SCIENTIFIC EXPLANATION OF PHENOMENA AND CONCEPT FORMATION AS CORRELATES OF STUDENTS' UNDERSTANDING OF PHYSICS CONCEPTS

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Abstract
The significant facet of Science Education is to make Science relevant in Students' learning. This involves the ability to draw in examples from daily contexts, to begin with, the learning or to apply concepts learned into familiar everyday phenomena. The main purpose of this study was to find out the relationship between the scientific explanation of phenomena and concept formation on students' understanding of physics concepts. The study adopted a correlational research design. The sample size for this study consisted of 385 Senior Secondary 3 Physics Students for the 2015/2016 academic session in Government-owned secondary schools in Akure Education Zone of Ondo State. The findings of the study revealed among others that there exists a statistically significant positive relationship and a certain proportion of variation among students' scientific explanation of phenomena, scientific concept formation and students' understanding of physics concepts. Also, there was a statistically significant relationship between the linear combination of students' scientific explanation of phenomena and concept formation on students' understanding of physics concepts. The implication from the findings was that students' scientific explanation of phenomena and concept formation are major factors in determining students' understanding of physics concepts. The educational implications of the findings were highlighted, and recommendations were equally made. One of the recommendations is that; Physics teachers, the Authors, and Publishers of physics textbooks should take illustrations by models beyond their physical limitations to involve the application of physics concepts learned into phenomena that students observe and experience around them.
Keywords: Scientific Phenomena, Concept Formation, Understanding Physics Concepts

INTRODUCTION

Science and Technology are incomplete without Physics. Physics is one of the pure science subjects taught at the Senior Secondary School Level of Nigeria educational system. Physics is the study of systematized knowledge produced by careful observation, measurement, and experiment which attempts to establish general laws or principles to describe phenomena under study. It is the most quantitative and fundamental of the sciences. Therefore, understanding physics concepts (such as mass, energy, time, electric charge) which are abstract and tends not to allure with human senses (Griffith and Brosing, 2009); is understanding the fundamental nature of the universe. Hence, the training of science students to acquire a proper understanding of basic principles of physics as well as its applications becomes the aim of physics teaching and learning in the secondary school.

In a domain such as physics, a student may learn the steps for correctly solving certain types of problems (e.g. motion problems) but still retain misconception of the basic underlying concepts (such as force, velocity, weight, acceleration). Therefore, there is little correlation between conceptual understanding and the number of solved problems (Kim & Pak, 2001). In electricity, for example, the current is the key concept that students use to explain the phenomenon in a circuit whereas voltage is a poorly understood concept and is usually identified with current (Madu, 2009). Hence, recent research in physics education shows that many students still retain fundamental conceptual difficulties even after instruction (Ugwanyi, 2012; & Orji, 2013). These common difficulties in understanding basic concepts of physics by students were observed when responding to questions probing conceptual understanding (Gunstone in Kim & Pak, 2001). Students' misconceptions of physics concepts will, therefore, contribute to the wrong answers given by students and present problems to students understanding of physics. This makes students' understanding of physics concepts limited.

Conceptual Understanding of Physics in its most basic form according to National Assessment of Educational Progress (NAEP, 2005) means understanding the principles of science, especially the physics concepts used to explain and predict observations of the natural world and knowing how to apply this understanding efficiently in the design and execution of scientific investigations and in practical reasoning. Added to this is the idea that students' conceptual understanding in physics will have occurred when a person has applied sound scientific concepts to explain specific phenomenon relating to physics concepts (Lawson and Verah, 1993). Meanwhile, Griffith and Brosing (2009) have noted that many of the basic concepts of physics become clearer if applied to everyday phenomena. Therefore, studying everyday scientific phenomena could make abstract ideas more accessible and relevant to students' learning.

Several studies have been reported on the use of the application of everyday phenomenon in deepening students' understanding of physics concepts (Wilkinson, 1999b; Ng and Nguyen, 2006; Griffith and Brosing, 2009). This involves the ability to draw examples from daily contexts, to begin with, the learning or to apply concepts learned into familiar everyday phenomena that students observe and experience around them. This will make physics concepts relevant to students learning. For example: why sound is more audible on a cold day than on a hot day is because on a hot day, the air close to the earth's surface is heated to a much higher temperature than the one farther away from the earth's surface, making the former to be less dense than the latter. Due to the difference in their densities, therefore, the sound is refracted away from the earth's surface making it less audible. Whereas, on a cold day, the air close to the earth's surface is cooler than the layers above it, making the former to be denser than the latter. Sound is therefore refracted towards the earth's surface making it more audible. Here, understanding of physics concept "refraction" may be attained if taken through scientific explanation of a phenomenon.

In cognitive science, how concepts are formed in student's mind and most importantly how they are connected is termed deep understanding (Grotzer, 1999). The term deep understanding was used by Grotzer (1999) to mean scientific understanding. Girard and Wong (2002) stated that deep understanding requires both knowledge of and the ability to use scientific concepts to develop mental models about the way the world operates following a current scientific theory. According to Colman (2003), Concepts are related to the phenomenon of conceiving ideas or thoughts about concrete or abstract matters. They are a means of producing knowledge and organizing ideas to categorize information. Knowledge is a product of learning. Nnachi (2009) refers to processes of concept learning to mean as concept formation.

Concept formation entails discernment of properties common to a class of the object which may involve discrimination training (Chance, 1994). Kaur (2014) views this training as a classification activity, using item characteristics for classification. This classification activity is what Kaur refers to as concept formation. Parker (2008) opines that concept formation is an inductive teaching strategy that helps students to form a clear understanding of a concept (or idea) through studying a small set of examples of the concept. It is therefore pertinent to say that concept formation as a process which involves categorization and classification activity may lead students to an understanding of physics concepts.

Adeyemo (2010) claimed that lack of proper understanding of concepts goes a long way to confuse students the more in physics classrooms, to the extent that when they are strongly attached to their false conception, students may be unwilling to accept the conventional view of the concept offered by their teachers. Physics students', therefore, experience conceptual blockages in their construction of knowledge and may remain unaware of other blockages of physics concepts (Ng and Nguyen, 2006). For example, it is assumed that students will not develop a scientific understanding of DC Circuits if they don't accept scientific reasoning about electric circuit (Madu, 2009).

Ostergaard, Dahlin, and Hugo (2007) show the role of phenomena studied in the understanding of science concepts. Ng and Nguyen (2006) who studied the use of phenomenon in physics teaching at Victorian high schools, reported teachers awareness in the use of phenomenon to improve students' understanding of physics concepts. Khan (2011) studied the existing level of understanding of chemistry concepts among class IX students by administering an achievement test to investigate the effectiveness of concept formation teaching model over the traditional method on class IX students. The study shows a positive relationship as it promotes students understanding of chemistry concepts.

From the foregoing, it is therefore evident that students' understanding of physics concepts may not be attained under teaching and learning approaches that favor rote memorization and incorrect prior knowledge. But, looking from scientific enterprises perspective, teaching and learning approach that will bridge the gap between everyday experience and science-based knowledge is expected to actively engage students in their construction of understanding. In Vietnamese high schools, the use of everyday phenomena in physics teaching and learning is currently in use. In Nigeria, as observed in developing countries, making physics education becoming more relevant in students' learning by involving the ability to draw in examples from everyday phenomenon and applying concepts learned into familiar everyday phenomena is expected to aid students' understanding of physics concepts. The current study sought to find out the relationship between the scientific explanation of phenomena and concept formation on students' understanding of physics concepts.

Statement of the Problem

Knowledge of physics to many students is described in quantitative terms such as how much scientific vocabulary and how many formulae have been memorized. Many physics students prefer answering physics questions using quantitative way of clarifying concepts and thereby, putting great effort in rote memorization and may not have much difficulty in using physics formulae and mathematical definitions to answer questions in physics. Hence, students' knowledge of physics concepts is not understood, and such knowledge may soon be forgotten.

In a typical physics classroom, students answer questions concerning their convergent views which mainly based on their prior knowledge about an everyday experience which is at variance with scientific knowledge. Therefore, no relationship exists between students' prior knowledge in physics and scientific understanding of physics concepts as they attempt to answer physics questions probing their scientific understanding. Though frantic efforts have been made towards curriculum and pedagogical redesigning, textbook rewriting and the education management system restructuring to improve quality of teaching and learning of physics in secondary schools. Also, to raise the level of understanding of physics concepts, illustrations by models are needed to be taken beyond their physical limitations. This involves the ability to apply concepts learned into everyday phenomena that students observe and experience around them. Hence, the question is: To what extent are scientific explanations of phenomenon and concept formation as correlates of students' understanding of physics concepts?

Research Questions

The following research questions were formulated to guide the study:

1. What is the relationship between students' scientific explanation of phenomenon (SSEP) and understanding of physics concepts (SUPC): and the proportion of variance in SUPC accounted for by SSEP?
2. What is the relationship between students' scientific explanation of phenomenon and understanding of physics concepts: and the proportion of variance in SUPC accounted for by SSCF?
3. What is the relationship between SUPC and the combination of both SSEP and SSCF: and the proportion of variance in SUPC accounted for by the combination of both SSEP and SSCF?

The following hypotheses were tested at the $p<0.05$ level of significance:

H01: There is no statistically significant relationship between students' scientific explanation of phenomenon and students' understanding of physics concepts.

H02: There is no statistically significant relationship between students' scientific concept formation and students' understanding of physics concepts.

H03: There is no statistically significant relationship between SUPC and the combination of both SSEP and SSCF.

METHODOLOGY

The study adopted a correlational survey research design. The population of the study comprised of all the SS2 physics students' of the entire government-owned senior secondary school in Akure Education Zone of Ondo State. The sample size for this study consisted of 385 Senior Secondary III Physics Students for the 2015/2016 academic session in Government-owned secondary schools in Akure Education Zone of Ondo State. Three instruments were used for the study, namely: Students' Scientific Explanation of Phenomena Test (SSEPT), Students' Scientific Concept Formation Test (SSCFT), and Students' Understanding of Physics Concept Test (SUPCT). Three experts in the Department of Science Education validated the instrument. Content validity of SSEPT, SSCFT, SUPCT were determined using a well-constructed table of specification.

The concept test contains ten (10) essay questions for each of SSEPT and SUPCT, and SSCFT having a twenty (20) multiple-choice test. After trial testing of the instrument, the reliability coefficient of 0.79, 0.81 were obtained for SSEPT and SUPCT using Kendal tau and 0.81 for SSCFT using K-R20 respectively. The instrument for the collection of relevant data was administered to physics students in the sampled schools. The data collected were analyzed using Pearson Product Moment Correlation and Multiple-Regression analysis to answer the research questions and test hypotheses that guided this study.

RESULTS

The results were presented according to the research questions and hypotheses that guided the study.

Research Question One

What is the relationship between students' scientific explanation of phenomenon (SSEP) and understanding of physics concepts (SUPC): and the proportion of variance in SUPC accounted for by SSEP?

Table 1. *Pearson's Product Moment Correlation and Regression Analysis among the Predictor Variables and the Criterion Variable*

Variable	SSEP	SSCF	SSEP+SSCF	SUPC
SSEP	1			
SSCF	0.52 (0.27)	1		
SSEP+SSCF	0.85 (0.72)	0.89(0.79)	1	
SUPC	0.62 (0.38)	0.60(0.36)	0.70(0.49)	1

Predictors: SSEP and SSCF; Criterion: SUPC; (R2): Coefficient of Determination is in parenthesis

The result in table 1 shows the correlation coefficient of students' scientific explanation of phenomenon (SSEP) and students' understanding of physics concepts (SUPC) to be 0.62. This means that there exists a direct positive relationship between students' scientific explanation of the phenomenon and students' understanding of physics concepts. Table 1 also shows that the coefficient of determination (R2) associated with the correlation coefficient of 0.62 is 0.38. This coefficient of determination (R2) indicates that 38% of the variation in students' understanding of physics concepts is attributed to the scientific explanation of the phenomenon. This is an indication that 62% of the variation in students' understanding of physics concepts is attributed to other factors other than students' scientific explanation of the phenomenon.

$H0_1$: There is no statistically significant relationship between students' scientific explanation of phenomena and students' understanding of physics concepts.

Table 2. *Regression Analysis of Students' Scientific Explanation of Phenomena and their Understanding of Physics Concepts*

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	8.864	.457		19.392	.000
Students' Scientific Explanation of Phenomena	1.004	.065	.618	15.378	.000

The result in table 2 further confirms the contribution of Students' Scientific Explanation of Phenomena to Students' Understanding of Physics Concepts; and that Students' Scientific Explanation of Phenomena predicts significantly Students' Understanding of Physics Concepts since the t-value of 15.398 with an associated exact probability value of 0.000 was obtained. Furthermore, the partial correlation coefficient of Students' Scientific Explanation of Phenomena revealed a positive relationship with Students' Understanding of Physics Concepts. This implies that any improvement in Students' Scientific Explanation of Phenomena would bring about Students' Understanding of Physics Concepts. Hence, there is a statistically significant relationship between Students' Scientific Explanation of Phenomena and Students' Understanding of Physics Concepts.

Research Question Two

What is the relationship between students' scientific concept formation SSCF and understanding of physics concepts SUPC: and the proportion of variance in SUPC accounted for by SSCF?

Analysis of data in table 1 shows the correlation coefficient of students' scientific concept formation (SSCF) and students' understanding of physics concepts (SUPC) to be 0.60. This means that there exists a direct positive relationship between students' scientific concept formation and students' understanding of physics concepts. **Table 1** also revealed that the coefficient of determination (R2) associated with the correlation coefficient of 0.60 is 0.36. This coefficient of determination (R2) indicates that 36% of the variation in students' understanding of physics concepts is attributed to scientific concept formation. This is an indication that 64% of the variation in students' understanding of physics concepts is attributed to other factors other than students' scientific concept formation.

$H0_2$: There is no statistically significant relationship between students' scientific concept formation and students' understanding of physics concepts.

Table 3. *Regression Analysis of Students' Scientific Concept formation and their Understanding of Physics Concepts*

Variable	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-8.349	1.529		-5.459	.000
Students' Scientific Concept formation	.335	.023	.595	14.504	.000

The result in table 3 further confirms the strong contribution of Students' Scientific Concept formation to Students' Understanding of Physics Concepts; and that Students' Scientific Concept formation predicts significantly Students' Understanding of Physics Concepts since the t-value of 14.504 with an associated exact probability value of 0.000 was obtained. Furthermore, the partial correlation coefficient of Students' Scientific Concept formation revealed a positive relationship with Students' Understanding of Physics Concepts. This implies that any improvement in Students' Scientific Concept formation would bring about Students'

Understanding of Physics Concepts. Hence, there is a statistically significant relationship between students' scientific concept formation and students' understanding of physics concepts.

Research Question Three

What is the relationship between SUPC and the combination of both SSEP and SSCF: and the proportion of variance in SUPC accounted for by the combination of both SSEP and SSCF?

Analysis of data in table 1 shows the correlation coefficient of the combination of both SSEP and SSCF, and students' understanding of physics concepts (SUPC) to be 0.70. This means that there exists a direct positive relationship between the combination of both SSEP and SSCF and students' understanding of physics concepts (SUPC). Table 1 also revealed that the coefficient of determination (R2) associated with the correlation coefficient of 0.70 is 0.49. This coefficient of determination (R2) indicates that 49% of the variation in students' understanding of physics concepts is attributed to the combination of both SSEP and SSCF. This is an indication that 51% of the variation in students' understanding of physics concepts is attributed to other factors other than the combination of both SSEP and SSCF.

$H0_3$: There is no statistically significant relationship between SUPC and the combination of both SSEP and SSCF.

Table 4. *Analysis of Variance (ANOVA) of Students' Understanding of Physics Concepts and the combination of Students' Scientific Explanation of Phenomenon and Students' Scientific Concept Formation*

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	3756.380	1	3756.380	358.886	.000
Residual	4008.778	383	10.467		
Total	7765.158	384			

To test hypothesis 3, ANOVA was used. The result in table 4 shows that an F-ratio of 358.89 with an associated exact probability value of 0.00 was obtained. This probability value of 0.00 was compared with 0.05 set as the level of significance for testing the hypothesis and it was found to be significant because 0.00 is less than 0.05. The null hypothesis which stated that; there is no statistically significant relationship between SUPC and the combination of both SSEP and SSCF was rejected and inference drawn was that the combination of both students' scientific explanation of phenomenon (SSEP) and students' scientific concept formation (SSCF) is a correlates of students' understanding of physics concepts (SUPC). In other words, there is a statistically significant relationship between SUPC and the combination of both SSEP and SSCF.

DISCUSSION

The findings of the study in Table 1 shows that there exists a direct positive relationship between students' scientific explanation of the phenomenon and students' understanding of physics concepts. Also, 38% of the variation in students' understanding of physics concepts is attributed to the scientific explanation of a phenomenon. This is an indication that 62% of the variation in students' understanding of physics concepts is attributed to other factors other than students' scientific explanation of a phenomenon. Meanwhile, result from Table 2 shows that there is a statistically significant relationship between students' scientific explanation of the phenomenon and students' understanding of physics concepts. The finding from this study agreed with the finding of Ng and Nguyen (2006) who investigated the use of everyday phenomena and practical work on physics teaching and reported that scientific explanation of everyday phenomena enhanced students' understanding of physics concepts.

Finding from Table 1 also revealed that there exists a direct positive relationship between students' scientific concept formation and students' understanding of physics concepts. And 36% of the variation in students' understanding of physics concepts is attributed to scientific concept formation. This is an indication that 64% of the variation in students' understanding of physics concepts is attributed to other factors other than students' scientific concept formation. Furthermore, Table 3 shows that there is a statistically significant relationship between students' scientific concept formation and students' understanding of physics concepts. This finding agrees with Yao (2003) findings, who confirm that concept formation would improve students' understanding of concepts since concepts are the basic units of thought that underlie human intelligence and communication at both philosophical level and technique level. Also, the finding of Khan (2011) who researched on the effectiveness of concept formation teaching model over traditional method on class IX students' achievement revealed that the there is a greater improvement in the existing level of understanding of concepts in the subject of Chemistry among class IX students.

Moreso, the findings of the study in Table 1 shows that there exists a direct positive relationship between the linear combination of both SSEP and SSCF and students' understanding of physics concepts (SUPC). Also, 49% of the variation in students' understanding of physics concepts is attributed to the linear combination of both SSEP and SSCF. This is an indication that 51% of the variation in students' understanding of physics concepts is attributed to other factors other than the combination of both SSEP and SSCF. Meanwhile, the ANOVA result from Table 4 shows that there is a statistically significant relationship between SUPC and the combination of both SSEP and SSCF. The finding of this study corroborates the finding of Oluwatelure (2002) who found that explanations given by students on scientific phenomenon correspond to their level of imagination. In Grotzer, (1999) how concepts are formed in student's mind and most importantly how they are connected determines deep understanding.

CONCLUSION

Based on the findings of this study, the following conclusions have been made;

1. There is a direct positive relationship between students' scientific explanation of the phenomenon and students' understanding of physics concepts; and a certain proportion of variation in students' understanding of physics concepts attributed to students' scientific explanation of the phenomenon. Also, there is a statistically significant relationship between students' scientific explanation of the phenomenon and students' understanding of physics concepts.
2. There is a direct positive relationship between students' scientific concept formation and understanding of physics concepts; and a certain proportion of variation in students' understanding of physics concepts attributed to scientific concept formation. Also, there is a statistically significant relationship between students' scientific concept formation and understanding of physics concepts.

3. There is a direct positive relationship between the linear combination of both SSEP and SSCF and students' understanding of physics concepts SUPC. Also, a certain proportion of variation in students' understanding of physics concepts is attributed to the linear combination of both SSEP and SSCF. Meanwhile, there is a statistically significant relationship between SUPC and the combination of both SSEP and SSCF.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Physics teachers, the Authors, and Publishers of physics textbooks should endeavor to provide illustrations from everyday phenomena to apply physics concepts learned.
2. Curriculum planners, authors, and publishers of physics textbooks and physics teacher should stress on the most important ideas, principles underlying physics concepts and they're relevant to the world to promote effective teaching and learning of physics classrooms.

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