

Comparative Analysis of Grade Nine Students' Performance in Scientific Measurement in the Three Types of Written Tests

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ABSTRACT

Students perceive scientific measurement as one of the most challenging topics in almost all sciences. Thus, the researcher conducted a study on the comparative analysis of performance in scientific measurement of the grade nine students in the three types of tests, such as without learning aid, with formulas and conversion factors, and with formulas, conversion factors, and calculator. To address this problem, the researcher used a descriptive-comparative method utilizing the developed research instrument administered to the 43 participants. The findings of the study revealed that the level of performance in the scientific measurement of the students in the three types of tests is high. However, obtained mean scores show that the highest mean was in the third type of test. This type allows students to use formulas, conversion factors, and a calculator. When grouped according to gender, girls obtained the highest mean consistently in the three types of tests compared to boys. Furthermore, the study reflected a significant difference between the three types of tests. However, when grouped according to gender, boys and girls differ significantly in the first and third type of test only. These findings indicate that grade nine students have mastery of scientific measurement; however, girls perform better than boys in the first and third types of tests. Likewise, the study shows that the use of a calculator improves performance in finding out the correct answer to the problem. The study recommends that technology such as calculator, computers, and the like should be used in the classroom for these help students acquire computational and word problem-solving skills.

Keywords: Comparative Analysis, Types of Tests, Performance, Scientific Measurement

INTRODUCTION

Chemistry is one of the subjects taught in secondary schools. It is found useful in the field of engineering, industry, agriculture, and medicine. The relative importance of this subject to the society, therefore, creates awareness among teachers and learners. However, students perceive chemistry as a subject more difficult than any other sciences in the secondary curriculum.

As a chemistry teacher, the researcher often asks students, "Which do you think is more difficult, physics or chemistry"? Students' usual answer would be chemistry. Chemistry, because according to them, the subject is more abstract than physics. It is abstract in the sense that they cannot see when an atom combines with another atom. Physics, on the other hand, is concrete because they can see when two objects collide with each other.

In the study of chemistry and any other sciences, the study of scientific measurement is significant. It is significant because, in practical skills and laboratory activities, the concept of scientific measurement is often used. Measurement activities are the dominant aspects of practical skills and laboratory activities. However, the inclusion of this topic in the study of chemistry and any other sciences oppose some students to like the subjects primarily because scientific measurement involves the concept of mathematics. In the topic of converting one unit of measurement into another unit, the students need to have skills in numeracy or in mathematics in general, which the researcher believes is difficult for the majority of the students. Gilman (2013) expressed that students struggle with conversion. They find this topic and other related topics difficult. As mathematics and a science teacher, it is always my observation that students have difficulties with the conversion. Why is this difficult for them? Probably because mathematics is involved.

Along this line, many studies appear to show that mathematical ability, mathematical aptitude, or accumulated procedural knowledge is positively correlated to success in physics and chemistry courses that emphasize quantitative problem solving (Lukowski, 2014). This assumption is also confirmed by Herbert (1978) and Usoro, Akpan, Akpan, & Okoro (n.d.) when he said that mathematics has an age-old relationship with physics, chemistry, and other natural sciences. He also views mathematics as the queen and servant of the sciences. His view is backed up with this practical example that measurement and other mathematical techniques are vital in the work of the physicist and chemist. Physicists and chemists use mathematical concepts to solve an equation in physics and science. Likewise, they use mathematical concepts in converting one unit into other units like, for instance, changing

degrees Celsius to Fahrenheit and the like.

The classroom practitioners, notably the professional teachers of science and even non-science teachers, believe that no student can make headway in science and technology. They need to have basic knowledge of mathematics and according to Taylor (1970) as cited in Abdurrahman and Madugu (2014) fewer people seem to be aware that mathematics carries the main burden in all of the scientific reasoning and is the core of the significant theories of physical science. In recent years all fields of science have become more and more quantitative. The distinguishing feature of mathematics is its quantitative character. All sciences depend on investigations, and all investigations depend on measurements, and measurement is a branch of mathematics (Barnes, 1987 cited in Abdurrahman, 2014). It is for this reason that scientific measurement is difficult for the students.

On the other hand, the researcher pointed out that students' performance depends on teachers' instructional practices in giving tests. Teachers' use of the different types of assessment is one important consideration in instruction. Afflerbach (2002) asserts that a high level of student assessment includes designing instruction and assessment that allows all students to think about and monitor their learning.

According to Airasian (1991), "measurement-driven instruction" became the credo in the past decades. Accountability of it had reared its accusing head to denounce the escalating costs of education without accompanying increases in efficiency and effectiveness. As other services have increased in value (medicine, transportation, computerized offices), a parallel improvement in the quality and quantity of their services and products also followed. This situation is not so in education, where services and products can decline. In the 21st century, evaluation of students no longer needs to be based only on one-time

measurement. It can be augmented by objective evidence of how much growth has occurred over some time. Time-sample evidence is an important predictor of the growth expected in the future.

Another observation of why scientific measurement is difficult for the students is that it is hard for them to remember conversion factors and have spent more time in computation. They know the process, but they find it complicated to solve problems on conversion manually. Thus, the researcher argues that if students are provided with learning aids, learning scientific measurement would not be very difficult for them. According to Hook (2018), teaching or learning aid is a device designed to help students understand and remember more quickly and more sustainably. Its purpose is to keep it in students' memory so that they can easily recall it. Thus, it is in this context that the researcher decided to conduct a comparative analysis on the performance in the scientific notation of the grade nine students in the three types of written tests.

This study aimed to determine the level of performance in scientific measurement of the grade nine students of Philippine Normal University Center for Teaching and Learning.

Specifically, this study aimed to determine:

1. the level of performance in scientific measurement of the grade nine students in the three types of tests:
 - 1.1 first type of test (without learning aid)
 - 1.2 second type of test (with formulas and conversion factors)
 - 1.3 third type of test (with formulas, conversion factors, and calculator)
2. the level of performance of the grade nine students in scientific measurement in the three types of tests when grouped according to gender
3. the differences in the level of performance in scientific measurement of the grade nine students in the three types of tests when grouped according to gender.

METHODOLOGY

Research Method

To address the problems of the study and to achieve its purpose, a descriptive-comparative research design was used. This design is the most appropriate because this study intends to describe the level of performance in the scientific measurement of the grade nine students in the three written types of tests. On the other hand, comparisons are made between the levels of performance of the grade nine students in the three written types of tests and between grade nine male and female students' level of performance in the three written types of tests.

Research Participants

The research participants of the study were the 43 grade nine students of Philippine Normal University Visayas Center for Teaching and Learning. Of the 43 grade nine students, 19 of them are boys, while 24 are girls. Since only 43 students composed the grade nine students, the researcher decided to include the 43 students as actual participants of the study. The researcher believes that the number of grade nine students as participants of the study is manageable.

Research instrument

To determine the level of performance in the scientific measurement of the grade nine students, the researcher developed a 40-item

multiple-choice type of test. The test included topics on operations, significant figures, scientific notation, and conversion of one unit into another unit. The forty-item test covered the three essential topics mentioned. Ten of the items deal with the operation on significant figures. Another ten items deal with the operation on scientific notation. Twenty of the 40 items deal with the conversion of one unit into another unit. The test developed by the researcher followed the principles of test construction and was subjected to content validation and reliability test.

Data Gathering Procedures

To gather data on the level of performance in the scientific notation of the grade nine students, the researcher administered three types of written tests. In the first test, grade nine students were asked to solve each of the 40-item multiple-choice tests without learning aid. This type of test is a purely traditional type of testing. After an hour, the test papers were gathered, checked, and scored by the teacher. Three days after the first test, the second test using the same test items were administered to the same group of grade nine students. By this time, grade nine students were asked to open their notes. They were also provided conversion factors for test items that required the conversion of one unit into another unit. The same time element was provided to solve the 40-item test. After an hour, the test paper was gathered, checked, and scored by the teacher.

The last test was likewise provided after three days. In the last test, grade nine students were asked to open their notes, conversion factors were provided, and by this time they are asked to use a calculator. The same time element was also provided to solve the 40-item test. After an hour, the test paper was gathered, checked, and scored by the teacher.

After three types of tests were completed,

the data were sorted out and transported to SPSS for computation. Its purpose was to determine the level and differences in the performance of the grade nine students in scientific measurement in the three types of tests.

Data Analysis

In the analysis of the data, mean and standard deviation were used to determine the level of performance in scientific measurement of the grade nine students in the three types of tests and when grouped according to gender. On the other hand, a t-test for independent means was used to determine significant differences in the level of performance in scientific measurement of the grade nine students in each of the types of tests when grouped according to gender. One-way analysis of variance was used to determine the significant difference in the level of performance in scientific measurement of the grade nine students in the three types of tests.

RESULTS

Table 1 reflects that the level of performance in scientific measurement of the grade nine students in the first written test ($M = 25.25$, $SD = 2.88$), second written test ($M = 26.64$, $SD = 3.43$), and third written test ($M = 28.61$, $SD = 3.73$) is high. However, when obtained mean scores were considered individually, results indicate that the highest mean score ($M = 28.61$, $SD = 3.73$) was obtained by the grade nine students in the third type of written test. The lowest mean score ($M = 25.25$, $SD = 3.73$) on the other hand, was obtained by them in the first written type of tests.

Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests when Grouped According to Gender

Table 1. Mean and Standard Deviation on the Level of Performance in Scientific Measurement of the grade Nine Students in the Three Types of Written Tests

Types of Written Tests	No. of Items	M	SD
First Test (Conventional)	40	25.25	2.88
Second Test (with formulas and conversion factors)	40	26.64	3.43
Third Test (with formulas, conversion factors, and calculator)	40	28.61	3.73

Note. The mean scores are interpreted as follows: 0.00 – 8.00 (Very Low); 8.01 – 16.00 (Low); 16.01 – 24.00 (Average); 24.01 – 32.00 (High); and 32.01 – 40.00 (Very High)

Table 2. Mean and Standard Deviation on the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests when Grouped According to Gender

Types of Written Tests	No. of items	Boys		Girls	
		M	SD	M	SD
First Written Test (Conventional)	40	24.08	2.93	26.27	2.49
Second Written Test (with formulas and conversion factors)	40	25.54	3.26	27.60	3.40
Third Written Test (with formulas, conversion factors, and calculator)	40	26.54	4.04	30.40	2.29

Note. The mean scores are interpreted as follows: 0.00 – 8.00 (Very Low); 8.01 – 16.00 (Low); 16.01 – 24.00 (Average); 24.01 – 32.00 (High); and 32.01 – 40.00 (Very High)

Table 3. Result of t-test on the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests when Grouped According to Gender

Types of Tests	Boys		t	df
	Boys	Girls		
First Written Test (Conventional)	24.08 (2.93)	26.27 (2.49)	-2.14*	41
Second Written Test (with formulas and conversion factors)	25.54 (3.26)	27.60 (3.40)	-1.63	41
Third Test Written (with formulas, conversion factors, and calculator)	26.54 (4.04)	30.40 (2.29)	-3.16*	41

Note. * = $p \leq 0.05$. Standard deviations appear in parentheses to the right of the means.

When grade nine students were grouped according to gender, Table 2 indicates that the level of performance in scientific measurement of boys in the first written test ($M = 24.08$, $SD = 2.93$), second written test ($M = 25.54$, $SD = 3.26$), and third written test ($M = 26.54$, $SD = 4.04$) is high. On the other hand, girls level of performance in the written first test ($M = 26.27$, $SD = 2.49$), second written test ($M = 27.60$, $SD = 3.40$), and third written test ($M = 30.40$, $SD = 2.29$) is also high. However, when obtained

mean scores were considered, result shows that girls obtained the highest means than boys in the three types of written tests.

Significant Differences in the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests when Grouped According to Gender

Table 3 reflects that when t-test for

Table 4. *Variance Analysis in the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests*

Types of Tests	M	F	η^2
First Written Test (Conventional)	24.08 (2.93)		
Second Written Test (with formulas and conversion factors)	25.54 (3.26)	7.04	0.15
Third Written Test (with formulas, conversion factors, and calculator)	26.54 (4.04)		

Note. * = $p \leq 0.05$. Standard deviations appear in parentheses to the right of the means.

Table 5. *Scheffe Test on the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests*

Groups	Mean Difference	Std. Error	p
First Written Test – Second Written Test	-1.39	0.90	0.31
First Written Test – Third Written Test	-3.36	0.90	0.01*
Second Written Test – Third Written Test	-1.96	0.90	0.10

Note. * = $p < 0.05$

independent means was used to determine significant differences in the level of performance in scientific measurement of boys and girls grade nine students, result shows that the difference in the level of performance between boys ($M = 24.08$, $SD = 2.93$) and girls ($M = 26.27$, $SD = 2.49$) in the first test was statistically significant, $t(41) = -2.14$, $p \leq 0.05$ with girls receiving higher overall mean score than boys. Likewise, significant difference existed between the level of performance in scientific measurement of boys ($M = 26.54$, $SD = 4.04$) and girls ($M = 30.40$, $SD = 2.29$) in the third type of written test with girls receiving the highest mean score. On the other hand, no significant difference was noted in the level of performance in scientific measurement of boys and girls grade nine students in the second type of written test.

Significant Differences in the Level of Performance in Scientific Measurement of the Grade Nine Students in the Three Types of Written Tests

Table 4 reveals significant differences in the level of performance in the scientific measurement of the grade nine students in the three types of

written tests. A one-way ANOVA reflected that there is a significant difference in the level of performance in scientific measurement of the grade nine students in the three types of written tests $F(2, 40) = 7.04$, $p = 0.01$, $\eta^2 = 0.15$. This result disclosed that significant differences existed between the performance of the students in the first written test and third written test.

Further analysis of the result presented in Table 5 reflects that significant differences in the level of performance in scientific measurement of the grade nine students in the three types of written tests can be traced between the first type of written tests and the third type of written tests ($M = -3.36$, $p = 0.01$) which allows the students to use formulas, conversion factors, and calculators. However, no significant differences were observed in the level of performance in scientific measurement between the first written test and the second written test ($M = -1.39$, $p = 0.31$) and between the second written test and the third written test ($M = -1.96$, $p = 0.10$).

DISCUSSION

The primary purpose of this study was to determine the level of performance in the

scientific measurement of the grade nine students in the three types of written tests. Scientific measurement was conceived by the majority of science teachers as one of the most difficult topics in chemistry, physics, and other related fields. Difficult in the sense that the concepts of mathematics are involved. However, in this particular topic, students can perform the task with consideration of using learning aids like conversion factor table and calculator. These learning aids help them work faster and solve word problems easier without sacrificing the essence of learning. Thus, in this study, the researcher attempted to compare the level of performance in scientific measurement of the grade nine students in the three types of written tests where learning aids are used for the second and third written tests.

Along this line, results revealed that the level of performance is the scientific measurement of the grade nine students in the three types of written tests is high. However, considering obtained mean scores, the highest mean was on the third written test, while the lowest was on the first written test. Likewise, results indicate that boys' and girls' levels of performance in the three types of written tests were also high, but girls obtained the highest means in the three types of written tests than boys. In consideration of the differences in the level of performance of the grade nine students in the three types of written tests, results show that grade nine students differ significantly in the level of their performance in the first and third written tests. When grouped according to gender, a significant difference was noted in the level of performance between boys and girls in the first and third written tests.

Results obtained indicate that the level of performance of the grade nine students improves in the third type of written test. This means that the use of learning aid, more specifically the use of a calculator, has improved grade nine students'

level of performance in scientific measurement. Authorities in mathematics and science have observed that for many years now (since the early 1970s), hand-held calculators have been widely used in mathematics instruction in many educational systems of the world. Advances in technology have improved the use of a calculator, and mathematics curricula have been designed to involve this technology. Studies have indicated that the use of calculators can enhance students' ability to learn basic facts and those students who used calculators frequently exhibited more advanced concept development and problem-solving skills than those who did not use them (Cockroft, 1982; Suydam, 1982; Howson, 1991; Hembree and Dessart, 1992 cited in Kaino and Salani, 2004). These studies reduced some earlier fears that calculators could affect students' mastery of computational skills acquired from traditional paper-pencil methods (NCTM, 1974; Cockroft, 1982 as cited in Kaino and Salani, 2004). Likewise, in a meta-analysis of 54-research studies conducted by Ellington (2003), it was revealed that students' operational skills and problem-solving skills improved when calculators were an integral part of testing and instruction. The meta-analysis also showed that calculator use did not hinder the development of the mathematical skills after instruction and transfer of skills to other mathematics-related subjects.

Also, results disclosed that significant differences existed between the performance of the grade nine students in the first written test and third written test. According to Torrance and Pryor (1998), modes and methods of assessment make a difference in the learning of the child. Using a wide range of techniques and employing formative feedback can promote learning and achievement. This indicates that the way a test is given to help improve students' level of understanding. Likewise, integrating the use of technology, more specifically, the use of calculator

in the classroom during tests and examinations helps students attain an understanding of the lesson that involves the facilities of numbers.

Considering gender, boys' and girls' levels of performance in scientific measurement are almost the same. However, when obtained mean scores were considered, girls obtained mean scores higher than boys in the three types of written tests. This result is also reflected when performance was compared using a t-test for independent means showing that the level of performance in scientific measurement between boys and girls was significant. Kahle and Meece (1994), in a synthesis of researches, found gender differences in science achievement. However, Mura (1995) asserts that boys and girls have different ways of learning, and that is better taught separately, while Fennema (1996) revealed that in a co-educational classroom setting, boys received more attention than the girls. However, Heller and Persons (1981) had earlier deputed this difference by finding no difference in the feedback given to boys and girls. Although boys and girls differ in their physical, emotional, and intellectual development, efforts to link gender differences in science with intellectual capabilities have, however, proved weak (Inyang & Hanna, 2001; Orimogunje, 2006, as cited in Orimogunje, 2013). Social and cultural factors are the primary reasons leading to the gender difference in academic performance. These factors include student's familiarization with the subject, changes in career aspiration, gender perceptions of a specific subject, and presentational styles of boys and girls (Streitmatter, 1994; Gallagher, 2000, as cited in Orimogunje, 2013).

Furthermore, the issue of gender is an essential factor in science education, especially with the increasing emphasis on the way to boost human resources for technological development as well as increasing the population of females in science and technology fields. However, research

findings have been inconclusive as to who achieves higher, male or female. It has been reported that females have markedly improved their educational performance (Omoniyi, 2006; Fasola, 2009, as cited in Orimogunje, 2013). Although there are no clear contentions as to gender differences in science performances, however, Adigwe (1992) investigation in chemical problem-solving achievement indicated that differences favor males in all the skills investigated. Amara (1987) as cited in Orimogunje (2013) discussed the state of girls in science education in Sierra-Leone and suggested that a science curriculum based on indigenous technology may be more appropriate to their needs than the current westernized syllabus.

Along this line, if learning aids, like conversion factors and the calculator, will be used in the teaching of scientific measurement, grade nine students will likely improve their academic performance. They will also develop positive attitudes and interest in the subject. In this regard, learning aids are encouraged to be used in the teaching-learning process. Teachers, more specifically, science teachers should allow students to use conversion factors and calculator in learning scientific measurements and any other topics in chemistry and physics where the application of mathematics is possible. Further, students should not necessarily memorize formulas but need to have a better understanding of how formulas will be manipulated and derived.

However, some limitations should be noted. First, the study made use of comparative analysis, where the focus is only to compare grade nine students' performance in the three types of measurement. In this case, findings may be influenced by the nature of participants. Thus, it is suggested that an experimental design should be conducted to determine the impact of learning aids. Second, the sample of 43 grade nine students is small enough to qualify for this study; the data

may not assume normality. It is suggested that future research along this line is encouraged by utilizing a larger sample for the researcher to be confident in rejecting and accepting hypotheses. Third and last, the use of parametric statistics is not the most appropriate considering that the sample is very small. Using non-parametric statistics would validate the results more clearly.

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