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Effect of Naïve Impetus Application Theory on Misconceptions of Newtonian Motion among Nigerian Secondary School Students

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ABSTRACT

Researches had shown that every learner especially at introductory physics class begins the learning of physics with a well-established system of common senses belief about how the physical world works. This system of belief is known as naïve impetus theory is gathered from the environment of the learner over the years. It is also entrenched into the system of thought process to the extent that it is very difficult to unseat. Simple common sense belief about motion is incompatible with Newtonian concept of motion. Therefore, any classroom teacher does not take this concept into consideration would be totally ineffective because students interpret new experiences through these erroneous understandings thereby interfering with their ability to grasp new information. Population of 200 students comprising 82 male and 118 female SSII physics students in Njaba LGA Imo State was used to conduct a descriptive survey design research. Impetus theory application test (ITAT) was used for the collection of data which was analyzed using frequency counts simple percentage and pie chart to show the degree of distribution of impetus theory among learners. Result shows that out of 82 male students, 58 (70.7) showed poor conception and 24(29.3) exhibited good conception. Similarly, out of 118 females 95 (80.5) exhibited poor conception and 23 (19.5) of the entire female sampled population exhibited good conception Chi squares to test showed no significance difference in the pattern of males and females □2 (1, 200) = 2.57, p = 0.109. Every student in this population exhibited the application of naïve impetus.

KEYWORDS: Impetus Theory, Misconceptions, Newtonian Motion

Introduction

Conceptual understanding is very germane to the teaching and learning process. It promotes learner understanding in Science and Physics in particular, however it has been an issue of concern to Science educators. This is mainly due to the fact that physics is the most abstract of all the Sciences and yet the most fundamental (National Education Research and Development 2005). The understanding of physics as a concept helps to a very large extent the understanding of other Sciences. Chukwunenye, Ihekwoaba and Akano (2017), Duit and Treagust (2003) posited that students come to class with already formed conception. It is therefore the ability of the teacher to identify this alternative conception and rearrange facts in other to either subsume or reorganize this knowledge to fit into the new concept in the process of teaching and learning that brings about conceptual understanding and real learning. The concern of a very good teacher should be how to move the learner from the present level of limited knowledge to a higher level of wider scope of understanding.

According to National Research Council (2010) conceptual understanding of physics begin when the learner recognizes the relationship among bits of facts, concepts, or procedures and can produce an intelligent argument, extrapolation or analysis to explain the relationship. The implication of this action by the learner is that within the cognitive domain, knowledge are no longer isolated but had become organized in the form Coherent Structures which are based on either relationships or generalization.

Research had shown that every learner, especially at introductory class begins physic with a well-established system of common senses belief about how the physical world works. This system of belief is known as naïve impetus theory or model (Cataloglu and Ates 2013). It is a system of belief gathered from the environment of the learner over the years and has been entrenched into system of the thought process that it has became very difficult to

unseat them and it plays a dominant role in introductory physics (Ates and Cataloglu 2007). It has equally been established that simple common sense belief about motion and force are incompatible with Newtonian concepts of motion. Therefore, any classroom teacher or instruction that does not take this theory into account in a classroom instruction would be totally ineffective. Secondly, it is also an established fact that the conventional way of teaching physics cannot challenge these naïve beliefs because it is independent of the instructor or mode of instructions (Mc Dermott 2001).

Newtonian model is any model or representation that obeys Newton's law. It is a model that shows the relationship amongst force, mass and motion. Natural philosopher and 17th Century Scientist Sir Isaac Newton developed a set of universal principles to help explain and predict the motion of any object in the natural world. He also provided an explanation in the inter relationship among the physical concept of force, mass and motion. This explanation was later metamorphosed into Newtonian three laws of motion, therefore Newtonian model is said to be any model or representation that obeys Newton's law.

Naïve impetus theory on the other hand is an alternative to Newtonian model or theory (Franco 2004). It is any model that does not obey Newtonian's law, in other words, it is an alternative conception. The naïve impetus theory is a modification of Aristotelian null model (Liu & Mc Isaac 2005). The impetus theory put forth initially to explain projectile motion, against gravity is also referred to as naïve impetus theory. The use of impetus theory is widespread among students and seems to be cross-cultural (Erdat and Sali hates 2013). In Nigerian is setting for instance, the word ''energy'' and ''power'' are synonymous when used in local dialects of Igbo and Yoruba tribes consequently, they are used interchangeably. However, the concept of energy and power are different according to Newtonian concept of mechanics. This and many other environmental factors have made it even more difficult to unseat this erroneous system of common senses belief that has been entrenched into the thought process of the learner. Also, the concept of kinetic energy and momentum which explains energy in motion are not well explained in many physics textbooks at secondary school level (Chukwunenye,Ihekwaba & Akano 2018)

When a learner finds it is difficult to relate a concept been taught with the learners' pattern of cognition such learner would be compelled to cope with the subject in question by rote-learning or memorization. The learner memorizes bits of knowledge or fact to pass an examination which is usually a meaningless cognitive task because it does not connote understanding. This could account for the reasons why some students are repelled from learning physics; a few that are successful have become so through their own device, this form of learning has become a hindrance for cognitive task. This is because in conceptual understanding, facts are no longer isolated but well organized coherent in structure. No wonder the physics lesson taught in many classroom environment, become futile cognitive tasks consisting of bits of isolated facts which are not cohesive.

In most educational system, conceptual understanding is negated in work done both in and out of the classroom setting, in physics for instance, emphasis are placed on numerical application of concepts alone which on its own make little or no meaning. Whereas, emphasis should be placed on conceptual understanding, and then backed up with the proper mathematical manipulation and properly explaining the concept behind these application. Teacher must always remember that mathematics is meant to buttress or explain a particular concept. In most introductory physics classes the learner is unable to strongly connect equations and mathematical manipulation to their related concept. Information presented to the learner in the classroom is void of coherency in structure which in turn does not provide a solid foundation for basic conceptual understanding in physics as fundamental blocks on which the rest of their knowledge would be built.

In addition to already existing problem of misconception, the numerous homework or class work given to the students are numerical and can only be solved using mathematical formulae or equations. Although this method would lead to correct answer, however, the manipulation of these equations does not engage any explanation of the physics concept which is usually not understood even by brilliant students with mathematical proficiency. Research has shown that learning neither occurs in a straight line or easy progression. For a learner to gain conceptual understanding it involves more than knowing isolated facts or manipulating variable but rather it is the ability to understand the fact to the extent of transferring these facts in or out of the classroom to a completely new situation (Kola, 2017). It is against this background that the researcher examined the effect of naïve impetus theory on misconception of Newtonian motion among senior secondary school students.

Statement of Problem

The performance of students in physics continues to be discouraging. Physics education research had shown that learners begin the study of physics with a well-established system of common senses belief about their physical world known as naïve impetus theory. This belief usually emanates from years of personal experiences and it plays a dominant role in introductory physics. This is because things that we have already learnt are not helpful in learning new concept or theories. This occurs when the new concept is inconsistent with previously learned ideas. Any classroom instruction that does not take these into account will be totally ineffective because they pose serious impediment to learning. It has also been established that common sense belief about motion and force are incompatible with

Newtonian concept in most respect. The conventional physics instruction produces little or no change in this belief hence there is need to educate researchers on this belief especially as students are generally unaware of this belief which are strongly entrenched in the students' thinking to the extent that they interpret new experiences through these erroneous understandings thereby interfering with the students' ability to grasp new information.

The following research question guided this study

1. What is the percentage of students' that exhibited misconception on Newtonian motion during classroom instruction?
2. What is the percentage of conceptual understanding is exhibited by the learners during classroom instruction?
3. What is the pattern of conceptual understanding exhibited by males and females during classroom instruction?
4. Is there any significance difference in the pattern of conceptual understanding exhibited by males and females students during classroom instruction?

Theoretical Framework

This study was hinged on Robert Mills Gagne Theory of conditions of learning. He proposed that prerequisites are identified by doing a task analysis of learning or training task. Learning hierarchy provide basis for the sequencing of instruction. The theory further outlined nine instructional events, and corresponding cognitive processes which are;

Level 9: Enhancing Retention and Transfer (Generalization)
Level 8: Assessing Performance (Retrieval)
Level 7: Providing Feedback (Reinforcement)
Level 6: Eliciting Performance (Responding)
Level 5: Providing Learning Guidance (Semantic Encoding)
Level 4: Presenting the Stimulus (Selective Perception)
Level 3: Stimulating recall of prior learning (Retrieval)
Level 2: Informing learners of the objectives (Expectancy)
Level 1: Gaining Attention (Reception)

Robert Gagne Theory of Conditions of Learning stipulated five major categories of learning. These are: verbal information, Intellectual Skills, Cognitive Strategies, Motor Skills and Attitudes.

Different conditions are required for each type of learning. Gagne also suggested some learning tasks for intellectual skills which could be arranged in hierarchy according to complexity: stimulus recognition response generation, procedure follows, use of terminology discrimination, concept formation, rule of application and problem solving. The primary significance for hierarchy is to identify pre-requisites that should be completed to facilitate learning at each level.

This theory is relevant to this study because it shows that learning is a process in which the learners construct their own understanding of the world around them, experiences and discrepancies between what they already know and ability to accommodate same in new learning. This theory emphasize the need for progressive learning from simple to complex, when a learner tried to learn the complex without good and deep understanding of the simple one, there is bound to be misconception which is referred to as Naïve impetus theory or alternative conception.

Methodology

A descriptive survey design was adopted for this study. It is a design in which post test was administered to elicit information on conceptual understanding of the learner on Newtonian motion. The researcher found this method useful because the study involved administering diagnostic test to elicit responses from students on level of understanding of already taught concept of motion. The dependent variables being learning outcome in the form of conceptual understanding, a conceptual test model contained in the impetus application test (ITAT) on motion was being used.

The study covered Njaba Local Government Area of Imo State Nigeria. Population of the study consisted of two hundred senior secondary school two students (SS2) in the Njaba Local Government Area in Imo State. Since it is a rural setting and the population was manageable, intact classes of the whole population of SSII students of the five schools in the area were used by the researcher.

Research Instrument and Collection of Data

The instrument used for data collection was Impetus Theory Application Test (ITAT). This is a two-tier test developed to assess students' conceptual understanding of the basic concept of mechanics test designed by Ates and Catalogues 2007. It was produced using the Turkish version of force concept inventory (FCI) and Mechanic Based Test (MBT) (Ates and Catalogues 2007). These two-tier test consist of five multiple choice items assessing the application of the naïve impetus theory on the concept of motion. It measures students' conceptual understanding not only by distracter choice, but also by further written explanation about students' in choice of a particular answer.

This test facilitates assessment of alternative conceptions of a larger number of students in a more efficient and relatively easy way (Treagust 1986, Odom and Barrow 1995). This test instrument was constructed by Cataloglu & Ates 1992. It was designed to be meaningful to students without formal training in mechanics to determine the misconceptions about Newton's law. Most of the multiple choice distracters are common sense alternatives which usually relates to the pattern of cognition and understanding of students. The instrument has a list of distinct alternative conception along with a corresponding inventory items that suggest the presence of alternative conception or otherwise. It is also evidence that the students believes in some kind of impetus and that Newton's law is not understood.

Administration of Instrument

The instrument was administered as a post test to the target population (SS II physics students') in some selected schools. The condition of administering the instrument was based on the fact that these students have been taught the Newtonian concept or topic in question by their teacher within the period in view.

Validation of Instrument

The two instruments which constituted the Impetus Application Test (ITAT) have a published alpha reliability coefficient of 0.70 and mean item difficulty of 0.42 for the Mechanic Based Test (MBT) while Force Concept Inventory (FCI) has an established alpha reliability coefficient of 0.89 and a mean item difficulty of 0.35. There is also an established evidence of positive correlation between previously administered MBT and FCI items as related to ITAT. For the purpose of this study the ITAT was administered to an independent group and was found to have a reliability of 0.87 and validity of 0.90

Scoring

The test was scored zero for correct options to the multiple choice questions, and correct explanation of their reasoning on the second tier response which indicated the absence of impetus reasoning. The response was coded one if there is presence of any impetus application. Getting the multiple choices correct and getting the second-tier question wrong indicated rote learning or guess work. This is because if the concept is well understood, the explanation will be correct. This aspect was presumed to be wrong because the learner has not understood the Newtonian concepts and therefore the opted for rote memorization of isolated fragment by carrying out futile cognitive task in order to cope with the examination which does not connote understanding.

On the other hand, if the second aspects are correct and the multiple choice question chosen was wrong. It reveals that such student must have copied response from classmates.

Results and Discussions

The data obtained were analyzed using frequency counts and simple percentage and pie chart to show the degree of distribution of impetus theory among learners. Chi square was used to test if the distribution of males and females in conceptual understanding of concept of motion were equal.

Research Question 1: What is the percentage of students' that exhibited misconception on Newtonian motion during classroom instruction?

Research Question 2: What is the percentage of conceptual understanding is exhibited by the learners during classroom instruction?

Table 1: Distribution of students in conceptual understanding by school

Name of School	Total number of students	Poor conception (0-4)	Good Conception (5-6)	Rote Learning (7-8)	Outstanding conception (8-10)
School 1	41	19	27	04	0
School II	40	20	13	07	0
School III	42	12	30	02	0
School IV	37	25	9	03	0
School V	40	14	21	05	0
Total	**200**	**73**	**100**	**27**	**0**

Table 1 show that 100 students exhibited good conceptual understanding of Newtonian concept of motion out of the 200 students in the class. None of the students exhibited out standing in understanding. Table 1.also shows that 100 students had poor conception on Newtonian concept of motion. The fact that none of the learner exhibited excellent level of conceptual understanding is an indication that every student exhibits a level of misconception.

For pictorial representation of the conceptual understanding a pie chart as shown in figure 1 was drawn.

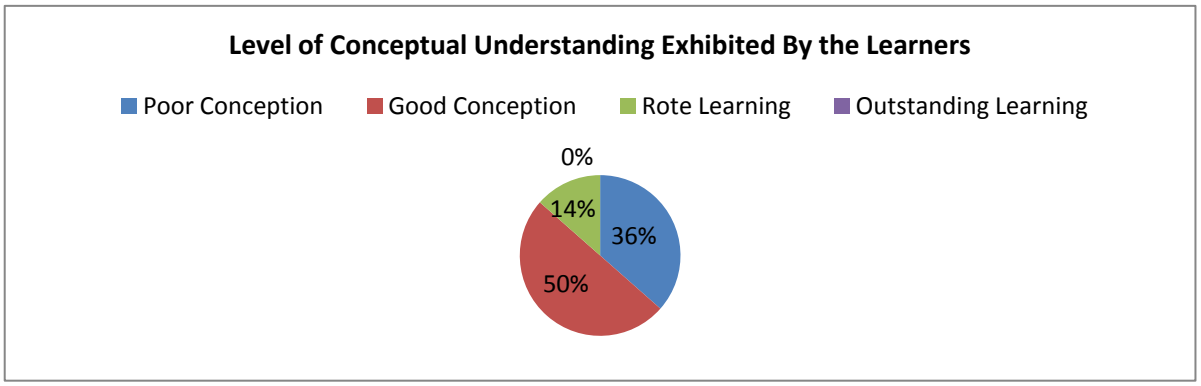

Fig 1: Level of Conceptual Understanding Exhibited By the Learners

Research Question Three: What is the pattern of conceptual understanding exhibited by males and females during classroom instruction?

Table 2 shows that out of 82 male students, 58 which are 70.7% of the entire male sampled population exhibited showed poor conception and 24 which are 29.3% of the entire male sampled population exhibited good conception. Similarly, out of 118 females 95 which is 80.5% of the entire female sampled population exhibited poor conception and 23 which is 19.5% of the entire female sampled population exhibited good conception.

Table 2: Pattern of conceptual understanding exhibited by males and females

Group	Poor Conception (0-4)	Good Conception (5-6)	Very Good Conception (7-8)	Outstanding Conception (8-10)	No. of Students	Chi Square
Male	58 (70.7)	24 (29.3)	-	-	82	2.57
Female	95 (80.5)	23 (19.5)	-	-	118	
Total No. of Students	153	47	-	-	200	

Note: Number in parenthesis represents percentage of cases

Research Question Four: Is there any significant difference in the pattern of conceptual understanding exhibited by male and female students during classroom instruction?

To test if there was any significant of the conception exhibited by males and females, Chi square test was conducted. Results showed that there was no significance difference in the pattern of males and females χ^2 (1, 200) = 2.57, p = 0.109.

It has been established from this research that students come into the classroom instruction with already established system of common senses belief picked from their environment. (Cataloglu and Ates 2013) This established system of common senses belief plays a dominant role in every classroom instruction. This theory which is referred to as naïve impetus theory or alternative conception is not compatible with Newtonian concept of motion or any other physics concept. Conventional physics instruction would produce little or no change in this belief which has been established to obstruct learning. Unfortunately this system of belief is not taken into cognizance in the arrangement of learning experiences. This experience although naïve, but usually originate from daily experiences of the students as they interact with the real world and are usually backed up with viable and logical explanations. This system of belief according to research could be very resistant to change, and therefore poses as very strong hindrance in learning correct scientific concept (Mc Dermott 2001). It is therefore imperative for science teachers and physics teachers in particular to learn about common alternative conceptions that students bring into the classroom in other to plan how to unseat them through contemporary teaching method; especially for physics which are even more abstract nature than other sciences. This is in agreement with (Kola 2017) who investigated the conceptual understanding of physics students through an interactive lecture – engagement. The result revealed that there was a significant interaction between the students' high scores in conceptual understanding and the interactive lecture – engagement method used in teaching physics which are not a conventional kind of teaching. Through the interactive lecture – engagement teaching strategy, students were able to identify some misconceptions they had in physics.

The results of the findings showed that about 50% of the entire population that participated in the test had good conception the remaining population of 50% showed that poor conception. Also some of the learners that appears to have understood the concept was discovered to have passed the test by Rote Memorization because they could not explain the reasons for their chosen answer. This is in agreement with (Erdat Cataloglu and Saliti Ates 2013) who carried out a study on the effect of cognitive style on naïve impetus theory application degrees of pre-service science teachers. The group embedded figure test and impetus theory application test was administered to assess the field dependence and field independence of sampled population to determine the level of application of naïve impetus theory respectively. The result shows that majority of the students have applied naïve impetus theory repeatedly and the degree of the student's application of naïve impetus theory is related to their cognitive styles.

The percentage of female students that had misconception was 47.5% of the entire population whereas; the percentage of male students that had misconception was 25% of the entire population. When his is compared to the ratio of the entire population of about 118 female students to 82 male students, there is an indication that the female students can perform better than the male students when given fair chance to enable them develop the necessary confident needed to perform well in the class and deal with misconceptions?

Conclusion

It is quite interesting to note that every student operates with a level; of application of naïve impetus theory and also that

the level of the application of naïve impetus theory could varies among students even brilliant ones are not exempted. The implication is that the use of alternative conception is exhibited does not differ significantly by sex. Naïve impetus theory is an alternate conception which neither the students nor teachers know that it exist in the class and incompatible with the Newtonian concept of motion as well as general physics concepts. Once it is recognized to be presented in learners. Engel hard (1994) stated that the attitude of teachers would change and understanding would greatly improve. This is why alternative conception is tenacious and resistance to extinction by conventional teaching strategies. It cuts across age, ability, gender and cultural boundaries. Therefore, the following submissions were made;

1. The prior knowledge of the learner has been the origin of alternative conception in diverse set of personal experiences including direct observation, perceptions, culture, and language.
2. Teachers' explanation interacts with knowledge presented in a formal instruction setting resulting in diverse set of unintended learning outcomes. Therefore, there is need for the teacher to explore new teaching strategies such as web-based interactive tutorial, web based drilling, computer simulated experiment and many other contemporary and interactive teaching strategies which are learner centered to ascertain of it could improve learner's conceptual understanding.
3. Conceptual understanding is a factor of exposure of the learner to a learning experience in quality time. Therefore, teachers should not rush lessons but patiently give the required quality time to every given concept in other to achieve the goals of instruction. This study implies that teacher should create more time to interact with the learner instead of dictating notes. In teaching Newtonian concept of motion every teacher or instructor should provide the basis for clear distinction between force and motion since it appears to be consumable to learners in classroom teaching and learning environment.
4. Wording of questions by the teachers during classroom instruction should be discouraged. This is because when questions are answered during instruction the concept becomes clearer to the learner and understanding is enhanced.
   Every learner should be given opportunity to prove one's self irrespective of the age or sex. The female students when given equal opportunity with their male counterpart could perform better than the male.
5. Teachers should also be aware that they could equally be sources of misconception to learners; therefore, there must be adequate preparation by the teachers before engaging in teaching.

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