

## ASSESSMENT OF SENIOR SECONDARY SCHOOL PHYSICS STUDENTS' KNOWLEDGE OF METRICATION IN KWARA STATE, NIGERIA

<sup>1</sup>Yahaya, Wasiu Olayinka & <sup>2</sup>Akanbi, Abdulrasaq Oladimeji

<sup>1,2</sup>Department of Science  
Education, Faculty of  
Education,  
University of Ilorin, Ilorin, Nigeria

### Abstract

*The study assessed the senior secondary school physics students' knowledge of metric/sub-units system conversion. Sub-units conversion is an essential skills required by students of all categories for problem-solving processes. Physics is a course that makes use of metric system to solve problems relating to mathematical concepts, for laboratory activities, analysis and for industrial works. The population for this study was all senior secondary school three physics students in Kwara state that sat for senior secondary certificate examination in year 2022. Seven hundred and fifty (750) physics students were selected and engaged in the study using purposive and simple random sampling technique. An open ended instrument tagged "Metric Conversion Test" was used to elicit information about students' knowledge of sub-units conversions. Descriptive statistic (frequency count and percentage) was used to analyze the collected data. The result of the study revealed that students' strengths were recorded in metric conversion of gram(g) to kilogram (kg) and their weaknesses were recorded in metric conversion of watt (w) to horsepower (hp). The study concluded that the teaching and learning of sub-units/metric conversion should be prioritized and students should be informed that poor/wrong knowledge of sub-units conversion invalidates problem-solving processes in mathematics related problems in physics.*

**Keyword:** Metric System, Conversion, Post-Basic Students, Multiple Intelligences

### Introduction

The metric system has its origin traced back to 17<sup>th</sup> century and precisely 1670. The previous version of metric system use to be centimeter-gram-second (CGS), metre-tonne-second (MTS), metre-kilogram-force-second (MKS) and metre-kilogram-second-ampere (MKSA). Scientist Abbè Gabriel was the pioneer physicist that proposed one thousandth of a minute of arc at the meridian as a rational standard of length named the unit "milliare" the latin name for a thousand and also make the division of milliare decimally into multiple units namely "centuria, decuria and virga" with the three submultiples as "decima, centesima and millesima.

The adoption of Système International d'unités was considered during the General Conference on Weights and Measure (CGPM) with mandate to unify measurements, establishment of main physical quantities and to preserve international prototypes. Other mandate includes carry out comparisons of national and international standards, to ensure coordination of appropriate measurements techniques and to carry out and coordinate determination of physical constants involved in the above conversion (Cardarelli, 2012).

Tutors teaching physics and mathematics tend to avoid teaching the aspects they do not know or aspects they have limited knowledge of. Conversion understanding as a tool for the teaching and solving problems in physics always suffer set back due to teachers no or little knowledge of conversion (metric) system (Adendorff, 2014).

Scientific fields and disciplines require the use of metric system of physical quantities' units and their system. The interaction among the various fundamental physical quantities' units and symbols give birth to many physical formula and complex units in physics.

Raje (2019) opined that physical sciences like physics, chemistry with interdisciplinary to mathematics centered on the understanding of metric conversion and units.

### **Literature Review**

Dincer and Osmanoglu (2018) worked on dealing with metric unit conversion: an examination of prospective science teachers' knowledge of and difficulties with conversion. The study was qualitative in nature and engaged 73 prospective science teachers (55 female and 18 male) who were taken astronomy course in one of the western universities in Turkey. The study used a measurement test that consist 14 questions with 1st to 11<sup>th</sup> questions were about metric conversion of length, area, volume and mass. The finding of the study revealed that participants' strength was recorded in metric conversion estimation of length units' i.e 94.5% of participants were able to convert centimeter to meter correctly. The study also found out that participants' weakness was recorded in metric conversion of gram to microgram.

Raje (2019) carried out a study on utility of metric for success in introductory college science courses. The study was an exploratory work using multiple methods. 24 middle and high school physical science and mathematics teachers from three different counties in the state of Maryland and the state of Connecticut. 132 college students who were primarily freshmen and sophomores who were enrolled in an introductory chemistry course. The findings of the study revealed that the contents of chapter one in the ten introductory physics college textbooks were physical quantities, dimensional analysis, units and conversions, scientific notation' measurement and significant figures, logarithms and trigonometry.

### **Statement of the Problem**

Sub-units conversion is an essential part of physics problem solving skill and other science disciplines. West African Secondary School Certificate Examination (WASSCE) Chief Examiner's report (2013-2019) reported that the performance of the physics students so far was inconsistent in both the school and private candidates' physics examination. The reports pointed out some students' weaknesses in the physics examination which includes poor knowledge of computational skills, poor knowledge application of numerical functions like unit conversion, approximation, decimal point/place, significant figures and other functions. This study assessed the senior secondary school physics students' knowledge of sub-units conversion to check their readiness and proficiency in solving mathematical related problems in physics.

### **Objective of the Study**

The main objective of this study was to assess the knowledge and proficiency of senior secondary physics students in sub-units conversions.

### **Research Question**

1. To what level could senior secondary school physics students convert physical quantities sub-units?

### **Methodology**

#### **Measurement Tool**

The research instruments used for the study was tagged " Metric Conversion Test" which was open ended in nature. The measurement tool was divided into two sections. Section A was used to elicit information about demographic profile of the participants and section B consist of the metric/sub-units to be converted. The validation of the Metric Conversion Test was carried out by three experienced physics teachers, one physics education expert, and two mathematics education experts that have been teaching for the minimum period of ten years. The validity and reliability indexes are 0.84 and 0.88 respectively.

### **Participants**

The study engaged 750 senior secondary school physics students III that comprises of 251 Female and 499 Male students who sat for secondary school certificate examination in year 2022. The choice of the participants' category was premised on their expected proficient in metric conversion of physics physical quantities sub-units and to check their readiness for external examination. Twenty (20) schools were considered for the study and twenty-five (25) students were selected from each school through purposive and simple random selection technique.

### **Data Collection**

The data used for the study was collected with an open ended measurement test tagged “Metric

Conversion Test” which comprises the conversion from decimeter to millimeter, millimeter to centimeter, centimeter to meter, and meter to kilometer for length physical quantity. Conversion from Fahrenheit to Celsius, Celsius to Kelvin and Kelvin to Celsius for temperature. Conversion from hour to minutes, minutes to seconds for time, conversion from kilometer per hour to meter per second for velocity/speed, Watt to kilowatt, Watt to megawatt, watt for horsepower for power, gram to kilogram, kilogram to gram for mass, centimeter cube to meter cube for volume and millimeter square to meter square for area. The data collected was analyzed using descriptive statistics (frequency counts and percentages).

**Data Analysis and Findings**

The table below shows the breakdown of the participants’ gender and multiple intelligences’ distribution frequency and percentage.

**Table 1 : Demographic Profile of the Selected Participants**

---

<b>Sex</b>	<b>N</b>	<b>%</b>
Female	251	33.5
Male	499	66.5
<b>Total</b>	<b>750</b>	<b>100</b>

---

Source: Field work 2022

Physical	Conversion from	Conversion to	Procedure	Correct Attempt		Incorrect		No		
				#	%	#	%	#	%	
				311	41.5	368	49.1	71	9.5	
<b>Attempt</b>	<b>Quantitie</b>							<b>Attempt</b>		
<b>Length</b>	Decimeter (dm)	Millimeter	$1dm \times 100$							
				306	40.8	382	50.9	62	8.3	
		(mm)	$^{\circ}C = ^{\circ}F - \frac{32}{1}.8$ $= 100mm$							
	Millimeter (mm)	Centimeter (cm)	$X_{mm} \div 10 = 0.X_{cm}$	496	66.1	175	23.3	79	10.5	
	Centimeter (cm)	Meter (m)	$X_{cm} \div 100 = 0.0X_m$	486	64.8	231	30.8	33	4.4	
	Meter (m)	Kilometer (km)	$X_m \div 1000 = 0.00X_{km}$	266	35.5	378	50.4	106	14.1	
<b>Temperat ure</b>	Fahrenheit (°f)	Celsius (°C)								
	Celsius (°C)	Kelvin (K)	$^{\circ}K = ^{\circ}C + 273.15$	376	50.1	278	37.1	96	12.8	
	Kelvin (K)	Celsius (°C)	$^{\circ}C = ^{\circ}K - 273.15$	360	48.0	288	38.4			
								102	13.6	
<b>Time</b>	Hour (hr)	Minute (m)	$X_{hr} = X \times 60_{minutes}$	572	76.3	147	19.6	31	4.1	
	Minute (m)	Second (s)	$X_{min} = X \times 60_{seconds}$	538	71.7	156	20.8	56	7.5	
<b>Velocity/ Speed</b>	Kilometer per hour (Km/hr)	Meter per second (m/s)	$X_{km/hr} = X \times 1000 / 60 \times 60 \text{ m/s}$	490	65.3	175	23.3	85	11.3	
<b>Power</b>	Watt (W)	Kilowatts (Kw)	$X_W \div 1000 = 0.00X_{kW}$	330	44.0	297	39.6	123	16.4	
	Watt (W)	Megawatts (Mw)	$X_W \div 1.0 \times 10^6 = X_{Mw}$ $1.0 \times 10^{-6} \text{ mW}$	242	32.3	257	34.3	251	33.4	

	Kilo Watts (W)			$X_{kw} \div 1000 = 0.00X_{mw}$	292	38.9	290	38.7	168	22.4
			<b>Megawatts (Mw)</b>							
	Watt (W)			$X_w \div 746_{hp}$	174	23.2	389	51.9	87	24.9
			<b>Horsepower (hp)</b>							
<b>Mass</b>	Gram (g)		<b>Kilogram (Kg)</b>	$X_{gram} = x / 1000 = 0.00X_{kg}$	633	84.4	99	13.2	18	2.4
	Kilogram (Kg)		<b>Gram (g)</b>	$X_{gram} = X \times 1000_{kg}$	292	38.9	207	27.6	251	33.5
<b>Volume</b>	Centimeter Cube (cm <sup>3</sup> )		<b>Meter Cube (m<sup>3</sup>)</b>	$X_{cm^3} \div 10^6$	200	26.7	291	38.8	259	34.5
<b>Area</b>	Millimeter square (mm <sup>2</sup> )		<b>Meter Square (m<sup>2</sup>)</b>	$X_{mm^2} \div 10^6$	320	42.7	309	41.2	121	

Table 2: Result of the Students' Conversion Knowledge

**Source: Field work 2022**

311 students representing 41.5% of the sample size got the decimeter (dm) to meter (m) conversion correctly. 368 students representing 49.1% of the sample size got the conversion of decimeter (dm) to meter (m) wrongly while 71 students representing 9.5% failed to attempt the question.

496 students representing 66.1% of the sample size got the millimeter (mm) to centimeter (cm) conversion correctly. 175 students representing 23.3% of the sample size got the conversion of millimeter (mm) to centimeter (cm) wrongly while 79 students representing 10.5% failed to attempt the question.

486 students representing 64.8% of the sample size got the centimeter (cm) to meter (m) conversion correctly. 231 students representing 30.8% of the sample size got the conversion of centimeter (cm) to meter (m) wrongly while 33 students representing 4.4% failed to attempt the question.

266 students representing 35.5% of the sample size got the meter (m) to kilometer (km) conversion correctly. 378 students representing 50.4% of the sample size got the conversion of meter (m) to kilometer (km) wrongly while 106 students representing 14.1% failed to attempt the question.

306 students representing 40.8% of the sample size got the Fahrenheit (°F) to Celsius (°C) conversion correctly. 382 students representing 50.9% of the sample size got the conversion of Fahrenheit (°F) to Celsius (°C) wrongly while 62 students representing 8.3% failed to attempt the question.

376 students representing 50.1% of the sample size got the Celsius ( $^{\circ}\text{C}$ ) to Kelvin ( $^{\circ}\text{K}$ ) conversion correctly. 278 students representing 37.1% of the sample size got the conversion of Celsius ( $^{\circ}\text{C}$ ) to Kelvin ( $^{\circ}\text{K}$ ) wrongly while 96 students representing 12.8% failed to attempt the question.

360 students representing 48.0% of the sample size got the Kelvin ( $^{\circ}\text{K}$ ) to Celsius ( $^{\circ}\text{C}$ ) conversion correctly. 288 students representing 38.4% of the sample size got the conversion of Kelvin ( $^{\circ}\text{K}$ ) to Celsius ( $^{\circ}\text{C}$ ) wrongly while 102 students representing 13.6% failed to attempt the question.

572 students representing 76.3% of the sample size got the Hour (hr) to Minutes (min.) conversion correctly. 147 students representing 19.6% of the sample size got the conversion of Hour (hr) to Minutes (min.) wrongly while 31 students representing 4.1% failed to attempt the question.

538 students representing 71.7% of the sample size got the Minutes (min.) to seconds (s) conversion correctly. 156 students representing 20.8% of the sample size got the conversion of Minutes (min.) to seconds (s) wrongly while 56 students representing 7.5% failed to attempt the question.

490 students representing 65.3% of the sample size got the Kilometer per hour( $\text{Kmh}^{-1}$ ) to Meter per seconds ( $\text{ms}^{-1}$ ) conversion correctly. 175 students representing 23.3% of the sample size got the conversion of the Kilometer per hour( $\text{Kmh}^{-1}$ ) to Meter per seconds ( $\text{ms}^{-1}$ ) wrongly while 85 students representing 11.3% failed to attempt the question.

330 students representing 44.0% of the sample size got the Watt (w) to Kilowatts (Kw) conversion correctly. 297 students representing 39.6% of the sample size got the conversion of the Watt (w) to Kilowatts (Kw) wrongly while 123 students representing 16.4% failed to attempt the question.

242 students representing 32.3% of the sample size got the Watt (w) to Megawatts (mw) conversion correctly. 257 students representing 34.3% of the sample size got the conversion of the Watt (w) to Megawatts (mw) wrongly while 251 students representing 33.4% failed to attempt the question.

292 students representing 38.9% of the sample size got the Kilowatts (Kw) to Megawatts (mw) conversion correctly. 290 students representing 38.7% of the sample size got the conversion of the Kilowatts (Kw) to Megawatts (mw) wrongly while 168 students representing 22.4% failed to attempt the question.

174 students representing 23.2% of the sample size got the Watt (w) to horsepower (hp) conversion correctly. 389 students representing 51.9% of the sample size got the conversion of the Watt (w) to horsepower (hp) wrongly while 187 students representing 24.9% failed to attempt the question.

633 students representing 84.4% of the sample size got the Gram (g) to Kilogram (Kg) conversion correctly. 99 students representing 13.2% of the sample size got the conversion of the Gram (g) to Kilogram (Kg) wrongly while 18 students representing 2.4% failed to attempt the question.

292 students representing 38.9% of the sample size got the Kilogram (Kg) to Gram (g) conversion correctly. 207 students representing 27.6% of the sample size got the conversion of the Kilogram (Kg) to Gram (g) wrongly while 251 students representing 33.5% failed to attempt the question.

200 students representing 26.7% of the sample size got the Centimeter cube ( $\text{cm}^3$ ) to meter cube ( $\text{m}^3$ ) conversion correctly. 291 students representing 38.8% of the sample size got the conversion of the Centimeter cube ( $\text{cm}^3$ ) to meter cube ( $\text{m}^3$ ) wrongly while 259 students representing 34.5% failed to attempt the question.

320 students representing 42.7% of the sample size got the millimeter square ( $\text{mm}^2$ ) to meter cube ( $\text{m}^2$ ) conversion correctly. 309 students representing 41.2% of the sample size got the conversion of the millimeter square ( $\text{mm}^2$ ) to meter cube ( $\text{m}^2$ ) wrongly while 121 students representing 16.1% failed to attempt the question.

### **Discussion**

Metric conversion is an essential knowledge required to excel in physics lesson and by extension in solving mathematics-related problems in physics. This is considered important because of physics physical quantities sub-units nature. Most mathematics related aspect of physics gives their data in subunits and request the students to convert such units to appropriate and required units. Students' inability of failure to do the metric conversion invalidates the whole processes and would be termed student's failure.

Strength in length sub-units conversion indicated that most students find it difficult to convert decimeter to millimeter correctly. Most students use prefix values that are not appropriate to do the conversion. For instance 1dm equals 100mm but many students equate 1dm to 10mm and 1000mm and the results are wrong.

Higher strength were recorded in conversion of millimeter (mm) and centimeter (cm) to meter (m) but students weakness were recorded in converting meter (m) to kilometer.

Temperature as a fundamental physical quantity has sub-units of Fahrenheit ( $^{\circ}\text{F}$ ), Celsius ( $^{\circ}\text{C}$ ) and Kelvin ( $^{\circ}\text{K}$ ). Students' weaknesses were recorded when converting Fahrenheit ( $^{\circ}\text{F}$ ) to Celsius ( $^{\circ}\text{C}$ ). Moderate strength of students' conversion ability were recorded in converting Celsius ( $^{\circ}\text{C}$ ) to Kelvin ( $^{\circ}\text{K}$ ) and Kelvin ( $^{\circ}\text{K}$ ) to Celsius ( $^{\circ}\text{C}$ ).

Measuring time of an event is a common practice physics classroom and out of classroom activities. Most physics classroom practical activities do considered time measurements and students proficient in converting from one sub-unit to another.

The result of this study indicated that the students had higher strength in converting hour (hr) to minutes (min.) and minute (min.) to seconds (s).

Velocity/Speed are derived physical quantities that depends on fundamental physical quantities for their definition, word equation, formulae and sub-units formation though the distinction between the two is that velocity has both magnitude and direction while speed has only magnitude. Both quantities with similar meaning have same sub-unit. The findings of this study revealed that students' metric conversion knowledge of kilometer per hour (Km/hr) to meter per second was high and students' frequency that got it done correctly stood at 65.3%.

Power as a derived physics physical quantity is measured in sub-units of watt (w), kilowatts (Kw), megawatts (Mw), and horsepower (hp) for the generating power stations. Students significant frequency strength was recorded in conversion of watt (w) to kilowatts (Kw) but the frequency of students who did the conversion of watt (w) to megawatts (Mw), kilowatts (Kw) to megawatts (Mw) and watt to horsepower (hp) was low.

Mass of a body was initially measured in tonnes before the adoption of Systèmè International

Unit (SI unit). Gram and Kilogram are verified units of mass of a body and students' conversion knowledge indicated larger percentage ability to convert from gram (g) to kilogram though most of the samples were unable to convert kilogram (Kg) to gram (g).

Conversion from centimeter cube ( $\text{cm}^3$ ) to meter cube ( $\text{m}^3$ ) signifies the measurement of volume of a substance. The estimated frequency of students' who attempted the conversion correctly was low. Area of an object is measured as the product of the length, l, and breadth, b. the students' frequency recorded shows that not up to half of the sample (42.7%) converted millimeter square ( $\text{mm}^2$ ) to meter square ( $\text{m}^2$ ) correctly.

### **Conclusion**

The study assessed the senior secondary school physics students' knowledge of metric conversion of some physical quantities sub-units. The sub-units conversion's knowledge is prerequisite to positive performance at all level of education to solve problems relating to mathematics in physics. The study concluded that higher percentage of senior secondary school physics students are finding it difficult to convert from one sub-unit to another. The authors recommended that the study can be conducted at higher education institutions and also engage participants across the disciplines that required the knowledge of metric system and its conversion. Other

moderating variables that can influence (s) the students' performance in metric system and its conversion should be considered in the future studies.

### **Acknowledgement**

Acknowledging the samples and elements that make this study a success was required. The researchers appreciate the students engaged in this study for their patience and for showing true reflection of their metric conversion ability. The researchers also appreciate the sample schools authorities for their hospitality and permission to use the time allocated for physics classes to collect the data. Those people to be appreciated also were the research assistants that participate in the study and make the research a successful one.

### **References**

- Adendorff, S.A. (2014). Conversion in the metric system: reflecting on the GET mathematics curriculum.
- Cardarelli, F. (2012). Scientific unit conversion: a practical guide to metrication. Springer science & business media
- Dincer, E. O. & Osmanoghu, A. (2018). Dealing with metric unit conversion: An examination of prospective science teachers' knowledge of and difficulties with conversion. *International Council of Association for Science Education*, 29(3), 174-182.
- Gardner, H. (1983). Frames of Mind: the theory of multiple intelligences. Basic Books, New York.
- Gonzalez-Trevino, I. M., Nunez-Rocha, G. M., Valencia-Hernandez, J. M. & Arrona Palacios, A. (2020). Assessment of multiple intelligences in elementary school students in Mexico: An exploratory study. *Elsevier Ltd.*, 1-5. <https://doi.org/10.1016/j.heliyon.2020.e03777>
- Inan, C. & Erkus, S. (2017). The effects of mathematical worksheets based on multiple intelligences theory on the academic achievement of the students in 4<sup>th</sup> grade primary school. *Universal Journal of Educational Research*, 5, 1372-1377. <https://doi.10.13189/ujer.2017.050810>

Lei, D-Y., Cheng, J-H., Chen, C-M., Huang, K-P. & James C. C. (2021). Discussion of teaching with multiple intelligences to corporate employees' learning achievement and learning motivation. *Frontiers Psychology*, 12, 1-5.  
<https://doi:10.3389/fpsyg.2021.770473>

Raje, S. (2019). Utility of metric conversion for success in introductory college science courses. *Journal of Curriculum and Teaching*, 8(2), 32-42. <https://doi:10.5430/jct.v8n2p32>

Ronald, J. N. (2023). Multiple intelligences: psychological theory. The editors of Encyclopaedia Britannica

Yaghoob, R. A. & Hossein, Z. P. (2016). The correlation of multiple intelligences for the achievements of secondary students. *Educational Research and Reviews*, 11(4), 141-145. <https://doi:10.5897/ERR2015.2532>

West African Senior School Certificate Examination Chief Examiner's Report (2013)

West African Senior School Certificate Examination Chief Examiner's Report (2015)

West African Senior School Certificate Examination Chief Examiner's Report (2017)

West African Senior School Certificate Examination Chief Examiner's Report (2018)

West African Senior School Certificate Examination Chief Examiner's Report (2019)