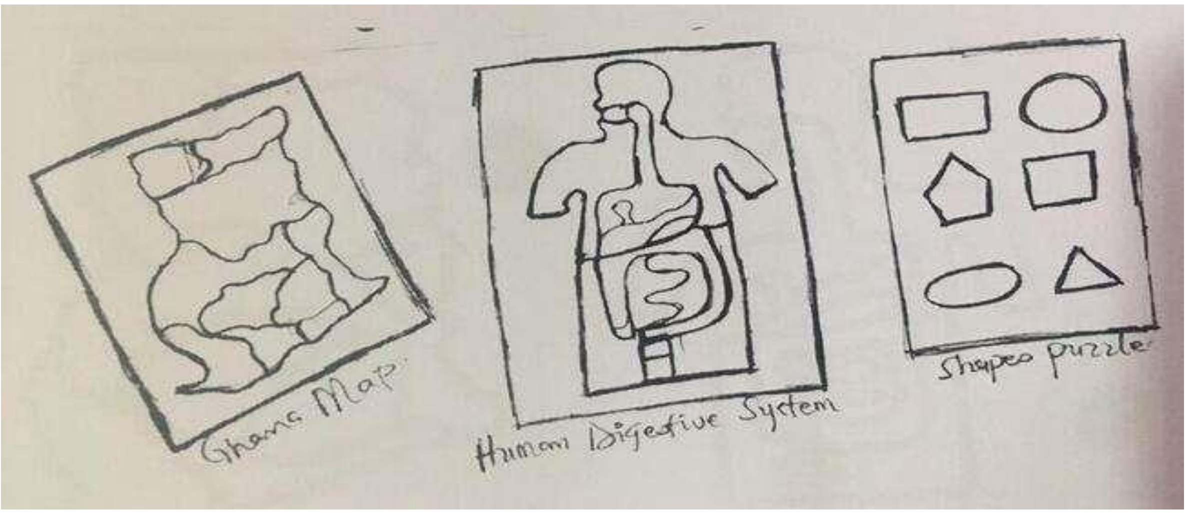

Figure 1. Concept Design Sketches.

The above figure is a scanned sketch (from the left) of the geographical map of Ghana, the digestive system, and the toddlers' shape puzzle.

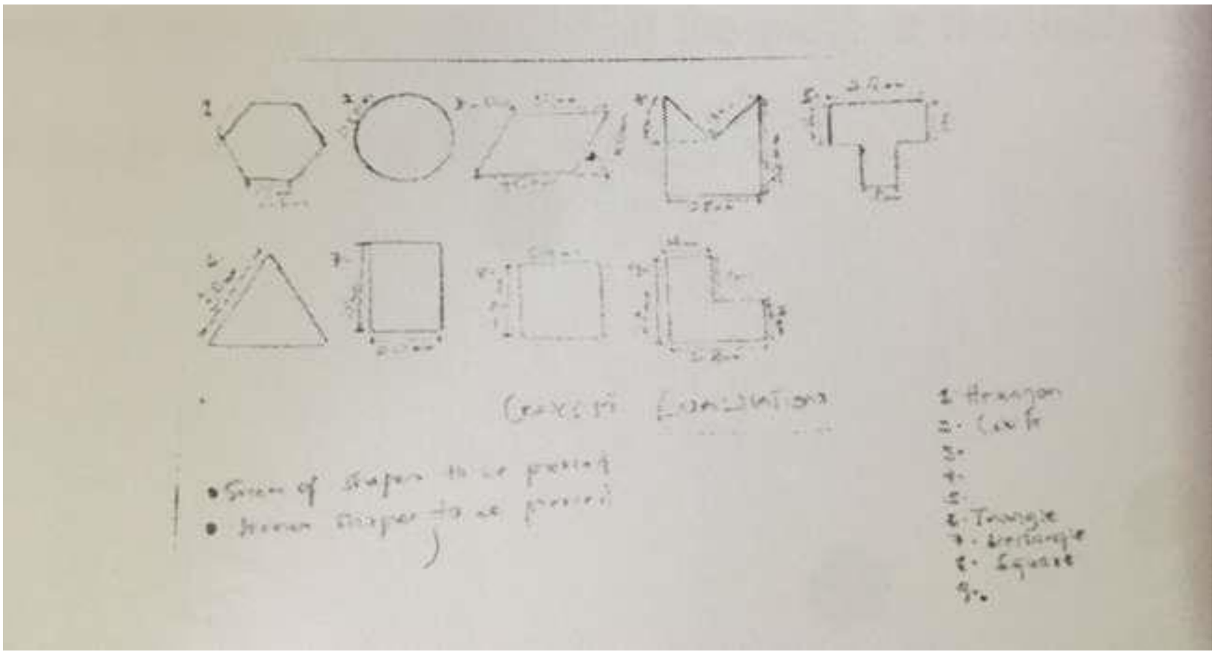

Figure 2. Dimensions of Shapes for Toddlers' Puzzle.

With the toddlers' shape puzzle as seen in Figure 2, the various shapes will be pierced out of the wood. In order for there to be a correct dimension of all the various shapes, the shapes were individually calculated to fit their purpose.

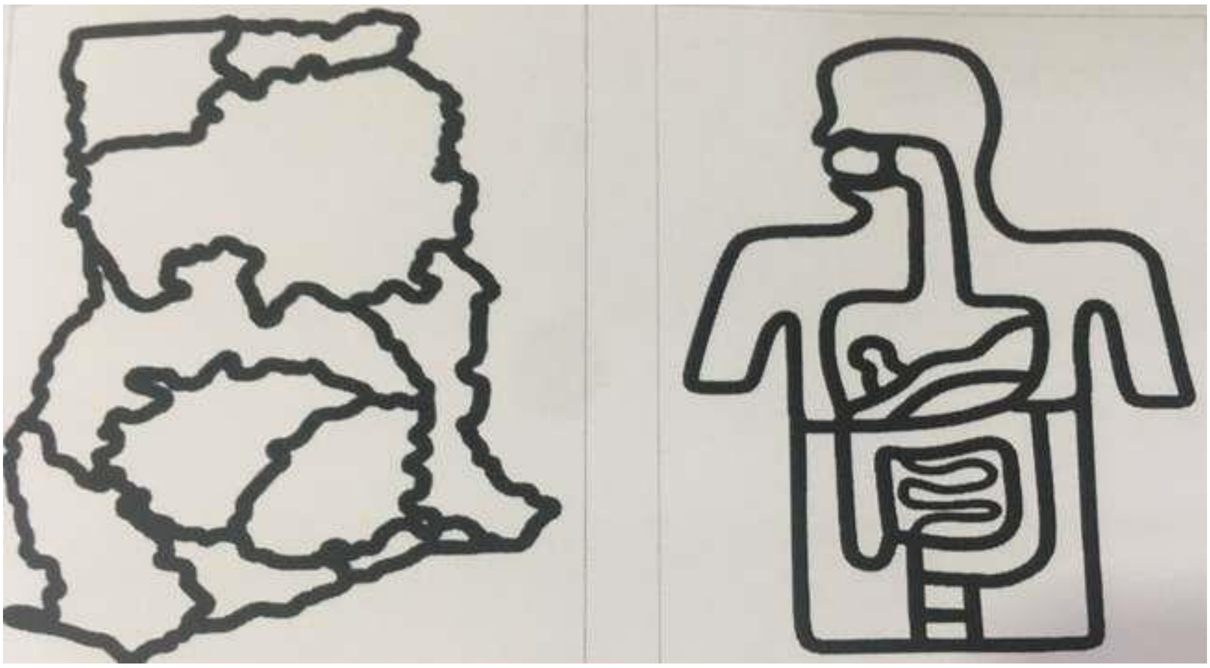

Figure 3. Corel Draw of the Ghana Map and Digestive System.

Since the puzzles are being designed to show the various parts of an object, the Corel draw was used to thicken and edges of all the parts of the digestive system, and the Ghana map was for easy piercing of the sides as seen in Figure 3.

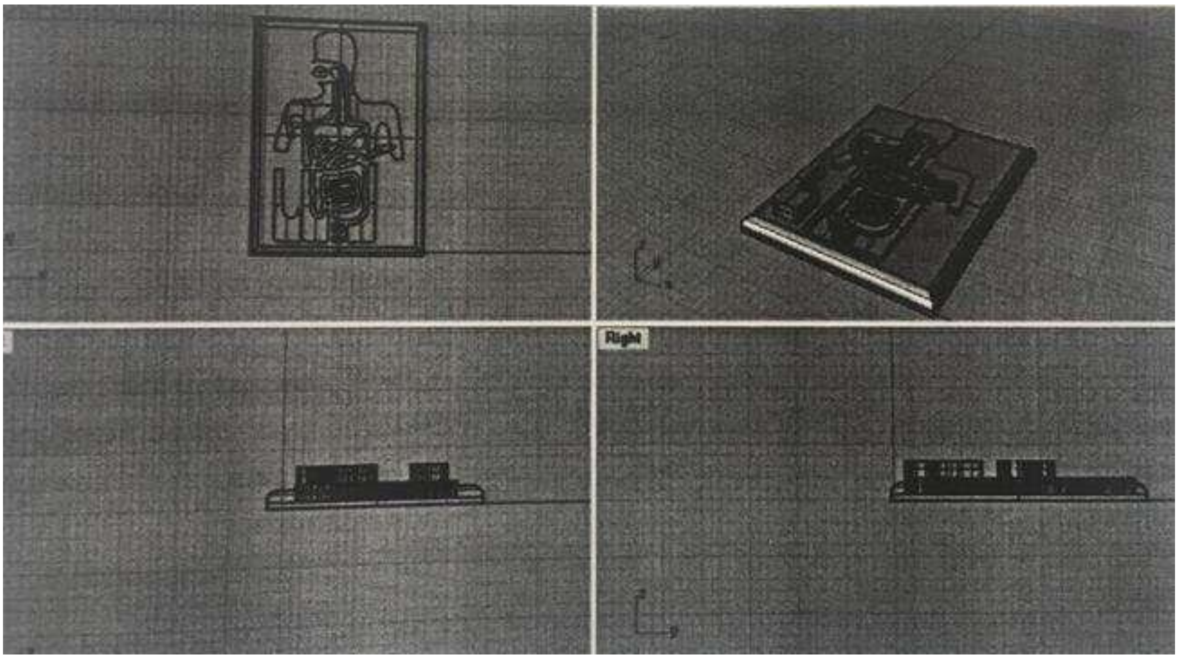

Figure 4. Different views of the Rhino version of the Digestive System.

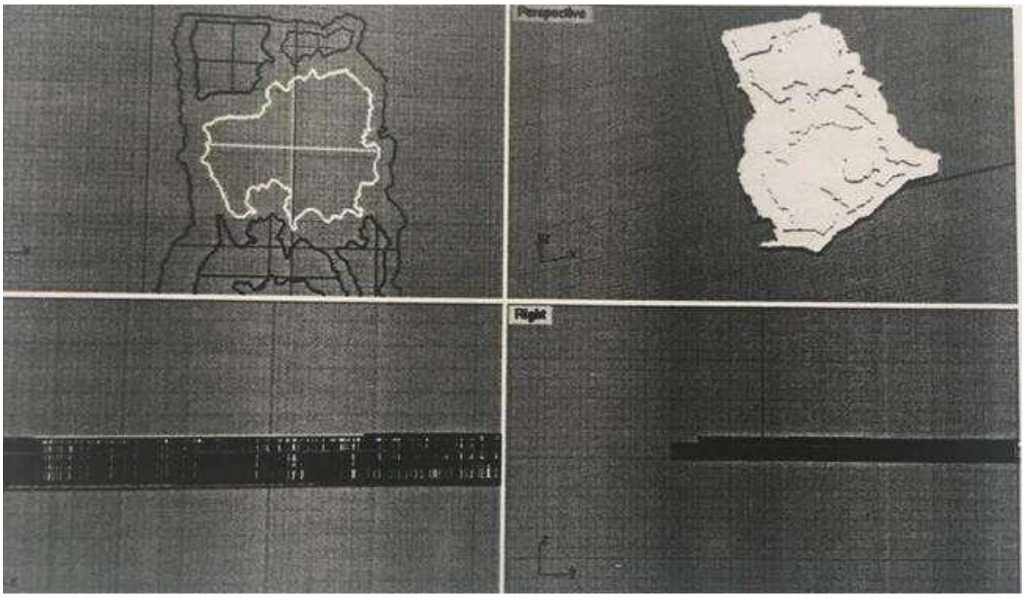

Figure 5. Different views of the rhino version of the Ghana map.

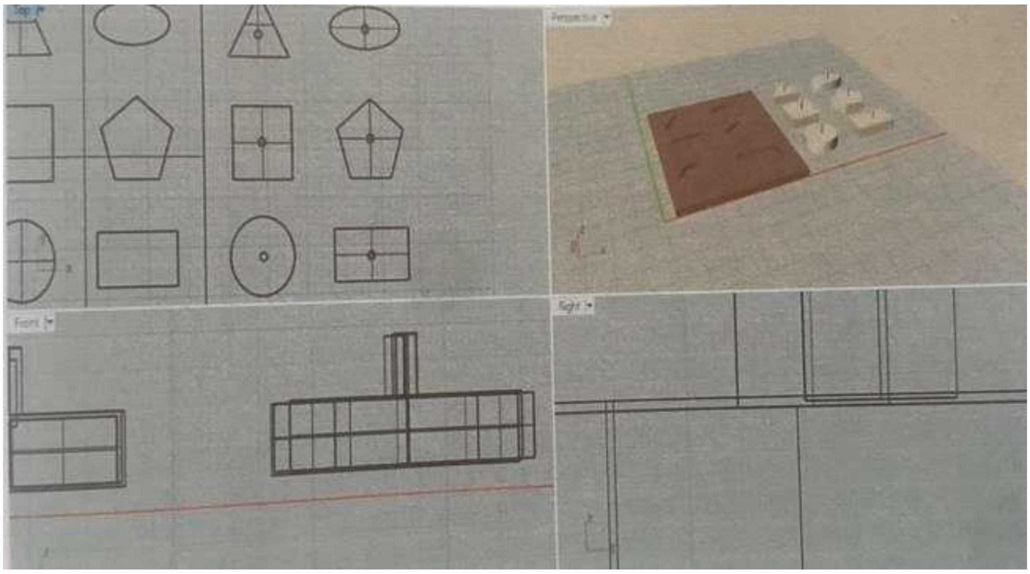

Figure 6. Various views of the rhino version of the toddlers' puzzle.

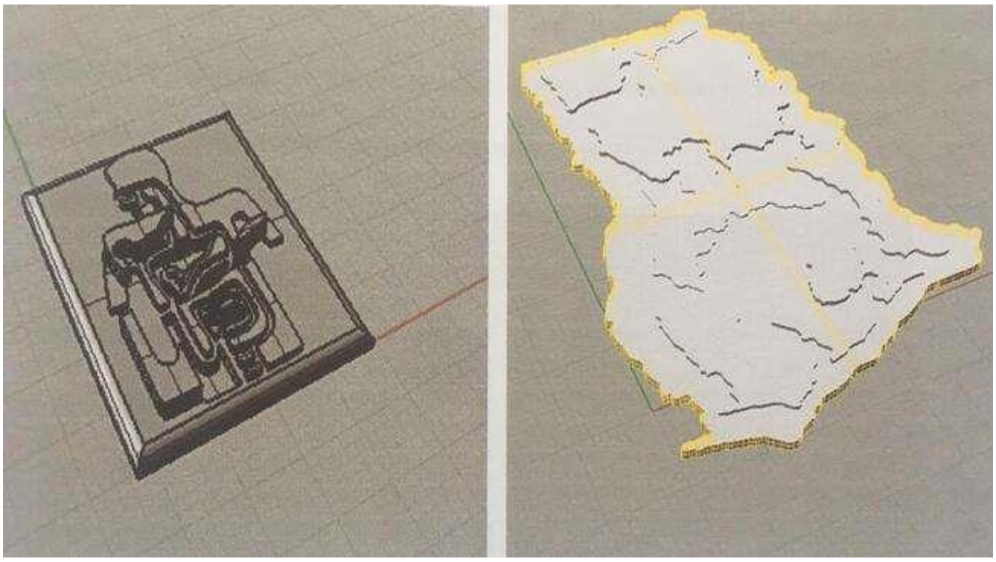

Figure 7. Rhino model of Digestive system and Map of Ghana.

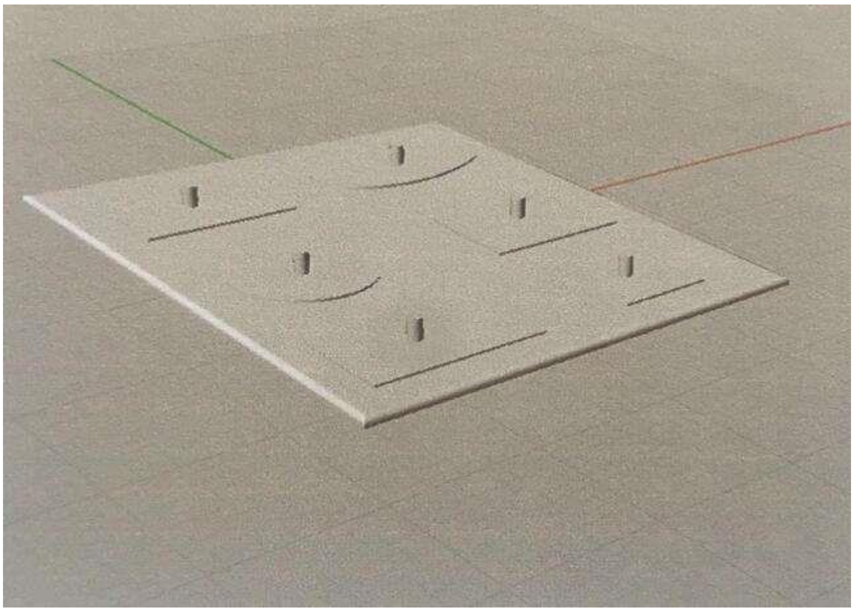

Figure 8. Rhino model of the Toddlers' puzzles respectively.

Figure 9. Key shot rendition of the Digestive system and the Map of Ghana.

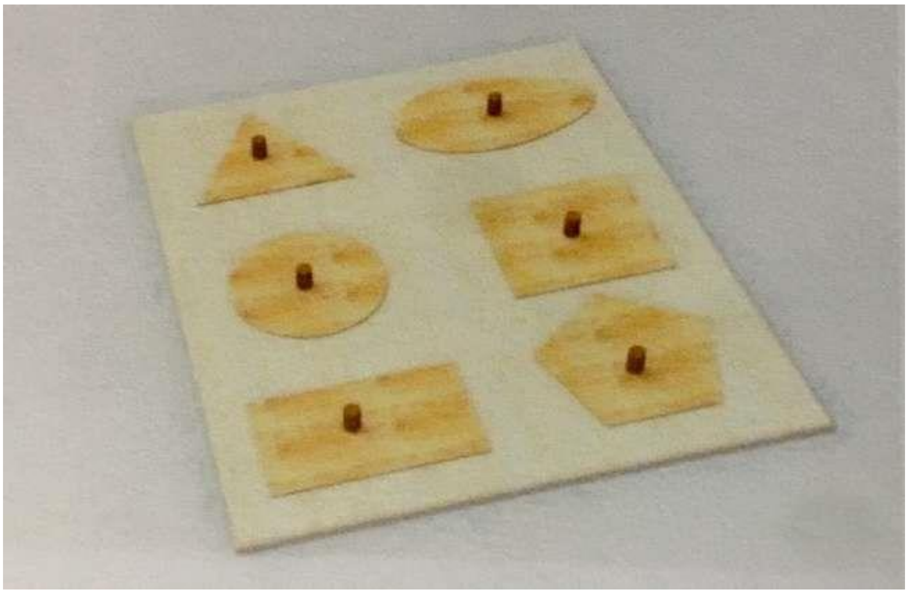

Figure 10. Key shot rendition of the Toddlers' puzzle.

After the puzzles were rendered in key shots for certainty and a clearer view, the production process began. The production process started with the cutting of the wood for the items. The wood that was used was plywood of 1 inch and 0.5cm in thickness. The cutting was further done with the use of crosscutting machine into the various required shapes of 21cm (in width) by 29cm (in length). Figures 11 and 12 show the cutting process.

3.3 Production phase of the puzzles

Before the production of the Toddlers' Puzzle, there was a critical look at the wooden material designed and all necessary checks were also critically looked at.

Figure 11. Cutting and sanding of wooden boards on the sander.

The wooden boards were cut along and across the grain into appreciable sizes. The boards were then sanded using the sander (sanding machine) to achieve a smooth surface. When the sanding process was complete, the designs were transferred onto the board and pierced with the automated piercing machine, as seen in figures 12-14.

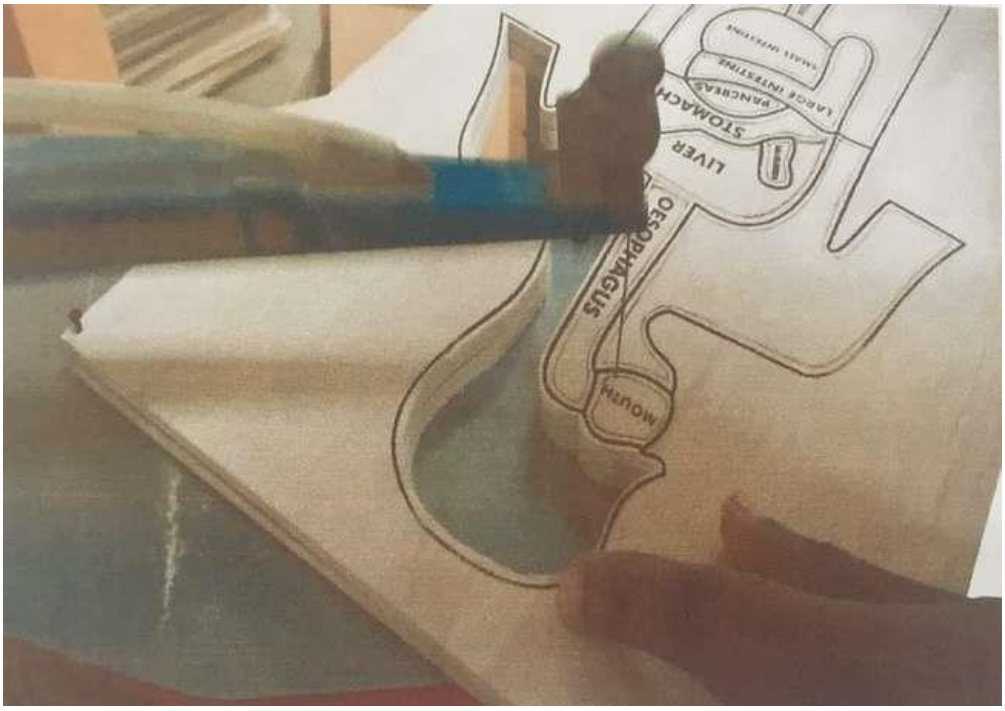

Figure 12. Piercing of the Digestive system puzzle.

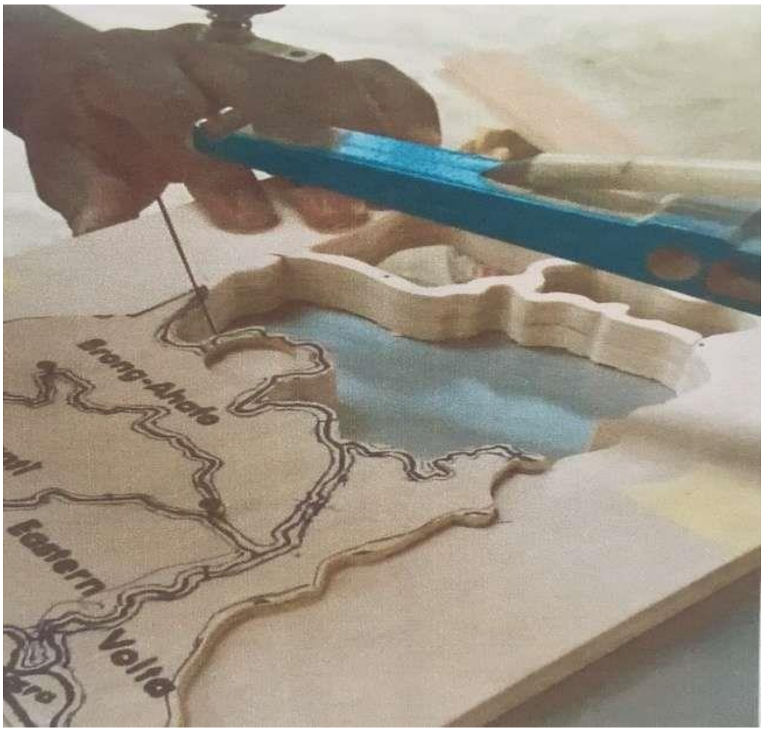

Figure 13. Piercing of the Map of Ghana puzzle.

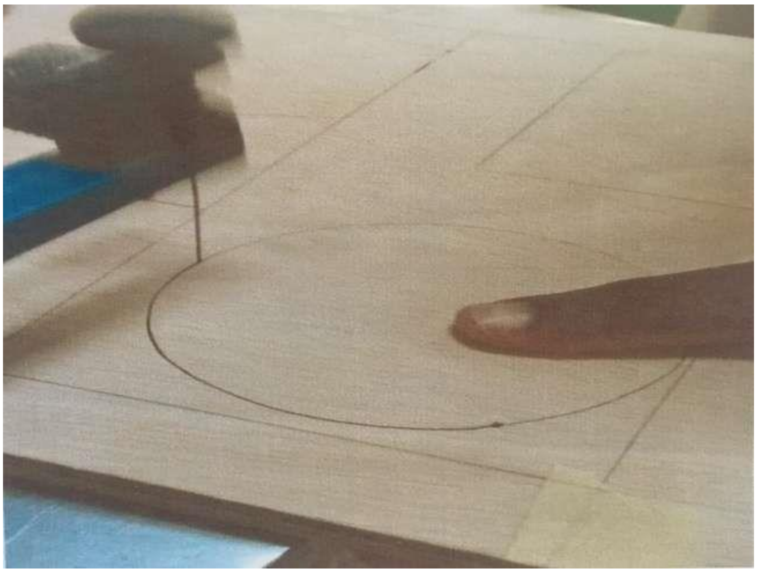

Figure 14. Piercing of the Toddlers' puzzle.

Before the designs were pierced, the sanding process took place. This was not done for the joining but also to give a smooth finish for the final finishing process. The parts when pierced cannot be sanded because of the hollow and fragile nature of the board after the piercing was done. Hence, the reason for sanding the board before piercing.

The next step after piercing was joining. The boards came in two parts for each item. The upper board, which is the pierced work, and the lower

Figure 15. Smearing of white glue on a pierced map of Ghana puzzle.

board will be joined to the pierced work as a covering or base. The mode for joining was the smearing of PVA glue (also known as white glue) on both surfaces and joining together. They were further clamped together for a stronger bond and joint. Figures 15-17 show images of the joining process.

Figure 16. Smearing glue on pierced digestive system puzzle.

Figure 17. Smearing glue on Toddlers' puzzle.

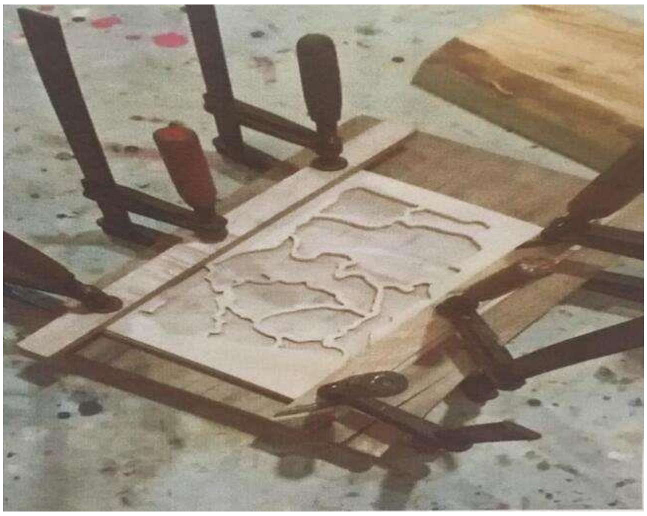

Figure 18. Clamping of the various puzzles.

The puzzles are clamped for close to 5 hours to achieve a strong bond and joints. When the clamps were removed, the sanding sealer was applied with the help of the brush on the entire surface. Thereafter, they (puzzles) were sanded manually using the emery cloth (a smoother grain of sandpaper). The reason for the smearing of sealer over the works is simply to cover all pores and make it extra smooth and fine for the application of the final finish. Finally, the works were sprayed with a mixture of oil dissolved in thinner as seen in Figure 19.

They were then made to dry under the sun for hours to achieve a sheen appearance.

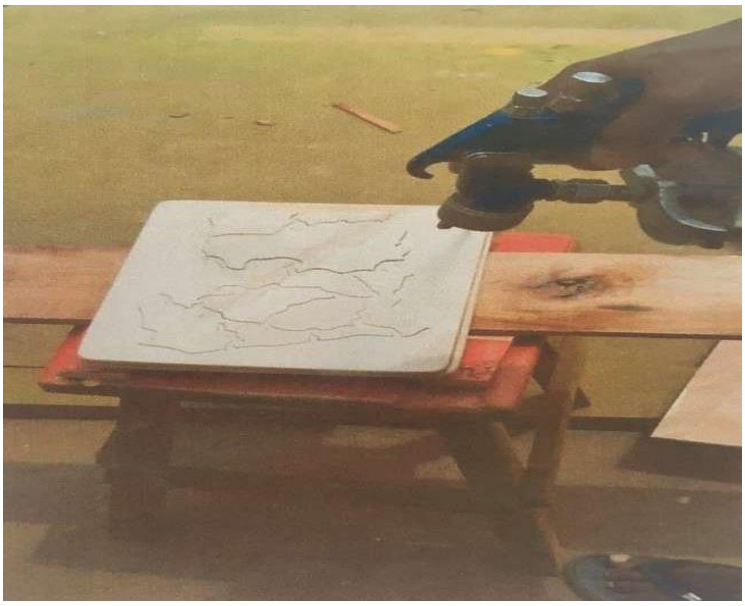

Figure 19. Spraying of the wooden puzzles.

3.4 Designing phase of the shape posting box

The designing phase started with concept designs which are sketches of how the shapes look and how they will be presented on the box. The designing phase continues with rhino models and key shot renditions of the item (see Figure 20).

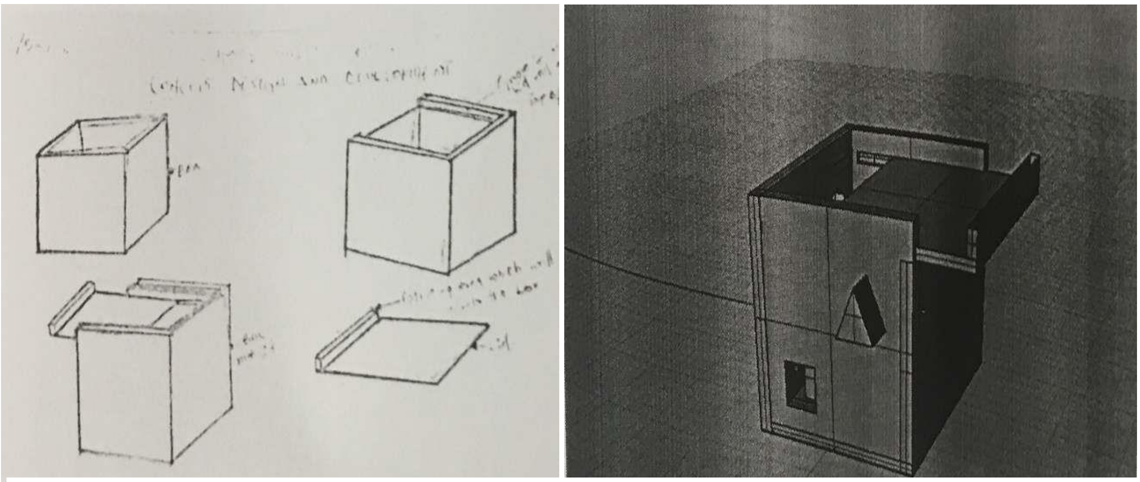

Figure 10. Sketches and rhino renditions of the shape posting box.

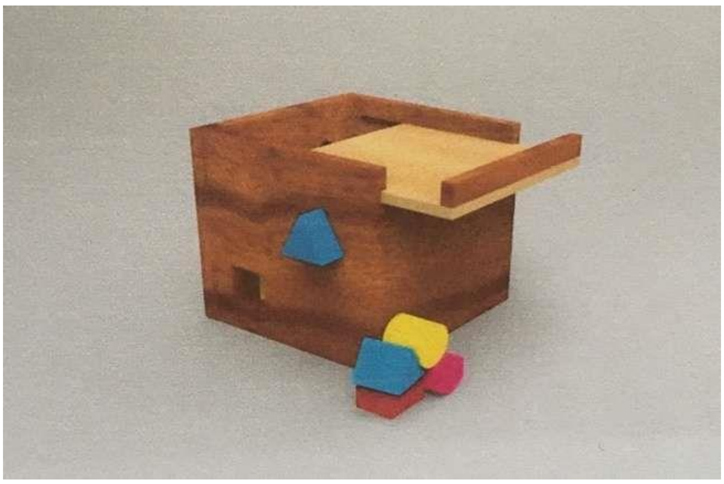

Figure 21. Final Key shot rendition of the shape posting box.

The shape posting box (Figure 21) is an item used for teaching pupils how to identify various shapes. Shapes such as squares, rectangles, circles, etc. The shapes are inserted through the box which has various holes for every shape. A template of the various shapes used during the production was made. These were accurately measured in part. The squares' dimensions were 24mm x 24mm (all four sides), the rectangle was 20mm (vertical height) x 28mm (horizontal height), the circle was 28cm circumferential and the pentagon was 30mm on all five sides and the hexagon 28mm also on all six sides.

The carpenter's square was used to check the accuracy of all the sides after which grooves were created to serve as borders in the wood. The piercing process was done to cut out the various shapes after which the box and the cut-out shapes were sanded completely to attain a smooth and neat finish. The various shapes were neatly painted and allowed to dry. Thereafter the emery paper was applied to the box for a smoother and finer finish. The box was further finished by spraying with lacquer and allowed to dry in the sun as indicated in figures 22-24.

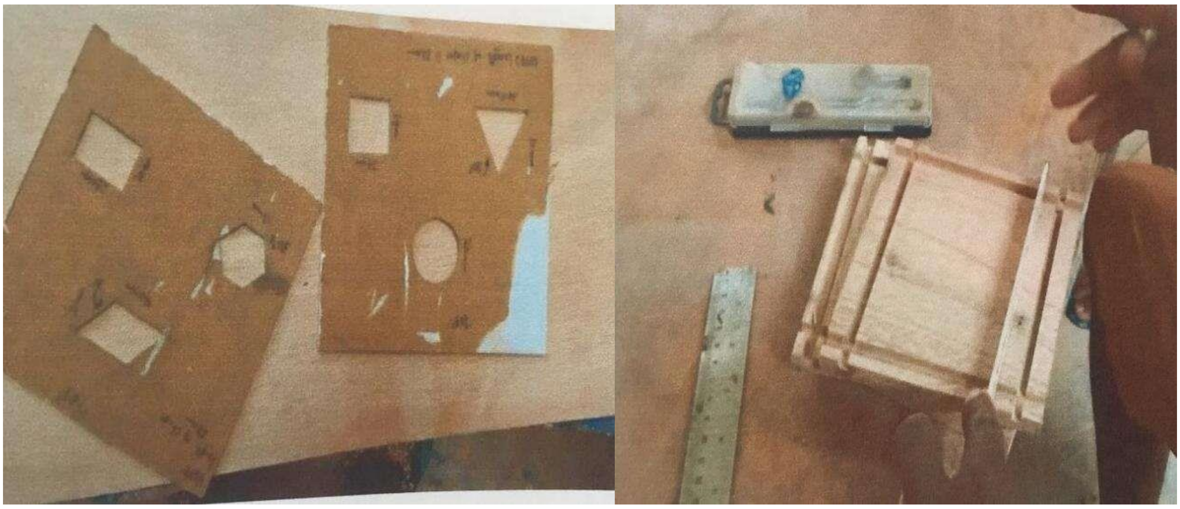

Figure 22. Carpentry works of the shape posting box.

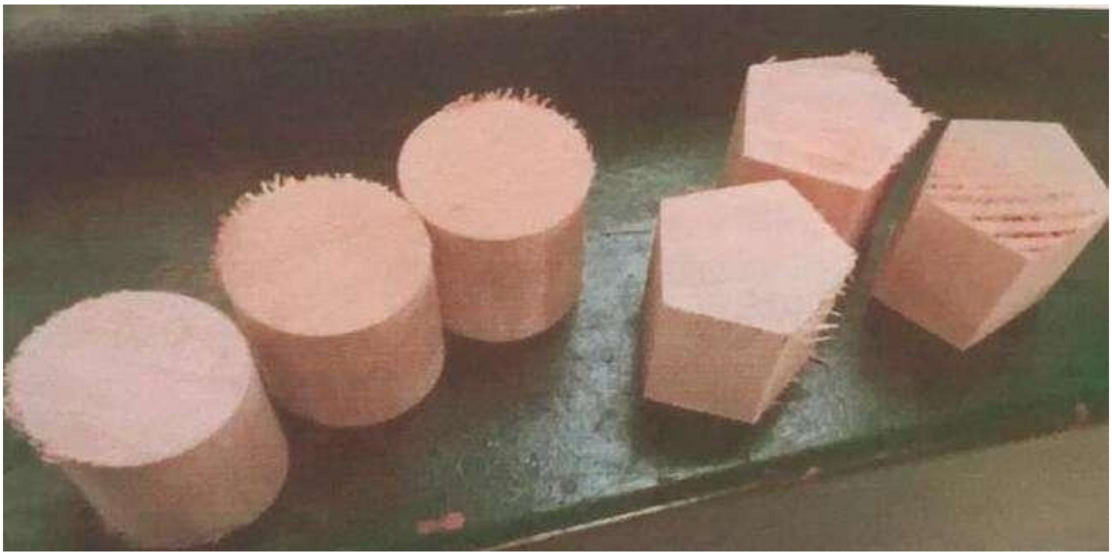

Figure 23. Pierced shapes for the insertion on the box and painting of shapes.

Figure 24. The complete painted shapes and assembled box.

3.5 Designing phase of the addition machine

The addition machine is a box for teaching mathematics. It has been designed such that a student can count several items by placing the countess through two (2) different holes of a box and counting out the sum from a collector attached to the box. The process from designing to production has been described below. The design started with a series of sketches, modeled in rhino and further rendered in key shots.

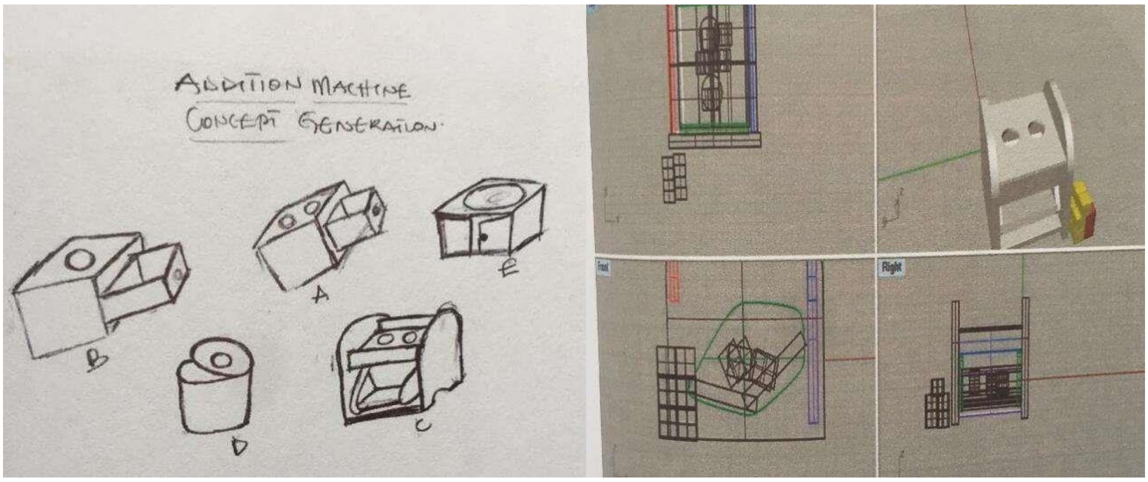

Figure 25. Series of sketches and rhino renditions of Addition machine.

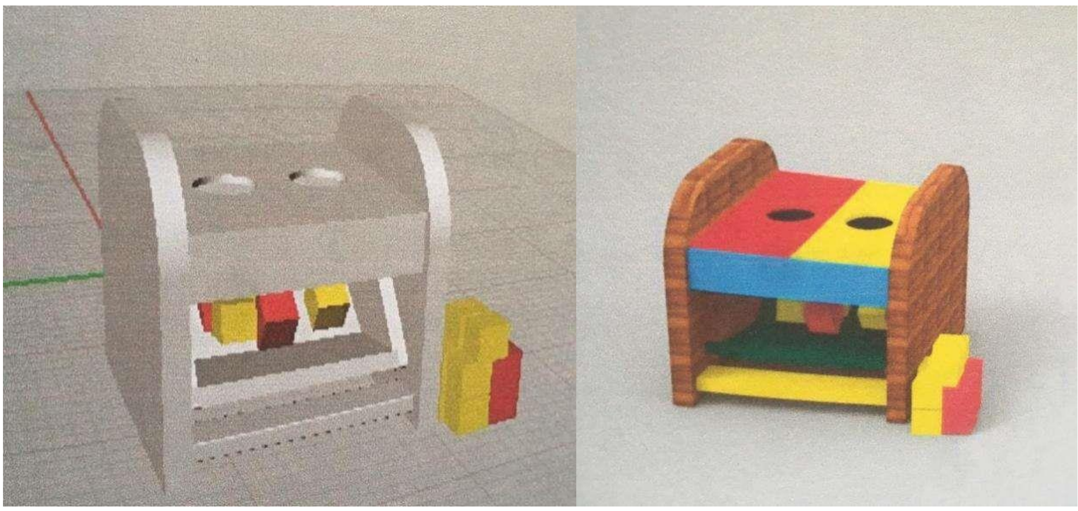

Figure 26. Final rhino renditions of Addition machine.

3.6 Production phase of the addition machine

Figure 27. Cutting and template grooving of addition machine.

The production started with a template designed to follow the steps in making the addition machine. The wood of 6 x 6 inches was cut to fit the template and with the use of the router, grooves were made in the wood. The parts of the addition machine are the box, the collector, and the counting hole. The process started with the production of the box.

The addition machine comes in parts, which have been put together. They are the box, the collector, and the holes for counting. The collector is then created by making grooves in the pieces of wooden boards with grooves created in them. They are then painted leaving the parts and put together by gluing the parts to form the collector as seen in Figure 28.

Figure 28. Cut and joint parts to form the final collector.

All the various parts are then assembled and fixed together. The assembling was done by smearing glue into the grooves and all the parts fixed together. Figure 29 shows an assembled addition machine.

Figure 29. An assembled Addition and Subtraction machine.

At the end of the entire production, packaging, and labeling were done. Packages were produced from wood and they came in wooden boxes. They were produced in sizes that can house the items. For example, all the puzzles were contained in the same package since they were all of the same sizes.

4. Results and discussion

After the execution of the project, post-project personal interviews were conducted with four teachers and six learners living with blindness and visual impairment in the Akrokeri School for the Blind. The teachers and students were very much excited about the innovative projects which they averred would improve the teaching and learning activities in the school. The teachers mentioned that they were handicapped in terms of teaching and learning resources. They remarked that aside from the usual Braille and Kebarison board, they did not have any other resources to aid in their teaching. They mentioned that their greatest challenge had to do with getting teaching and learning resources for teaching Basic Science and Mathematics. The Science teachers disclosed at the interview that:

The tactile TLMs that you have produced for us which are the Human Digestive System and the Respiratory System would tremendously help me and the students when teaching biology, especially in topics such as respiration and digestion. The students with these tools would be able to identify and have a feel of the specific body organs that perform these functions and the chain of their operations (Teacher-Akrokeri School, Personal Communication, May 2022).

Likewise, the students were overjoyed as they experimented with these tactile TLMs. They said that it would bolster their understanding, heighten their interest in the Science subject and make them active participants in the class. One of the students living with blindness told the researchers:

I can now enjoy the class because I can learn better when I learn through touching things. Now, I do not have to just imagine things in my mind's eye but get a feel of how there are, their distinctive features that merit consideration. Learning the shapes of the body parts and organs via these tactile TLMs gives me joy and it has taken my mind off the notion that I have been excluded from the teaching and learning processes in the classroom (Blind-Student, Personal Communication, May 2022).

Their assertions noted by the Science tutor and students in this study are in tandem with the findings from the studies of Onasanya (2004) as well as Ayerteye et al. (2019) who equally observed that TLMs enhanced students' motivation, increased their levels of understanding, and ensured their active participation during the study of the Social Studies subject at the Basic school level. Ayerteye et al. (2019) further observed that the basic schools that rarely used TLMs experienced passive involvement of their learners and concepts were taught in abstraction making it difficult for the students to understand. Opare et al. (2018) similarly noted in a Physics practical class in selected Colleges of Education in Ghana that due to the absence of TLMs in the delivery of class lessons, the students were observed as listeners instead of they been active participants. This implies that when efforts are put to design and produce TLMs in relation to the content to be taught to students, it has the advantage of aiding in achieving the set learning objectives for a subject (Frimpong, 2017) with the maximum cooperation and participation of students.

The Mathematics teacher was equally grateful for the production of the Toddlers' Puzzle to enable the students in identifying certain basic shapes by touching them. Also, he expressed profound gratitude for the Addition and Subtraction Machine designed to help the students in performing basic arithmetic functions such as additions and subtractions. He told the researchers that:

There is a phobia of studying Mathematics among Ghanaian students as you may be aware and this is also evident in the students living with blindness and visual impairment in this school. Therefore, increasing their retention and interest in Mathematics requires the provision of efficient TLMs. I am glad your tactile TLMs will make my Maths lessons more fruitful (Mathematics Tutor, Personal Communication, April 2022).

The study's observation of increased retention, interest, and practical involvement in the Mathematics subject similarly agrees with the observation of Kyeremeh and Osei-Poku (2020) at the St. Ambrose College of Education in Ghana. They observed the active participation of students in the subjects that were taught, which bolstered their interest and retention. Agreeably, Tomlinson (2011) observed the heightened interest of learners anytime TLMs are used in lesson delivery.

The Geographical Map of Ghana TLM which was designed to help the students in identifying various locations, regions, and their capitals in Ghana via touching was also lauded by the Social Studies teacher and the students. They also indicated that the TLMs will boost interest and make the class lively. Generally, the teachers and students suggested that if there were more of these tactile TLMs to assist the teaching and learning of other topics in Science, Mathematics, and Social Studies, as well as in other subjects, they would greatly help improve the learning outcomes of the students. Their views indicate that TLMs make the class lively, and deepen the meaningfulness of a lesson through the active involvement of students as Frimpong et al. (2021) equally observed in an early childhood education setting at the Agona East district in the Central Region of Ghana. These significant benefits of TLMs observed in the lesson delivery in this study elevate the import of the view of Lucy et al. (2022) who posit that the entire success of a lesson is pivoted on the use of well-developed and customized TLMs.

5. Conclusion and policy implication

This design-based research under the qualitative approach was conducted with the overarching purpose of designing and producing innovative tactile teaching and learning materials for teaching students living with blindness and visual impairment at the Akropong School for the Blind, Ghana. The tactile TLMs were to serve as an intervention to improve the teaching and learning activities in Integrated Science, Mathematics, and Social Studies. After the production of the tactile TLMs, post-project personal interviews with selected tutors and students living with blindness and visual impairment to evaluate and garner their reflections on how the tactile TLMs affected teaching and learning activities. The key findings of the study were that the tactile TLMs produced using the procedural steps in the design-based research positively reflected on the retention, interest, participation, and learning processes of the students living with blindness and visual impairment. Therefore, the study contends that tactile TLMs have the potential to positively motivate students living with blindness and visual impairment to be active participants in the teaching and learning processes. Moreover, tactile TLMs have the potential of heightening the interests, and deepening the knowledge and retention levels of students living with blindness and visual impairment even in seemingly difficult subjects such as Mathematics. These conclusions drawn from the key findings of the study have significant policy implications in the education of students with special needs, especially those living with blindness and visual impairment. The production and supply of tactile TLMs customized for specific subjects must be a key factor in all policy-related documents for the education of students living with blindness and visual impairment at all levels of education. The Ministry of Education should drive the need to establish instructional resource centres in their respective education district offices where artists will be engaged to produce subject-specific tactile TLMs and other forms of TLMs to positively impact the teaching and learning activities of all students. Non-Governmental Organizations and funding agencies in education at all levels especially those for special needs education must prioritize funding for the production of TLMs to bolster the interest and ensure the active participation of students. Future studies must consider using quantitative approaches in measuring the impacts of tactile TLMs on the learning processes and learning outcomes of students living with blindness and visual impairment by using control and experimental groups. These studies will help us to better appreciate the significance of tactile TLMs in improving the learning potentials and outcomes f students living with blindness and visual impairment.

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