TOWARDS EFFECTIVE TEACHING OF UNITS AND MEASUREMENTS IN NIGERIAN SECONDARY SCHOOLS: GUIDELINES FOR PHYSICS TEACHERS

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Abstract

The concern of Physics educators in today's modem world is that teaching of physics should shift from teacher-dominated approach to student-centered approach of hands-on and minds-on activities. The r*el*evance of units and measurements particularly in sciences and commerce in today's world cannot be over-emphasised. Through units and measurements, one can determine the magnitude of certain physical quantities. It is good to realise that when measurements are carried out, it must be followed by their units otherwise the values obtained become meaningless. Based on these assertions, this paper examined the brief h/story of units and measurements, concepts of units and measurements, the international Standard Units (SI) units and the traditional systems of units and measurements. The paper as well provided some guidelines for physics teachers on units and measurements and ended up with student's activities and recommendations.

Physics is a practical and experimental science. Its relevance to scientific and technological development of any nation cannot be overemphasized. As such, its effective teaching and learning must be encouraged by all nations of the world. During practical and experiments, teachers usually ask students to measure length, mass, temperature, time and so on of different objects using some measuring instruments. Students carry out these activities in the laboratory during practical and experiments. They do these activities using knowledge and skills imparted to them by their teachers. Teaching science, particularly physics is not to load students' minds with facts and figures but to make them acquire *knowledge,* skills, attitudes and values. These could be achieved through effective teaching of physics. This is because effective teaching is at the heart of science education (Okebukola, 2002). It involves a conscious arrangement of resources in an effort to make science skills and content accessible to students which in turn nurtures or changes the students' ability, knowledge and attitudes. There is no doubt that all scientific disciplines and other disciplines require experimental evidence to corroborate a theory or hypothesis. Experiments are carried out by observers using certain equipments, making measurements and interpreting the results of the measurement graphically or otherwise. The analysis of the result will determine how accurate the measurement was done. However, no experimental evidence is absolutely true due to certain errors involved in measurement (Ike & Echetama, 2004). These errors according to them include systematic error, mistake, observer skill, instrument error and most *i*mportan*tl*y the random error. Physics teachers should put Into consideration these types of errors while conducting practicals and experiments with students.

The thrusts of this paper are:

i. Brief History of Units and Measurements

During the primitive period; humans made use of ropes to measure length of objects, use their feet to measure length of buildings during construction on. Even today in some rural communities, people still make use of different measuring apparatus available to them to measure different things. It has been reported that units of measurements were among the earlier tools invented by humans. Primitive societies needed rudimentary measures for many tasks constructing dwellings of an appropriate size and shape, fashioning clothing, or battering food or raw materials. The earliest known uniform systems of weights and measures seem to have been created sometime in the 4th and 3rd millennia BC among the ancient peoples of Mesopotamia, Egypt and the Indus valley, and perhaps also Elam in Persia as well.

In "The Magna Carta" of 1215 (The Great Charter) with the seal of King John, put before him by the Barons of England, King John agreed in class 35" there shall be one measure of wine *throughout* our whole realm, and one measure of ale and one measure of com..namely, the London quart; ...and one width of dyed and russet and hauberk cloths...namely, two ells below the selvage (joint committee for guides in metrology, 2008). The Magna Carta helped lay the foundations of freedom codified in English law and subsequently American law. Many systems were based on the use of parts of the body and natural surroundings as measuring instruments (Wikipedia, 2011).

ii. Concept of Units and Measurements

A unit of measurement is a definite magnitude of a physical quantity, defined and adopted by convention and/or by law, that is used as a standard for measurement of the same physical quantity (International Vocabulary of Metrology, 2008). This means that any other value of the physical quantity can be expressed as a simple multiple of the unit of measurement. For example, mass is a physical quantity. The kilogram is a unit of mass which represents a definite predetermined mass. When we say 5 kilograms (or 5kg), *we* actually mean 5 times the definite predetermined mass called "kilograms." In physics, when we measure the length of an object, then we give the unit of its measurement. The unit for measuring length is metre (m). It is meaningless to say that the length of a building is 25 without putting the unit metre (m).

Measurement is the process or the result of determining the magnitude of a quantity, such as length or mass, relative to a unit of measurement, such as a metre or kilogram (Wikipedia, 2011). The word measurement stems from the middle French term measure, from Latin mensura, and the verb metri (Oxford Dictionary of English). Measurement seems like a simple object on the surface at least; indeed, all measurements can be reduced to just two components namely number and unit. Quantities frequently measured include time, length, area, volume, pressure, mass, force and energy- To express a measurement, there must be a basic unit of the quantity involved. Infact, measurement is one of the fundamental processes of science because it provides the data on which new theories are based and by which older theories are tested and retested. A good measurement should be both accurate and precise in nature. The tables below show fundamental quantities and derived units.

Table 1: Showing Fundamental Quantities and their Units of Measurement

No.	Fundamental Quantities	Units
1.	Length	M
2.	Mass	Kg
3,	**Time**	**s**
4.	Current	A
5.	Temperature	K
6.	Luminous intensity	Cd
7.	Amount of substance	Mole

The above quantities are called fundamental quantities because they are not derived from the combination of other units.

Table 2: Showing Some Derived Quantities and their Units

No.	Some Derived Quantities	Units
1.	Velocity / speed	MS^{r1}
2.	**Acceleration / retardation**	$\mathbf{MS^{-2}}$
3.	**Pressure**	$\mathbf{Nm^{-2}}$
4.	**Density**	$\mathbf{Kgm^{-2}}$
5	**Momentum**	$\mathbf{KgmS^{-2}}$
6.	**Moment**	**Nm or** $\mathbf{Kgm^{2}S^{-2}}$
7.	**Impulse**	**Ns or** $\mathbf{KgmS^{-1}}$

These quantities are called derived quantities because they are obtained by a combination of fundamental units. There are also some derived units that are associated with the names of renowned scientists and sometimes they have one letter symbol. They are not fundamental but derived. Examples of such units are force, work/energy, power and so on. They have the units of (Newton, N), (Joule, J), (Watt, W) respectively.

iii. International Standard Units and other Units of Measurements

In physics and metrology, units are standards for measuring any physical quantities which need clear definition to be useful. Today the most widely used system of units is the international system of units abbreviated as (SI). There are seven (SI) base units which all other units can be derived from. *These base units are metre (M),* kilogram (Kg), Second (S)f ampere (A), Kelvin (K), Candela (Cd) and mole. *These are the units of length,* mass*, time, electric* current, temperature, luminous intensity and the amount of substance respectively.

For most quantities in physics, a unit is absolutely necessary to communicate values of that physics quantity. For example, conveying to someone a particular mass without using some sort of unit is impossible because a mass cannot be described without a reference used to make sense of the value given. However it is important to note that not all quantities require a unit of own. These quantities are called derived quantities (see table 2). The international system of unit (SI) is the modern revision of the metric system, It is the most widely used system of units today both in everyday commerce and in science. The SI system was developed in 1960 from the metre-kilogram-second (mks) system rather than the centimeter-gram-second (CGS) system which in turn had many variants.

Other units used before the adoption of the international standard unit in 1960 Include: metric systems, natural systems, imperial systems, and so on. The metric system is a decimal systems of measurement based on its units for length, the metre and for mass, the kilogram. It exists in several variations, with different choices of base units, though these do not affect its day-to-day use. Metric units of mass, length, and electricity are widely used around the world for both every day and scientific purposes.

The natural systems of units are based on arbitrary unit values, formalised as standards, some unit values occur naturally in science. Systems of units based on these are known as natural units. Before the SI units were widely adopted around the world, the British systems of English units and later imperial units were used in Britain, the commonwealth and the United States. Many imperial units remain in use in Britain despite the fact that it has officially switched to the SI system. For a examples, road signs are still in miles, yards, miles per hour, and so on, people tend to measure their height in feet and inches and milk in pints, to give just a few.

iv. Guideline for Physics Teachers

1. Treat units algebraically i.e. always add like terms when dealing with units. Remember that when a unit is divided by itself, the division yields unit less one.

2. Remember that when two different units are multiplied, the result is a new unit, referred to by the combination of the units. For instance, the SI, unit of acceleration is metres per second squared (M^2/S^{-2}) (check dimensional analysis).

3. Remember that a unit can be multiplied by itself, creating a unit with an exponent. For example (M^2/S^{-2}) this means that units obey the laws of indices.

4. Remember that some units have special names, but these should be treated like their equivalents. For example, one Newton (N) is equivalent to one Kgm/S^2. Thus a quantity may have several unit designations, for example: the unit for surface tension can be referred to as either Mm (Newtons per metre) or kg/S^2

(kilograms per second squared*)*. However, whether these designations are equivalent is amo*n*g metrologists (Emerson, 2003).

5.
Students Activities

Group the students into three A, B and C depending on the availability of the instrument/materials. Distribute the materials to the students. The instrument/materials to be provided must be in line with what the teacher wants the students to measure.

Instrument/ Materials

These include tapes, metre rules, chemical balance, stop clock/watch, masses of objects, thermometer(s) papers etc,

Table 3: Showing the Description of Students Activities

S/N	Instruments/ Materials	Activities	Brainstorming	Records	Units
1.	Tapes, metre rules	Use the instruments provided to you to measure the length or height of your body.	**Discuss among yourselves how you carried out the exercise.**		
2.	Thermometer	Measure the temperature of your body using the thermometer provided.	Explain how you carried out the **exercise**		
3.	**Chemical balance**	Use the instrument given to you and measure the mass(s) of the objects given to you.	Describe how you carried out the exercise among yourselves.		
4.	Stop clock/ watch	**Repeat activity number** 3 end record the time it takes you to do so	Brainstorm among yourselves how you carried out the *t*asks.		
5.	Micrometer screw gauge	Use the instrument given to you measure the *t*hickness of the papers provided to you.	Explain how you carried out the exercise.		

After completing the exercises on table 3 the teacher should discuss with students the activities. The teacher should evaluate the students by way of asking relevant questions with the aim of clarifying the students difficulties/ areas or weaknesses.

Recommendations

Based on the discussions in this paper, the following *recom*mendations are proffered:

1. **Physics teachers should teach units and measurements through practical/experimental activities.**

2. **Government at all levels should provide adequate materials for physics teaching in schools.**

3. **Physics teachers should be sent to up-date their knowledge through training and retraining.**

4. **Workshops and conferences should be organised in every state of the federation with the aim of sensitizing physics teachers on the current challenges of physics teaching.**

5. **Federal and State Ministries of Education should ensure that symposium, workshops, exhibitions are organised frequently and should be made mandatory to all physics teachers.**

References

Emerson, W. H. (2008). *On quantity calculus and units of measurement. Metrologia*, 45; 134-138. http:// www.answers.com/rneasurements.retrived 17/06/2011.

Ike, E. E. & Echetama, K. N. *(2004)*. Practical physics and alternative to practical **physics for WASSCE and NECO. Printed by Saniez Books**

International Vocabulary of Metrology (2008). ***Basic and general concepts and associated terms*** (VIM) (htt://www,hipm.org/units/commori/documents/icgm/ GCGM 2008).

Joint Committee for Guides in Metr*ology (2008). http/www.org*units common/documents/jcgm/JCGM 200 2003.pdf.

Okebukola, P. (2002). Beyond the Stereotype to New Trajectories in Science Teaching. Text of Special Lecture presented at the 43rd. Annual Conference *o*f STAN and CASIME

Oxford Dictionary of English 2nd Ed. Oxford University Press.

Wikipedia the free Encyclopedia (2011).