Full Research Paper

Breaking the Backbone of Difficult Concepts in the New Secondary School Physics Curriculum in Africa

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ABSTRACT

The new senior secondary school physics curriculum for Anglophone West African countries came into use in 2015. Since the beginning of its implementation, even though, the performance of the candidates has not been high, yet reported empirical studies on the difficulty level of the content, and specifically the topics or concepts have been scant. Moreover, there have never been any published studies which conducted an in-depth probe into the aspects of the topics students find difficult in physics and science in general, beyond mere cataloguing of such topics, nor have there been any, in which students were qualitatively engaged in making inputs towards the amelioration of the topic difficulty. This is a huge gap in literature which this study determined to fill. The effort is significant to the extent that understanding the areas of difficulties of the topics as perceived by the students is good pointer towards remedy by teachers and stakeholders. The study therefore undertook five missions: (a) to find out the topics in the new physics curriculum that secondary school students find difficult (b) undertake in-depth probe of the specific aspects of the topics for which students have learning difficulty. (c) probe the possible causes of or factors responsible for these difficulties (d) determine if school location, school ownership and students' gender have impacts on students' perception of physics topics difficulty; and (e) deriving from students' views, suggest how physics can be made easy to learn. A sample of 1,105 students was drawn from 21 secondary schools in Nigeria and Ghana. These schools comprised 12 private and nine public schools randomly selected from rural and urban areas. 75% of the schools were urban while about 25% were rural. Randomly selected 10 students and five teachers were interviewed for qualitative data, while all the participants were involved in responding to the questionnaire. From data gathered, five top most difficult topics were refractive index, electromagnetism, radioactivity, curved lenses and sound: production, propagation and modulation. Rich qualitative data unique for this study, was reported. There was marked difference between urban and rural, private and public, but not in gender. Recommendations were made for better teaching and meaningful learning.

Keywords: Backbone of difficult topics; meaningful learning of physics

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1. INTRODUCTION

Since after Ghanaian and Nigerian independence in 1957 and 1960 respectively, secondary school physics curricula in most African countries, have witnessed so many innovations in accordance with the education system they adopted. This education system metamorphosed from six years of primary, five years of secondary, two years of higher school and three years of university education (6,5,2,3) to six years of primary, five years of secondary and four years of university education (6,5,4) and presently six years of primary , three years of junior secondary, three years of senior secondary and four years of university education (6,3,3,4). In 6,5,2,3 and 6,5,4 education systems, physics as a separate subject was introduced in third year of secondary education and was compulsory in that class just like the other two separate sciences-chemistry and biology, whereas in the current 6,3,3 4 physics is introduced in the first year of the senior secondary and is optional from the beginning. To this effect the physics curriculum has also been moved from topical to spiral thematic, some advanced topics have been added and the objectives broadened.

However, within this 6,3,3,4 system, and more so in 2015, the science arm of the national curriculum development body- Nigerian Educational Research and Development Council (NERDC) in conjunction with the West African Examinations Council (WAEC) improved the curriculum/syllabus the more by jettisoning some topics and adding new ones in compliance with the new level of scientific and technological demands of the global society. However, since all these years, science (physics, chemistry and biology) education research has been inundated with studies that majorly sought mechanism to either stimulate the interest of the students and attract them to science (Novak, 1996; Wandersee, 1999; Smith, 2019) or improve the academic achievement of the students that have been won over for science(Agholor, 1999; Parsons, 2018).

Both of these research objectives converge at identifying the concepts or topics that are perceived difficult to learn by the students. It is these difficult concepts that scare students and deter them from being attracted to science. Further, they become impediment to the students' performance (Adams, 2016; Joshua, 2017; Johnston, 2018). At this level, the studies become mere survey that would not effect any meaningful change and ever since has not. So to expand the frontiers of knowledge on the global quest to win more students for science while ensuring improved performance, there is an urgent need to shift research gaze beyond this point. It is this gap that this study wishes to fill.

Moreover, before now, there have not been any studies that identified the topics in the new secondary school physics curriculum of 2015, perceived difficult by students. Even the previous researchers before 2015, only succeeded in narrowing down their objectives to mere listing of the difficult concepts or topics (Ajani, 2001; Allison, 2006; Turniclle, 2012. The studies lacked in-depth probing of the perceived difficult topics, exploring why the students find those topics difficult, and how in the view of the students, they can be taught to make the topics easy. They did not examine the impact of such variables as school type, school location and students' gender. It is these deficiencies that this study hopes to make up.

The significance of this study to African science education community and to socio-economic development of the continent is worthy of expatiation. The outcome of this study will attract more students to physics, improve their academic performance and Africa will generate more professionals who will not only build the continent scientifically and technologically but also economically. If the recommendations of this study are not implemented, African continent will run dry of physicists, scientists, engineers, technologists, pharmacists, doctors and all professionals whose training has something to do with physics. This will lead to Africa being perpetually a consumer of imported technology.

In Africa, the study of physics as a separate subject, starts in senior secondary school. From there, the fewer successful secondary school physics students we have in Africa, the fewer physicists, medical doctors, engineers, pharmacists, scientists, inventors, technicians and technologists we will have in Africa, and invariably, the lower and slower our economic development, a situation that will compel Africa to perpetually lag behind and maintain her derogatory status of a third world continent or underdeveloped continent. On the other hand, the more successful secondary school physics students in Africa, the more all physics-related specialists and professionals, and the more Africa will develop in all ramifications. If there are enough scientists, technicians, technologists, designers, manufactures, producers, marketers and exporters which are all, brain children of physics, what again will deter Africa from economic development the end-product of scientific and technological development. This is the ultimate target of this study and wants to approach it from the classroom where every student passes through before choosing a career. If students find physics easy to learn, then choosing physics and physics-related careers becomes feasible.

Some previous studies have tried to adduce various reasons for the poor performance and the consequent low enrolment, but not much has been done to identify the concepts or topics in the new physics curriculum that the students find difficult and why. For instance, Balla and Ugwumba (2015) and Fenstermacher (1996) acknowledged that teachers and other external factors ranging from unprecedented expansion at all levels of education, lack of school facilities and equipment for effective teaching and learning of the subject, contribute to poor academic performance of the students. Morakinwa (2003) believed that the poor academic performance of students in physics is attributed to teachers' attitude to their job which is reflected in their poor attendance to lessons, lateness to school, as well as scarcity of physics teachers. Okoronka and Wada (2014) in their study identified poor teaching methodology. In a series of studies, Chi and Slotta (2005) have found that a major reason for students' difficulties in learning physics is that students think about concepts as 'things' rather than as processes and that there is a significant barrier between these two ontological categories. Ivowi (2012) and STAN (1992) identified many factors that are responsible for poor performance of students in public examination in STM (physics inclusive) and classified these factors into government-related, examination body- related, teacher-related, student-related, and home-related.

In all, these previous literatures only revealed poor performances in physics. Some addressed poor teaching method, some lack of or inadequate instructional materials, some large syllabus, and so on. But summarily, all reasons for poor performance converge at the fact that the students find the topics or concepts difficult to understand principally because the teacher find them difficult to teach (Obafemi & Onwioduokit, 2013). This corroborates with the assertion of

Nkwo, Akinbola and Edinyang (2008) that most physics concepts are perceived difficult because both teachers and students are unable to construct understanding of the concepts. The indictment of teachers seriously calls for urgent conscientious study to remedy and redeem the situation, for Mohapatra (2015) opined, if the learner did not learn, then the teacher has not taught; we don't have a child who cannot learn, rather we have a teacher who cannot inspire and teach.

From available literature however, there has not been enough study or detailed work as to pin down the topics or concepts in physics that the students do find difficult which leads to poor performance and consequently low enrolment. This is the lacuna this study intends to fill. Elaborate and comprehensive study comprising identifying the concepts or topics in the new physics curriculum which African secondary school students find difficult, identifying the reasons for the difficulty, and proposing ways of breaking the barriers, had been a grey area until Okebukola (2019) delved into such study. This therefore calls for further study. So far, there is no reported study that has proceeded to inquire qualitatively from the students, how the difficult concepts or topics would be taught to effect easy understanding for them, but this study, delved into these areas to extend the frontiers of knowledge.

1.1 Topic or concept difficulty

'Concept' is an idea, a process or a phenomenon. 'Concept' is expressed in word or words and that expression can be regarded as a 'topic' containing related ideas. In this paper, 'concept' and 'topic' are used interchangeably or as complements or one as subset of the other. In the typical African secondary school physics curriculum, the label 'topic' is commonly used as descriptors of what the students are expected to learn in a lesson or lessons. For instance, motion, reflection, refraction, waves are 'topics' listed in the new senior secondary physics curriculum 'concepts' in many African schools, whereas in the curriculum literature (Johnstone, 2016), these topics are often labelled 'concepts' (Townsend, 2011). One can also see 'topic' as the name but 'concept' as the discussion of the ideas under that name.

Now, what are the terms 'difficult topics or concepts'? These are topics students find difficult to learn or understand and integrate into their cognitive structure. It is the topics for which the students can at best achieve only rote learning or memorisation instead of meaningful learning. Rote learning is shallow learning that is based on cramming, memorisation and repetition with little or no effort to integrate new knowledge with existing concepts in the cognitive structure. What is learned under rote is easily forgotten, and hardly applied to new situations. Whereas meaningful learning is not based on memorisation and repetition, but on linking prior knowledge with the new, incoming information. Here what is learned is long lasting, and can be easily applied to new situations. There is a deliberate effort to link new knowledge with higher order concepts in the cognitive structure. Okebukola (1990) confirmed that meaningful learning involves understanding how all the pieces of an entire concept fit together. Meaningful learning is active, constructive and long lasting, but most importantly, it allows students to be fully engaged in the learning process.

Therefore, topic or concept difficulty is the extent to which a concept or topic can be comprehended by a learner (Okebukola, 2020). The spectrum stretches from 'least difficult' where the learner very easily and readily progresses the concept from rote to meaningful learning (Novak, 2005) and to the polar end of 'most difficult' where the learner encounters challenge from meaningfully learning the concept. It means the easiness or difficulty in attaining the comprehension of a concept (Goddard, 2015; Akintunde, 2012). Concept formation has been defined as the process by which a person learns to sort specific experiences into general rules or classes (Smith & Johnson, 2012; Howsey, 2013). This according to Howsey (2013) can be weakly or strongly achieved. Weak attainment is associated with difficulty of the concept while if fully achieved the learner finds the concept easy.

1.2 A Quest in the Physics Curriculum

In most African secondary schools, physics as a separate subject is offered at the senior high school level (grades 10 to 12) or senior secondary one to three (SS 1-3) in Nigerian nomenclature. Before senior school, physics is taught in an integrated form with other sciences –earth science, chemistry and biology. At this level it is tagged basic science or integrated science in some African countries. Physics is introduced in SS 1 and is expected to run through to SS3. Before the era of 6,3,3,4 in Nigeria for instance, the physics curriculum was structured with the conceptual approach to content selection, and topical, a situation where physics was divided into sections or concepts comprising mechanics, heat, optics, waves, electricity, magnetism, and nuclear physics. It was not a spiral curriculum of which any topic or concept treated in any class would not be visited again.

From the era of 6,3,3,4, the curriculum in operation was based on thematic approach and spiral in nature, of which physics was divided into themes. For this curriculum to ensure compliance with national, continental and global issues without necessarily overloading the content, related concepts and topics were aggregated into the following six themes:

1. Interaction of matter, space and time;
2. Conservation principles;
3. Waves: motion without material transfer;
4. Fields at rest and in motion;
5. Energy quantisation and duality of matter;
6. Physics in technology.

With the spiral approach, the topics for the content were selected, organised and spread across the three years. Guided discovery method of teaching was recommended in order to achieve the objectives of the curriculum. The objectives of the new curriculum among others are to:

1. Provide basic literacy in physics for functional living in the society;
2. Acquire basic concepts and principles of physics as a preparation for further studies;
3. Acquire essential scientific process skills and correct attitudes as a preparation for technological application of physics; and
4. Stimulate and enhance creativity.

With these objectives in mind, the course is planned to be student-activity oriented with emphasis on experimentation, questioning, discussion and problem-solving. In the light of this, we selected the physics curriculum for its unequalled role in science and technology as well as in the economic development of nations.

1.3 The new physics curriculum

The most expansive sub-regional examination board in Africa is the West African Examinations Council (WAEC). It was established in 1952 and has ever since remained relevant in Africa. Presently it examines over two million candidates annually from Ghana, the Gambia, Liberia, Nigeria, and Sierra Leone at the end of secondary education. In 2015, it approved new curricula for most subjects including physics. It is this new physics curriculum that this study sought to investigate the levels of difficulty of the topics as perceived by the students. The new curriculum had been in operation for four years at the time the study was conducted in 2019. The topics investigated covered all the themes and areas of physics.

1.4 Purpose of Study

The purpose of this study was to (a) identify the ten concepts or topics in the new physics curriculum, which African secondary school students consider most difficult to learn; (b)undertake in-depth probe of the aspects of the topics for which the students are having difficulty; (c)probe the possible causes of or factors responsible for these perceived difficulties; further, the study would seek to (d) elicit suggestions from the students as regards how and what, would be done for them to learn those perceived difficult concepts with ease. (e) determine the effect of school location, school ownership and gender, on students' perception of topic difficulties.

1.5 Research questions.

The study sought to answer the following questions

1. What are the ten topics in the new secondary school physics curriculum, African students find most difficult?
2. Why do they find those topics difficult?
3. What would be done to remedy the situation?
4. Is there any statistically significant difference in the perception of the difficult concepts by students in rural and urban areas?
5. Is there any statistically significant difference in the perception of the difficult concepts by students in private and public schools?
6. Is there any statistically significant difference in the perceptions of difficulty of the new physics syllabus topics, between male and female?

2. METHODOLOGY

A mixed method (quantitative and qualitative) design was adopted for data collection. First the study employed a survey design to elicit information from the students regarding how they find the topics or concepts in the new physics curriculum, why so, and suggestions for improvement. Further, the qualitative data was collected through phone call interviews.

The study population comprised senior secondary physics students in Africa with particular reference to Nigeria and Ghana. Ghana and Nigeria were selected because both countries use the same physics WAEC syllabus and are comparable in terms of the educational objectives and goals. The study involved a sample of 1,105 senior secondary three (SS 3) students spread across Nigeria and Ghana in randomly selected 21 senior secondary schools of urban and rural settings, as well as public and private status. SS3 students were selected because, they must have been taught almost all the topics which puts them in good position to judge all the topics. The sample comprised 12 private and 9 public schools, about 75% urban and 25% rural locations. Quantitative and qualitative data were collected through administration of questionnaire and telephone interview (of ten randomly selected students and five physics teachers) respectively.

2.1 Instrumentation

Two instruments were designed for data collection. Difficult Concepts in Physics Questionnaire (DCPQ) comprising five sections A-E was constructed to obtain (A) the students' demographic data; (B) rating of the degree of difficulty of 20 popular topics in the new curriculum, spread across board all sections of physics in a three-point rating of 'not difficult', 'moderately difficult' or 'very difficult'; (C) related factors to teaching and learning; (D) reasons for the difficulty using Likert-scale of four levels of strongly agree (SA), agree (A), disagree (D) and strongly disagree (SD); and (E) elicit from the students, suggestions for improvement. This instrument was validated through ratification among 12 research team members supervised by a world class expert in research in science education. Its reliability, 0.88 determined through test-retest on 50 students was found to be good enough.

Interview protocol for selected students was also designed and validated among the research team of 12 members under the supervision of the same research expert. The protocol contained four questions (a) mention three topics you consider most difficult to learn in the new physics syllabus (b) Please explain why you find each of them difficult to learn (c) what did you learn in each topic before other aspects became difficult?(d) please suggest how each of the difficult topics can be made easier to learn.

2.2 Procedure

After seeking and obtaining permission from the school authorities to conduct the study, the research team discussed with the physics teacher who assisted in organising the physics students for the study. The questionnaire was administered to senior school (SS) 3, physics students in 12 private and nine public schools, out of which 13 were located in the urban area while eight were from rural area. At the end of the questionnaire was a provision for the student's name and phone number with which he/she was contacted for interview.

3. DATA ANALYSIS AND FINDINGS

IBM-SPSS Version 23 was used to analyse the data generated from the questionnaire as to find answers to the research questions. After the initial raw analysis of the three-point scale of not difficult, moderately difficult and very difficult and the four-point scale of strongly agree, agree, disagree and strongly disagree, for parsimony, clustering them into difficult or not difficult and yes or no respectively were achieved via data transformation. The later was used to address research question 2. (See table 2 & fig. 2). In the data coding process, not difficult was scored 1, moderately difficult=2, very difficult=3. For each respondent, it was then possible to get a difficulty score which ranged between 1 and 3 for each topic. The mean rank method (Okebukola, 1986; 1987) was used to answer the main research question of the study. This involved a two step-process.

The first step was the summing up of the difficulty scores of the respondents for each topic, and dividing by the number of respondents to get the mean difficulty score for that topic. The second step was to rank the mean topic difficulty scores for the 20 topics in the questionnaire. This resulted in ranking from 1st (most difficult of the 20 topics) to 20th (least difficult) as perceived by physics students in the sample. To address research question 4, the chi-square statistic was applied on the cross-tabulated.

For research question 1: What are the ten topics African secondary school students find most difficult?

Table 1: Mean rank analysis of difficult concepts in physics

Difficult Concepts	Mean	Mean Ranking
Refractive Index	2.32	1st
Electromagnetism	2.29	2nd
Radioactivity	2.25	3rd
Convex and Concave Lenses	2.19	4th
Sound Production Propagation and Modulation	2.19	4th
Simple Harmonic Motion	2.18	6th
Specific Latent Heat	2.18	6th
Voltage Resistance or Current in an Electrical	2.16	8th
Simple machine Pulley system Levers and Inclined Planes	2.08	9th
Waves	2.07	10th
Gravitational Fields	2.05	11th
Specific Heat Capacity	2.02	12th
Density and Relative Density	1.99	13th
Velocity Time Graph	1.97	14th
Projectiles	1.90	15th
Vectors	1.84	16th
Linear Expansivity	1.81	17th
Friction	1.77	18th
Newton's Laws of Motion	1.76	19th
Gas Laws	1.74	20th

In table 1, from the mean ranking analysis conducted on the difficult concepts, refractive indices of rectangular and triangular prisms with mean rank of 2.32 emerged as the most difficult concept, followed by electromagnetism (2.29), radioactivity (2.25), convex and concave lenses (2.19), and sound-production propagation and modulation (2.19). Others were simple harmonic motion (2.18), specific latent heat (2.18), voltage resistance or current in an electric circuit (2.16), simple machine: pulley system, levers and inclined planes (2.08), and waves (2.07). The least difficult was gas laws with mean rank of 1.74, followed by Newton's laws of motion (1.76), friction (1.77), linear expansivity (1.81) and vectors (1.84).

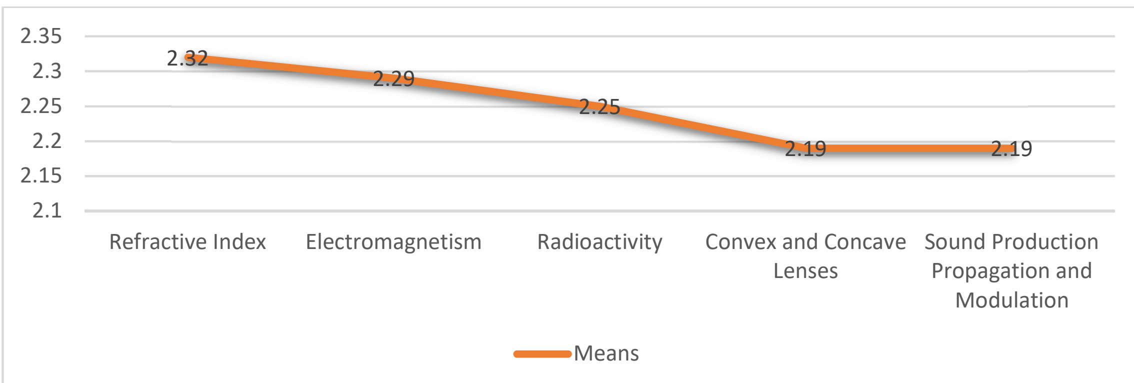


Figure 1: Graph showing five most difficult concepts in physics

Research question 2: Why do African students find these topics difficult?

Table 2: Level of agreement (%) on reasons for difficulty

S/N	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
1	Physics is abstract	26.3	36.5	23.1	13.6
2	There are too many mathematical formulae	44.3	35.3	16.5	3.5
3	The concepts are not related to what I am used to	14.3	39.8	35.6	10.0
4	Physics terms need to be explained in our language	16.5	23.6	35.9	23.5
5	Our teacher doesn't look happy and cheerful while teaching	11.7	18.2	45.4	24.2
6	Our teacher does not use familiar instructional materials	10.4	24.4	42.0	22.8
7	There are little or no practical	13.8	36.0	32.3	17.5
8	Syllabus is too broad	19.4	39.6	28.5	11.9

S/N	Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
9	Our teacher does not explain the concepts well	13.9	28.4	38.8	18.5
10	The examination questions are more difficult	38.8	34.7	21.0	5.3
11	I feel discouraged when my teacher is unable to answer me	24.0	35.5	23.1	17.0
12	Our teacher does not change his/her method of teaching	25.4	27.7	33.3	12.1

Further, the four options of strongly agree, agree, disagree and strongly disagree, were collapsed to two options of Yes or No, by merging strongly agree and agree to be Yes, and then disagree and strongly disagree to be No

Table 3: Level of agreement (Yes/No) on reasons for difficulty

S/N	Statements	Yes	No
1	Physics is abstract	62.8	36.7
2	There are too many mathematical formulae	79.6	20.0
3	The concepts are not related to what I am used to	54.1	45.6
4	Physics terms need to be explained in our language	40.1	59.3
5	Our teacher doesn’t look happy and cheerful while teaching	29.9	69.7
6	Our teacher does not use familiar instructional materials	34.8	64.8
7	There are little or no practical	49.7	49.8
8	Syllabus is too broad	59.0	41.0
9	Our teacher does not explain the concepts well	42.4	57.2
10	The examination questions are more difficult	73.5	26.5
11	I feel discouraged when my teacher is unable to answer me	59.5	40.5
12	Our teacher does not change his/her method of teaching	53.1	45.9

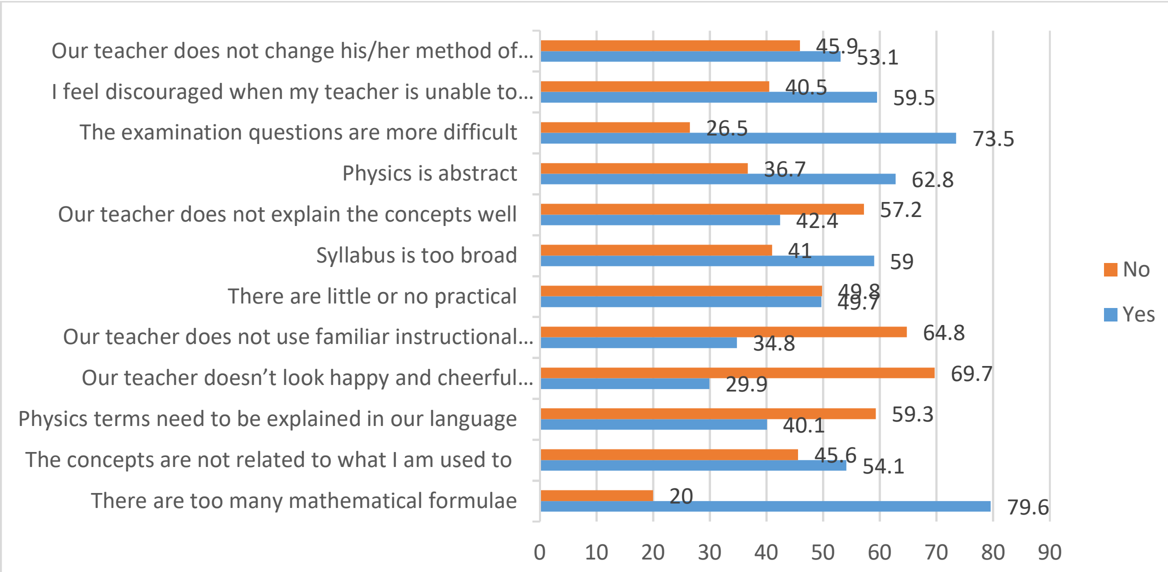


Figure 2: Graph of level of agreement (%) on reasons for difficulty in physics

It can be seen that 'too many mathematical formulae in physics concepts' has 79.6% which is indicated as the most causal factor of difficulty.

Research question 3: In the opinion of the students, what could be done to make these topics less difficult to them?

Ten randomly selected students were interviewed on what should be done to make these difficult topics less difficult. The theme of their responses centred on : First teaching them the mathematics that is required in any topic, guiding them to perform adequate practical by themselves, not being too fast in teaching those confusing topics, solving enough examples. Some of the students expressed themselves thus:

Student C (female, 15years, SS3, public school). 'Confusing topic is done small-small and explained very well. We need more practical'.

Student D (male, 17 years SS3, private school): 'We should do practical regularly and practise all the calculations. Our teacher should not be angry, let him teach us well.'

Student E (male 16 years SS2, public school): 'Let there be enough materials for us to do practical. During practical we don't sleep. If we do practical I won't forget. Let the calculations be explained so that it can enter'

Student F (15 years, SS3, public school): If you don't know mathematics, graph and drawing with math set, that is my problem in refractive indices. Our teacher is supposed to teach us those things before coming to the topic. He will say he is not mathematics teacher. We supposed to do the practical well-well and many times '

All the teachers interviewed complained of inadequate laboratory equipment and instructional materials in the physics laboratory, overload of work in the school leading to inadequate practical and poor mathematical background of most students.

Research question 4: Is there any statistically significant difference in the perception of the difficult concepts by students in rural and urban areas?

Rural and urban students' perceptions were compared using crosstab (Chi Square) statistics to find if school location has effect on perceptions of students.

Table 4: Chi-square analysis of perception of difficulty of physics concepts in rural and urban schools

S/N	Concept	Rural		Urban		Chi-Square
		Difficult	Not Difficult	Difficult	Not Difficult	
1	Refractive Index	43.9	56.1	55.8	44.2	14.44*
2	Electromagnetism	50.2	49.8	56.2	43.8	3.66
3	Radioactivity	51.7	48.3	53.2	46.8	.24
4	Convex and Concave Lenses	55.6	44.4	54.2	45.8	.23
5	Sound Production Propagation and Modulation	49.3	50.7	64.3	35.7	23.67*
6	Simple Harmonic Motion	61.8	38.2	54.7	45.3	5.24
7	Specific Latent Heat	64.0	36.0	53.4	46.6	11.77*
8	Voltage Resistance or Current in an Electrical	61.8	38.2	60.0	40.0	1.64
9	Simple machine Pulley system Levers and Inclined Planes	65.4	34.6	57.5	42.5	6.86*
10	Waves	71.8	28.2	55.5	44.5	29.99*
11	Gravitational Fields	64.9	35.1	62.7	37.1	1.23
12	Specific Heat Capacity	68.4	31.6	66.2	33.8	.82
13	Density and Relative Density	78.4	21.6	69.1	30.9	11.65*
14	Velocity Time Graph	69.1	30.9	68.1	31.9	1.04
15	Projectiles	77.2	22.8	74.5	25.5	1.70
16	Vectors	78.7	21.3	77.0	23.0	7.31*
17	Linear Expansivity	78.9	21.1	81.0	19.0	1.16
18	Friction	87.7	12.3	70.6	29.4	43.37*
19	Newton's Laws of Motion	81.1	18.9	83.7	16.3	1.57
20	Gas Laws	79.7	20.3	80.0	20.0	1.13

* Significant level at less than .05

When students in rural and urban schools were compared on their perception of physics difficult concepts, urban students had higher levels of difficulty in refractive index (55.8%), electromagnetism (56.2%), radioactivity (53.2%), and sound production propagation and modulation (64.3%). Table 4 shows no statistically significant differences were largely found in the perception of difficult concepts among students enrolled in rural and urban.

Research question 5: Is there any statistically significant difference in perceived difficult concepts between students in private and public secondary schools?

Table 5: Chi-square analysis of perception of difficulty of physics concepts in private and public schools

S/N	Concept	Private		Public		Chi-Square
		Difficult	Not Difficult	Difficult	Not Difficult	
1	Refractive Index	52.9	47.1	51.0	49.0	3.28
2	Electromagnetism	30.6	69.4	59.1	40.9	55.23*
3	Radioactivity	27.5	72.5	58.4	41.6	65.58*
4	Convex and Concave Lenses	30.8	69.2	60.0	40.0	58.63*
5	Sound Production Propagation and Modulation	67.2	32.8	56.8	43.2	10.53*
6	Simple Harmonic Motion	49.0	51.0	59.0	41.0	8.88
7	Specific Latent Heat	28.3	71.7	63.7	36.3	86.13*
8	Voltage Resistance or Current in an Electrical	43.3	56.7	64.5	35.5	33.05*
9	Simple machine Pulley system Levers and Inclined Planes	34.3	65.7	66.2	33.8	71.67*
10	Waves	35.2	64.8	67.3	32.7	70.89*
11	Gravitational Fields	30.3	69.7	70.9	29.0	118.91*
12	Specific Heat Capacity	35.0	65.0	74.0	26.0	114.04*
13	Density and Relative Density	55.1	44.9	76.6	23.4	45.58*
14	Velocity Time Graph	52.2	47.8	72.3	27.7	33.18*
15	Projectiles	85.2	14.8	73.3	26.7	16.67*
16	Vectors	82.2	17.8	76.4	23.6	7.28
17	Linear Expansivity	84.7	15.3	79.1	20.9	4.05
18	Friction	57.4	42.6	81.5	18.5	56.21*
19	Newton's Laws of Motion	90.4	9.6	81.6	18.4	11.68*
20	Gas Laws	68.0	32.0	82.7	17.3	30.42*

* Significant level at less than .05

From Table 5, out of the ten most difficult concepts revealed, students in private schools showed a higher level of difficulty in two - refractive index (52.9%) and sound: production, propagation and modulation (67.2%), whereas students in public schools showed a high level of difficulty in the rest eight-electromagnetism (59.1%), radioactivity (58.4%), simple harmonic motion (59.0%), specific latent heat (63.7%), Voltage, resistance and current in an electrical circuit (64.5%), simple machines: pulley system, levers and inclined planes

Research question 6: Is there any statistically significant difference in the perceptions of difficulty of the new physics syllabus topics, between male and female?

Table 6: Cross tabulation of perception of difficulty of physics concepts by male and female students

S/N	Concept	Male		Female		Chi-Square
		Difficult	Not Difficult	Difficult	Not Difficult	
1	Refractive Index	51.8	48.2	50.8	49.2	.11
2	Electromagnetism	52.5	47.5	55.3	44.7	1.94
3	Radioactivity	56.0	44.0	49.2	50.8	5.57
4	Convex and Concave Lenses	57.9	42.1	51.3	48.7	4.80
5	Sound Production Propagation and Modulation	61.2	38.8	55.6	44.4	3.48
6	Simple Harmonic Motion	60.0	40.0	53.9	46.1	6.18*
7	Specific Latent Heat	57.7	42.3	57.1	42.9	.27
8	Voltage Resistance or Current in an Electrical	65.1	34.9	56.0	44.0	9.82*
9	Simple machine Pulley system Levers and Inclined Planes	67.0	33.0	53.1	46.9	21.77*
10	Waves	57.0	43.0	67.2	32.8	12.45*
11	Gravitational Fields	63.6	36.2	63.4	36.6	.93
12	Specific Heat Capacity	68.3	31.7	65.6	34.4	1.10
13	Density and Relative Density	72.9	27.1	72.4	27.6	.84
14	Velocity Time Graph	70.5	29.5	66.0	34.0	4.73
15	Projectiles	76.5	23.5	73.9	26.1	4.25
16	Vectors	80.3	19.7	74.3	25.7	5.67
17	Linear Expansivity	80.7	19.3	79.6	20.4	.81
18	Friction	79.1	20.9	74.3	25.7	4.48
19	Newton's Laws of Motion	85.2	14.8	79.7	20.3	7.48*
20	Gas Laws	81.7	18.3	77.8	22.2	2.55

* Significant level at less than .05

4. DISCUSSION OF FINDINGS AND RESULTS

This study investigated the concepts in the new physics curriculum that are perceived difficult by African senior secondary school students. The top ten topics in decreasing order of perceived difficulty were found to refractive indices of rectangular and triangular prisms, electromagnetism, radioactivity, convex and concave lenses, sound: production, propagation

and modulation, simple harmonic motion, specific latent heat, voltage resistance and current in an electric circuit, simple machine: levers, inclined plane pulley system; and waves.
The ten topics perceived to be easy in increasing order of easiness were: gravitational field, specific heat capacity, density and relative density, velocity-time graph, projectiles, vectors, linear expansivity, friction, Newton's laws of motion and gas laws. Since this is an international study, and Nigerian and Ghanaian students had been taught these topics before their senior school certificate examination in physics, we are confident of the reliability of their claim. The performance profile on these topics of the candidates who had taken the examination in physics is also reflective of the difficulty levels as reported in the physics chief examiners' reports.

Majority of the ten most difficult topics found in this study agrees in part with those found by Okpala & Onocha (1988) in studies carried out on the physics curriculum in the last twenty years. Refractive indices, electromagnetism and radioactivity all these years have been perceived as difficult topics in the physics curriculum in West African Examinations Council.
In contrast, our study found gas laws perceived as easy by students as against difficult by students who operated in the old physics curriculum. Perhaps the crop of physics teachers these days might have accounted to this development.

Since most previous studies terminated their investigation at this level of mere listing down the perceived difficult topics, the key objective of this study was to dig deeper and probe these difficulties to their genesis. We therefore made qualitative investigation, interviewing students and teachers and doing content analysis of physics curriculum and textbooks. Out of five physics textbooks surveyed, it was only one that treated refractive indices very well with good explanation of the mathematics. One textbook of even four authors, gave wrong calculations in refractive indices.

However, as noted in the results section, interesting findings emerged. We will focus our discussion on the first five of the ten perceived difficult topics beginning with the most difficult-refractive indices of rectangular and triangular glass prism. What do the students need to learn in the topic?

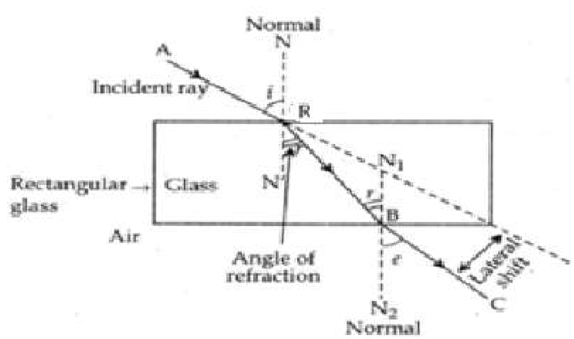
1. Theoretical knowledge and definition of refractive index from two perspectives- speeds and angles.
2. The laws of refraction
3. Adequate technical drawing ability.
4. Accurate linear and angular measurement skill.
5. Practical survey knowledge of rectilinear positioning of poles/optical pins.
6. Trigonometry knowledge.
7. Construction of table of values.
8. Plotting and reading of graph.
9. Calculation of slope/gradient/tangent..
10. Ability to read and interpret intercepts on either axis.

4.1 Refractive indices of rectangular and triangular prisms as a topic in physics

Whenever light ray travels from one medium to another, two changes occur-there will be change in velocity as well as in direction. This change in velocity or direction is known as refraction. The nature of these changes depends on whether it is coming from optically denser medium to a less dense medium or vice versa. If it moves from a less dense medium to a denser medium such as from air to water or from air to glass, there will be decrease in velocity and decrease in the angle of refraction as compared to angle of incidence. The ray moving to the medium boundary or interface is the incident ray while the one moving away from the boundary after refraction is known as the refracted ray. The perpendicular line at the point of refraction is called normal. The angle between the incident ray and the normal at the point of refraction is known as the angle of incidence while that between refracted ray and the normal inside the second medium is called the angle of refraction.

Two laws of refraction are: 1. the incident ray, refracted ray and the normal, all lie on the same plane at the point of refraction. 2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant known as refractive index ‘n’, thus Sin i^o/ Sin r^o= n. This is the Snell’s Law of refraction. It is also true that n= velocity of light in first medium/ velocity of light in second medium.

Refractive index of a rectangular or triangular prism can be determined practically in the laboratory by tracing the outline on a plane sheet, drawing a normal at about the middle of one of the sides. Measure and draw a line at an angle of incidence i^o=30^o. Mount two optical pins P_1,P_2 vertically along line AO, insert back the prism on its outline, and from the other side, view through the prism, and fix two other pins P_3,P_4at positions that are in straight line with the images of P_1 , P_2 as seen through the prism. Draw another line BC through P_3, P_4 to the normal. Using a protractor, measure the angle of refraction r^o. Repeat this for other values of i^o. Then calculate ‘n’ for each set of readings of angle of incidence i^o and angle of refraction r^o.



(b) Refractive index of glass from air $a^ng = \frac{3}{2}$

Refractive index of air from glass $g^na = \frac{1}{a^ng} \Rightarrow \frac{1}{3/2} = \frac{2}{3}$

Figure 3: Ray diagram of refraction in rectangular prism.

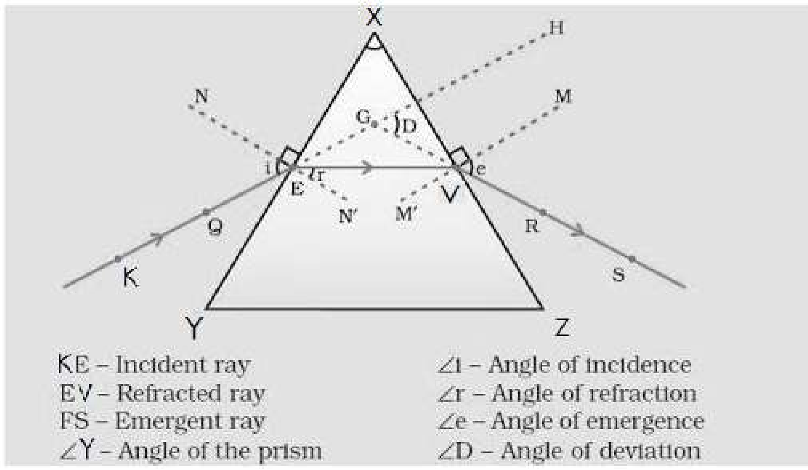


Figure 4. Ray diagram of refraction in a triangular prism

Several values of i^o and r^0 and then sin i^o, sin r^o can be obtained and tabulated. Plot a graph of Sin i^o against Sin r^o. Calculate the slope and compare with the individual values of sin i^o/sin r^o. This is the refractive index. It should be noted that in a rectangular prism, the emergent ray is displaced but in triangular prism is deviated.

It should be noted that whereas the emergent ray in a triangular prism has undergone deviation, and at minimum deviation Dm, i^o=e^o, but in rectangular prism, the emergent ray has undergone lateral shift or displacement, thus being parallel to the original course of the incident ray. Given this summary of the demands of the curriculum in this topic, why do students find it difficult? Interview data showed that refractive index requires so many things at the same time and all those things are not always acquired. One of the students, 'Joe, male,16 years' reported:
It is a confusing topic. It 'carry' drawing. Sometimes the prism will shift and spoil the work. Maths, graph and peeping into the prism in one work. I can peep well but the calculation is too much and there is no time.

> What are the things 'Joe' is complaining about? –Tracing the prism outline, constructions, measurements, calculations, plotting and interpreting graphs. 'Mary', (Female; 17 years) confirmed by saying:
>
> *If you don't know mathematics, graph and calculations before such topic, it will be difficult. Many things at a time hence it becomes more difficult. Our teacher does not wait for anybody.*

On probing further, at what point does the difficulty start, 'Adex' (male, 17years) said
The definition, explanation and laws of refraction, as well as the definition of refractive index were clear, but the drawings, graphs and calculations are big problems.

Some physics textbooks surveyed have good diagrams of the phenomenon but still requires the teacher's explanation and students' good mathematical background. Probing deeper on how the difficulty would be removed, one of the students 'Jane' (female, 16year) said

More periods for practical should be added. Enough equipment should be provided because the one we did was once and 12 students to one apparatus. Our teacher should explain to us well and teach us the mathematics that will help us. Practical is good because, that time everybody is active.

Another student 'Kunle', male 17years corroborated: *'I know that refractive index n is sine i^o/sine r^o, but to get it from drawing into graph is what is confusing me, and we didn't do it well and it was only one time. This makes the topic very difficult'*
This portrays that the government, school owners, mathematics and physics teachers have to live up to expectation.

Second in the order of difficulty was electromagnetism. Under this topic in the physics curriculum, the students were expected to combine their knowledge of magnetic field such as concept of magnetic field, pattern of magnetic field between a N/S bar magnet, unlike poles and like poles; magnetic field around a current-carrying conductor and a solenoid, with electric field or force exerted by a current carrying conductor. Identification of the direction of current, magnetic field and force in an electromagnetic field. Explanation of the working principle of electric bell, telephone ear piece, galvanometer and electric motor. Statement of Lenz's law and Faraday's law of electromagnetic induction. Explain the principles and uses of transformers and induction coils, d.c. and a.c. generators.

4.2 Electromagnetism

Magnetic field is the space or region around a magnet, within which any magnetic material experiences a force whether attractive or repulsive. This force is detected using iron filings or a magnetic compass needle.

Figure 5. Magnetic field lines around a bar magnet.

An electric field (also magnetic field) is a region around a current carrying conductor (wire) within which iron filings or a magnetic compass needle will experience a force.

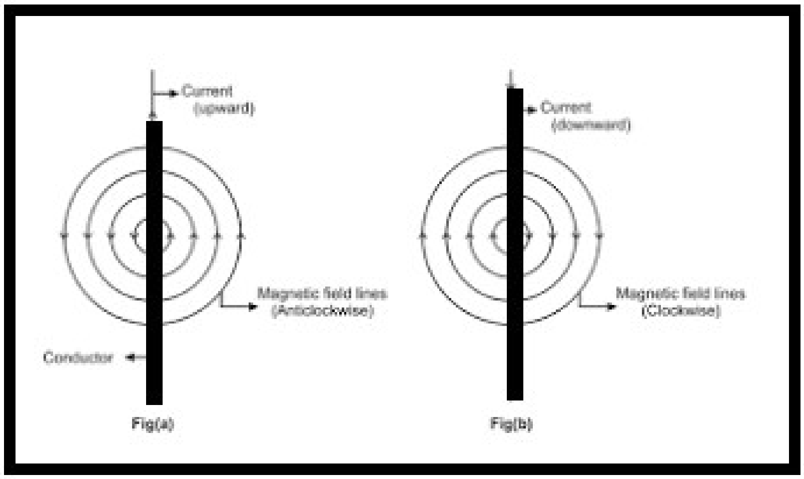


Figure 6. Magnetic field round a current carrying conductor.

Electromagnetic field is a field where the joint interaction of electric and magnetic forces act. The concept of electromagnetism is that a changing electric field is always accompanied by a magnetic field and conversely a changing magnetic field is accompanied by an electric field. This joint interplay of electric and magnetic forces gives rise to an electromagnetic field. e.g. current carrying wire through the 'U' space of a horse shoe magnet. These observations leads to the conclusions that:

1. a mechanical force acts on a current carrying conductor whenever the conductor is placed in a magnetic field at an angle to this field;
2. the direction of the force is always perpendicular to the direction of the current and the direction magnetic field;
3. the magnitude of the force produced is always proportional to the current and the field strength;
4. The magnitude of the force decreases when the angle between the conductor and the field decreases from 90^o, and becomes zero when the conductor lies parallel to the field. So, the force F is directly proportional to the current I, the field strength B and the angle between the conductor and the field.

It is this principle that is applied in electric motor, moving coil galvanometer, a. c. and d. c. generators, moving iron ammeter, and transformers.
Now why do students find electromagnetism difficult? One of the students, 'Jane' (female) responded thus:

We need to handle the bar magnet or horse shoe magnet, bring wire carrying current to it and feel the force and see the direction of the force. Story, story makes everything look confusing and difficult; and it is like that in many topics.

On probing her more with the questions ‘ what did you learn with ease in electromagnetism, at what point did learning difficulty of electromagnetism set in, and what do you suggest as the remedy so that you can learn electromagnetism without difficulty? Her response was beautiful:

> *The initial concepts and definitions such as bar magnet, magnetic materials, making of magnet, demagnetisation and some laws like Lenz’s law, Faraday’s law are acceptable, at least I can memorise and remember them. But when it comes to transformer, a. c. and d.c.generators with their calculations, I don’t follow at all. Let our teacher show us these things and explain, it will be easy.*

From these responses we gathered that, most teachers present most physics topics in abstract form, without practicalising them. This would be due to either absence of the instructional materials or lack of use due to inadequate content and pedagogical knowledge. Poor mathematical background of the students was a contributory factor towards the topic difficulty.

Another difficult topic revealed was radioactivity which is nuclear physics. It came out as the third topic that students in the sample found difficulty with. The new physics curriculum demands that students should learn types and nature of radiations: alpha, beta particles and gamma radiation; radioactivity: spontaneous and induced/stimulated; nuclear reactions: fusion and fission, effects and application of radioactivity; binding energy, neutron-proton ratio, and half life; calculations involving half-life. With this broad range of concepts, which stands out as the most difficult and which ones are easy? We found answers in the response to our interview of the students.

For ‘Pamela,’ female:
The meaning of radioactivity and the types of radiation are quite easy because we have been taught. The definition of alpha particle, beta particle and gamma particle are equally not difficult. Also, uses of radioisotopes because it is applied in different work area like medical field and industries. Our challenges are in calculation of half-life of a radioactive element, radioactive disintegration, radioactive decay series, rate of radioactivity decay, concept of nuclear fission, fusion and binding energy.

Calculation of half-life of a radioactive element is a challenge for ‘Andy’ (male, 17 years) and for many of the students as our qualitative data show. How is half-life calculated that students find difficulty with understanding the process? Half-life (symbol $t_{1/2}$) is the time required for a radioactive substance to reduce to half of its initial value. It is calculated using any of the following three equivalent formulae:

$$N(t) = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$

$$N(t) = N_0 e^{-\frac{t}{\tau}}$$

$$N(t) = N_0 e^{-\lambda t}$$

where

- N_0 is the initial quantity of the substance that will decay (this quantity may be measured in grams, moles, number of atoms, etc.),
- $N(t)$ is the quantity that still remains and has not yet decayed after a time t,
- $t_{1/2}$ is the half-life of the decaying quantity, i.e. when $t=t_{1/2}$
- τ is a positive number called the mean lifetime of the decaying quantity,
- λ is a positive number called the decay constant of the decaying quantity.

As we purposed in this study to dig deep into the origin of the difficulty with any concept, we probed further into the aspects of the calculation of half-life that students find difficulty with. There are two main methods to the calculation. The first is using proportionality. For instance, if given the problem:

Question: The half-life of radon-222 is 3.8 days. How much of a 300-gram sample is left after 7.2 days?
This can be solved using the proportionality method as follows:

- After 3.8 days, half of the 300-gram sample will be left=150gm
- After another 3.8 days (to make 7.2 days) half of the remaining 150gm will be left.
- Answer is 75gm

This is as elementary as it comes. The second method is using any of the three formulae listed above. This will give us the same answer. When interviewed, students for example, 'Adex' found this proportionality method easier. Another student ('Joyce') expressed preference for
The formulae

$$N(t) = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$$
$$N(t) = N_0 e^{-\frac{t}{\tau}}$$
$$N(t) = N_0 e^{-\lambda t}$$

We can explain the difficulty of students with calculating half-life by the pervasive phobia for any activity that demands calculations and formulae (Okebukola, 2015). Even with simple formulae, many students abhor calculations. They would appear wired to fear any form of calculation. In physics examinations, students score the lowest in questions where calculations are involved (WAEC) Chief Examiners' Reports, 2015-2019). It is worth noting that the other aspects of nuclear physics that students find difficulty with as expressed by 'Pamela'- radioactive disintegration, radioactive decay series, rate of radioactivity decay, are coloured with calculations. From these responses it was deduced that the students find this topic very difficult due to weak mathematical knowledge background, inadequate practical exposure, teacher's weak content and pedagogical knowledge (especially ability to link the students' indigenous knowledge to the topic at hand) and teacher's scaring temperament

The forth in the order of difficult physics topics revealed in this study of the new curriculum is curved lenses which are mainly convex and concave. The students are expected to be able to identify each type of lens in diagram or the real thing, state their qualities or characteristics or perculiarities and their applications. They should be able to perform calculations involving each type and manipulate equation relating their focal length f, radius of curvature r, object distance u, image distance v, object height, image height and magnification of image.

A lens is a transparent glass designed in such a way that it can converge or diverge rays of light that pass through it. If the lens is thicker at the middle and thinner at the end or circumference, it is called a convex lens or converging lens. But if it is thinner at the centre or middle and thicker at the circumference, it is called a concave lens or diverging lens

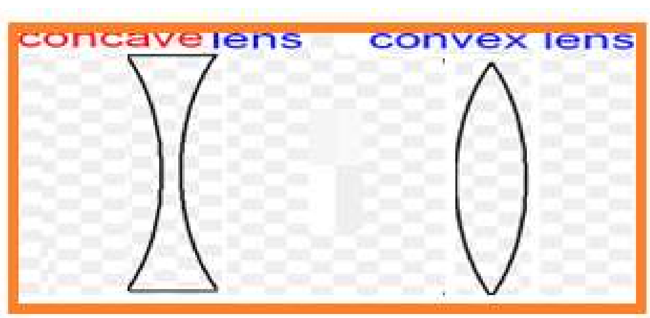


Figure. 7. Convex and concave lenses.

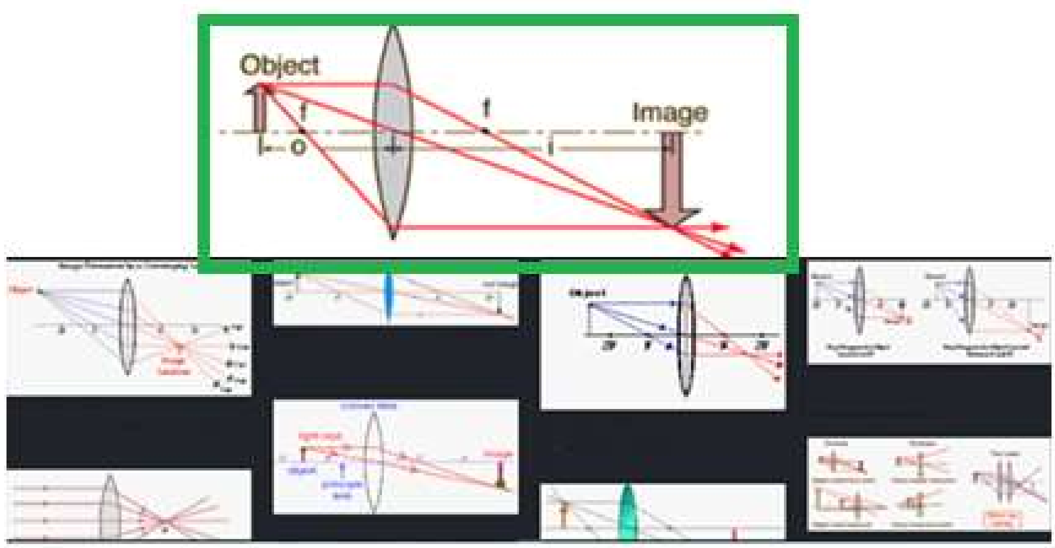


Figure 8.Image formation in convex lens.

When the object is before the centre of curvature of a convex lens, the image is real, inverted and diminished. At the centre of curvature, it is real, inverted and same size. Between centre of curvature and the principal focus, the image is real, inverted and magnified. When the *object is at the focus, no image is formed. Between the focus and the lens, the image becomes virtual, erect and magnified.*

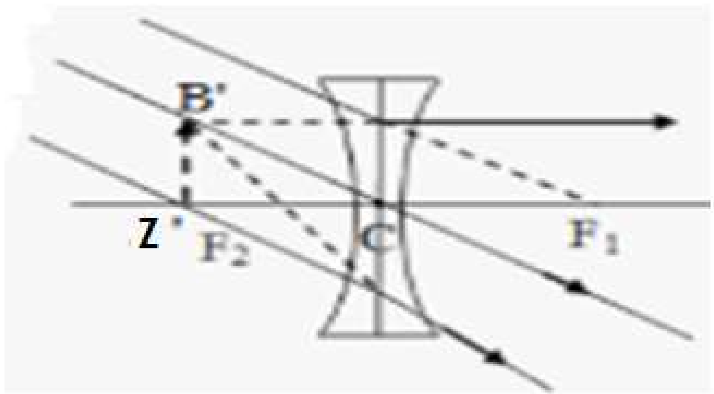


Figure 9: Image in a concave

In a concave lens:
No matter the object position, the image formed is always virtual, diminished and between the object and the lens.

The equation relating the object distance, image distance and the focal length of the lens is $1/u + 1/v = 1/f$ but the sign of v or f might change to negative when they are virtual.

Why do students find convex and concave lenses difficult? To this Bayo (male, 17 years) answered:

The ray diagram is difficult to draw. I don't understand how to locate the image of the object in a ray diagram as to say it is real or virtual, inverted or erect, diminished or magnified or the same size. The calculation, I don't know where to start.

When probed the more, what and what did you understand in curved lenses? Bayo went ahead to say,

I know the meaning of real, virtual, inverted, erect, diminished, and magnified, but to draw the ray diagram or do the calculations is difficult.

Image formation in lenses require practical. If the explanations are backed up with practical, the students will see it to be true and real. This is implied in the response of Bayo to the question : Please suggest the way you will be taught so that you don't find this topic difficult.

Let our teacher explain well and show us practically what he is talking about. Ordinary talking, talking cannot solve the problem.

4.3 Sound: production, propagation and modulation

Sound is a wave produced by friction, vibration or explosion. A car tyre skidding or screeching on the ground produces sound. A vibrating tuning fork produces sound. A plucked string of guitar produces sound. A Gunshot also produces sound. Sound is a mechanical wave that requires a material medium for propagation. Sound is a longitudinal wave because its direction of vibration is parallel to the direction of motion. Sound cannot travel in a vacuum as demonstrated in electric bell inside an evacuated glass jar.

Sound wave can undergo diffraction, interference and reflection (echo). Sound wave has frequency f, velocity v, wavelength, amplitude and therefore mathematics is involved in performing some calculation.

When asked why is sound difficult, 'Chichi' (female, 16 years, SS 3) answered,
Any physics involving mathematics is talking about two subjects. Calculation is always difficult and those who teach them are most of the time not friendly, that is why they don't explain well.
Probing her further on what could be done to make the topic easy, she said:
If the teacher can teach well, answer questions and explain well, I must understand

Research question 4. Is there any statistically significant difference in the perception of the difficult topics by students in rural and urban locations?

As shown in table 6, when students in rural and urban schools were compared on their perception of physics difficult concepts, urban students had higher levels of difficulty in refractive index (55.8%), electromagnetism (56.2%), radioactivity (53.2%), and sound production propagation and modulation (64.3%). However there was statistically significant difference in refractive index, sound: production, propagation and modulation; specific latent heat, and simple machines: pulley system, levers and inclined planes out of the ten most difficult topics.

Ordinarily it is expected that students in urban areas would not find topics more difficult than those in the rural, but this result might be due to students' over population in urban schools, very high students-teacher ratio, and less class control and management.

Research question 5. Is there any statistically significant difference in the perception of the difficult concepts by students in private and public schools?
From Table 5, out of the ten most difficult concepts revealed, students in private schools showed a higher level of difficulty in two - refractive index (52.9%) and sound: production, propagation and modulation (67.2%), whereas students in public schools showed a high level of difficulty in the rest eight-electromagnetism (59.1%), radioactivity (58.4%), simple harmonic motion (59.0%), specific latent heat (63.7%), Voltage, resistance and current in an electrical circuit (64.5%), simple machines: pulley system, levers and inclined planes (66.2%), and waves (67.3%). The perception of difficulty varies with students in public schools. The observed differences between private and public schools in their perception of difficult concepts in physics were largely statistically significant ($p< 0.05$) in favour of private schools.

This observed more difficulty in public schools could be attributed to the fact that most private schools have less number of students that the teachers can manage very well. Moreover laxity is not tolerated among teachers in private schools as against what is obtainable in most public schools.

Research question 6. Is there any statistically significant difference in the perceptions of difficulty of the new physics syllabus topics, between male and female?
From table 6, the chi- square test conducted on the male and female students' perceptions of the twenty difficult topics showed no significance at the alpha level of 0.05. This portrayed that the perception of these difficult topics is not gender dependent. This can be explained by the fact that in Africa today, in general, education including physics, is not discriminated against sex. This is in agreement with the findings of Ojerinde, Onoja and Ifewulu (2013) that there was no gender difference in the Unified Tertiary Matriculation examination (UTME) in 2012 and 2013. Also in agreement with this findings are the findings of Alao and Abubakar (2010) that there was no significant difference between male and female students' performance; and Mlambo (2011) who concluded in his study that learning preferences were independent of age and gender of students.

However this finding is in contrast with that of Aina and Akintunde (2013) whose finding was that male students performed better than female students in physics. The fact that since 2011 the highest scorers in UTME by Joint Admission and Matriculation Board (JAMB) in Nigeria has been male candidate, is in contrast to the finding of this study.
However the finding of the study is justified by female efforts to ensure they are not relegated to the background as inferior gender. This is connoted by the campaign that 'whatever men can do women can do also'.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

In this study, a survey was carried out among African secondary school students to identify ten topics they find most difficult, which happened to be refractive indices of rectangular and triangular prisms, electromagnetism, radioactivity, curved lenses, sound: production, propagation and modulation, simple harmonic motion, specific latent heat; voltage, resistance and current in an electrical circuit; simple machines- pulley system, levers and inclined planes; and waves. Related factors or possible causes of the difficulty were ascertained. Further, ten randomly selected students and five teachers were interviewed as to find out the barriers to learning these topics and the suggestions for improvement.

The barriers among others, were teachers' weak content and pedagogical knowledge, inadequate exposure of students to practical, inadequately equipped laboratory, students' poor mathematical background and teacher's scaring temperament. No student comes to school empty, at least there are some previous knowledge, indigenous knowledge and cultural beliefs and practices which are the foundations of science. An effective teacher should build on them.
From the responses during interview, the physics teachers are supposed to be good mathematicians that would always clarify the students of any mathematical confusion.

The students need to be exposed adequately to practical. If the physics students are taught by the findings of this study, the backbone of the difficult concepts and topics will be broken and the students will enjoy the study of physics.

Other findings of this study are (a) these difficulties are not gender dependent. (b) the difficulties are more in urban schools and public schools. (c) the students know the topics that they find difficult and have good suggestions of the remedy.

It is therefore recommended that:

1. Government, school owners and stakeholders should endeavour to equip physics laboratory adequately while ensuring the equipment are actually used;
2. Mathematical background of students should be ascertained and upgraded by teachers to suit the physics topics;
3. Physics teachers should be well trained in content and pedagogy as to ascertain, and harness the students' entering behaviour and previous knowledge in teaching every topic;
4. Teachers should comport themselves in a manner that should not scare the students, since learning takes place better in a relaxed mood;
5. Physics teachers should through workshops and seminars, avail themselves of the powerful and effective flexible multidimensional strategy known as CTC Approach developed by Peter Okebukola, which will make the students feel at home, learn better and physics-phobia will disappear.

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