The Assessment of Student Misconceptions of Newton's Laws of Motion Using Force Concept Inventory Achievement Test among Undergraduates in Ondo State, Nigeria

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Abstract: **The study was conducted to determine the assessment of students' misconception of Newton's Law of motion using Force Concept Inventory (FCI) achievement test in some selected tertiary institutions in Ondo State. A validated Force Concept Inventory (FCI), (r = 0.97) questionnaire was administered on 450 students in the selected tertiary institutions in the state. The data collected were analysed with mean, standard deviation and T-test Statistics at 5% level of significance. The findings revealedthat students like force as a topic despite their little exposure to experiments on Newton's Third Law. The findings further revealed that there was a significant difference in the mean scores of pre-test and post-test performance in Force Concept Inventory(FCI) based on gender (T-value = 3.94, p<0.05). It was discovered that the male students performed better in force than female students. Also, there was a significant difference in the mean score of pre-test and post-test performance in Force Concept Inventory(FCI) based on school type (T- value = 6.70,p<0.05). It was discovered that private student performed better in the concept of force. This is, therefore, recommendation that there should be current information (data) or an idea on teacher conception of the concept of force and motion.**

Keywords: **Misconception, Motion, Force, Inventory, Achievement**

I. INTRODUCTION

A sufficient background and knowledge in Physics is required for the furtherance and progression of Science and Technology in our society. It is important for Physics students to acquire the appropriate understanding of the different Physics terms (concepts) which they are being taught in schools so as to utilize this education in their daily activities (Omosewo, 2007). Over the last decade, the performance of students in Physics have been unsatisfactory as an analysis of this performance shows a decreasing course(Omoifo, 2012).The West African Senior School Certificate Examination (WASSCE) Chief Examiners' Reports(WAEC, 2008) showed that students' shortcoming in Physics were attributed to insufficient knowledge of the fundamental principles, ideas, laws and their suitable applications to explaining and solving Physics problems.These are as a result of Physics students having inadequate comprehension of Physics concepts. Such a situation can be traced to a number of factors including that candidates have misconceptions of Physics concepts. These lead to having ideasthat are at variance with the current scientific agreed ideas, views or explanations.

According to (Savinainen & Scott, 2002), the Force Concept Inventory is a multiple-choice test designed to monitor students' understanding of force and related kinematics. It is usually adopted as a credible method for improving both the teaching and learning of mechanics. This is necessary since the research evidence (Alwan, 2011; Clement, 1982; Gilbert, Michael Watts, & Osborne, 1982; Liu & Fang, 2016; Soeharto, Csapó, Sarimanah, Dewi, & Sabri, 2019; Watts, 1982)on students' comprehension of Physics concepts, particularly those related to Newton's laws of motion, indicate that many students lack a basic understanding of the fundamental concepts Whether in force and motion(Dariese, 2012), conservation of principles and fields (Ivowi U. , 1986), or electricity and magnetism(Rowland & Chee, 2010) the situation occurs despite formal teaching.Generally,it is recognized that students' misconceptions in Physics hinders their substantial understanding of and excellent achievement in the subject(TABER, 1997) and(Rowland & Chee, 2010).

Students' misunderstanding in Physics may emerge from many origins, which incorporate: interactions with the socio-physical world before formal science teaching, textbooks, reference books, teachers, language, cultural beliefs and practices(B. Balci & Inceoglu, 2006; F. Balci & Demirbaş, 2012). Of special concern in this study are teachers as a source of students' misconceptions in Physics, since teachers are an influence or control of expertise to students(Akpan, 1999) and (Akpan, 2017). It is however, anticipated that formal teaching in Physics should result to either the adjustment, lessening orcomplete alteration of misunderstanding in students. This is so because effective instruction not only inculcates in students what is accurate, it also makes sure that students do not believe what is

inaccurate(Dergisi, 2010). Teachers' proper theoretical knowledge of the subject matter they teach allows them to be conscious of students' likely misunderstanding andthe learning problems.The absence of conceptual knowledge among some Physics instructors may be one of the reasons why Physics instructors do not seem to know or predict the level of misconceptions in their students and this, thus, affect learning(Härmälä-Braskén, Hemmi, & Kurtén, 2020).

By adopting innovative teaching techniques, there is the possibility of the teacher assisting the learners to rectify these misperceptions and also help the students in addressing these learning challenges(Gunstone, 1984; Oyelekan, 2017). The Force Concept Inventory presents a unique advantage for connecting student learning with teaching techniques (Evans et al., 2003; Wang & Bao, 2010). Some arguments is that the normal force can be the Newton's Third Law reaction to weight.If an operational definition of weight (essentially "what a scale reads", or what might be called load in engineering) is being used instead of the gravitational definition (W = Fg = mg) then it suggests that the operational definition is not only acceptable, but even preferable. However, we teach the gravitational definition exclusively to our students, and use it in applications such as free-body diagrams. In this language, "the weight of the book" means "the gravitational force of the Earth on the book". When we treat Newton's Third Law, we emphasise that it describes a relationship between two bodies where the two forces associated are similar.

In Nigeria, a study by (Ivowi U. , 1986)showed that most post-primary school Physics instructors (about 73%) scored below 50% of the highest mark on conceptual comprehension of force and motion. The total mean mark for conceptual understanding was 35.6% of the full conceptual mark. However, the marks on the numerical performance were above that of the conceptual accomplishment. This therefore, suggests that most Physics instructors do not have conceptual knowledge of the concepts of force and motion. This outcome is same as that of(Dergisi, 2010) whose research unveiled that pre-service Physics instructors have conceptual challenges of Physics concepts in Turkey. These resultsare in agreement and show consistency.

Many of the misunderstanding that Physics teachers hold in Physics may be attributed partially toPhysics literature and reference materials they consider for their teaching and partially from the misunderstanding they too had developed as students of Physics; this partially accounts for the reason students still have misconception in Physics after formal training in Physics(Ivowi U. , 1984); (Ivowi U. , 1984); (Soyibo, 1993) and (Adair, 2013; Oberoi, 2017; Soyibo, 1995; Yates & Marek, 2014).Therefore, since most of Physics instructors do not have sound arguments to enhance learners' comprehension, the explanations they offer their students for a specific concept are feeble and notsufficient for the learners. The utmost the teachers could now do is to give the learners numerical clarifications and compromise the theoretical clarification of a concept.Thus, to minimize poor comprehension of Physics notions among learners, it is imperative that instructors themselves should first of all have a conceptual knowledge of the ideas.

Statement of the problem

As already stated above, findings from studies on student understanding in Newton's laws reveal that several wrong notions about the physical world are common among students of different educational levels and ages. Various researches have been carried out so as to better comprehend what students think about the real world. Majority of studies about Newton's laws is geared towards identifying student misconceptions or substitute perceptions. Researches reveal that students have a substitute idea of force and each learner constantly applied substitute ideas of force in various situations about Newton's laws. Developing a substantial comprehension of Newton's laws of motion is highly challenging for beginners. In this study, we concentrate on students' misconceptions in Newton's laws of motion at the start and at the finish of a formal instructionusing Force Concept Inventory achievement test in some selected tertiary institutions in Ondo State.

Research Questions

1. What reason for the variation in the student concept of force especially the Newton's Third law?
2. What is the effect of illustrations and instructional materials on the teaching and learning of Newton's third law.
3. What is the effect of practical on the teaching and learning of Newton's third law?

Research Hypothesis

Ho_1: There is no significance difference in the mean scores of pre-test and post-test in Force Concept Inventory (FCI) achievement test based on gender.

Ho_2: There is no significance difference in the mean scores of pre-test and post-test in Force Concept Inventory (FCI) achievement test based on school type.

II. METHODOLOGY

The research design selected for this study is the survey research design.The population of the study consists of all tertiary institutions in Ondo State.A purposive sampling technique was used to selectthree higher institutions in Ondo State. The population of the study consisted of 450 undergraduate students selected randomly from three tertiary institutions in Ondo West Local Government Area, Ondo State. The institutions are Adeyemi College of Education, Ondo; University of Medical Science and Wesley University, Ondo, Ondo state. A total of 450 students is 30% of the entire population in the Local Government Area. Four of the faculties/schools were selected from each institution randomly to prevent clumsiness and make it manageable using random sampling techniques.In this research work, two instruments

were used, firstly is the questionnaire which gives the general overview of the concept of force and this research instrument was subjected to Cronbach reliability test. The Cronbach coefficient value was 0.97.This value confirmed that the instrument was trustworthy in achieving the study objectives.The research questionnaire was designed in a closed form with multiple-choice questions to fit the assessment of students' concept of force as described by Newton's third Law (Fulmer, 2015; Hestenes, Wells, & Swackhamer, 1992; Stewart, Zabriskie, Devore, & Stewart, 2018). The questionnairewas divided into three parts: the introductory section, the "A" section and the "B" section. The introductory part consists of the topic of the research work and stated the aim of the study. Section A collects the respondent'sbiographicaldata whilesection B focuses on the multiple-choice assessment questions on concepts of force. The latter section gave instructions on how to fill the questionnaire, which was distributed to the students in the various departments which were based on four rating scale.The second instrument is the FCI, and it wasutilised to evaluate students' convictions about Newton's laws and force. It is one of the most dependable and effective Physics tests presently accessible for preliminary Physics instructors and is the best test presently available to appraise the usefulness of teaching in preliminary Physics courses. Questions on the FCI test were structured to be relevant to students without formal instruction in mechanics and focus on their preconceived ideas on the topic. (Hestenes & Halloun, 1995; Hestenes et al., 1992) designed the FCI to investigate student convictions about force and how their convictions match with the many scope of the Newtonian concept. Questions on the FCI were formulated based on their suitability for real world presentation of Newton's laws. In this research, the FCI was selected as a guide to point out the mentioned misunderstanding in questions. As an instrument for examination, the survey can be used to ascertain and categorize misunderstanding. It is particularly worthwhile for instructors/tutors to enhance their understanding of misconceptions among their own students, also for assessing teaching; the survey is a very precise and dependable tool. The FCI is made up of 30 multiple-choice questions. We gave the FCI as the pre-test on the second week of class. Researcher exercised great caution that all question sheets and answer sheets are returned. The researcher gave the FCI post-test without prior notice near the final week of classes, and possibly as part of the final exam with considerable course credit allocated for post-test achievement as this impels students to take the post-test with all seriousness and thereby reveal more correctly their comprehension, especially if time dedicated to the post-test cuts from the time spent on the rest of the final exam(Evans et al., 2003; Halloun, 2007). Data acquired were later subjected to a statistical analysis package using Mean, Standard deviation and T-test statistics to analyse the collected data from these institutions.

III. RESULTS AND DISCUSSION

*Research Question One***:** What reason for variation in the student concept of force especially the Newton's third law?

Table 1: Mean Response on the Reason for Variation in the Student Concept of Force especially the Newton's Third Law

S/N	ITEMS	MEAN	SD	REMARK
1	I like force as a topic	3.43	0.88	Agreed
2	Laws and formula are usually easy in understanding Newton's third law	3.97	0.29	Agreed
3	I usually find it difficult to understand concept of force.	3.60	0.66	Agreed
4	Force alters the state of motion of a body.	3.09	0.17	Agreed
5	The force due to friction always opposes motion	3.88	0.43	Agreed
6	Force is an interesting topic	2.89	0.90	Agreed

From the Table 1 above, the mean score of 3.43 was obtained for Item one, which was greater than 2.50 cut-off mean,this implies that respondent agreed that students like force as a topic. The results of analysis of data also revealed the same trend for other items as stated above. The findings revealed that respondents agreed with the laws and formulae are usually easy in understanding Newton's Third law and that learners usually find it hard to comprehend concept of force. The respondentalso agreed that force alters the state of motion of a body and the force due to friction always opposes motion. Based on these responses the respondent agreed that force is an interesting topic.

Research Question Two: What is the effect of illustration and instructional material on the teaching and learning of Newton's Third law?

Table 2: Mean Response on the Effect of Illustration and Instructional Material on the Teaching and Learning of Newton's Third Law

S/N	ITEM	MEAN	SD	REMARK
1	The period you are having for the Physics class is it enough for you to understand the topic better	3.69	0.74	Agreed
2	There are facilities put in place for you to be able to understand better	3.54	0.94	Agreed
3	Force can be apply to normal day life	3.86	0.45	Agreed
4	Downward force of gravity is greater than the upward force	3.81	0.61	Agreed
5	Concept of force and Newton's law are my interesting topic	2.68	0.72	Agreed
6	My Physics teacher is not friendly when teaching force	3.31	0.80	Agreed

From the Table 2 above, the mean score 3.69 was obtained for Item one, which was greater than 2.50 cut-off mean,this implies that the respondent agreed that the period you are having for the Physics class is it enough for you to understand the topic better. The results of analysis of data also revealed the same trend for other items as stated above. The finding of the results revealed that the respondent agreed that thereare facilities put in place for them to be able to understand better

and that the force can be apply to normal day life. The respondent further agreed that the downward force of gravity is greater that the upward force and the concept of force and Newton' law are my interesting topics. Also, the respondent agreed that my Physics teacher is not friendly when teaching force.

Research Question Three: What is the effect of practical on the teaching and learning of Newton's third law?

Table 3: Mean Response on the Effect of Practical on the Teaching and Learning of Newton's Third Law

S/N	ITEM	MEAN	SD	REMARK
1	There is no practical experiment on Newton's third law.	3.76	0.51	Agreed
2	At rest there must be no unbalanced force on a body	3.76	0.65	Agreed
3	Ifacceleration due gravity varies the weight of a body may vary with its location	3.75	0.69	Agreed
4	Experiment determines the coefficient of friction	3.52	0.90	Agreed
5	Centripetal force in circular motion account for acceleration toward the centre	3.91	0.47	Agreed
6	Weightlessness in orbiting satellites is equivalent to motion in free fall	3.71	0.48	Agreed
7	The starting force is greater than the force required to keep an object moving after it started.	3.81	0.59	Agreed

From the Table 3 above, the mean score 3.76 was obtained for Item one, which was greater than 2.50 cut-off mean, this implies that the respondent agreed that there is no practical experiment on Newton's third law. The results of analysis of data also revealed the same trend for other items as stated above. Finding revealed that the respondents agreed that at rest there must be no unbalanced force on a body and acceleration due to gravity varies the weight of a body may vary with its location. It was also agreed that experiment determine the coefficient of friction and that centripetal force in circular motion account for acceleration toward the earth, with weightlessness in orbiting satellites is equivalent to motion. Finally, the respondent agreed that the starting force is greater than the force required to keep an object moving after it started.

Research Hypothesis One(H_{01}): There is no significance difference in the mean scores of pre-test and post-test performance in force concept inventory(FCI) based on gender.

Table 4: T-test analysis of mean scores of pre-test and post-test performance of student base on gender

FCI	N	MEAN	SD	Std. error mean	DF	T-cal.	T-table	Remark
Male	100	3.43	0.88	0.03	98	3.94	1.96	Significant
Female	100	2.89	0.90	0.03				

From the Table 4, T-calculated value (3.94) was greater than t-table (1.96) at 5% alpha level. Therefore, null hypothesis was rejected while alternative hypothesis was accepted.This implies that there was significant difference between male and female student on the understanding and misconception of Newton's laws. The mean score of male students is 3.43, while that of female students was 2.89.This suggests that male students had a better understanding and performance than female students.

Research Hypothesis Two (H_{02}): There is no significant difference in the mean scores of pre-test and post-test performance in the force concept inventory(FCI) base on school type.

Table 5: T-test analysis of mean scores of pre-test and post-test performance of student base on school type

FCI	N	MEAN	SD	Std. mean error	DF	T-cal	T-table	Remark
Private school	100	3.69	0.74	0.02	98	6.70	1.96	Significant
Public school	100	3.31	0.80	0.02				

From the Table 5, T-calculated value (6.70) was greater than t-table (1.96) at 5% alpha level. Therefore, null hypothesis was rejected while alternative hypothesis was accepted.This implies that there was significant difference between private and public school in the misconception and importance of understanding Newton's third law. The mean score of private school was 3.69, while that of public school was 3.31. This means that student in private school had much performance than public school. The result was in line with works of (Helm, 1980); (Ivowi U. , 1986); (Soyibo, 1993); (Dariese, 2012); and (Omoifo, 2012).

IV. CONCLUSION

The researcher-designed questionnaire provided the basis for exploring concepts of force that the learners were familiar with, setting the stage for an assessment using theForce Concept Inventory(FCI) method.The FCI was used to evaluatePhysics teaching andconceptual learning.As shown in the above assessment, the respondents agreed that there are facilities put in place for them to be able to better comprehend the concept of motion and that the force can be apply to normal day life. We proposethe ongoing reporting of the entire FCI mark along with themark on the reduced unbiased tool. The reduced unbiasedtool mark should be utilized for makinginstructional decisions and to allot course credit. By many of the measures available to conceptual tool developers where little preliminary deployment is feasible, theFCI does extraordinarily well.This work should be expanded to examineequity for other poorly represented populace.

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