Vol. 4, No. 4 April 2014 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Diagnosing Error Pattern of Physics Students in Solving Problems Using Progressive Wave Equation (PWE) In Senior Secondary Schools in Rivers State, Nigeria

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ABSTRACT

This study attempts to diagnose error pattern of physics students in solving problems using progressive wave equation. A simple random sampling was used to select 96 senior secondary two (SS2) physics students for the study. The instrument used for the study was "Diagnostic Test of Error Pattern Using Progressive Wave Equation (DTEPUPWE) with reliability of 0.82. The data obtained were analyzed using the frequency count, ANOVA and Scheffe' test. The findings revealed that among the three identified errors committed by physics students, Computational Error (CME) was the highest followed by Translational Error (TNE) and then Conceptual Error (CNE). The study also revealed that there is significant difference between the types of error mostly committed by physics students when solving problems using Progressive wave equation. The study therefore recommends that physics teachers should guide the students using systematic procedure so that the students can acquire the relevant computational skills needed in problem solving and appropriate explanation of all physics parameters during content delivery which is paramount for effective learning of physics.

Keywords: *Error pattern, Progressive Wave Equation, Conceptual Error (CNE), Translational Error (TNE), Computational Error (CME).*

1. INTRODUCTION

Physics is a physical science that deals with the behavior of energy and matter and their relationship with other physical parameters. It generates fundamental knowledge which is essential for the required technological advancement needed to propel the economic engine of the world. Secondary school physics is aimed at developing the students understanding of basic scientific phenomenon and application of scientific ideas to everyday life. It enables the learner to acquire relevant knowledge with understanding, ability to handle and process information and problem solving through the acquired knowledge. This has been identified in the curriculum document (FME, 2004) wherein the objectives of the physics curriculum were stated to;

a. Provide basic literacy of physics for functional living in the society,
b. Acquire basic concepts and principles of physics as a preparation for further studies.
c. Acquire essential scientific skills and attitudes as a preparation for the technological applications of physics and
d. Stimulate and enhance creativity.

The study of physics has an internal coherent structure in which concepts are built on other concepts. Tuminaro (n.d) stressed that a complete understanding of the concepts in physics requires fluency in the mathematical language in which these concepts are couched. This means that in order for the students to understand the computational operations in physics, students should be acquainted with mathematical principles. Mathematics is an abstract science and it operates with a specific language. Adeyemo (2010), Adolphus and Aderonmu (2008) had identified that the abstract nature of mathematics makes students perform poorly in physics. There are at least two possible reasons for this poor performance in physics: (i) students simply lack the mathematical skills needed to solve problems in physics (ii) students do not know how to apply the mathematical skills they have to particular problem situation in physics.

Understanding students' poor performance in physics entails comprehensive examination of their error pattern in solving mathematical tasks in physics. The International Commission for the Study and Improvement of Mathematical Teaching (CIEAEM) in 1987 in Canada defines "error" as when a person chooses the false as the truth, when the undertaken actions are not compatible with the accepted procedures. Duverney quoted in Rouche (1988) stated that an error reveals the inadequacy of knowledge and is closely connected with imagination and creativity in a new situation and is caused by an insufficient mastery of basic facts, concepts and skills.

It is imperative to state that students' errors affect their grading process and the result in a lower evaluation of the students' cognitive knowledge or skill. Therefore, teachers should place emphasis on students' scripts or any means of feedback by analyzing and diagnosing to remediate errors in the conceptual, translational and computational procedures of physics tasks. This involves a comprehensive error analysis on the part of the teachers. Board of Studies, New South Wales (2013) explained that error analysis involves the identification of difficulties that students may have with facts, concepts, strategies and procedures.

Ekwueme and Nenty (2001) revealed that error analysis is the most accurate method of determining how the learners are able to assimilate the quality of learning that has taken place. Identification of error pattern enables the teacher to address learners' needs efficiently by remedial teaching, adopting concise instructional methodology and materials. Encountering error is inevitable in solving problems in physics and as such, teachers should make effort in analyzing errors made by students in order to find corrections to the problem.

Booker (1989) reiterates that teachers should understand that students might err especially when faced with a new concept; therefore, teachers should understand the way students think, because they do not make errors thoughtlessly. They either believe that what they are doing is correct or not at all sure what they are doing. Freudenthal cited in Legutko (2013) linked students' error with the teacher's role in the concept presentation by explaining that students who make errors always do so with the teacher who teaches them. The steps that teachers can employ in the analysis of students' error are:

(i) Collect evidence of learning by giving learners a number of task
(ii) Assess students responses for error pattern
(iii) Analyze the various error types and consider the causes
(iv) Provide clarification by involving the learner through demonstration and possibly interview.

Several research studies have identified different types of errors made by students (Carpenter, Fennema & Romberg, 1993; Kerslake, 1986; Eichelmann, Narciss, Schnaubert & Melis, 2012). Errors students make in problem solving in physics are inevitable and as such an in-depth analysis is required so as to enhance students' performance in physics, especially in a mathematical concept like Progressive Wave Equation (PWE). The mathematical representation of progressive wave motion is given as:

$$y = A \sin (\omega t \pm \Phi) \quad - - - - - - - \qquad (1)$$

Equation (1) above is the motion of a sine wave. The sign indicates the direction of the wave motion. Therefore, a progressive wave in the negative x – axis is given as:

$$y = A \sin (\omega t + \Phi) \quad - - - - - - - - \qquad (2)$$

while a progressive wave in the positive direction is given as:

$$y = A \sin (\omega t - \Phi) - - - - - - - - \qquad (3)$$

where y is the vertical displacement; A is the amplitude of the wave and Φ is the phase angle.

$$\omega = 2\pi/T \text{ or } 2\pi f - - - - - - - - - \qquad (4)$$

$\Phi = 2\pi x/\lambda$: x is horizontal coordinate of the vibrating particle and

$k = 2\pi/\lambda$: k is known as the wave number. - - (5).

Substitute equation (4) & (5) into equation (3)

$$y = A \sin (2\pi t/T - 2\pi x/\lambda) - - - - - - \qquad (6)$$

$$y = A \sin 2\pi (t/T - x/\lambda) - - - - --- \qquad (7)$$

equation (7) can be written as

$$y = A \sin 2\pi/\lambda (\lambda t/T - x) - - - - - - \qquad (8)$$

but $\lambda/T = v$: where v is the wave speed, therefore

$$y = A \sin 2\pi/\lambda (vt - x) - - - - - - - - \qquad (9)$$

The equations generated above are used for solving problems on progressive wave. Basically tasks presented to secondary school students on PWE entail the comparing of the given task to the standard PWE (equations 2, 3, 6, 7, 8 and 9). Parameters usually expected to be determine includes amplitude of the wave (A), period of the wave (T), frequency of the wave (f), wavelength of the wave (λ), velocity of the wave (v), phase angle (Φ) and wave number (k). There are three fundamental skills required to effectively solve problems using progressive wave equation;

(i) Conceptual skills: This is the skill required to relate a given task to a particular concept based on the parameters given in the task
(ii) Translational skills: This is the skill required to accurately identify the specific terms, parameters and the sequence of operation of a given task.
(iii) Computational skills: This is the skill required to use the correct algorithm or operation in solving the problem.

The skills highlighted above form the classes of error that is employed in this work for the study. Therefore the study diagnoses errors such as Conceptual Error (CNE), Translational Errors (TNE) and Computational Error (CME) that students make when performing mathematical operations on progressive wave equation.

2. OBJECTIVES OF THE STUDY

The main objective of this study is to diagnose error pattern of physics students in solving problems using Progressive Wave Equation (PWE) in senior secondary

schools in Rivers State. Sequel to this, the specific objectives are to:

a. Determine the type of error most committed by physics students when solving problems using progressive wave equation.
b. Determine if gender affect errors made by physics students when solving problems using progressive wave equation.
c. Determine if age difference affect errors made by physics students when solving problems using progressive wave equation.

3. RESEARCH QUESTIONS

In an attempt to diagnose error pattern of physics students in solving problems on Progressive Wave Equation (PWE) in senior secondary schools in Rivers state, the following research questions were raised;

a. What type of error is mostly committed by physics students when solving problems using Progressive Wave Equation?
b. What type of error is mostly committed by male physics students when solving problems using Progressive Wave Equation?
c. What type of error is mostly committed by female physics students when solving problems using Progressive Wave Equation?

3.1 Hypothesis

Ho: There is no significant difference between the types of error mostly committed by physics students when solving problems using Progressive wave equation.

3.2 Methodology

The research methodology employed for this study is survey research design. The research design was employed to obtain both qualitative and quantitative data for the study. The population comprises all public senior secondary schools and all senior secondary schools two (2) physics students in Rivers state. This population was chosen because the use of Progressive Wave Equation in the topic "Waves" is been taught in this class. A simple random sampling technique was employed to determine the sample size which consists of ninety-six (96) SS2 physics students consisting of 59 male and 37 female.

3.3 Research Instrument

The research instrument employed for the study which was captioned "Diagnostic Test of Error Pattern Using Progressive Wave Equation (DTEPUPWE) was utilized to diagnose the errors physics students make as a result of solving problems using the progressive wave equation. The DTEPUPWE consists of two sections A and B. Section A includes personal data of respondents which include their sex, age and school, while section B consist of ten (10) test questions on the use of progressive wave equation to solve related problems. The research instrument was subjected to a pilot study to establish the consistency of the instrument. Using the Pearson Product Moment Correlation Co-efficient (PPMCC), the reliability of the instrument which was obtained as 0.82.

3.4 Method of Data Analysis

The script of the students was critically diagnosed to determine the type of errors made by the physics students. The results obtained were basically used for the purpose of data and were analyzed using the frequency count, ANOVA and Scheffe' test.

3.5 Results and Findings

(1) What type of error is mostly committed by physics students when solving problems using Progressive Wave Equation?

Table 1: Analysis of students' error type made.

Error type	No of students	Error Analysis		
		Frequency of error	Percentage (%)	Error Score (ES)
CNE	96	13	13.5	74
TNE	96	30	31.3	141
CME	96	53	55.2	280

Source: Researchers fieldwork (2013)

The table above shows the analyzed data of the type of error mostly committed by physics students when using the progressive wave equation. The result revealed that out of 96 students that attempted the questions, 13 of them made Conceptual Error (CNE) resulting to 13.5% and ES (74), Translational Error (TNE) 30 (31.3%) and ES (141) and Computational Error (CME) 53 (55.2%) and ES (280). This indicates that the major error committed by physics students is the Computational Error (CME). Computational error can be corrected if procedural knowledge is utilized as there are specific algorithms to solve a given task as stated by Wittmann (2009). Teachers should select corrective means and methods in order to deepen their students' understanding of mathematical concepts that are couched in physics, improve their reasoning methods and to perfect their problem solving skills.

3.6 Research Question 2

What type of error is mostly committed by male physics students when solving problems using Progressive Wave Equation?

Table 2: Analysis of male students' error type made

Error type	No of students	Error Analysis		
		Frequency of error	Percentage (%)	Error Score (ES)
CNE	59	5	8.5	33
TNE	59	21	35.6	103
CME	59	33	55.9	180

Source: Researchers fieldwork (2013)

The result in table 2 shows the error type committed by male physics students when using progressive wave equation. Out of the sample 59 male students, the frequency of Conceptual Error (CNE) made was 5 (8.5%) and ES (33); Translational Error (TNE) was 21 (35.6%) and ES (103); finally, Computational error (CME) was 33 (55.9) and ES (180). The result indicates that the most error committed by male physics students is the computational error.

3.7 Research Question 3

What type of error is mostly committed by female physics students when solving problems using Progressive Wave Equation?

Table 3: Analysis of female students' error type made

Error type	No of students	Error Analysis		
		Frequency of error	Percentage (%)	Error Score
CNE	37	8	21.6	41
TNE	37	9	24.3	38
CME	37	20	54.1	100

Source: Researchers fieldwork (2013)

Table 3 revealed the type of error mostly committed by female students when solving problems using Progressive Wave Equation. The frequency of error for the Conceptual Error (CNE) was 8 (21.6%) with error score of 41, while Translational Error (TNE) was 9 (24.3%) with error score of 38. Computational Error (CME) was 20 (54.1) with error score of 100. Therefore, it was shown that Computational Error (CME) is the error most committed by female physics students.

3.8 Hypothesis

There is no significant difference between the types of error mostly committed by physics students when solving problems using Progressive wave equation.

Table 4: one way analysis of variance on errors made by physics students

Source of variation	Sum of squares	Df	Mean square	F_{cal}
Between groups	21	2	10.5	3.28
Within groups	295	93	3.2	
Total	316	95		

Source: Researchers fieldwork (2013),

The critical value of F with 2 and 93 degrees of freedom at 0.05 level of significance is 3.11. Since the computed F_{cal} (3.28) is greater than the critical value of F (3.11), we reject the null hypothesis and accept the alternative hypothesis stating that there is significant difference between the types of error mostly committed by physics students when solving problems using Progressive Wave Equation. Since the ANOVA result is significant, the Scheffe' test was used to identify the pairs of means that have given rise to the significant difference established by the F – value for ANOVA.

Table 5: Scheffe' test analysis

SCHEFFE' TEST	MEAN
CNE	5.70
TNE	4.70
CME	5.28

With the Scheffe' test the following results were obtained

CNE – TNE = 16.7 > 3.28 - Significant at .05 alpha level = reject

CNE – CME = 6.0 > 3.28 - Significant at .05 alpha level = reject

CME – TNE = 8.5 > 3.28 - Significant at .05 alpha level = reject

Therefore the overall result establishes that there is significant difference in the compared means.

4. CONCLUSION AND RECOMMENDATIONS

Efforts have been made to diagnose error pattern of senior secondary school physics students when using the progressive wave equation to problems on waves. Progressive wave equation is a mathematical equation that involves certain mathematical principles like trigonometry, change of subject formulae etc, and students tends to shy away from tasks that involve the usage. This study has significantly revealed the aspect which students find difficult in other to arrive at the solution of a problem when using PWE. Therefore, physics teachers should guide the students using systematic procedure so that they can acquire the relevant computational skills needed in problem solving. It is also critical that appropriate explanation of all physics

parameters during content delivery is paramount for effective learning of physics.

REFERENCES

[1] Adeyemo, S.A. (2010). Teaching/ learning physics in Nigerian secondary school: The curriculum transformation, issues, problems and prospects. International Journal of Educational Research and Technology, 1(1), 99-111

[2] Adolphus, T and Aderonmu, T.S.B (2008): Factors affecting the teaching and learning of electromagnetism among secondary school physics students. Nigeria Journal of Vocational Teacher Education (NJVTE). Vol 8(1), 25 – 37.

[3] Board of studies, New South Wales (2013): K-6 Educational resource. Error Analysis. Retrieve on 11/11/2013, http://k6.boardofstudies.nsw.edu.au

[4] Booker, G (1988): The role of errors in the construction of mathematical knowledge: the role error play in the learning and teaching of Mathematics. CIEAEM, 39 Canada; University of Sherbrooke. 63 – 69.

[5] Ekwueme C.O and Nenty,J.H (2001): Common errors and performance in junior secondary school three certificate examination in Cross River State, Nigeria. Global Journal of Pure and Applied Sciences. 7(3), 591 – 596.

[6] Federal Ministry of Education (2004): The Nigerian Physics curriculum document. NERDC.

[7] Rouche, N (1988): "Questions sur les erreurs" The role error play in the learning and teaching of mathematics. CIEAEM. 39 Canada; University of Sherbrooke. 97 – 121.

[8] Tuminaro, J. (in preparation). A Framework for Describing Common Mathematical Errors Students Make in Introductory Physics. Unpublished doctoral dissertation, University of Maryland, College Park.

[9] Wittmann, G (2009): The consistency of students' error patterns in solving computational problems with fractions. Retrieved on 12 / 11/2013: http://cerme8.metu.edu.tr/wgpapers/WG2/WG2_Wittmann.pdf