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Exploring the Effectiveness of a Design-Thinking Instructional Module in STEM Context for Optimal Learning of Difficult Physics Concepts

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Abstract:- Study focused on investigating the effectiveness of a developed design-thinking instructional module in STEM context on learning difficult physics concepts. Study was carried out in an afterschool environment. Developed instructional modules combined the STEM and design processes of empathy, ideation, brainstorming prototyping, testing and retesting to learning physics concepts Modules were validated by experts for face and content validity. Modules were subjected to use for learning the selected difficult physics concepts in a single group design. In order to investigate the extent of impact on physics learning study was carried out on 48 male students and 41 female students in purposively selected secondary schools. Interview reports as feedback from selected 10 study participants at intervention were subjected to thematic analysis .Findings revealed that the design thinking activities in STEM context had positive impacts on improving learners' knowledge and arousing their curiosity to learning perceived physics concepts as against the usual conventional method.

Keywords:- *Instructional Module, Physics concepts, STEM, Design thinking, learning.*

I. INTRODUCTION

Physics teachers' continued use of traditional teaching approach had long time resulted to inability to effectively teach and learn physics concepts which consequently results to low performance in physics (Uwizeyimana, Yadav, Musengimana & Uwamahoro, 2018). The poor method of teaching physics had cultivated in students preconceived bad notion that physics is a difficult subject . This invariably had affected the overall students' achievement in physics with an impacting consequence on the technological growth of any nation (Jegede & Adebayo, 2013).

Besides, Okpala and Onocha(1988) reported in a study on difficult concepts in physics at the secondary schools using 4344 final year physics students with 3215 males, and 1129 females from 1086 secondary schools that students' difficulty were observed in some isolated physics concepts. The difficult concepts isolated were Newton laws of motion, work, energy, power, friction, speed, velocity, acceleration and forces among others. This was further collaborated by Kiptum (2015) that achievement in physics at the secondary school is disheartening because of the difficulty students associate with understanding physics concepts. Difficulty in learning physics occurs when students cannot relate physics concepts to real-world situations.

A. Purpose

Therefore, it becomes very imminent that teachers of physics require training innovations that can make them develop and use instructional modules such as will enhance male and female students' improvement in achievement scores in perceived difficult physics concepts of force, energy, motion, speed , velocity and acceleration. The specific objectives of this study was to:

- Develop an instructional modules based on design thinking approach in STEM context for learning some difficult senior secondary school physics concepts. .
- Do a thematic analysis of the impact of using the developed design thinking in STEM context instructional modules on learning difficult physics learning at the senior secondary school by gender.

B. Rationale for Learning Difficult Physics Concepts Using Design Thinking Approach in STEM context.

Design thinking is problem solving approach based on a complex of skills, mindsets and processes used to creating novel solutions to world problems. Design thinking is a user-centered, empathy-driven approach which aims at generating solutions through real insight into the users' needs (Goldman & Kabayadondo, 2017).).Design thinking is an approach that focuses on real problem solving through empathy driven solution and promoting creativity confidence (Zielezinski, 2017).

STEM learning according to Vasquez, Comer and Sneider(2013) in Jolly (2017) is an interdisciplinary learning approach which eliminates traditional barrier that separates the disciplines of science, technology, engineering and mathematics thus integrating them into rigorous, real-world relevant experiences for learners. In this study, STEM learning is defined as the context for learning selected physics concepts of force, energy, motion, speed, velocity and acceleration with their relevance to the interdisciplinary approach of science, technology, engineering and mathematics.

The integration of design thinking into STEM learning can enable learners develop set of skills that includes ideas which are not basically fostered within traditional school settings as well as contribute significantly to different levels of creative confidence (Carroll et al, 2010).This consequently develops students' STEM content knowledge areas and invariably enhances their achievements . Design +thinking approach to learning according to Kwek (2011) focuses on developing the learners' creative confidence through hands-on projects by empathy, promoting a bias toward action, encouraging ideation and fostering active problem solving skills and competencies in learners.

Learning physics in the context of STEM learning minimizes learning around the facts thereby changing the paradigm**.** Teaching and learning physics must go beyond the facts and the theories (Fisher, 2011). The goal of science is to draw as close as possible to understanding the cause effect realities of the natural world. It is never "truth" or the "facts" because "truth" and "facts" could have different meanings to different type of people. The conventional ways teachers teach physics has been by the conventional method thereby stressing only the facts or theories without active learning. This is collaborated by Fisher(2011)who observed that conventional science instruction isn't effective as expected, but with only 10 to 20 percent of lecture content being retained by the students, to the dismay of the instructors who had spent much hours explaining the facts only to their students.

Although, there is the buzz surrounding STEM learning and the confusion on how to teach it which inspired the rationale for the use of design thinking approach culpable of developing learners, creative confidence and acquisition of a wide range of STEM knowledge to real world problems (Brophy,Klein, Portsmore & Rogers,2008). Moreover, the negative mind set of students about STEM as an interdisciplinary discipline is viewed to be too difficult, boring and uninteresting (Johnson et al, 2015).

II. METHODOLOGY

A. Research Design

Single-group design was used in the study in line with Borg and Gall(1989) in Mertens (2005) who justified the use of the design in circumstances a researcher is making attempt to change knowledge or behaviour as well as when schools do not allow possible provisions for control groups. The single-group design with the intact group were administered a treatment in an afterschool environment using the design thinking modules within STEM context. Single-group design is used primarily to determine the effectiveness of an intervention or program (Kazdin, 1982). In this type of pre-experimental research design, subjects serves as their own control. because it was highly flexible and highlights the individual differences in response to the effects of the intervention (Thompson, 1986).

B. Sample

The two schools used for this study were purportedly selected in the federal capital territory, Nigeria. This was based on schools that will allow an afterschool school programme in their school. After which ethical considerations of writing to the relevant school authorities for permission to use school and students for research purpose was done. Study involved 48 male and 41 female participants giving a total of 89 participating students on the overall in the two selected schools. A total of 10 students were used after the use of the instructional module to obtain feedback by interview for study thematic analysis of the impact of instructional module on learning selected physics concept.

C. Procedure

The developed design-thinking STEM learning instructional module was to enhance learning difficult physics concepts is such as driven by NGSS standards to complements the trans-disciplinary philosophy. According to Glancy and Moore. (2013), STEM is the combination of each components of science, technology, mathematics and engineering and the translations connecting them. The framework of STEM translation model depicts that interdisciplinary STEM instructions and learning activities are optimal when students are made to focus on making translations between the ideas of each of these STEM components of science, technology, mathematics and engineering. Therefore, participants were allowed to generate some solutions to world problem through the well outlined design processes in STEM context as shown in Figure 1

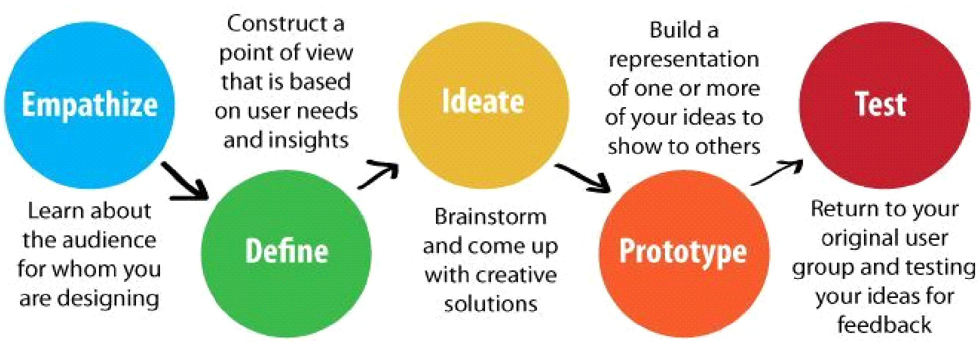

Fig. 1: Design Thinking process adapted from Stanford Design Thinking Model(Hasso Plattner Institute of Design, 2004)

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- *Empath***y-**participants through the use of the developed instructional modules in the truss bridge design tasks were enabled to develop deep insights into the needs of users putting themselves into their place. The main goal in the building a rural community sturdy bridge challenge, the main goal was identifying some problems with a Nigeria railroad corporation with just acquired new fleet of trains for nation-wide transportation of goods and services. However, in one section of the railroad plan, there exist a river which running through a deep valley so that constructing a railroad for the trains across the valley in the community is a problem.

- *Define***:** It entails identifying the design challenges, clearly stating the problem and what potential solutions are available. It entails participants to brainstorm and write down what they can invent as a solution to the identified problem and how it will work out in the zip line deliveries and truss bridge design challenge tasks. The participants in this stage of design process therefore clearly state the problem as does engineers and thereafter spell out how to possibly work out the solution to bringing daily deliveries to this children in the thick jungle. Similarly, in the building of a rural community sturdy bridge challenge, participants were made to identify, write down and brainstorm on how to offer possible solution in the rural community.

- *Ideation***:** This design process stage involves various techniques as brainstorming, identifying possible solutions or worst ideas to the design challenge. It involves sketching and drawing diagrams or pictures like engineers while listing the materials needed for creating solutions. Participants therefore choose after the brainstorming the best ideas of the many generated ideas to the identified problem and how it will work out. Participants sketch and draw diagrams and pictures as does engineers, listing the materials for creating solutions for the zip line deliveries and building a rural community sturdy bridge challenge.

- *Prototypes*: Creating solutions of inexpensive versions of the product. Building a model of your design based on your plans is pivotal in engineering design process. Participants build a model of a zip line as the first challenge and truss bridge design as the second STEM-design challenge. In the zip line challenge, participants were guided to describe and design a model zip line. .As they engage in the design task, concepts of , potential energy , kinetic energy and Newton Law of universal gravitation were brought into play with vivid discussion on how the acceleration of an object is affected by it(*the science*). They were guided to apply the mathematical formula: speed=distance /time as well know units' conversion (*the mathematics*). In this design, the concepts of friction and forces in two dimensions and torques to solving the zip challenge were highlighted to design the zip line structure (*the technology*). Students therefore knew and had better understanding of the physics and engineering principles involved in zip lines (*the engineering*).

Similarly, in the truss bridge design, participants were guided with clarity on the concept of force in design of bridges such as the force of reaction(*the science*), weight of bridge and their calculations(*the mathematics*) .As they engage in building the prototype bridge as solution to the problem of this rural community they learnt and understood basic fundamental principle of engineering in bridge design, know how to design a model of a sturdy truss bridge by generating ideas, showing creative thinking and exploring solutions from different perspectives (*the engineering*).Besides, the participants learned and applied the Newton's third law of motion as done by engineers in designing bridges, learnt and applied the concepts of equilibrium, static and dynamic loads, vibrations, and resonance while building their bridges(*the Science*). Also learnt while designing their own prototype of truss bridge the concepts of tension and compression while determining the effective geometric shapes used in bridge design (*the Mathematics*).

- *Testing***:** Here the designers evaluates by testing their finished product using the best possible solutions identified in line with Siang (2017). Participants test their own prototypes of the zip line structure in design challenge as well as of the truss bridge challenge.

- *Improving and Retesting***:** In this design stage, study participants repeated the design process step several times, by going back to previous steps and starting all over. There is no specific right or wrong way to going through the procedure. For the truss bridge design participants view to see if their invention could be improved or modified to hold more weights (*the technology*). They try a more challenging level by increasing the span to more than one (1) meter and so on. They review the design steps for quality assurance. Similarly, for the zip line deliveries challenge, study participants repeated the design process step several times, going back to previous steps and starting all over to see if their invention can be improved or modified for increasing or decreasing the span as required. The following steps based on the Kemp model was adopted in development of modules:

- Firstly, was to identify the instructional challenges and problems and specifying necessary goals for an instructional program design**.** Identifying the instructional challenges and problems of students' difficulties in the concept of force among other difficult physics concepts .as asserted by Obafemi et al. (2013); Reiner, Slotta, Chi, and Resnick (2000) with Okpala et al.(1988) .Besides, the instructional challenge identified was in line with the framework on crosscutting concepts, and core ideas practices of the next generation science standards (NGSS) outlined in National Research Council (2011) also observed that these are essential concepts in all disciplines of science and engineering. These essential concepts are often in connection with systems as crosscutting concepts which have applications across all domains of science. They have value because they provide learners with connections across various disciplines. Consequently, the following Table 1 outlined the step by step of specific objectives.

Moreover, for the building a rural community sturdy bridge challenge, the main goal is identifying some problems with the Nigeria Railroad Corporation which has newly acquired a set of fleets of trains for transportation of goods and services across the country. Unfortunately, in one section of the railroad plan, there exist a narrow river which runs through a deep valley so that construction of an additional railroad for the trains to cross the valley in a community is a problem. Participants generating some solutions to the problem by designing a truss bridge as shown in Figure 3 was the imminent challenge goal study for the participants.

Therefore, the truss bridge design challenge goal was to use the design thinking process to solve the problem of some villagers in a remote area. The following Table 1 outlined the step by step of specific objectives in the truss bridge STEM-Design challenge:.

S/No	Instructional Main Goal	STEM Standard Content	Instructional Objectives
1	Students at the end of the lesson will be able to use the design thinking process to build a rural community sturdy bridge to solve the problem encountered by the Nigeria Railroad Corporation which has newly acquired a set of fleet of trains for transportation of goods and services across the country. Unfortunately, in one section of the railroad plan, there exist a narrow river which runs through a deep valley so that construction of an additional railroad for the trains to cross the valley in a community was a problem	Science	Students at the end of the instruction should know the application of force concepts in design of bridges such as the force of reaction. Understand Newton's third law of motion. Understand the concepts of equilibrium, static and dynamic loads, vibrations, and resonance while building bridges. Know and understand the concepts of tension and compression and be able to explain how materials react to tension and compression forces.
2		Technology	Students at the end of the instruction should know how to design a model of a sturdy truss bridge by generating ideas, showing creative thinking and exploring solutions from different perspectives
3	Students at the end of the lesson will be able to use the design thinking process to build a rural community sturdy bridge to solve the problem encountered by the Nigeria Railroad Corporation which has newly acquired a set of fleet of trains for transportation of goods and services across the country. Unfortunately, in one section of the railroad plan, there exist a narrow river which runs through a deep valley so that construction of an additional railroad for the trains to cross the valley in a community was a problem	Engineering	Students at the end of the instruction should know and understand basic fundamental principle of engineering in bridge design. Application of Newton's third law application by engineers in designing bridges. Apply the knowledge of geometry, compression, tension and vectors by engineers when determining and maintaining a state of equilibrium for bridges subjected to various static and dynamic loads.
4		Mathematics	Students at the end of the instruction should know how to calculate the weight of bridge, Identify and determine effective geometric shapes used in bridge design. Use mathematical formula to predict strength ratio of a truss bridge. Know how to plot graphs of strength ratio predictions for bridges.

Table 1: Instructional Goals and Objectives in STEM Standard Content in Truss Bridge Challenge

Secondly, was to examine the learners' attributes and characteristics requiring attention in the process of planning**.** In this step of module development, the researcher explores, examines and identified the learners' characteristics and needs that could impact and provide ample guidance in instructional planning process while measuring the achievement level of students in learning the selected physics concept. It also focused on procedures, tasks and cognitive attainment in relation to the expected design challenges in STEM context. Attribute of empathy needed by engineers in solving world problems was to be developed. This is to promote students' engagement in science and engineering practice. Module was to develop the characteristics of reflective and independent thinkers in participants who will be capable of seeking out new dimensions of knowledge and learning from failure when solving problems within engineering contexts. This is in alignment with the NGSS framework (2013) which promotes students' engagement in science and engineering practices. This emphasizes crosscutting concepts that deepen students' understanding of in science and engineering core ideas.

The study gave attention to students STEM activities in designing of the building a community sturdy bridge challenge meant to enhance learners' knowledge and achievement in physics learning concepts while using the design thinking approach . Similarly, the building a community sturdy bridge challenge entails design solution which identified the problem of the Nigeria railroad corporation that newly acquired a set of fleets of trains for transportation of goods and services across the country. Unfortunately, in one section of the railroad plan, there exist a narrow river which runs through a deep valley so that construction of an additional railroad for the trains to cross the valley in a community.

Thirdly, is identifying the subject contents, and analyzing the components of the tasks in line with the stated goals and purpose of instruction. The instructional standard contents in the selected physics concepts for learning achievement test are hereby presented in s standard content for physics learning achievement test .

Instructional challenge identified was in line with the framework on crosscutting concepts, and core ideas practices of the Next Generation Science Standards (NGSS) in National Research Council (2011) who also observed that these are essential concepts in all disciplines of science and engineering.

Fourthly, stating instructional objectives for the learners. The lessons are in line with the Next Generation Science Standards (NGSS, 2013).In each of the designed instructional modules for learning the selected concepts, the behavioral objectives were clearly stated. This was in line with the expected instructional goals.

Fifthly, was sequencing the contents within instructional units to enhance logical learning. The instructional content for each of the instructional modules were sequentially and logically structured. This was to facilitate the learning of the selected physics concepts in the context of STEM by the use of design thinking approach. The lesson plan for instructional modules lasted for a period of 12 weeks and were sequentially presented in accordance to each stages of the design thinking processes in STEM context. This was to deepen learning experiences that connects together the selected physics concepts.

Sixthly, was designing instructional strategies which enables every learner gain mastery of the learning objectives. Instructional objectives were analysed and there after translated into a more definite and specific goals. The instructional strategies and procedures of design thinking processes in learning the selected physics concepts in the context of STEM enabled every learner the ample opportunities to get involved in the design thinking activities in STEM contexts. Design thinking activities in STEM context through test, improve and retesting stages for participants was for gaining learning mastery in design tasks and knowledge acquisition in physics concepts .

These cycle of testing, improving and retesting was made to continue during the students' learning design engagement until participating learners accomplished or gain mastery in the design activities. After gaining mastery, they then move to the next challenge. To enable learners gain mastery of the learning objectives as outlined in the study based on Bloom's taxonomy. Participants were given opportunity to demonstrate the design activities in STEM context for the design challenges of zip line deliveries and building a truss bridge to foster learners understanding of selected physics concepts through design solutions to real-world problem people face.

Seventh step is the planning the Instructional Content and Delivery. Besides, the lesson plan on the use of design thinking approach for learning the identified content area in physics in STEM context was prepared and used for the study for the identified design product for a period of twelve weeks with an overall total of twenty-three lesson plans covering the adapted design processes of empathy, define, ideate, prototype, test, improve and retest.

The eight step was the consideration of evaluation instruments used to assess learning objectives in the module. Evaluation instrument deemed appropriate for measuring and assessing learners' achievement in learning physics concepts learning based on the instructional objectives were carefully developed and used after due consultation and validation from experts who made valuable corrections and inputs on the assessment instruments .The assessment instrument was designed based on Bloom's taxonomy to measure several learners' ability in the areas of knowledge, comprehension, application, analysis, synthesis and evaluation in learning the specified physics concepts. The study made use of ungraded formative assessment design task during the design activities to provide a view of participants' learning progress. It is also to provide feedback to the students and the facilitator while offering the learners some useful guide during the afterschool STEM-design activities. This assessment does not count or contribute scores to the final achievement scores in physics learning. Besides, is the summative graded assessment task which was used to measure participants' achievement in selected physics concepts.

The ninth step in developing the instructional module based on the adopted Morrison and Kemp model was selecting the resources capable of supporting instructions and the learning activities. Appropriate resources that supported both the instructional deliveries and the design thinking learning activities within the context of STEM were carefully selected. For the building a sturdy truss bridge the supporting instructional resources were paper, index cards, tooth pick, self-adhesive labels, bridge test site, small craft sticks, heavy-duty scissors and wire cutters, binders clips, weights of different sizes to measure bridge strength, masking tapes ,meter ruler, graph paper, computer with internet access, projector.

D. Students' Feedback on Effectiveness of STEM-Design thinking Instructional Module

Students' feedback was necessary to ascertain in accordance with the framework for Afterschool Alliance (2013) the capability of the modules in enhancing physics content areas as well as developing 21st century measurable competencies. Besides, students' feedback was essential as part of modules development to ascertain the ability of the modules to productively engage students in physics learning within STEM context using design thinking processes**.** Again, the reason for students' feedback in module development was to enable the researcher to establish in accordance with the framework for Afterschool Alliance (2013) if modules were able to potentially arouse curiosity for better understanding when learning physics concepts by design thinking processes within STEM context. According to Afterschool Alliance (2013) it was to ascertain if usage of the developed module promotes the value for physics learning in STEM context in relation to STEM profession development and STEM careers. The feedback in accordance with Seldin (1997) comprises of several semi-structured interview questions to which students were able to respond to extensively using their own words. Interview coverage was in line with the adopted framework for Afterschool Alliance (2013); National Academy of Engineering and National Research Council (2014) for STEM learning as follows:

First scope of the interview was the active participation in the physics learning in STEM context using design thinking. The National Academy of Engineering and NRC(2014) asserts that active engagement and focus in STEM learning activities such as evident in students' ability to persist in a STEM task or program; Ideas and knowledge sharing showing enthusiasm, joy, etc. are indicators for afterschool learning outcome

Second indicator for the interview is curiosity about learning physics concepts and STEM learning practices in design thinking processes. In accordance with the framework for Afterschool Alliance (2013) deep sense of curiosity on STEM learning are necessary indicators that should be measured when interviewing on students' outcome in STEM afterschool learning. Third indicator for the interview is the ability to productively engage in physics learning in STEM context using design thinking processes**.** According to National Academy of Engineering and National Research Council (2014) indicator for STEM afterschool learning outcome is students' demonstration of ability to productively engage and work in teams for effective collaboration.

The fourth indicator is the value for physics learning in STEM context in relation to STEM profession development and STEM careers. This refers to the demonstration of knowledge of how to pursue STEM careers, acquiring knowledge of what STEM courses are needed to prepare for or pursue STEM degrees; interests in STEM (National Academy of Engineering and National Research Council, 2014).

The fifth indicator is knowledge of physics content areas. National Academy of Engineering and National Research Council (2014) emphasized that the demonstration of STEM knowledge when the students show increase in knowledge in specific content areas. It is making relevant connections with everyday world and using scientific terminology as well as the demonstration of STEM skills. It is an understanding of STEM methods of investigation which is evident in their understanding of the nature of science; According to them, the demonstration of mastery of technologies and tools that can assist in STEM investigations and measurements with scientific instruments. Demonstration of applied problem-solving abilities to conduct STEM investigations and critical thinking are all attached to the fifth indicator for interview on STEM afterschool program.

The sixth indicator for the interview is the development of 21st century competencies in STEM learning using the design thinking process**.** The development of 21st century measurable competencies as indicators for STEM After school program as indicators for outcome. These includes cognitive competencies such as critical thinking, innovation; metacognition, interpersonal attributes such as collaboration, responsibility communication, as well as intrapersonal traits of initiative and flexibility (National Academy of Engineering and National Research Council, 2014).

In an attempt to ensure that the modules were well-developed before its usage in the quasi- experimental design intervention, semi structured participants' interview was conducted at the pilot testing stage of the modules. This was to provide a deeper understanding and rich details as feedbacks from students' perspectives on the design of the instructional modules. This consequently enabled the researcher in making necessary modifications necessary for a well-developed module before usage in the quasi experimental design.

In line with Mabuza, Govender, Ogunbanjo and Mash (2014) qualitative data is concerned with text derived from observations, interviews or some existing documents. Saldana (2013) observed that qualitative analysis deals with reducing data but not losing the meaning of the data. Interviews carried out in this study in line with Mabuza et al. (2014), Saldana (2013); Braun and Clarke (2006) was audio, video-recorded and was transcribed verbatim in an attempt to generate data that could be further analysed.

The interviews were transcribed word- for-word and was not paraphrased. The interview transcripts were verified and checked for accuracy before commencement of analysis. The study in a bid to evaluate the overall effect and outcome of the use of the STEM-Design thinking module in physics teaching, purposively selected ten participants with six male and four females for interview. Since there are diverse and complex qualitative approaches in line with Holloway and Todres (2003), the study therefore employed the thematic analysis. This according to Braun et al. (2006) is a foundational method for qualitative analysis with the potency of providing core skills across qualitative analysis.

It is known for flexibility and rich detailed account of data analysis.

The phases for conducting the thematic analysis in the study are hereby presented as follows:

E. Phases for Conducting Thematic Analysis on Effectiveness of Design Thinking Instructional Modules on Enhancing physics Learning.

Although thematic analysis according to Attride-Stirling (2001), Tuckett (2005) and Braun et al (2006) is been widely used, there is no concise agreement on what thematic analysis is and how it is been done so that thematic analysis was defined in the very simplest way as a categorization strategy for analyzing qualitative data. A theme to them refers to a cluster of categories linked together to convey synonymous meanings after some inductive analytic processes characterized by the qualitative paradigm. The study therefore adopted the phases for conducting the thematic analysis in line with the views of Braun et al (2006) as follows:

a) Familiarity with the interview data (Reading the transcript.).
   In line with Braun et al (2006), Bryman (2008) and Mabuza et al. (2014) familiarity with the transcribed interview data was done by first browsing through the interview transcript as a whole after transcribing from audio and video clips. Then notes were then made about the first impression. After this, the interview transcript was carefully read line upon line.

b) Generating Codes.
   This involved labeling of the relevant words, sentences, phrases, sections, concepts, processes, differences and opinions in line with Braun et al (2006) and Saldana (2013) who observed that coding ranges from a word, phrase, sentences, to a full text or a whole text page. Coding also ranges from moving images that is used to represent aspect of the data or rather used to describe the features and importance of the data. According to them, coding is the process of assigning specific labels to interview transcripts as it is carried out in this study. It was done as follows:

   The pre-coding stage, the researcher made sure that he was not influenced by biases, interest beliefs by bracketing his influence (Saldana, 2013). Next was the creating of a story line. In this study creating a story line was done to assist the researcher to provide main structure for coding, to direct on ways of organizing the data. It is also to know what concepts as well as themes to present in the evaluation. After this was the labeling which referred to as anchor codes were assigned to each of the interview questions to enable easy organization of codes (Braun et al ,2006; Saldana ,2013). The next step after the labeling was identifying suitable and right choice of coding.

   This was done with regards to the purpose of the interview which was to evaluate the use of Design -thinking in STEM context modules in physics learning. . After this was the selection of codes for the analysis. This was done in a bid to facilitate sorting, consistency and categorization process by attributes coding. Such coding was featuring the characteristics of participants, whether male and female as well as materials used in this study.

   Next, was the evaluation coding in participants' evaluation about the Design- thinking in STEM context modules. After this was the vivo coding in which coding entails using the words of the study participants. After this was the emotion coding. This coding was done in relation to participants' feelings and excitement about the STEM-Design thinking approach from the view point of the participants (Saldana, 2013).

   Besides, the compilation and arrangement of list of anchor codes and initial generated codes was done. The generated codes were compiled and also arranged orderly for easy categorization towards theming. The generated codes in the study was 14. After this was the categorization of the generated codes. In this study, codes were combined to form categories by sorting in accordance to Saldana (2010) and Saldana (2013) who asserts that two or more codes could be combined with respect to tallying the frequency of codes. Then defining meanings underlying the groups of codes and establishing relationship among generated codes. Then after this was the grouping which involves making reference to a specific concept or term (Saldana, 2013). 6 categories were identified out of the fourteen 14) generated codes.

   Moreover, the next step was the identification of the themes in line with the view of Braun et al (2006); Ryan and Bernard (2003) by looking for repetitions of categories, repetition of patterns of data meanings, similarities and differences among categories. After this was the linguistic connections among categories. Four themes were eventually identified on the final analysis for which the study report was based. After this was reporting of findings on the themes.

   From the four themes identified, the thematic analysis was able to address the how and the why questions as well as to see how these themes related to the study's conclusion as follows:

III. RESULTS

The findings by thematic analysis on impact of design-thinking in STEM context instructional module on learning difficult physics concepts is hereby presented. The following themes emerged from the categories generated in the study namely as engagement in STEM-Design thinking, knowledge and creativity enhancement. Next was positive impacts of STEM-Design thinking approach and then was the theme STEM professions and physics.

A. Engagement in STEM-Design activities while learning physics concept.

The theme refers to how the male and female participants viewed or perceived their engagement with the use of the STEM-Design thinking modules used in learning physics concepts. They were being asked: why do you like being actively engaged in these STEM activities using the design thinking process? To some participants engagement in STEM-Design thinking activities broadened their knowledge of difficult physics concepts. To some others, engagement was because they wanted to become engineers as the design tasks gingered out their desire and taste for engineering profession. To collaborate this, a male participant responded thus: *"I liked being actively engaged in STEM activities using the design thinking process as it really helps a lot, because in my quest to be an engineer I really need the practical activities. I really want to be a good engineer. If I want to be a good engineer, the STEM-design thinking process is really required in that" (*Interviewee 2, Male*).*

Thus, this feedback received from students that their engagement in the Design- thinking in STEM context activities broadened their knowledge of physics concepts was a proof and affirmation that the instructional modules were well-developed .Another participant also observed that his engagement in Design- thinking in STEM context activities was because equipped with necessary skills for be self –reliant in the nearest future by saying: "*Because it helps in building up our knowledge. There are some practical activities that we know nothing about but due to these STEM activities. It can also help us in the world outside there so that even after schooling without government work we can use our own initiatives and skills to make our living"* (Interviewee 8, Male).

This interview data does not only broadened students' knowledge of the selected physics concepts but also incorporated necessary skills that could make students' self-reliant.

Why others say they engaged in the STEM-Design activities was purely because it promotes their thinking and problem-solving skills as thus evident in a participant's response: *"To start with, I like participating in STEM activities using the design thinking process because firstly, it elaborates the physics concepts, secondly it makes you use your brain wisely, thinking well. For instance, I have not for sometimes now be engaged in thinking like this before. But when we were faced with the STEM challenge of how to make supply and deliveries to some refugees in a jungle, I sat down and think of what to be done. Since then, I now know that it is essential for anybody and physics student to have time to learn how to think to solve problems which I do know that STEM does help me to achieve. This was why I liked engaging in STEM activities using the design thinking process" -(Interviewee 6, Male).*The feedbacks from students was that the use of the developed modules deeply elaborates physics concept to them than ever.

B. Knowledge and Creativity Enhancement.

The theme, knowledge enhancement in physics concepts refers to how both male and female participants' views were identified. They responded that use of the Design- thinking in STEM context instructional modules enhanced and boosted their level of knowledge in the selected physics concepts. A totality of all 6 male and four (4) female participants responded to the question on what do you think about physics learning in STEM context using the design thinking process? If it has improved your academic knowledge in the concepts of force,? It was observed that learning physics concepts of force, had really improved their knowledge of these concepts.

Moreover, they responded by saying that learning physics in STEM-Design context broadened their knowledge of physics concepts, helping them to understand difficult concepts in the most unforgettable way in contrast to the conventional method they had always been exposed to. For instance, a female participant responded thus: *"Yes it has helps me a lot to acquire more knowledge in physics especially the zip line activities on the concept of motion" (*Interviewee 5, Female). This alluded to the fact that the modules had positive impact on learning difficult physics concepts of force.

Besides, another student had this to say on what he thinks about use of Design- thinking in STEM context instructional module for learning physics concepts. *"Yes I think it has improved my knowledge because in the physics class we are taught the theoretical part but when we come here for STEM activities we are exposed to the practical things which can be remembered easily than the theoretical parts because the practical activities are stored in our brains so that in future we can use them to solve difficulties or problems when they arise" (*Interviewee 2, Male).On enhancement, the participants observed impact was not only on their acquisition better knowledge of the physics concepts but that their creativities also was significantly enhanced :

*It has helped to increase my creativity in relation to the concepts of force, energy and motion"(*Interviewee 3, Male).Thus participants objective responses that the usage of Design-thinking in STEM context modules initiated creativity skills in them for problem solving so that they became positively enhanced.to learn physics like never before.

C. Positive impacts of STEM-Design thinking approach

Study participants expressed that such positive impacts of usage of Design-thinking in STEM context activities made them feel interested, gives feelings of fulfillment, feel good, feel enlightened, improvement, feel challenged, to learning physics concepts. It gave them connections to real-world challenges people face on daily basis as well as boosting their morale for STEM professional jobs especially with respect to their future ambition of wanting to become engineers.

These responses from the six males and four female participants' interviews was in response to the interview questions which asked: How do you feel about your interest in participation and engagement in these STEM activities using the design thinking process? Specifically, a male participant responded thus: *"I think it improve me positively because many things I do not know before when the teacher who taught us about the STEM and design process. It has taught us in depth about physics" (*Interviewee 7, Male*)*.Responses obtained from interviewees show that the students during the pilot study of the modules were deeply enlightened and challenged to learning physics concepts which led to their improvements and understanding of some of the supposedly difficult concepts

Another interviewee responded that the positive impact on their interest by saying thus: "*I feel very interested in participation because to start with it, it does not only open up my memory or understanding but also make me think, teaches me more physics concepts. Like before now, I don't even have the slighted idea on how to make a bridge but as we when we were doing it together in the STEM activities, i started learning, I started gaining some ideas and through that now by God's grace now I can construct a bridge and understand the underlining physics concepts behind it. I like to engage in STEM activities because the STEM activities enlighten me more it teach me more. Even most of the things that our teacher cannot teach (am not saying our teacher doesn't teach well) but most of the things not in our curriculum that are essential to us are taught us during the STEM activities"* (Interviewee 6, Male).A female participant also opined by saying that *"I feel very interested, I feel very good and I will like to participate in the STEM activities again"* (Interviewee 9, Female).

Besides, a good number of the male and female participants interviewed added that the STEM-Design thinking activities had a positive impact of arousing their curiosity to learn physics concepts. This they said when responding to the question of how curious were you when engaging productively in the STEM learning activities? Curiosity was one of the positive impacts of Design-thinking in STEM context modules . In fact, a female participant responded: "*I was very curious learning physics through these STEM activities by the design thinking process we engaged in" Yes I feel very curious as these things were new to me having never done them before in the physics class* (Interviewee 4, Female). From the feedback received from the semi-structured interview that Design-thinking in STEM context activities had a positive impact of arousing their curiosity to learning the physics concepts as against the usual conventional method.

Thus, feedback from the interview shows that the module made the participants to be aware of the relevance of which help to stimulate the students learning of physics with special focus on STEM professional areas as they use their knowledge of physics concepts to solve real-world human problems.

IV. DISCUSSION AND CONCLUSION

Study findings revealed that the use of the developed learner-centered, activity based and facilitators 'assisted Design thinking modules in STEM context had the capacity to improve students' knowledge and achievement in learning physics concepts of force. Therefore innovative pedagogical delivery of physics concepts should be done with such instructional modules developed around several non-negotiable design elements to offer supportive STEM learning environment as well as give exposure to real-world learning opportunities. This is with the intention of improving students' achievement, knowledge acquisitions and interest in physics learning. This is in line with the assertions of Gutulo and Tekello (2015) that to accelerate development in physics education, instructional delivery must be learner-centered, teacher-assisted, action oriented and project based such as is entailed in the developed instructional modules.

Therefore, physics teachers' innovative training in this direction is vital for effective pedagogical delivery to demystify the learning of difficult physics concepts. Physics teachers in line with the view of Yager (1991) should be trained to assist learners such as were involved in design tasks of zip line delivery and truss bridge to develop new insights and connections with previous knowledge while allowing them to make their discoveries and solution as in design- thinking tasks within STEM context as contained in the developed modules.

Besides, training teachers on social interaction with both male and female students alike will offer scaffolding to the students within Vygotsky's zone of proximal development in constructing new knowledge using such developed instructional modules in this study will avail learners the opportunity to be learner- centered, activity based, discover and explore new knowledge when learning physics concepts. This is in accordance with Bruner (1966) who observed that learning and problem solving is a product of exploration and discovery of new knowledge. This invariably will enhance students' achievement in perceived difficult physics concepts.

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