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Design and Development of A 3d Printer.

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Abstract

By design, this study takes a practical approach to address specific objectives defined as; to study different methods of 3-D printer and their application, Identify and study /investigate the working procedure of a 3-D printer and discuss its evolution thereby design and fabricate a 3-d printer using a tool kit.

In achieving the study objectives methods used and principles followed were observations, interviews and discussions on one hand and adherence to ethical issues that govern the study guidelines such as confidentiality considerations where this was applicable on the other. The study also explored and discussed the different 3-d printing methods, designs and components of the various different 3-d models by way of their respective illustrations.

3D printing is called as desktop fabrication. It is a process of prototyping where by a structure is synthesized from a 3d model. The 3d model is stored in as a STL format and after that forwarded to a 3D printer. It can use a wide range of materials such as ABS, PLA, and composites as well.3D printing is a rapidly developing and cost optimized form of rapid prototyping. The 3D printer prints the CAD design layer by layer forming a real object. 3D printing process is derived from inkjet desktop printers in which multiple deposit jets and the printing material, layer by layer derived from the CAD 3D data.

3D printing significantly challenges mass production processes in the future. This type of printing is predicted to influence industries, like automotive, medical, education, equipment, consumer products industries and various businesses.

KEYWORDS: *3d printing, Rapid Prototyping, ABS, PLA*

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CHAPTER 1

Introduction

A 3D printer is a machine designed to manufacture or produce a three-dimensional solid object from a digital file. This is unlike the opposite of subtractive form of manufacturing which involves cutting and hollowing out a piece of metal or wood or plastic in order to bring out a desired shape. The creation of a 3D printed object is achieved using additive processes where an object is created by laying down successive layers of material. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.

A 3-D machine also uses a CAD model for Rapid Prototyping Process. Through the process of desktop fabrication and prototyping, a structure is synthesized from a 3-d model. This 3-d design is stored in as STL format, and then forwarded to the 3-d printer. It uses a wide range of materials such as ABS, PLA and Composites as well. 3D printing is one kind of rapidly developing applications used in for rapid prototyping at a cost optimized form.

A 3-D Printing process is derived from inkjet at desktop printers, in which multiple deposits jets and printing is diversifying accelerating our lives, letting various qualities of products to be synthesized easier and faster. Three-dimensional 3D printing has the ability to influence or impact the transmission of information in ways similar to the influence of such earlier technologies as photocopying devices. This identifies sources of information on 3D printing, its technology, required software and applications. With the aid of 3D printing no possible challenges exist resulting from foreseeable mass production processes in the future. 3D printing influences many such as automotive architecture, education, medical, businesses and consumer industries to design and develop innovations that can favorably compete and fit into the demands of this market competitive technological and changing world.

The reason of this study is to find out how different methods of 3D printer are used and applied and discover how the 3D printer through its different components produces quality work. Further, the study will establish and explain how the 3D printer has evolved over space and time hence with this knowledge and information acquired being able to design and fabricate a 3D printer using a toolkit. A toolkit in this thesis is defined and described as a collection of teaching and training material package that explains details and processes or procedures on how the 3D printer works and also gives in depth information on the differences and similarities between and among types of 3D models. The identified training/teaching needs generated from the 3D study methods are to form a basis for developing the necessary training/teaching interventions that will enable the researcher make appropriate recommendations to training providers intended to contribute practical solutions to the growth, diversification and exploitation of the socio-economic opportunities that obtain in respective districts of our nation generally. The considered view is that using a toolkit as resource learning and teaching material leads to the promotion of learner-teacher close interaction as genuine dialogue between the learner and the teacher and the result of which is application, appreciation and sustainability in utilization of acquired knowledge and skills on the part of the learner in the world of work.

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Background Information.

The background to the study on 3D printer methods needs to be explained in order to help establish and understand the purpose for which this study was carried out in areas of studying the application, use and working procedures of a 3D printer and discover how it has evolved over time and space. Man's technological development has evolved over a long period of time and has equally been gradual from stone to iron ages and in between having passed through different stages of technological development. This means that according to history man has graduated from what has been described as primitive society to where we currently are in the computer age. In between man's historical development has not only grown from strength to strength and yet so too has been the increase in population globally thereby demanding new innovations required to meet the changing and increased socio-economic and political demands dictating and governing the same human society. Man has learnt to survive and fit into this changing world generally through new innovations such as 3D printing models. The need to design and fabricate a 3D printer using a tool kit can therefore not be separated from this equation.

It should be explained that originally printed scriptures had been dominated by 2-d printing methods. Although these methods provided the easy means to read and comprehend the imaging and creation of real pictures describing real life situations, they were by far not comparable to 3D printer innovations in so far as their level of quality products were concerned. In addition, the 2-d printing heavily depended on out sourcing thereby raising critical and crucial questions of empowerment and ownership. The other point worth stressing is that 3D models cannot be represented and displayed in a 2-d work place which is why the background and motivation as well as the scope of this thesis comes into picture that gives a descriptive illustration of this study's genesis. The rendering of the image ushered in the new era of much needed idea of 3-d printing systems. According to the available pieces of literature on 3-d printing it being argued and observed that the singular purpose for division of 3-d printer was to prepare 3-d samples directly on the bed of the printer. This has been described and identified as the most cost reduction and effective way of manufacturing massively well-designed goods and which is why many companies are opting for this type method. This is the basis for the scope and motivation for coming up with stated objectives framed to undertake this particular study.

Problem Statement.

Lack of skills in the provision of a particular service of a printed product has led to poor services and low-quality products. The school as an agent of socialization and teachers being key players in this process contribute to the acquisition of knowledge and skills required for the learner to apply. Learning by doing while pressing emphasis on hands-on teaching approaches is nothing much more other than being all that is required if any desired change among learners graduating from our formal school systems is to bare the meaning worth its sort. The formal school system where learners graduating from such school systems are un able to demonstrate competence in the various respective training fields and work, lack abilities and initiatives to design, fabricate and innovate new technologies will therefore never seize to rob of our nation the much-needed sustainable development in the printing field. Arising from this problematic statement of concerned need for positive discrimination in the manner practical subjects in the field of Design and Technology are taught deserve no much emphasis. Active learner participation in the absence of support learner materials such as toolkit accompanied by well labeled illustrations of different 3D printer methods will continue to impact negatively on desired learner achievement punctuated by reflective learning outcomes. At the core of the identified issues of problematic concerns was the fact that the schools visited during the study were found to be using printing machines which were not only in congruent with the increased pressure of work, usage, and increased demand but also above all resulting factors in compromising the very issues of quality.

1.4 Problem Analysis

Designing, fabricating and developing a 3D printer tool kit requires sufficient knowledge and skills generated from a carefully undertaken study methods on application, uses and evolution of a 3D printer over space and time and from one generation to the next in the manner society has defined development and technology. The insightful information around how 3-d different models, methods and components work is very crucial if the learner utilizing such a tool kit is to benefit from the same knowledge base gathered and documented following the study results.

Further, the frame –work of this problem analysis is drawn from the TEVETA Act No 13 of 1998 as amended by TEVETA Act No 11 of 2005 upon whose mandate TEVETA developed a Practical Assessment Toolkit in various D/T Practical study areas. This step was undertaken according to TEVETA in order to enable the learner achieved desired and required levels of competences that are answerable and in congruent work with market demands. The considered view in this toolkit development process was that the current status-quo was such that dealing with market global competition, there were some noted weaknesses in the way manuals were being designed and used. According to TEVETA a toolkit should be able to deal with formal and informal print challenges and empower the end user who is a learner by way of enabling a learner to being able at demonstrating maximum levels of competence in the world of work. Operating any business enterprise with a code of responsible conduct and training in the sector on how to apply, design, fabricate, use, operate, prepare and adhere to the agreed upon codes is necessary if desired change is to be achieved.

Through the TEVATA toolkit, a learner and a teacher engage in the process of dialogue and this is where a learner and a teacher right from the out- set agree on the ground rules to be followed defining the dos and don’ts. The learner is made to know the content and the way assessment procedures will be conducted and must agree on how this performance out-comes will be assessed and measured. There is an assumption and growing concern that currently 3D printer toolkits in our learning institutions are far from being adequate in field of design and technology. To this extent that this subject appears predominantly on the school time-table most workshops are not responding to need for question of talking walls. In this regard it was important for this study to collect data on various 3D designs and performance using toolkit in the identified learning institutions. To this effect various samples of printing methods and illustrations were explored and investigated as well as reviewed from the available pieces of literature availed during the study tour.

The considered view from the ongoing study scope is that knowledge and information on 3D printer machines is generally inadequate in every sense of the word. Therefore, for learners to be deemed competent there is need to gather insightful information regarding the various models of 3D printing and their respective components.

The study had to be undertaken at David Kaunda National Technical Secondary School and Lusaka Business College in to determine how learning institutions were utilizing and making learners benefit from the 3D print products. It was also envisaged that the findings relating to the studied machines' working principles would ascertain the 3D printing validity, reliability, availability, fairness and flexibility methods applied, utilized and designing and fabricating a localized 3D printing models that answer to local needs. The study had to be undertaken in order to understand how the 3D machines are working and responding to learner needs.

1.5 Justification of the study

Efforts to cause and bring about innovations within the school system which leave out change in the classroom are bound to be wasted. Thompson (1994) points out that best hope for change lie in the teacher who is a major factor in the classroom. But to the extent that limited knowledge in 3D printing continues to be a factor, the tied and tired hands of a teacher can result in poor results. The study was therefore justified in that it aimed to establish working principle of a 3D printer from a classroom situation and address one of the key agents of change who are teachers and with regard as to how teachers define, describe, discuss and explain different methods of 3D printing application, utilization and general performance of various components of a 3D printer to their respective clienteles called learners. The need for teachers who are sensitive to participatory learning approaches to practical subjects cannot be that overemphasized in this sense. For example if gender balancing even on subjects traditionally perceived as male dominated in the classroom is going to be practically approached through positive discrimination so as to create equal learning opportunities for both opposing genders then the nation will be on course moving towards the attainment of EFA millennium development goals enshrined within the desirable description of vision 2030. In this sense this study is justified because it has the potential of influencing the implementation of the classroom practices that promote dialogue as well as equitable participatory learning opportunities in practical subjects within the frame-work of design and technology by cutting across gender. The very fact that this study was by and large undertaken within the scope of the set objectives conceived and developed in order to design and fabricate a 3D printer using a toolkit to be subsequently used as resources for teaching/learning materials in the face of challenging teaching and learning aids in the educational sector of design and technology it is therefore more than justified in every sense of the

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word to be documented in the state that it represents.

1.6 objectives of the study

- The specific objectives are as stated below:
- To study the different methods of a 3D printer.
- To study and explain the working procedure of each component of a 3D printer.
- To design and fabricate a 3D printer using a toolkit.

1.7 Statement of the Scope

Originally the researcher had intended focusing the study on three specific objectives. The first objective was split into two to include the historical origin of the 3D printer as a separate dimension added to it and explaining how it evolved from a 2d printing methodological systems.

Realizing that data collection might have arisen due to none involvement to the affected people on the ground by way of discussion focusing on class room management situations the scope was thus adjusted to address and respond to the four specific objectives in a clearer detail.

This was done by adding a few dimensions to a study content generated from a broader analytical perspective here-in discussed with reference to TEVETA Toolkit requirements. Chilangwa and Maimbolwa in their joint gender study stress need and use of positive discrimination as a basis for promoting gender balanced teacher to pupil interaction, building learner capacity even in subject areas perceived to be male dominated like those in design and technology and suggest that one way for the teacher to succeed in building learner competency and confidence is by applying classroom responsibilities that buy into insightful learning across gender. The basis for scope of this study is learner –centeredness and yet for teachers to be effective in knowledge distribution to learners they need to gather more information on the way the 3D printer works and how the different components relate with each other. In this study the considered view was that clearly labeled illustrations of the 3D models will add more value to the knowledge base for printing and fabricating a 3D printer toolkit for the ultimate benefit for learners. Hence the study objective and scope were refocused to align the thesis within the said frame- work. To collect data around its observation, interviews and discussions were the techniques used define and achieve the set objectives.

1.8 Project Scope.

The general theoretical scope of this study is informed by theories of 3D printer's operational techniques in areas of methods, application, usage, components working procedures and the evolution. The term 3D printer has been defined in context as a desktop fabrication. It is also described as a rapid prototyping process whereby a real object can be easily created from a 3D design. Given the foregoing definition, the concepts of design specification and fabrication are relevant to this study since one of the major questions being addressed is to determine how different components of 3D printer work and relate with each other. Another key question being investigated is to understand the history of how a 3D printer has evolved over time and space. It is also important to discuss why 3D printer is more appropriate currently as compared to 2d prototyping machines which it has slowly replaced from the market. This required a review of literature. The possible difference might have

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been noted and identified in the quality of work produced. For this reason, theories propounded in the evolution and history of 3D were examined in detail to see whether they substantiate the view that the way design and technology is taught in schools may be a contributing factor for the failure of many learners to apply themselves well and be deemed to relevant in the industry or business. Ignoring the influence of culture on learning in this instance, design and technology implies that a student learning outcome may be separated from their day to day lives and, in that sense, create a feeling of dissonance or discontinuity between formal, informal and non-formal learning generally and what is learned as culturally ideal even after school.

1.8 The limitation of the study

It is **limited** to parameters below:

(i) Material

(ii) Sketching and drawing

(iii) Fabrication

I. Material

This study thesis largely depends on the available information collected from a 3D printer machine that was studied. This information is generated from methods, application, usage and working procedures and thereby learning to design and fabricate a 3D printer using a toolkit. As part of the study strategy the components of the 3D printer were investigated, examined, explored and documented by way of illustrations.

II. *Sketching and drawing*

In this study sketching and drawing refer to use of a free hand in sketching. However, while this would have been ideal to illustrate diagrams easily free hand did not apply. Computer software: Google sketch Auto CAD, Solid Works and Sketch Book instead for defining the different design in this study was considered more appropriate. Sketching being the simplest and fastest means of expressing ideas should have been used to illustrate concepts to the people and thereby converting them into CAD drawings.

The use of CAD software helps the designer on 2d to immediately benefit from 3D images as it is being created. After all it is possible to add a detail on 3D model and evolve it into creation that is built. AutoCAD will be used for this purpose.

III *Fabrications*

Utilizing angle grinder for cutting and cleaning arc welding machines for welding operations and sand method for dies (formers) as an ideal process was not particularly during this study situation for the sole reason that it was as much as possible the study was meant to design a toolkit using available data gathered on 3D operational methods.

1.9 Limiting Assumptions to the study Scope

Given that the sample to be studied was relatively small only two institutions of learning from Lusaka urban and that respondents were all from Lusaka, it is possible that the 3D machines identified and attitudes expressed by the people operating them were and are not reflective of a broader range of respondents' country wide.

Therefore, a limitation of the findings in that sense were that it was difficult to generalize the findings to all learning institutions using 3D printer machines country wide in terms of performance, learner participation, access, equity, quality out generally.

Designing and fabricating a 3D printer toolkit will require adequate collection of data and materials and this had to be broad based. To this effect making further recommendations for changes in training programs would have been difficult for this reason even when it comes to making genuine illustrations that require capturing learner interest from a toolkit making point of view.

In addition, it is very likely that different learning needs are manifested in different learning environments depending on time, location or place for example generalized between urban and rural settings and in that sense, this could have been a huge limitation in making appropriate recommendations for both rural and urban situations.

Another important limitation that was considered beforehand is that of language including attitudes that are very difficult to identify and articulate. Cultural nuances are known but may be not easily noted. However, as this research was essentially centered around observation, it did end up into using English in some discussion instances and English is a subject that gives some participants or respondents some grammatical challenges that had to be dealt with. Hence from that perspective it limited the research from following up on threads or practice that had to come out only after translation into local language the workshop attendants for example were not on hand to be aware of the points that required clarification. It was equally hard to come back to explain concepts that might not have been detailed given limited time and financial resources on the part of the researcher therefore at that level this was another factor contributing to the more extended study limitations generally experienced.

Despite the fact that subjects covered under design and technology are generally planned to be practical, observing teacher-pupil interaction was largely dependent on the methods teachers applied themselves to in a classroom situation supported by adequate learning- and – teaching aids. However as it turned out some teachers observed employed talk-and –chalk approach to disseminate information on 3D printing mechanisms to learners of which from the researcher's perspective, such approaches did not encourage active learner participation and this state of affairs was confirmed and noted when some learners were seen dozing instead of paying attention to the ongoing session explanation meant to keep the research well informed about how the 3D printer machine operates.

During the interview and discussions some participants wanted to impress the researcher by telling the researcher what they felt she wanted to hear. The researcher had to be on lookout for such participants and dealt with them professionally.

CHAPTER TWO

LITERATURE REVIEW

At the core of printing technology and associated innovations are designs, functions and methods applied and used that determine the level and degree of quality products obtained. This also describes ways through which a given printing production mechanism was carried out. The aim of which is to ultimately address and meet the needs expressed by the local market.

Chuck H. mentions that 3D printing Technology has a historical background on how it has evolved and developed overtime and space. It was evolved in the mid – 80s and was then developed as a rapid prototyping printing process by Dr Deckard of the Texas University then synthesized the Laser Sintering Technology in the 1990s in order to facilitate the art of printing process so that it grows far and wide. While doing this Dr Deckard was working in association with a project funded by the Defense Advanced Project Research and this is according to the literature reviewed.

However, to the extent that this technology was being improvised with locally advanced methods that utilized the UV light to solidify photopolymer, an argument is being advanced alluding to the fact this design was not originally intended to address poverty and illiteracy issues of problematic concern affecting the marginalized in society. This is particularly those living under very poor rural conditions of Africa and its perceived under developed contexts.

Bradshow et.al observes and mentions that the materials used in the production process of the printing technology were highly vicious and expensive to the extent that ownership was left in the hands of the elites who were also the rich scientists and electronic groupies.

This position therefore explains and justifies the argument and reasons advanced by Bradshow that the poor and illiterate communities did not own and enjoy any benefits from such an innovation during these earlier development stages.

Bord Bar, F (2010) adds by alluding to the fact that developed western countries embarked on their crusade to develop and design new innovations so that they could easily fund alternative ways of addressing their own problems. The poor such as the Africans were initially

not considered in this equation, instead Africans could only be used to provide labour and raw materials from their continent to boast their industrial development. Considered and argued from this perspective, perhaps one would agree with the views expressed by these scholars, African were poor, illiterate and underdeveloped as they had no immediate need and relevance to innovations that were far from addressing their expressed needs namely; food, shelter, safe drinking water, clothes, improved educational and medical facilities or devices.

Another important analytical dimension arising from Board Basic points of view, seem to suggest that not only do most learning institutions especially these located in rural poor African soils suffer from having no electricity but also this position contributes to not having print machines for their own works.

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To this effect printing machine electronically powered are assumed as very irrelevant. Unlike in the western world even the urban schools where machines are expected to perform various roles during examinations and beyond, most of them if not being obsolete, such schools are also under funded leading to equipment and learning material shortages.

Arising from these problematic concerns in school's learner performance in the school of design and technology is affected. One contributing factor is heavy dependency on innovations from abroad rather than developing our own through the Design and Technology Department.

Locally based innovation will meet local needs. While the provision of equal access needs quality, increased participation and issues of equity are continuously described and discussed within the Government revised policy frame – work of Educating Our Future the department of design and technology continues to experience challenges from equipment, computers, manpower shortage and limited infrastructure capacity.

Science and technology are critical in contributing towards the achievement of sustainable development of any nation and the need for increased funding in this sector and continuous human resource development cannot be over emphasized.

The present situation regarding the presence of equipment such as 3D printing machines in most schools is far from ideal in addressing learner challenges Bingimlas K stresses that with increased budgeting allocation model in printing materials can be purchased and facilitate the very desire of hands – on – teaching and learning techniques in schools. With absence of fully developed infrastructure, equipment and spaces for computer library in schools will continue being a source of concern more especially that these subjects are examined naturally.

In their joint report, Tubaishat, A and Lunsari contribute by suggesting that to improve issues of access, quality, participation and equity in design and technology education department need for trained manpower, increased funding, purchase of equipment, repairs priority from the Government's policy perspective.

This will lead to sharpening teaching skills, developing a sense of creativity and innovation among teachers and hence minimize reliance in foreign support for sustainable development of the Nation.

This is acknowledged by Kozma and Andereni who observe that and mention that political will in the development of Educational sector of design and technology should go a step further by having resources directed to this sector as no Nation can develop in the absence of quality education provision to its citizens.

To conclude the literature reviewed and discussed methods, evolution and functions of a 3D printer from a school system perspective. Factors affecting quality education outcomes were identified and discussed.

Further it has been observed and argued that there is sufficient rationale and increased amount of data collected during the study to validate that theories expressed and obtained from the various pieces of literature provided the basis for the frame – work of this study which sought to

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identify factors affecting learner performance in schools.

CHAPTER THREE

DESIGN METHODOLOGY

3.1 Introduction

Data Collection is an important aspect of any type of research study. Inaccurate data collection can impact the results of a study and ultimately lead to invalid results. During the research, the researchers collected primary data using specific qualitative and quantitative methods. Primary Data were collected using planned face to face interviews as well as questionnaires. Secondary Data was collected through reading of various literature which include, newspapers, web blogs, journals and other papers relevant to this research.

Research methodology design was based on the explicit formulation of research question: "Design and development of a 3D printer, perceived by designers". Taking in consideration design knowledge dimensions proposed by Cross research questions was subdivided into three questions about praxeology, epistemology and phenomenology. After that, a research matrix (table below) aligning each research question with research goals and method was developed.

Which are the main contributions of 3D---printing technological shift to product design, perceived by designers, in which concerns to:	Design knowledge (Cross, 2016)	Nature of research	Research goals	Research methods
Design methodology	Praxeology (process/ methodology)	Research throught design (Frayling, 1993; Findeli et al., 2008)	Collect subject perceptions about AM implications on design process	-- Record through individual project notebook; ---Post---intervention interviews (design students, product designers)
Individual design cognition	Epistemology (people/ designers)		Collect subject perceptions about AM implications on design cognition	-- Record through individual project notebooks; -- Protocol studies --- Post---intervention interviews (design students, product designers)
Final artefacts	Phenomenology (products/ artefacts)		Products evaluation regarding complexity, customization, assembly, and others	-- Focus group with external specialist (product designers, product engineers, AM specialists) --- Matrix evaluation

Table. Research methodology matrix.

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From the research of methodology matrix, a research through design two-phase project following the practice-based research concept was conceived. On phase one, two groups of subjects (higher education design students and professional designers) will receive a project brief forcing AM technology as main manufacturing technology. Throughout the project, subjects will record their process iterations and thinking strategies on an individual notebook. Protocol studies and interviews will be applied to collect their perceptions of AM implications on the process methodology and thinking. On phase two, artifacts produced during the phase one will be analysed by a group of specialists through focus group session. An evaluation matrix based on AM potential will help to identify AM features at final concepts/artifacts.

Expected results aiming to explore design possibilities allowed by AM, a practice-based research is being conducted. It is expected to produce knowledge concerning to project methodology, individual cognitive process and produced artifacts.

Starting from the clear formulation of research questions and aims, research methods were clearly defined. By recording and analyzing subjects‟ actions and strategic thinking throughout the design process it is expected to explore AM praxeological and epistemological implications.

Finally, the analysis of the resulting concepts/artifacts should contribute to understand AM phenomenological consequences on design

WORKING PRINCIPLES

ELECTRONIC COMPONENTS

NEMA17 and RAMPS wiring 1.

It is very good idea to have MAIN hot end cooling fan ALWAYS on and other fans for filament cooling controlled by software. In this case you avoid potential effector meltdown.

DCDC step-down electronics is to reduce main fan voltage (speed). Normally 9-10VKossel electronics without heated bed Kossel electronics with A4988 stepper drivers

Main components are microcontroller Arduino Mega, RAMPS 1.4, stepper drivers, Motors are NEMA17 in end switches are optical. Heated had is silicon 200W 12V. Power supply is 12V 20A Kossel electronics with DRV8825 stepper drivers.

Trimmer is on the power supply side Kossel electronics with heated bed connected with relay. If heated bed is big and needs a lot of amps relay is a must. So that RAMPS only opens relay and main current is not going Kossel electronics with heated bed connected with DC solid state relay. If heated bed is big and needs a lot of amps SSR relay is an option. So, RAMPS electronics only opens relay and main current is Kossel electronics with heated bed connected with AC solid state relay. If heated bed is big and needs a lot of amps SSR relay it.

POWER SUPPLY

48V 2.5A SMPS (Switch Mode Power Supply) adapters are used for stepper motors mounted in X and Z directions.24V 2.5A SMPS (Switch Mode Power Supply) adapter is used for stepper

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motor mounted in Ydirection.12V 1A SMPS (Switch Mode Power Supply) adapter is used to drive the microcontroller board.

MICRO-CONTROLLER BOARD

At mega 2561p Arduino Development board is used as the motion control board. At mega 2561 p is a 16-bit 24 pin ARM Architecture microcontroller. The microcontroller is flashed with the GCODE interpreter firmware written in optimized „C" language. Motion control is carried away through output pins connected to the stepper motor drives according to the firmware code in microcontroller. Inputs like RESET, FEED HOLD, CYCLE\ START/RESUME and axis Limits are given to the Inputs of microcontroller

STEPPER MOTOR

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation in a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any feedback sensor (an open-loop controller). A NEMA 23 stepper motor is a stepper motor with a 2.3 x 2.3-inch size is chosen to drive the motion of the axes. NEMA 23 stepper motors are high torque about 19KG-Cm holding torque. NEMA 23 stepper motors have 1.8-degree step angle with 2.5A rated Current Fabrication of Low Cost 3-Axis. The speed of rotation is directly proportional to the pulse frequency. The higher the output voltage from the driver the higher the level of torque drives.

STEPPER MOTOR DRIVER BOARD

The stepper motor driver receives step and direction signals from the microcontroller and converts them into rated high voltage electrical signals to run the step motor. RMCS-1102 is micro-stepping drive designed for smooth and quiet operation is chosen to drive the NEMA 23 stepper motorRMCS-1102 achieves micro-stepping using a synchronous PWM output drive.

RMCS-1102 receives PULSE/STEP, DIRECTION inputs from the microcontroller and generates high rated PWM output signals to stepper motor

LIMIT SWITCHES

A Limit Switch is the simplest type of end stops a simple mechanical switch positioned to trigger when an axis reaches the end of its motion. Limit switches are used to protect the stepper motor and circuit by shutting the motors by triggering the switch when the axis reaches its end. The signal pins from limit switches are connected to the microcontroller board to sense the axes ends.

DESIGN SPECIFICATION

FABRICATION WORK:

Fabrication work is carried away in various steps like Measuring and Marking, Gas cutting, Welding, Grinding, Drilling, Fitting of mechanical parts ready for assemble directly.

After gathering all metal parts and accessories required for assembling, the procedure of making the machine is listed below step by step.

- Start from the base Install four walls of Y axis
- Install main support for Z axis, Install Z axis chamber,

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- Assemble and fix Z axis leadscrew and slides, Install Z axis motor.
- Build XY axis, start from table at the top, Install screw nut connector underneath the table.
- Install and fix leadscrews.
- Install cross roller guide of X axis, Install two motor and complete XY.

Complete machine limit switches.

DESIGN PARTS

Specified pieces and dimensions used in the design and development of a 3D printer.

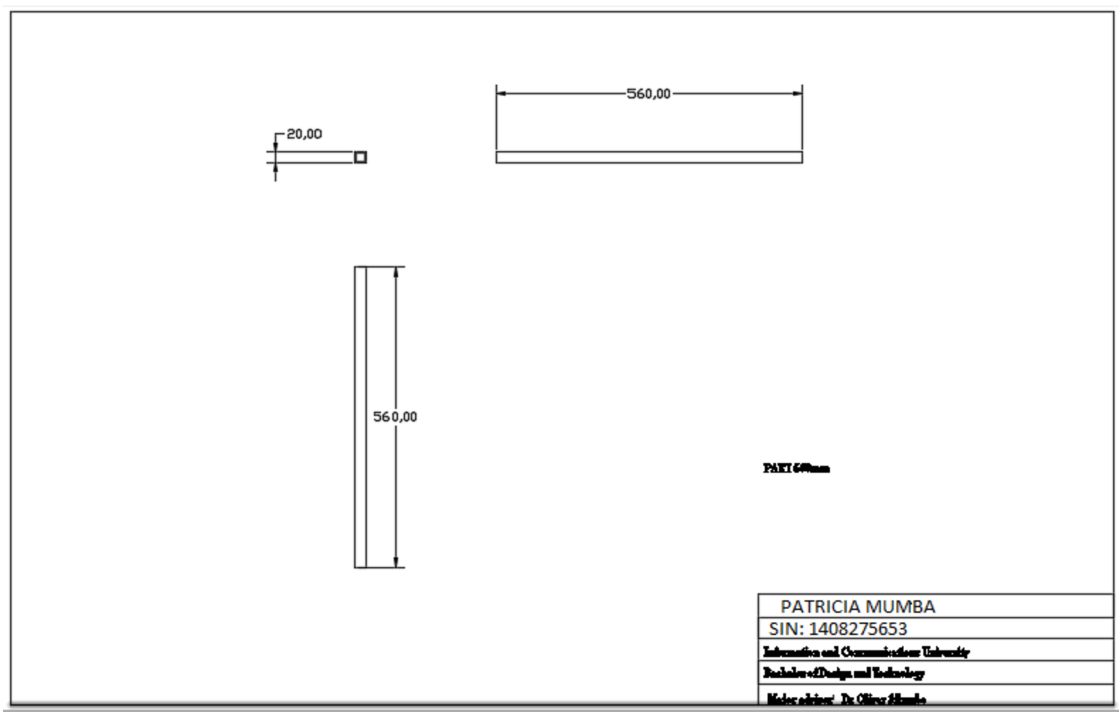

Figure 1 SQUARE TUBE

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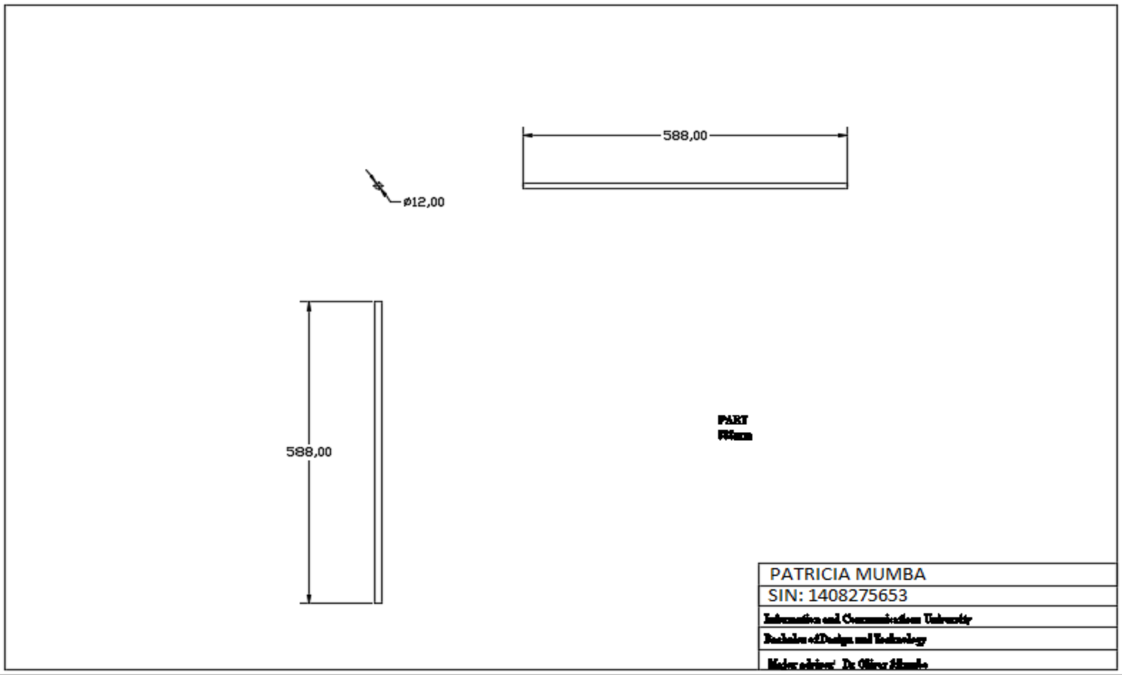

Figure 2 ROUND TUBE

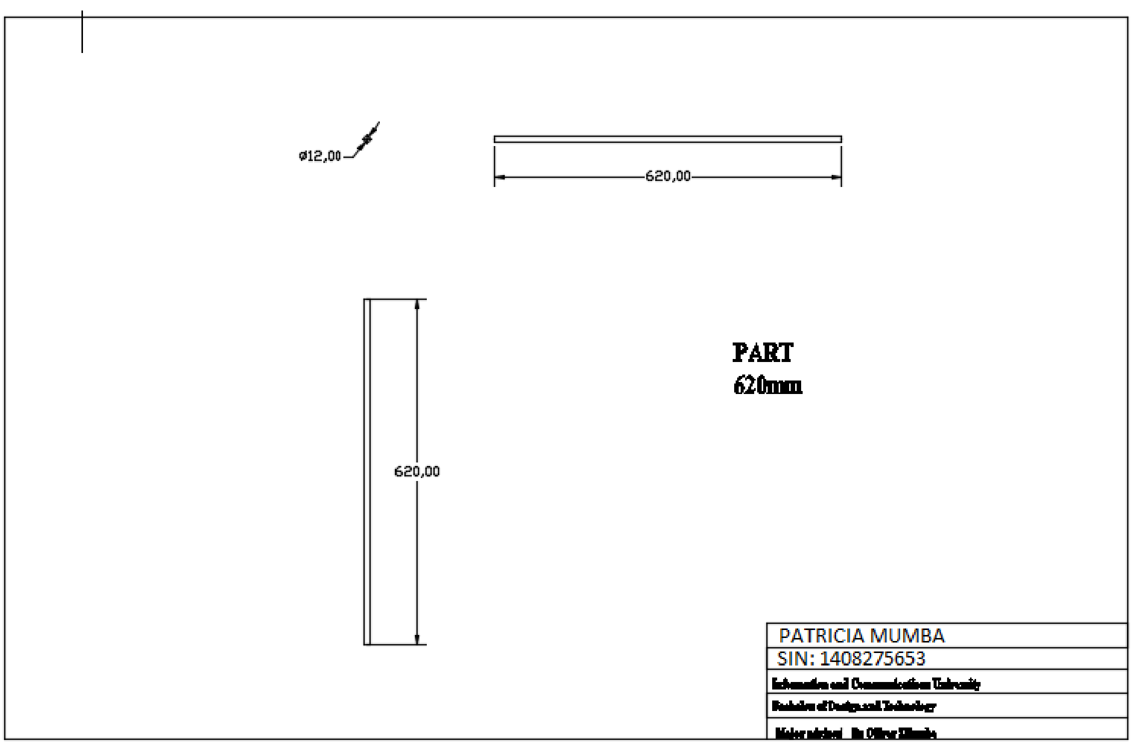

Figure 3 ROUND TUBE

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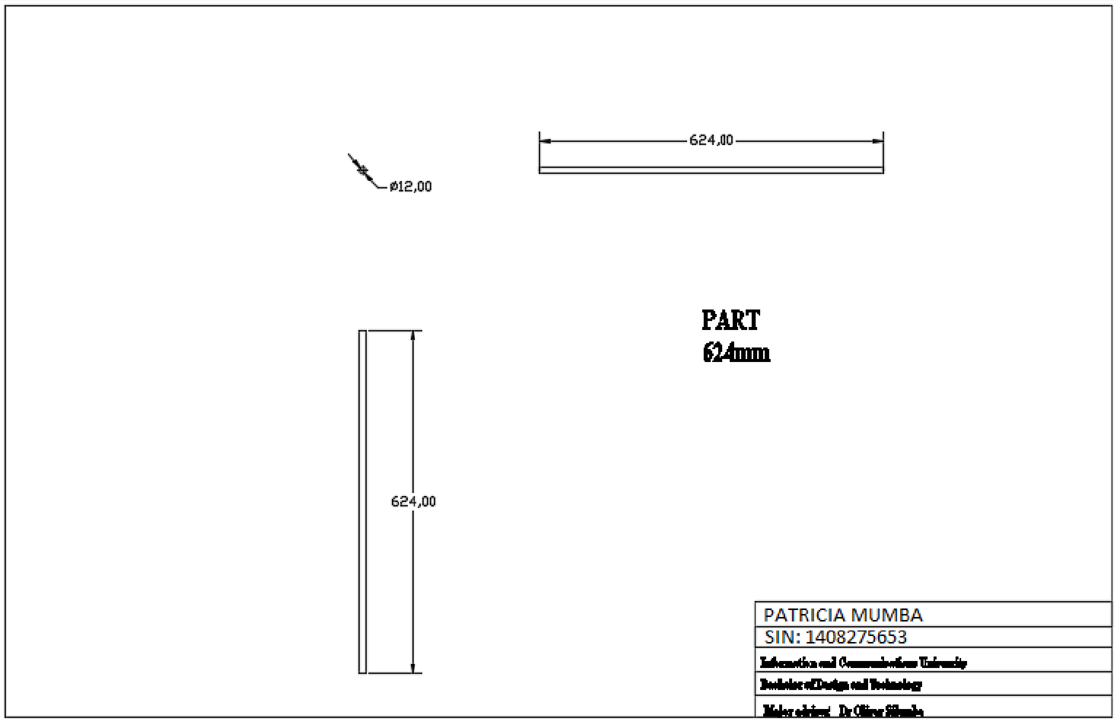

Figure 4 ROUND TUBE D-12

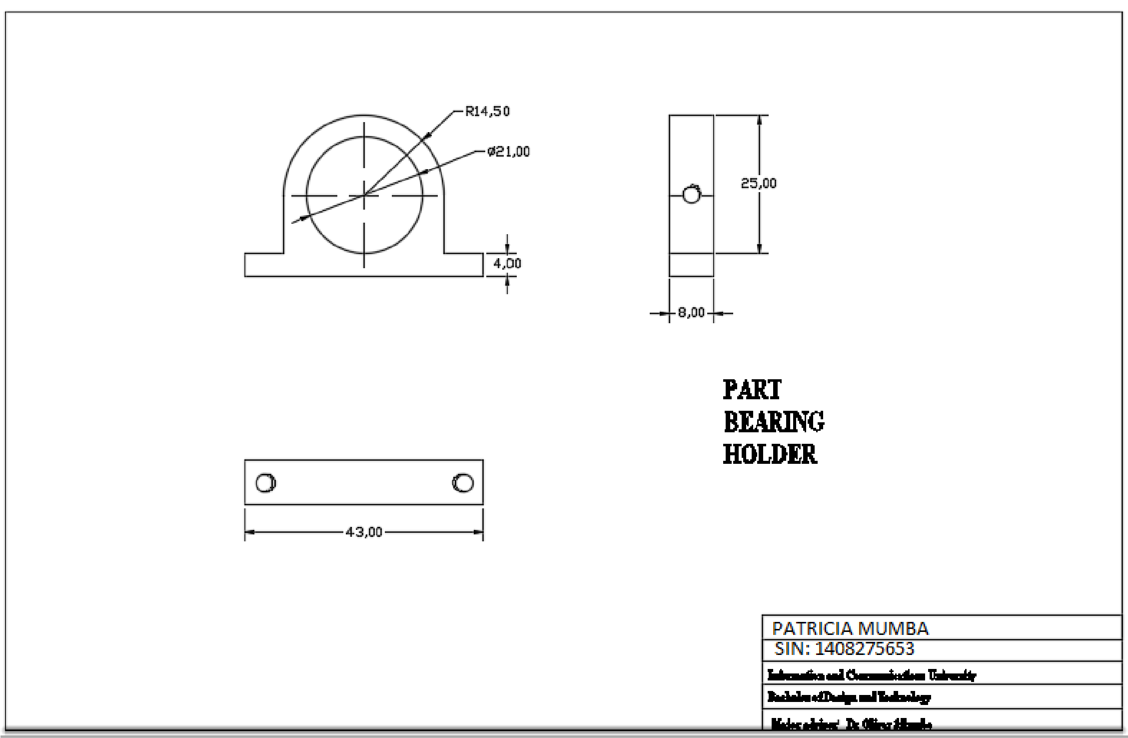

Figure 5 Bearing Holder

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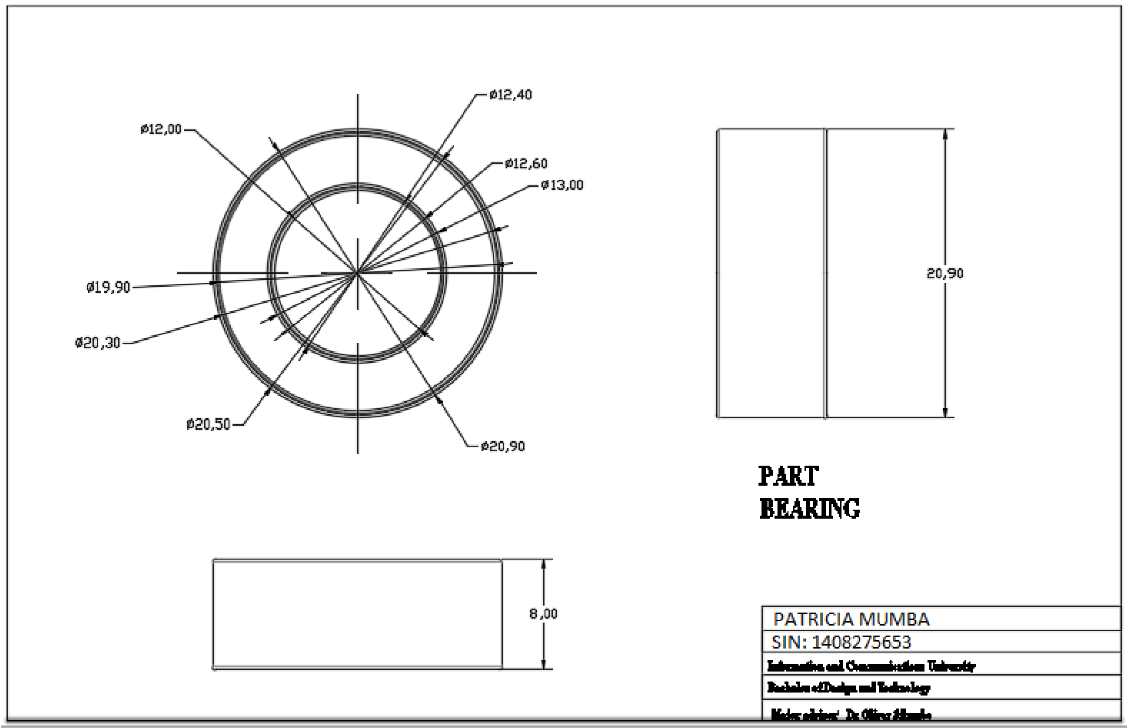

Figure 6 BEARING

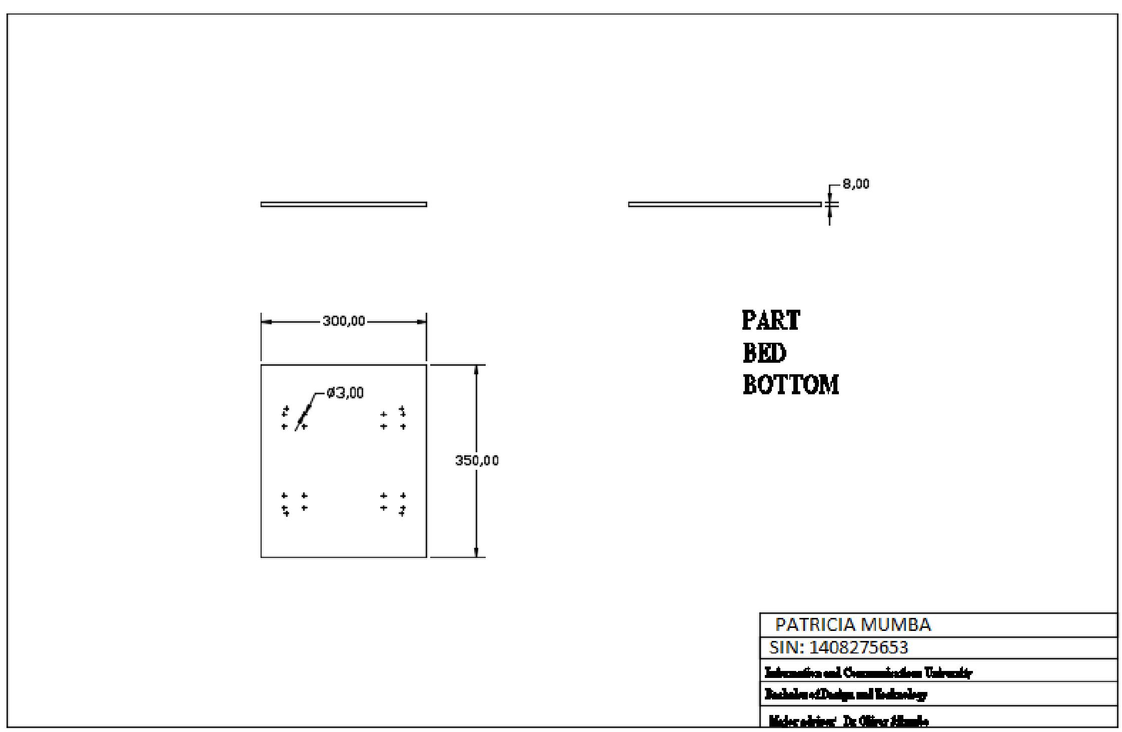

Figure 7 BED BOTTOM

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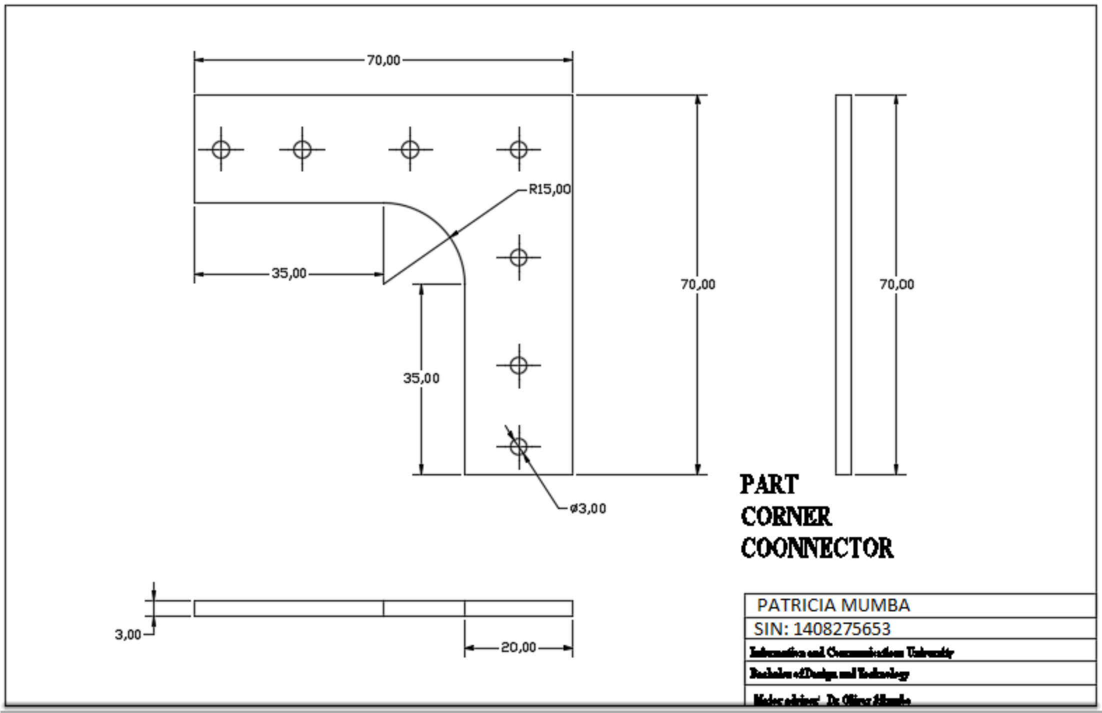

Figure 8 PART CORNER CONNECTOR

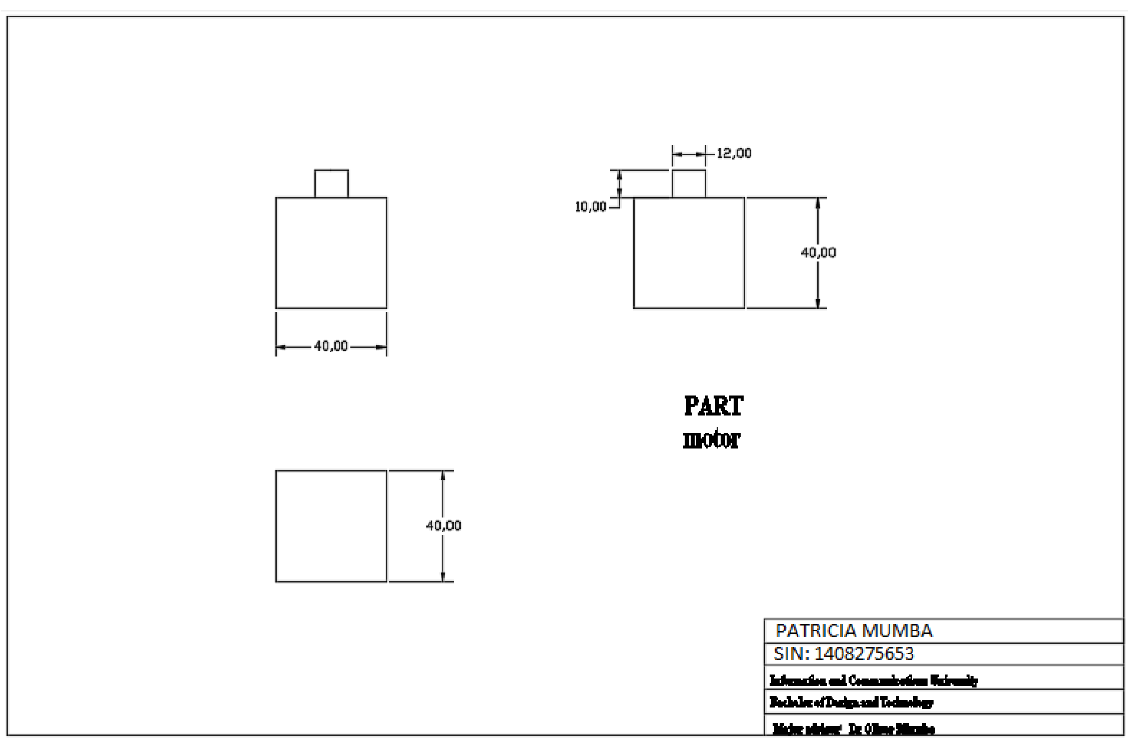

Figure 9 MOTOR

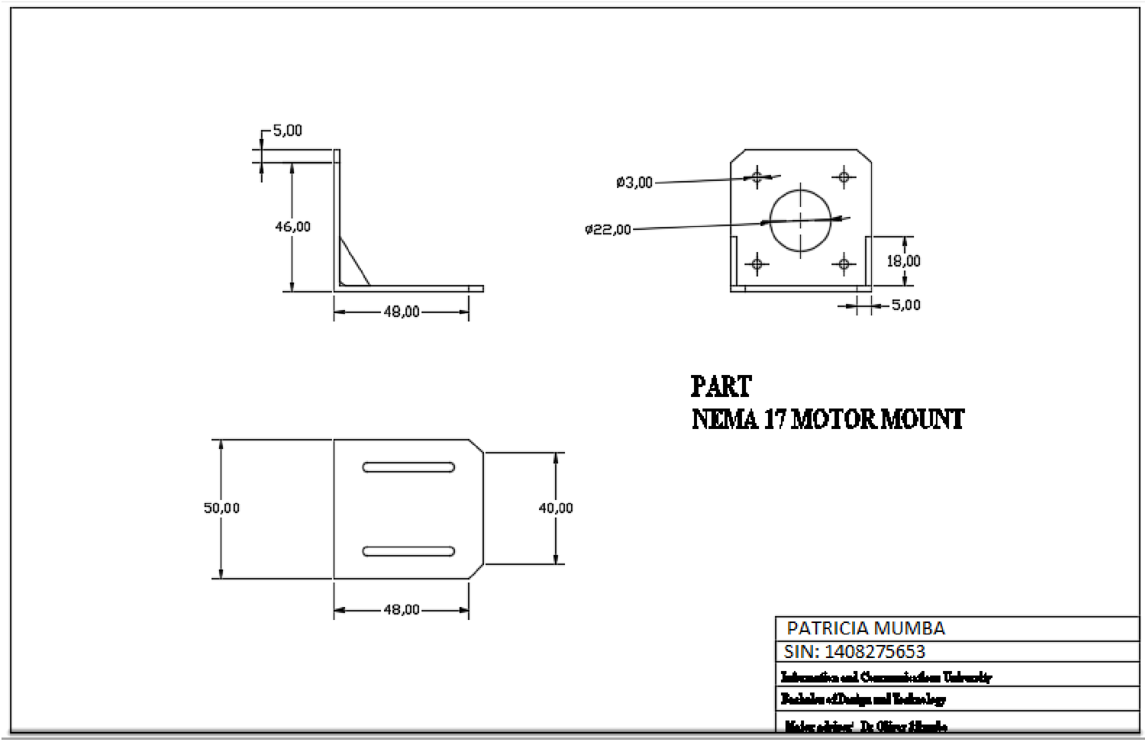

Figure 10 NEMA 17 MOTOR MOUNT

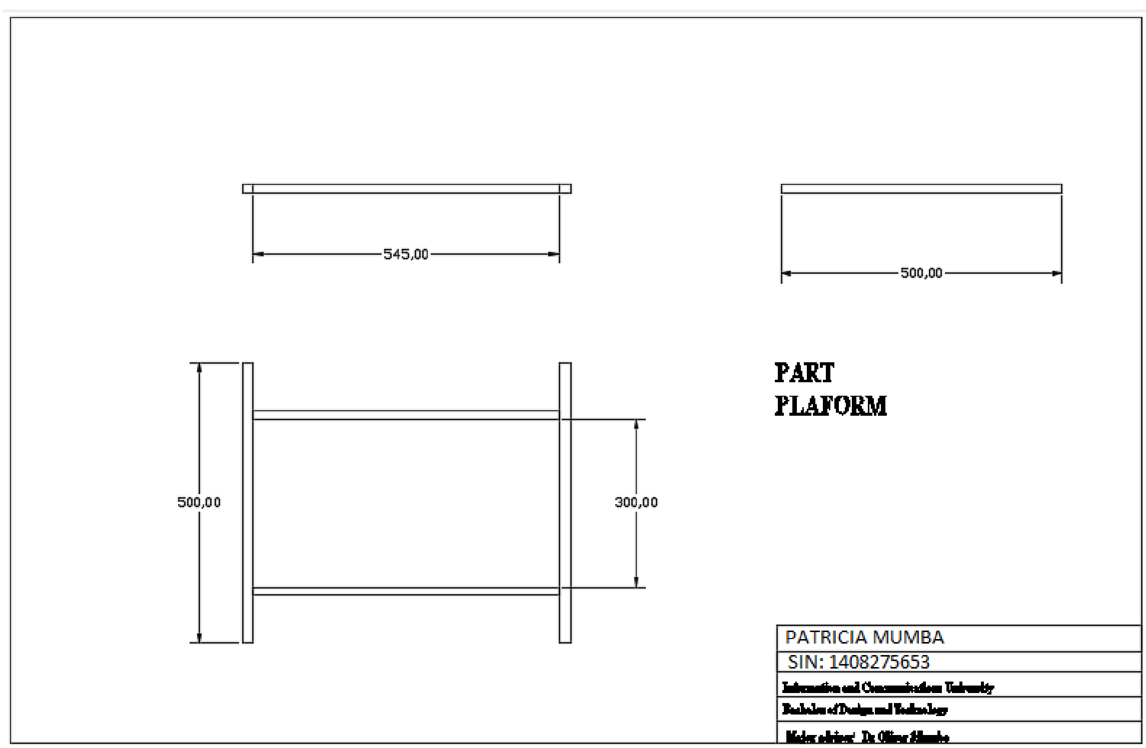

Figure 11 Platform

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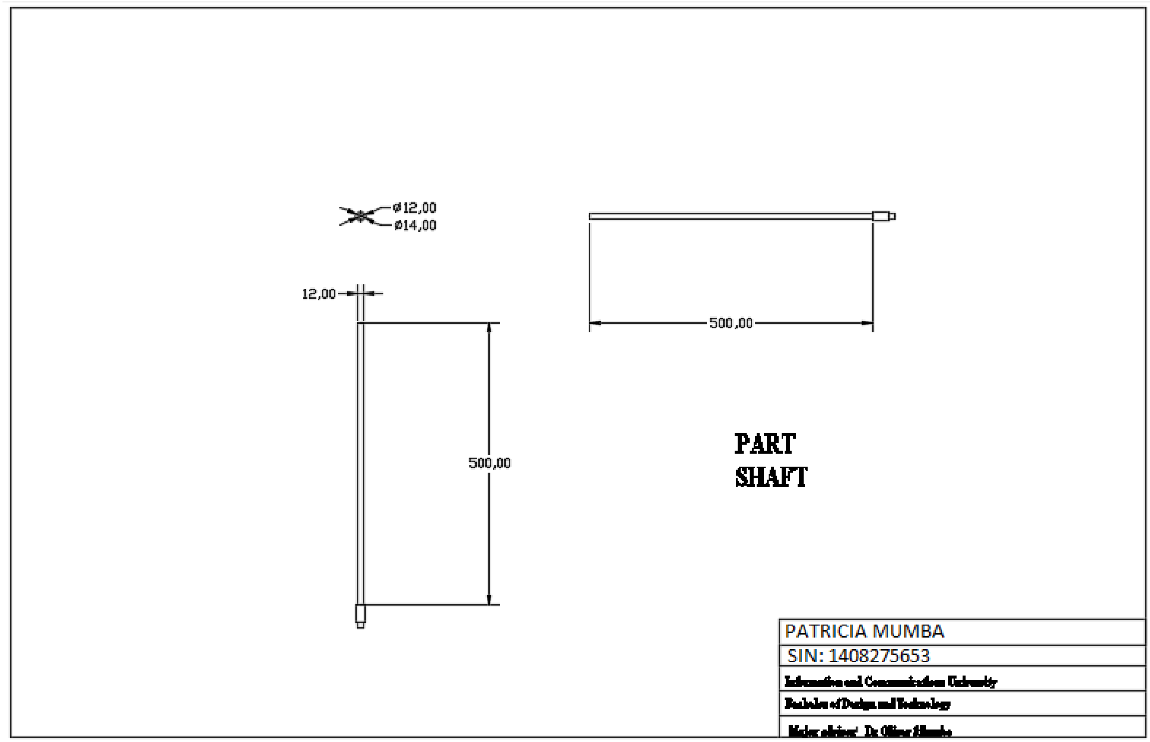

Figure 12 SHAFT

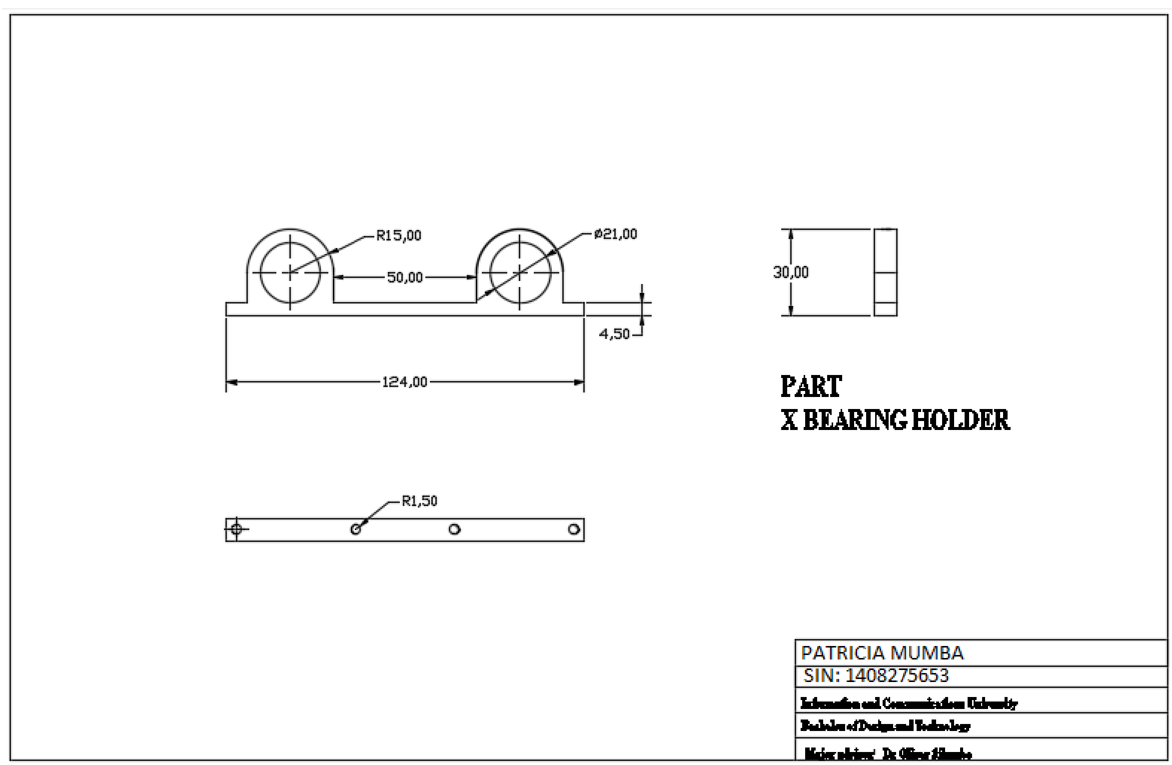

Figure 13 X-BEARING HOLDER

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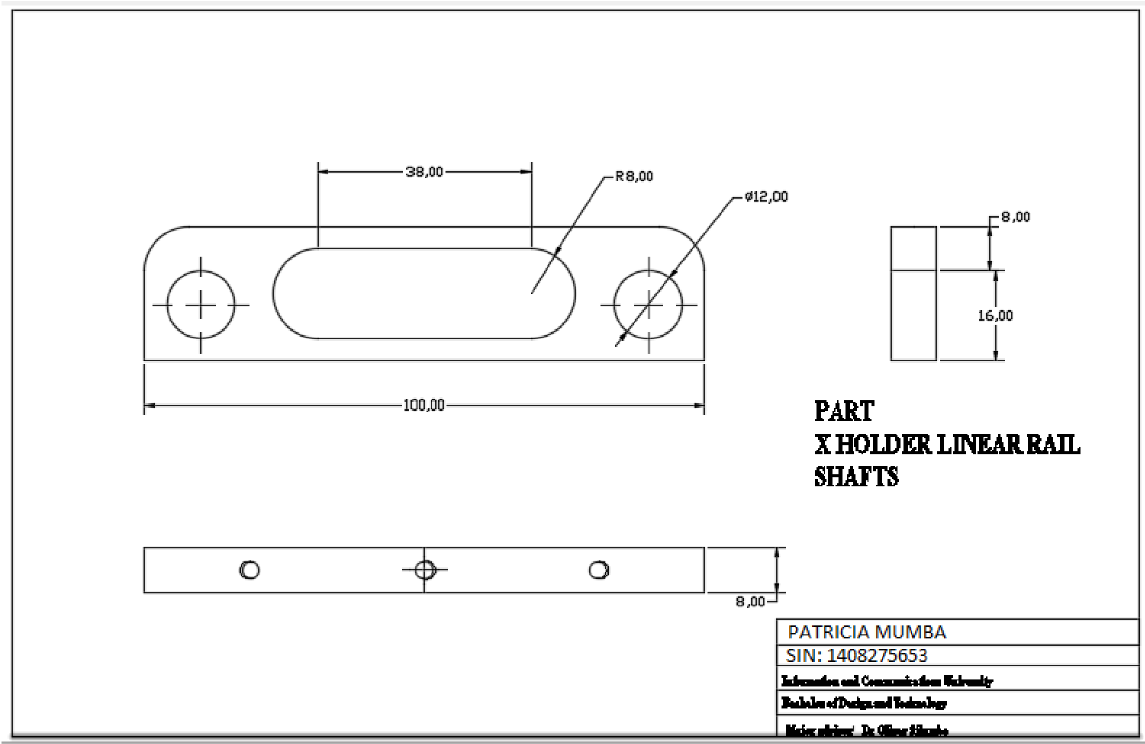

Figure 14 X-HOLDER LINEAR RAIL SHAFT

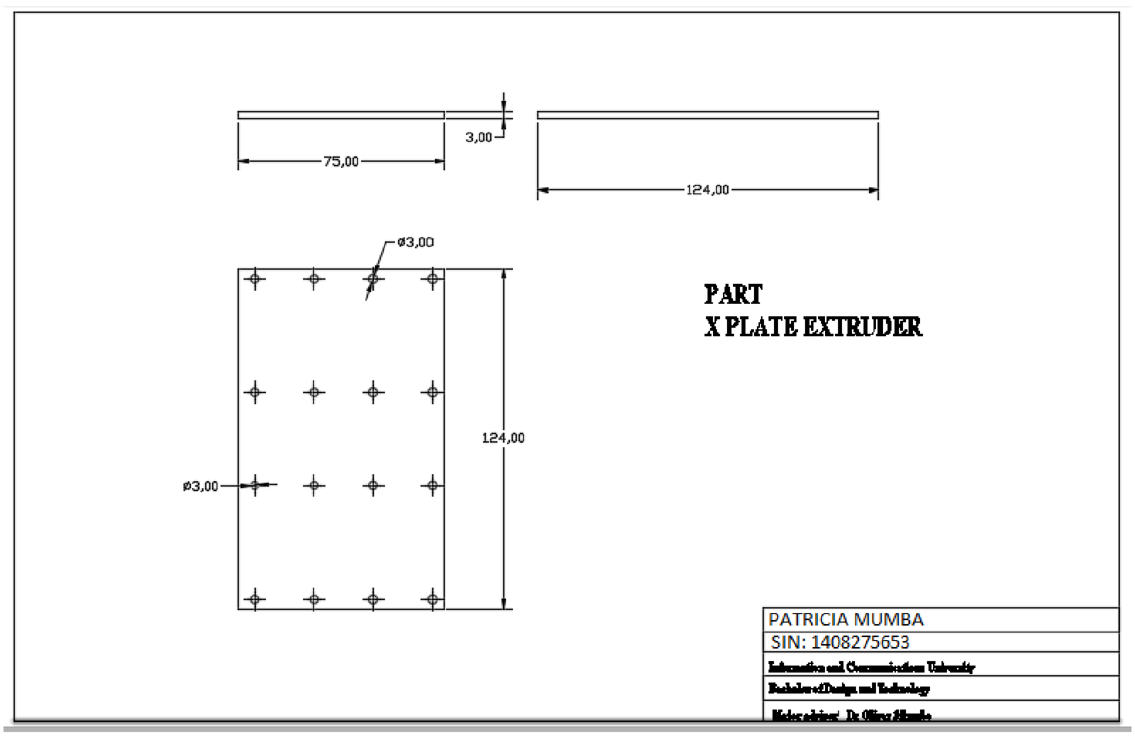

Figure 15 X-PLATE EXTRUDER

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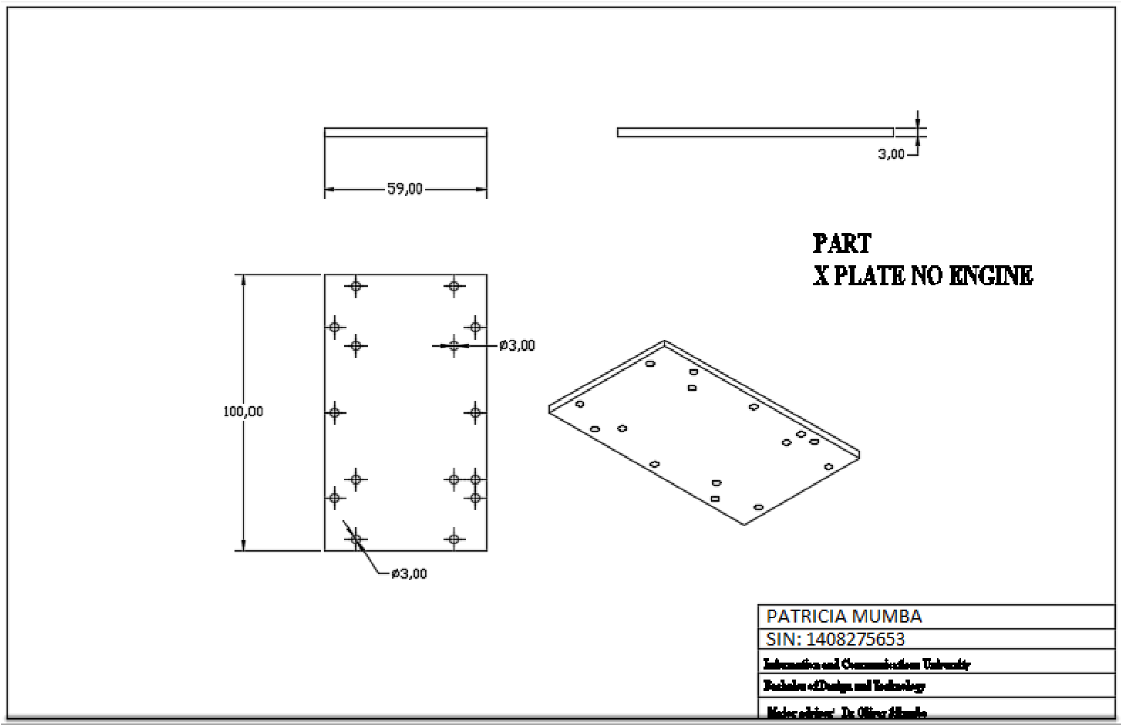

Figure 16 X-PLATE NO ENGINE

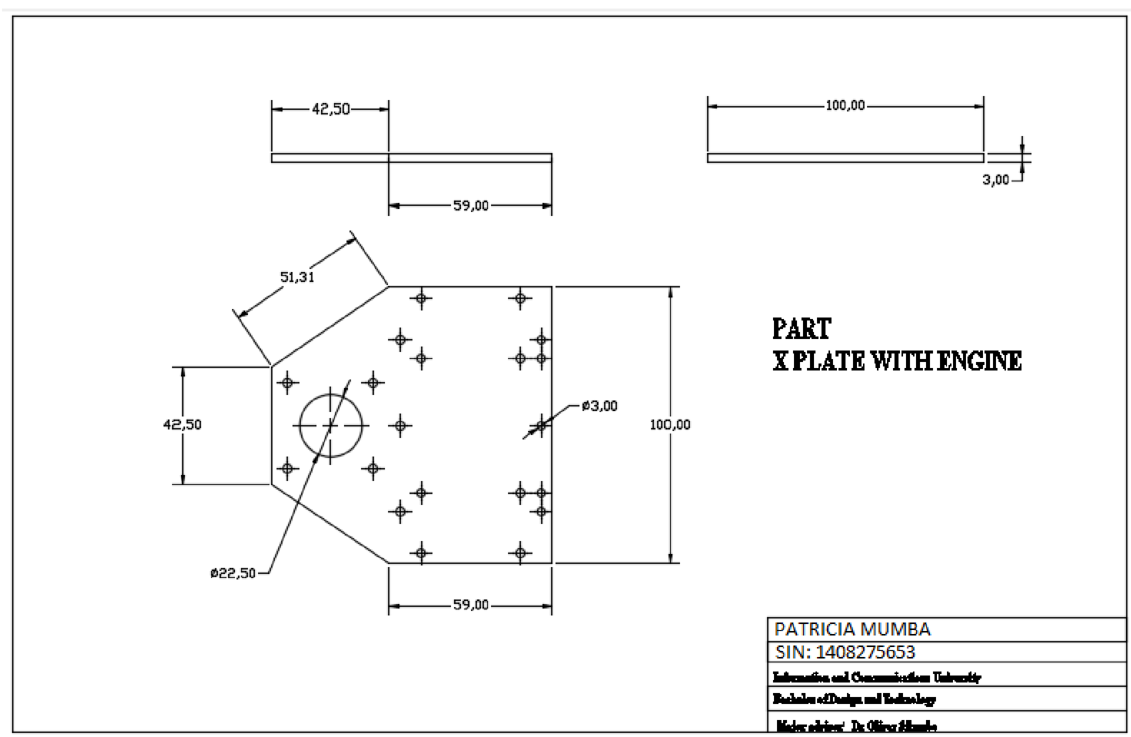

Figure 17 X-PLATE WITH ENGINE

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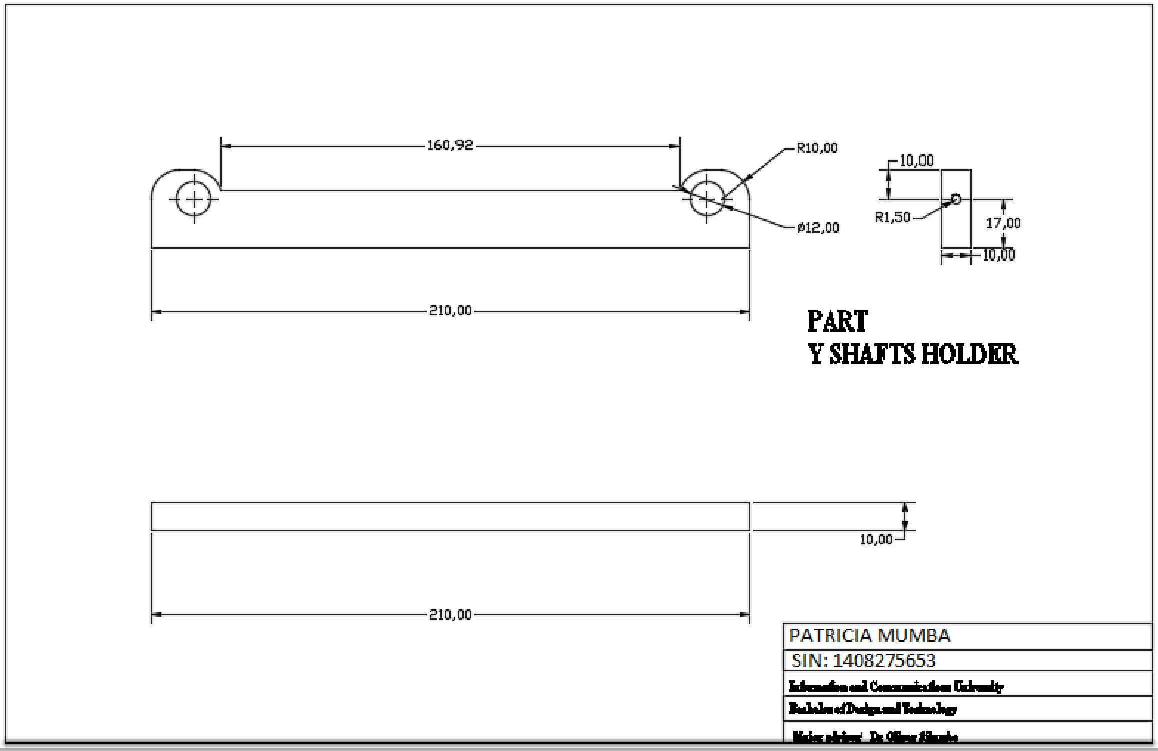

Figure 18 Y-SHAFTS HOLDER

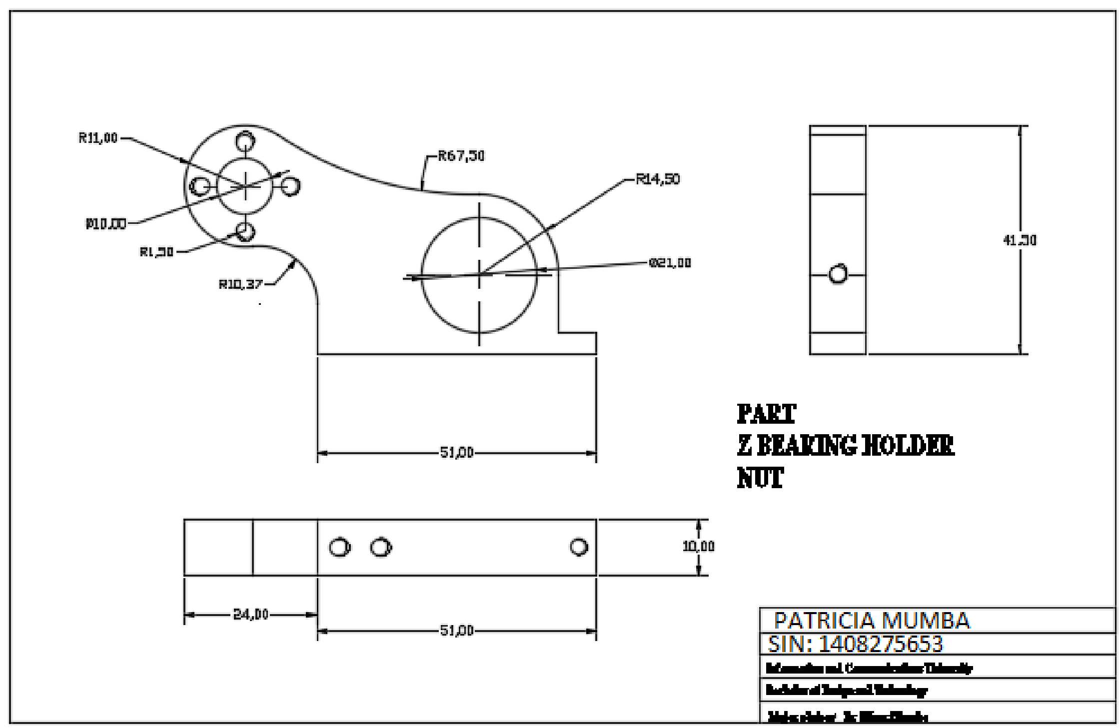

Figure 19 Z-BEARING HOLDER NUT

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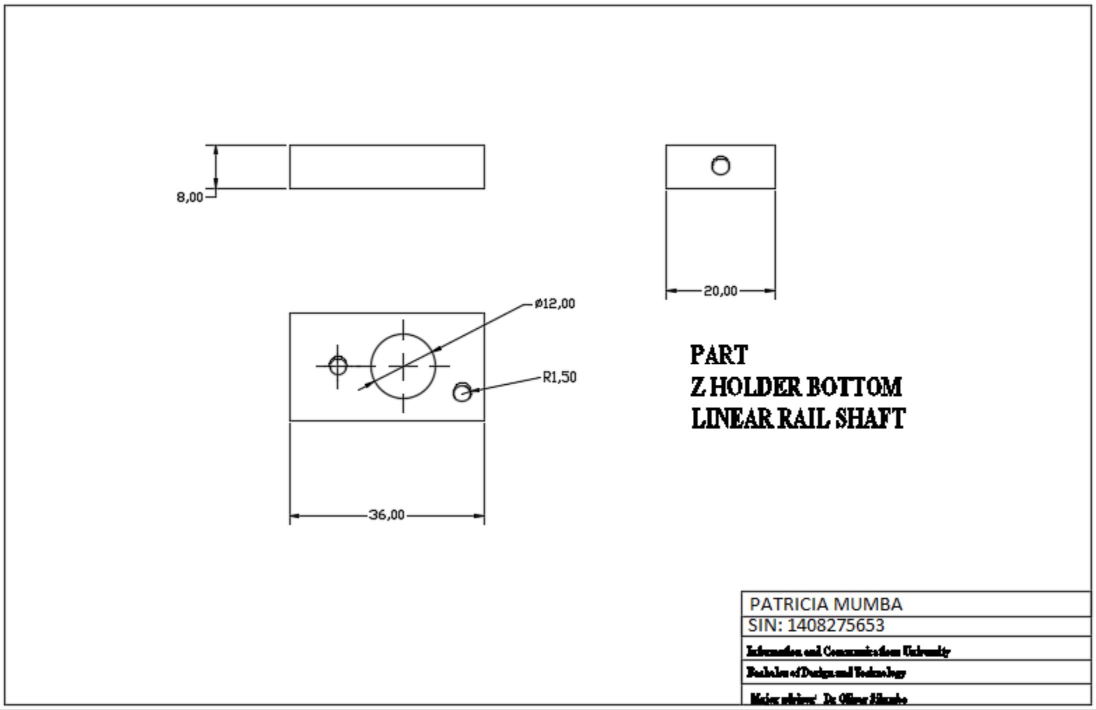

Figure 20 Z-HOLDER BOTTOM LINEAR RAIL SHAFT

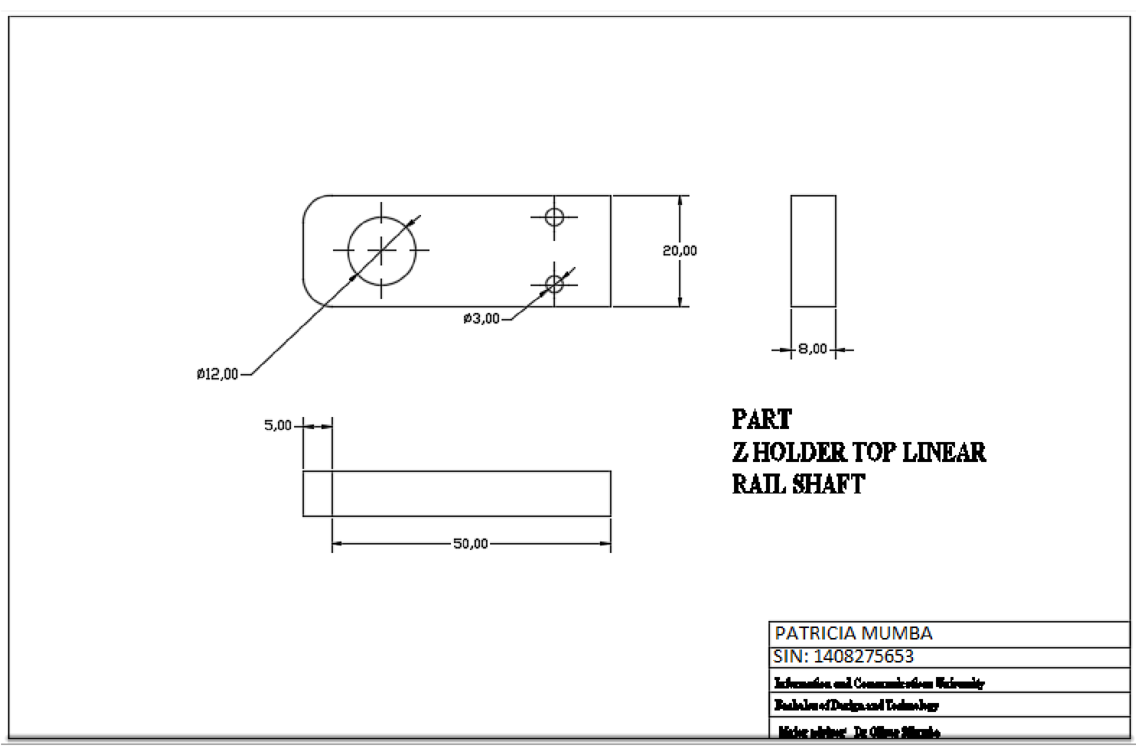

Figure 21 Z HOLDER TOP LINEAR RAIL SHAFT

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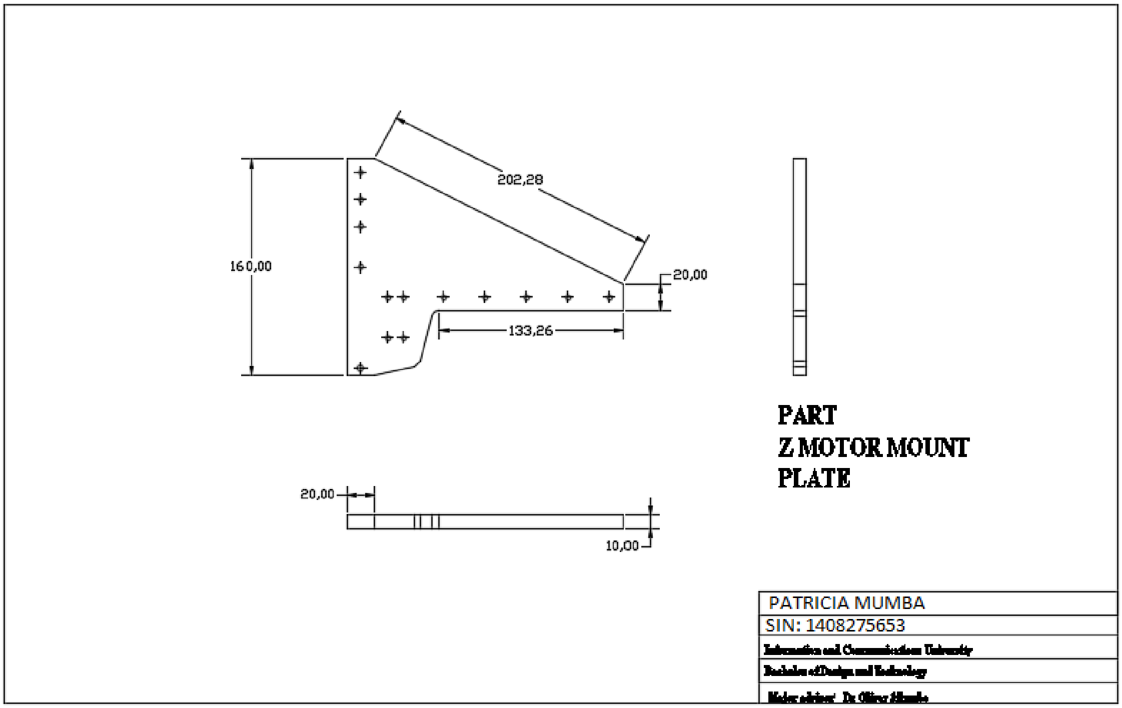
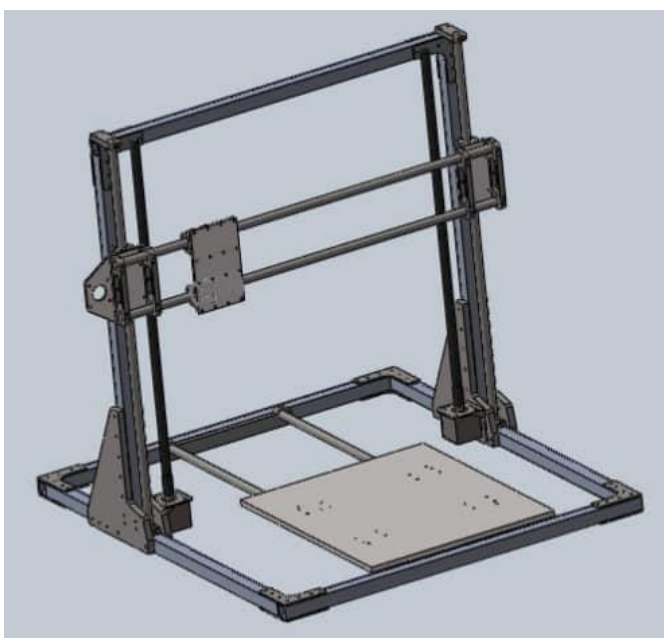


Figure 22 Z-MOTOR MOUNT PLATE

Frame of a 3D Printer



SOURCE: Author

Fig 23. Framework done using SolidWorks

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CHAPTER 4

4.0 Results and Discussion

This section of the thesis presents the findings or results and discusses the previous searches done.

4.1 Findings and Results

The findings and results from this study show that 3D printing has been published within the last several years dating as far back as two to three years ago. 3D printing has been around and has since existed for years as a commercially based business technology. The findings further indicate that the history of the first printer deposited dates as far back as 1977 and this is confirmed by Bradshaw et al.

In recent years the prices 3D printers have seen a significant drop. This has resulted in many individuals being able to own and afford them. This is a confirmation as to why many unemployed youths are using 3D printer to create self-employment opportunities and generate income for themselves and their families given limited job opportunities in the Third world countries like Zambia. From this finding it can be observed that the way teachers conduct their affairs in class in design and technology subject areas deserve to be punctuated with approaches or teaching methods that border on learner's active participation and thereby leading to enhancement of sustainable acquisition of knowledge and skills necessary for empowerment and economic emancipation.

4.2 Discussion and study details.

This study has helped in gaining more knowledge on 3D printing systems and giving a brief assessment of 3D printers to a researcher. Further of a particular importance piece of information to a researcher was that which covered the modeling software which was at a time said to be used for Rapid Prototyping. Probing further on this one revealed that most institution of learning particularly those from rural areas have to come to town schools to conduct and manage their practical exams thereby disturbing the normal running of town schools time-tables since these centers have to accommodate candidates coming from rural schools and this was case in point at David Kaunda Technical Secondary School.

However, an argument can be made in this presentation to the effect that although the three articles were very focused on their specific topics none of them clearly explained the usefulness of the 3D printing systems by stating how 3D printing methods impacted to a larger majority of rural poor populations particularly in the third world countries where poverty, illiteracy and underdevelopment have continued to be vexing issues of problematic concerns. However, the additional valued points narrowly discuss the use of 3D printer Scanners and 3D printers on how they can improve the conditions of learners to rural schools where electricity is not in good supply and show how these printers could be used to create replicas of modern stamps for example.

The findings and results showed the need for more formalized 3D printing standards. The question begging answers though were issues of how practical such standards can be achieved given that third world countries continue to be used as damping areas for obsolete machines imported from the developed nations. This was an issue raised during the focus group discussion at Lusaka Business College.

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CHAPTER 5

5.0 Conclusion and Recommendations

5.1 Conclusion

This thesis identified and discussed in detail different printing methods of a 3D printer, their application, use and by and large the study was aimed at generating information that could be used to design and fabricate a 3D printer using a toolkit. The materials gathered on 3D printer were necessary and relevant to design a 3D printer toolkit that could be used for learning and teaching purposes of subjects covered under design and technology. Further to this the printer toolkit would be a viable teaching and learning resource in schools given that the schools experience a lot of challenges as they try to cope and make do with inadequate learning and teaching aids in design and technology. It was also observed that while design and technology subject area of 3D printer was practical and so due to inadequate learning and teaching aids was found not to be proportional to the increased learner population in schools and hence subjecting them to an apply more teacher centeredness approaches than learner involvement and hence a recommendation is made to effect more printer toolkits be designed and fabricated to supplement the problem of learning and teaching materials in schools.

The data gathering techniques discussed in this thesis that focused on their main features, advantages, limitations and application in African educational contexts included all but not to the exclusion of Individual Interview, Focus Group Discussion, Observation, Audiovisuals and Documents. The study objectives which were stated within the scope or frame-work were achieved and these were specifically framed as follows; studying the different methods of a 3D printer, discovering and exploring the evolution of a 3D printer, studying and explaining the working procedure of different components of a 3D printer and designing and fabricating a 3D printer using a toolkit.

5.2 Recommendations

From the study and its findings here-in referred to as results, the following recommendations are made:

- First and foremost, it is important to point out that while it is identified that 3D printing was Originally developed and meant for Rapid Prototyping purposes and making less complicated physical samples cheaply most institutions of learning particularly those from rural areas have to travel to township schools for their printing jobs for example during mock examinations.

  It is recommended that rural schools be equipped with this new innovation so learners across board are allowed to acquire knowledge and skills needed for them to identify and rectify design flaws quickly and cheaply. Based on this recommendation it can be further stressed that movement costs on the part of rural schools could be minimized.

- The current status-quo is such that there appears to be not so many studies have been conducted locally on 3D printing operations in schools. It is therefore recommended that at policy level more studied on 3D printers be commissioned

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and financially supported so that enough printer toolkits are designed and fabricated which also positively impact adequate teaching and learning aids concerns in schools.

- Design and technology is by and large a practical subject teachers require in house capacity building through for example intensive CPD programs in order to enhance their abilities to adapting to participatory learning techniques and so to this effect more funding at school level should be allocated to design and technology sections so that not only adequate learning teaching materials should be purchased but also improve teaching learning approaches that speak to learner centeredness. The considered view based on this recommendation is that learner competence can be attainable with the aid of much acquisition of 3D printers at school levels.
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