

NIGERIAN INSTITUTE OF PHYSICS

36th Annual
National
Conference,
May 26 - 29, 2014

Theme:
**The Role of Physics
in the Nano World**

DEPARTMENT OF PHYSICS,
UNIVERSITY OF UYO, UYO,
NIGERIA

Book of Abstracts and Programmes

**SUB – THEME I:
PHYSICS, EDUCATION AND SUSTAINABLE DEVELOPMENT**

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PREAMBLE: I wish to sincerely appreciate the leadership of the Nigerian Institute of Physics (NIP) for inviting me not only to attend this conference but also to present a paper. Your theme for this conference is an interesting one; *the role of Physics in the Nano world*. This theme is apt considering the fact the world is going Nano. But my worry is that in our nation today we are still struggling to fully understand the *deci*, *milli* and *micro* worlds. The questions are- is it possible to understand the Nano world, Nanoscience and Nanotechnology without a full understanding and articulation of the pre-requisite worlds? To what extent can we succeed in the Nano world without the micro world, for instance? Then what are the roles of Physics and Physics Education in sustaining the Nano world? I am sure these and many more questions will be answered in this conference. On my own part, I will try to see how Physics Education can be carried out for sustainable development. This is important because the emphasis should be both on the role of Physics in the Nano world as well as the teaching of Physics in the same world.

INTRODUCTION:

Physics as a branch of physical science is a very crucial subject. It has to do with matter, how they relate with energy, move in time and space. Hence the universe and natural events cannot be understood without a proper understanding of physics. This is because physics is involved and can be seen in everything.

Application of physics principles and laws in the area of technology has resulted to significant contributions to human comfort, societal survival, progress and development. Several advances have emanated from theoretical breakthroughs in physics. For example, the concept of electromagnetism in nuclear physics have resulted to the development, technologically, of the products such as television, computers, nuclear weapons and several domestic appliances which have significantly impacted upon the quality of life and the economy of the society. Advancement in the understanding of mechanics and aerodynamics has resulted to aeronautical engineering. Today we have cars and bicycles that can fly, besides the airplanes. The traditional engine oil that helps in reducing friction in vehicle engines, for instance is being replaced by Nano-oils which unlike the traditional oil has no side effects on the engine.

Physics inter-relates with other disciplines such as Mathematics, Chemistry Biology and Engineering. Physics makes use of Mathematics and Ontology – philosophy dealing with the nature of beings; while physics is used by chemistry, cosmology, technology, medicine and Agriculture. In fact in the human body and its functioning, physics and physics principles abound. There is hardly any area of development that physics does not play a significant role;

Education

Considering the enormous value of physics and its interdisciplinary nature, it is imperative to teach and learn the subject in a more pragmatic and realistic way. While the responsibility for researches in physics and applied physics belong to Physicists, the responsibility to teach and to research into teaching strategies belong to Physics Educators. It is imperative here to ask, **what is Education?**

Professionally, education is one of the concepts that cannot be fully articulated and comprehensively appropriated with a single definition. An Encyclopedia of Education defines it as *a form of learning in which the knowledge, skills and habits of a group of people are transferred from one generation to the next through teaching, training and research*. I consider this definition very useful because of the component parts embedded in it. Specifically, it provides the purpose of education to include acquisition of appropriate

knowledge, skills and habits. Secondly, the definition also provides the means through which education can take place to include, teaching, training and research.

However, good as this definition seems, it could be necessary to ask the following questions:

- (i) Do all desirable learning result in education?
- (ii) Is it not possible to have learned something and yet not educated?
- (iii) Who is an educated man?

Analytically, an educated man is not only the person who has received learning in the knowledge, skills and habits but one who can:

(a). Function properly in the knowledge realm – the mind enlightened, intelligence sharpened and enhanced, and can think effectively and creatively.

(b). Apply skills acquired in solving specific problems of the society.

(c). Exhibit a positive habit; this has to do with societal values such as honesty, integrity, fairness, respect for elders and constituted authorities, among others.

It should be noted that these three-prong emphasis of the product of education is holistic. By implication, therefore anyone that scores even 2/3 of this cannot be said to be educated. One can therefore be certificated but not educated; intelligent, brilliant in his/her profession or any human endeavour, yet not education. One can be learned but not educated.

Education exists in three basic types, namely: formal, informal and non-formal, as indicated by the Organization for Economic Co-operation and Development (OECD). While formal education emphasizes institutionalization of education with formal curriculum, disciplines and school system; the informal education is expected to occur under informal settings at home and in public gathering. Non-formal education occurs outside the formal school system. It takes place mostly under artisans such as carpenters, mechanics etc. it should be emphasized that no form of education is dispensable. The current problem of unemployment in the country now could be associated with the overemphasis on formal education at the expense of other forms, especially the non-formal. The near total lack of emphasis on informal education has resulted in moral and social decadence in our society.

Physics Education

Physics Education has to do with the theory and practice of Physics teaching and research. For sustainable development, emphasis must be placed on both physics and Physics Education. Unfortunately, Education in Nigeria has not been properly fixed. This is, perhaps the reason we have not been able to fix anything, significantly. It should be noted that any country that cannot fix education will not likely be able to fix anything developmental.

For instance, in the institutions where physics teachers are produced, there should be enough training built into the system to adequately produce the required results. It should be noted that a gap in the teacher produces a gully in the student. In spite of the importance of physics and the fact that a credit pass is required for admission into technology-based and medical professions, yearly performances of Senior Secondary students in the subject have been abysmally low in the West African Senior Secondary School Certificate Examinations (Onwioduokit, 1996; Iwoli, 1999; Ogunleye, 2003). Precisely, for the period of thirteen years (1999-2011), only in three years (2006, 2010 and 2011) did the performance get up to 50% and above in WASSE (Onwioduokit, 2013), as shown in the table provided.

The reasons behind this are not farfetched; poor understanding and comprehension of concepts which lead to poor analysis and application of physics, top the list. It should, however, be understood that the observed problem with the output of the School system is an indicator of the problems in the process of production. The situation in our Universities cannot be claimed to be better; poor semesters' results in almost all physics courses cannot be overlooked. There are many graduates of Physics who cannot change fuses of appliances or replace wall sockets successfully due to non-acquisition of entrepreneurial skills. The lack of these skills occasioned by how physics is structured and taught has resulted to a high rate of unemployment in Nigeria, given as 23.9% (Nwachukwu, 2012). This translates to about 38.24 million Nigerians being unemployed.

SUMMARY OF RESULTS FOR THE WASSCE (1999-2011) IN NIGERIA.

Year	Subject	ENROLMENT			NO. OF CREDITS 1-6		%Credit	%Failure
		TOTAL SAT	MALE	FEMALE	MALE	FEMALE		
1999	Physics	210271	134650	75621	43199	21084	30.60	69.40
	Chemistry	223305	138618	84687	45244	24167	31.10	68.90
	Biology	745091	400470	344621	115117	92112	27.81	72.19
	Maths	756669	40889	347780	79257	58839	18.25	81.75
2000	Physics	195226	122489	72737	18203	19883	19.50	80.50
	Chemistry	202900	124049	78851	40284	24000	31.68	68.32
	Biology	641541	342760	298781	68558	54639	19.20	80.80
	Maths	656249	353362	302887	121567	92922	32.68	67.32
2001	Physics	298513	186526	111987	65350	35902	33.92	66.08
	Chemistry	312946	189881	123065	68871	42972	35.74	64.26
	Biology	1031767	554882	476885	128457	107874	22.91	77.09
	Maths	1059974	575287	484687	209032	173620	36.10	63.90
2002	Physics	335388	206460	128928	97940	59234	46.86	53.14
	Chemistry	348291	209255	139036	70425	48624	34.18	65.82
	Biology	1031767	554882	476885	128457	107874	31.18	68.82
	Maths	1059974	575287	484687	209032	173620	34.42	63.90
2003	Physics	305442	184463	120979	85498	57774	46.91	53.09
	Chemistry	313330	186256	127074	90375	64537	49.44	50.56
	Biology	1005549	539415	466134	218697	205937	42.23	57.27
	Maths	1024447	552392	472055	197255	180057	36.83	63.17
2004	Physics	321499	192535	128964	93711	65066	49.39	50.61
	Chemistry	327503	194093	133410	70772	53237	37.96	62.04
	Biology	1005894	540800	465094	156271	1422284	29.68	70.32
	Maths	1019524	550300	469224	178238	168172	33.98	66.02
2005	Physics	344411	206931	137480	85205	57738	41.50	58.50
	Chemistry	349936	208700	141236	104531	73743	50.94	49.06
	Biology	1051557	571645	479912	196821	179029	35.74	64.26
	Maths	1054853	574596	480257	212215	190767	38.20	61.80
2006	Physics	375823	225513	150310	128748	89450	58.06	41.94
	Chemistry	380103	226817	153286	99700	70969	44.90	55.10
	Biology	1137180	619569	517611	291346	268507	49.23	50.77
	Maths	1149276	627996	521280	248468	224206	41.13	58.87

Year	Subject	ENROLMENT			NO. OF CREDITS 1-6		%Credit	%Failure
		TOTAL SAT	MALE	FEMALE	MALE	FEMALE		
2007	Physics	418593	248021	170572	104145	76652	43.19	56.81
	Chemistry	422681	249545	173136	111804	82480	45.96	54.06
	Biology	1238163	673905	564258	210651	202560	33.37	66.63
	Maths	1249028	681542	567486	308337	275687	46.76	53.24
2008	Physics	415108	244565	170543	114841	85504	48.26	51.74
	Chemistry	418423	245742	172681	105759	80190	44.44	55.56
	Biology	1259965	682848	577117	218397	209247	33.94	66.06
	Maths	1268213	688884	579329	381258	345140	57.28	42.72
2009	Physics	465636	273617	192019	125453	97269	47.83	52.17
	Chemistry	468546	274690	193856	114717	90008	43.69	56.31
	Biology	1340206	736276	603930	194676	188436	28.59	71.41
	Maths	1348528	741577	606951	330397	195026	47.04	52.96

2010	Physics	463755	268564	195191	133398	104358	51.24	48.73
	Chemistry	465643	269240	196403	131111	104948	50.69	49.31
	Biology	1,300,418	709011	591407	326598	319035	49.65	50.35
	Maths	1,306,535	713240	593295	283609	264456	41.95	58.05
2011	Physics	563181	326656	236505	201086	159010	63.94	36.06
	Chemistry	565692	327688	238004	157083	123167	49.54	50.46
	Biology	1,505,199	823662	681537	292461	286971	38.49	61.51
	Maths	1,508,965	825971	682994	315563	293303	40.34	59.66

Source: The West African Examination Council, Test Division, P.M.B. 1076, Yaba, Lagos.

Physics and Sustainable Development

Development has to do with something getting larger, more matured and advanced. National development therefore implies advancement in the nation's economy, technology, industry, education and others. Development is different from growth. For instance, there is growth in our education system in terms of number of students, schools and Universities, teachers and the curricula, but we cannot confidently say that our education system is developed.

Sustainable development is the development which meets the needs of the present society without prejudice to the future generations meeting their own needs. As discussed in the World Council on Physics in 2005, three basic areas of sustainable development can be facilitated through Physics and Physics Education. These are:

- (a) Economic sustainability; which has to do with the ability to produce goods and services through industrialization,
- (b) Environmental sustainability which includes maintenance of biodiversity, atmospheric stability, and other ecosystems' functions not ordinarily classified as economic resources.
- (c) Social sustainability; which seeks to ensure fairness in distribution and opportunity and to ensure adequate health and education facilities, gender equality, among others.

For Physics to meaningfully facilitate sustainable development in Nigeria, and indeed the world, there must be a quality Physics Education.

There are quite a numbers of factors involved in the teaching process including student-oriented, teacher-oriented, as well as environmental factors. However, of the three key factors, the teacher is the most prominent for now. It should be noted that no gadget can successfully and ultimately replace the teacher. A skillful teacher can both make the learning environment conducive and facilitative as well as motivate students to learn. It behooves therefore on Physics lecturers, Physics Educators and teachers to be more pragmatic and committed to their work if the required results capable of sustaining development is to be obtained.

Effective teaching of Physics at all level has three major components, namely:

- (i) Knowledge of Subject Matter (Physics),
- (ii) Knowledge of appropriate teaching strategies that can facilitate learning, and
- (iii) Interaction of students with relevant materials.

It should be noted that these three components are mutually inclusive and inseparable.

Knowledge of Physics

This is where the difference lies between the teacher and the learner. Meaningful knowledge goes beyond cognitive to include affective and psychomotor domains. For instance, knowledge that cannot be applied towards the development of the society is not considered worthwhile and meaningful. Teachers should therefore be fully acquainted with physics concepts in all domains. Not knowing what to teach is worse than not knowing how to teach.

Knowledge of appropriate teaching strategies

Besides having a good knowledge of the subject, it is equally imperative to know how best to arrange the teaching/learning materials to motivate learners and facilitate learning. It is by so doing that physics could be made more interesting and real to learners. The teaching of physics at all levels should be real. Even when atomic and sub-atomic particles are involved, they should be a way of making such look real, how be it, using simulations and animations.

To teach physics for sustainable development, certain things should be considered. Some of these include:

- (i) Consideration of the nature and level of concepts.
- (ii) Integration of practical work in the teaching/learning process.
- (iii) The use of appropriate teaching approach/method.
- (iv) The use of multimedia approach.

Nature and level of physics concepts.

Generally, in science, there are two fundamental concepts – Theoretical and empirical. Theoretical concepts are those concepts which are not easily and directly measured and quantified. They are not directly linked with sense organs but mostly exist in our imagination.

On the other hand, empirical concepts directly appeal to sense organs and can be simply and directly measured and quantified.

It is however noteworthy that concept in science exists at different levels of abstraction. In other words, although a concept may be empirical, it may be more or less empirical than others. An empirical concept could be very close to a theoretical concept and vice versa. For instance, heat, temperature, thermodynamics are all empirical concepts of different levels of abstraction. It is imperative to identify the type of concept to be taught and the level of abstraction of the concept. The way a theoretical concept should be introduced and taught should be different from empirical concepts.

Besides the nature and abstraction of a concept, the level of the concept is also of paramount important. There are basically three levels of each concept in physics. In treating the concept of motion, the three levels are:

1. Descriptive – what motion is, the cause and the consequences.
2. Comparative – types of motion and how they are similar and different from each other.
3. Quantitative level – This has to do with qualification of the different types of motion. This will involve numerical problems solving.

Integration of practical work in the teaching/learning of concepts.

The tradition of separating physics practical from the theory classes does not seem to help much. It is time to begin to see that there exists no dichotomy between theory and practical work in physics.

In teaching physics for sustainable development, practical work should be incorporated into the theory. A more effective teaching starts with practical work in most cases. This fosters better understanding than starting it theoretically.

1. For instance, many teachers approach the concepts of heat capacity and specific heat capacity by defining what they mean. The next thing is to give their equation and then begin to solve numerical problems, when the actual conceptualization of the concept is not fully gaped. What could happen if the lesson starts with say 4 similar beakers containing the same volume of, say, water, kerosene, palm oil and groundnut oil and same amount of heat from a steady flame is applied to each beaker and its content for say 5 minutes after the initial temperature of each was taken? Taking the temperature of the liquids after the said time will indicate that within the same time frame, the temperature of the liquids rose differently. That is, same amount of heat given to those substances caused their temperature to rise differently. Then find the time required for the liquid to have its temperature risen by 1°C . This will give different time durations which shows different amounts of heat transferred to the system.

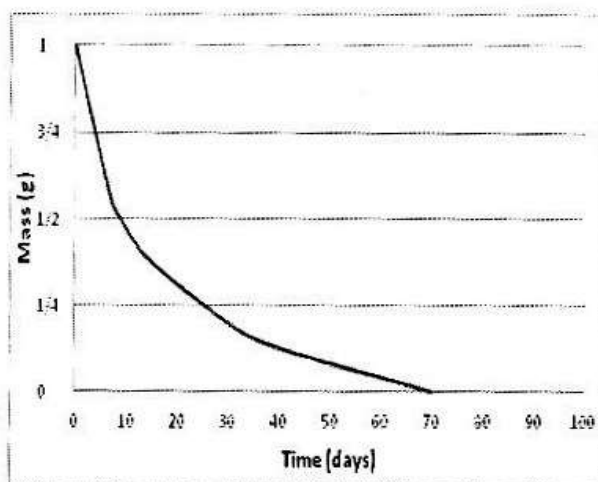
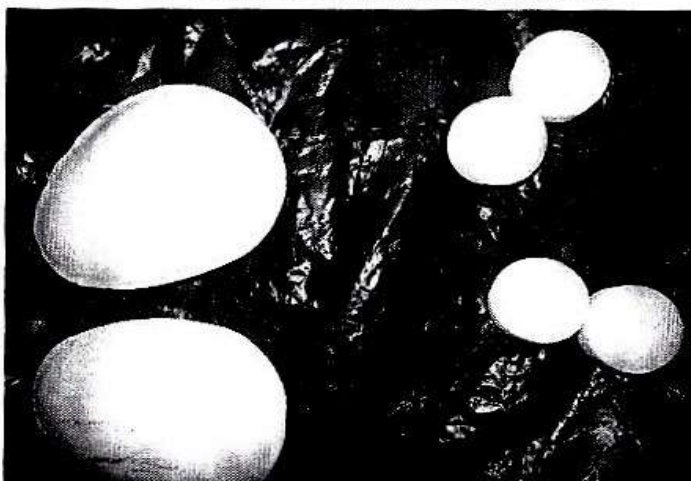


Figure 1: A plot showing the "disintegration" of camphor with time.

The time taken for half of the mass of camphor to remain denotes the "half- life" of the camphor, as a result "disintegration".

2. Radioactivity is a theoretical concept. The practice has been that we teach it mathematically as one cannot use a radioactive substance for practical. But we could use **camphor** to aid students understanding of the concept of half- life of a radioactive substance. The mass of the camphor can be observed periodically over time and a graph of mass with time plotted.

The use of appropriate teaching approach/method.

Central to most psychological theories applicable to science teaching is the emphasis on the structuring of learning materials. In making physics real for sustainable development there must be proper structuring of teaching/learning materials. While Ausubel (1968) prefers a structuring from the most inclusive to the least inclusive, Gagne, Briggs and Wagor (1992) prefer from the least inclusive to the most inclusive. Whichever structure is preferred, the principles enshrined in the structure should be followed to avoid haphazard delivery of lessons. For instance, Ausubel learning theory emphasizes the incorporation of the new material into the cognitive structure for learning to be made meaningful. The meaningfulness referred to here is analogous to making it real. It is the duty of the teacher therefore to effectively plan his lesson. On the other hand, Gagne emphasizes **task analysis** which is cored on prerequisite learning.

Moreover, besides structuring emphasized by Gagne, guided discovery (enquiry approach) is equally emphasized. **Students should be taught Physics in the same way Physicists practice physics.** Enquiry approach, although very tasking and involving is efficient in the development of skills such as reflective thinking and creativity. As students are provided with certain information and are guided to discover some additional information, the subject will become real to them.

Among the recommended ways of teaching physics effectively, therefore, are:

- ❖ Enquiry approach
- ❖ Demonstration method
- ❖ Integration of practical work in the teaching/learning process.
- ❖ The use of multimedia approach

Enquiry-based teaching/learning:

This approach is learner-centered. The intention is to develop in the learner scientific attitudes such as inquisitiveness, objectivity and the ability to undertake an objective observation of the environment and natural phenomena. Furthermore, Enquiry approach in physics teaching is capable of enhancing the acquisition of creative, critical and reflective thinking skills in the learners which are considered crucial for entrepreneurship. In an Enquiry approach, learners are encouraged to initiate teaching/learning process by asking questions based on what they observe practically in a particular concept. Alternatively, the process can start with the teacher assisting the learners to observe certain phenomena and then asking them to explain each. The fundamentals of Enquiry approach are objective observation and questioning. Enquiry approach, although very tasking and involving, is efficient in the development of skills. As students are provided with certain information and are guided to discover some additional information, the subject will become real and useful to them.

Demonstration method:

Another effective way of teaching science is by practical demonstration of the concept involved. Demonstration can be carried out in the following forms:

- ✓ Teacher demonstration
- ✓ Student demonstration
- ✓ Teacher-Student demonstration
- ✓ Student-Student demonstration

It should be noted that a lesson in physics or science, generally, does not, necessarily need to start with definitions; it could better start with demonstration. In other words, an effective lesson could start with practical sessions.

Multimedia physics

Another primary way of teaching physics for sustainable development is by using multimedia facilities either through simulators or animations. My experience with physics students has

shown that the great majority of them do not understand the concepts they are taught in physics, especially when the concept is a theoretical one. By using animation, the students will be able to see by multimedia arrangement, the activities involved and will have their understanding and comprehension enhanced.

Commitment to work

Let me round off by emphasizing that fundamental to all the areas we have considered in teaching physics effectively is our commitment to work. Teaching is different from lecturing. It is more demanding than other forms of professions. Physics lecturers should go beyond the traditional lecturing to teaching. This requires the knowledge of some principles of teaching as well as relevant teaching strategies which can be acquired as part of their commitment to work. Physics Educators and teachers, on their parts, should seek and acquire deeper knowledge of physics as part of their commitment to work. Moreover, Physics lecturers, Educators and teachers should attend promptly and regularly to students in all honesty and integrity. In this way, examination malpractice in our institutions will be eliminated. Collaborative teaching should be encouraged among physics lecturers, Educators and teachers. However, group practical should be discouraged among students as it is often abused.

CONCLUSION

Let me say in conclusion that this crucial conference is very timely and is expected to impact positively on the developmental strides of our nation because physics and physics education have crucial roles in sustaining development the world over. Once again, I appreciate the leadership of NIP for the opportunity to deliver this paper.

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