Journal of Education and Practice
ISSN 2222-1735 (Paper) ISSN 2222-288X (Online)
Vol.5, No.26, 2014 www.iiste.org

An Investigation into Shs3 Physics Students Understanding of Data Comparison of Scientific Measurement in Volta Region

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Abstract
Serious doubt have been raised in the Physics Chief Examiner's report of the West African Examination Council of Ghana of both physics-1 (theory) and physics-2 (practical) as to whether science students really understand data comparison of physical quantities.In view of this, the researcher use a mixed designed method to gather data from SHS3 physics students' on their understanding of data comparison of length and time. A population of 422 SHS3 physics students were sampled and a twelve item questionnaire on distance and time administered in order to find out whether the problem enumerated by the Chief Examiners' of Physics concerning physics students exist and were either with the set paradigm or the point paradigm concept. Also twenty SHS3 physics were purposively selected and interviewed in order to validate students' written responses.

Introduction

Science may also be seen as a product, a process and an enterprise (Wordsworth, 1998). It is a product because many body of knowledge (i.e. chemistry, physics, mathematics, biology among others) converge to form it (Cardamone, 2007). A process because it involves the use of scientific methodology in exploring and conducting experiments, as well as inquiry (Wordsworth, 1998) and enterprise because it can meaningfully be pursuit in academic and research institutions in order to unearth hidden knowledge (Wordsworth, 1998). Thus science, be it modern or contemporary has advanced, and has reshaped itself by investigating new questions, developing new experimental paradigms, and offering new interpretations. One of the most exciting challenges for today's science is that it investigates individual human experience through knowledge and understanding of concepts such as measurement of physical quantities (Azari & Bataille, 2003).

Five fundamental or base quantities are in science and all other quantities are related from these fundamental quantities. These fundamental quantities are length (l), time (t), mass (m), electric charge (q), amount of substance (n), temperature (T) and luminescent intensity (cd) are just five examples of the seven fundamental quantities (Bassarath & Whiteley, 2009).

Experimentation and measurement are fundamental to knowledge production in both the applied and natural sciences, including technology. Meaningful engagement by students in scientific activities that are experimentally based requires an understanding of science concepts for the procedures that are followed (Allie, Buffler, Campbell & Lubben, 2001). However, most science students in senior high schools in Ghana find difficulty in understanding measurement of physical quantities, the physics Chief Examiner's report of the West African Examination Council (WAEC, 2000, 2002, & 2006). Other countries such as USA, Australia, Denmark, Sweden and South Africa (Allie et al, 2003; Deardorff, 2001; Lippmann, 2003) also faced similar problems with their science students as has already been indicated by the physics Chief Examiner's report of the West African Examination Council (WAEC, 2000, 2002, & 2006). Due to this, the researcher deems it right to carry out an investigation into physics students' understanding of measurement of length and time in category A, category B, category C, and category D senior high schools in the Volta region of Ghana (Ghana Education Service, 2009).

Statement of the Problem

Several attempts have been made to understand the effectiveness of science students in terms of promoting students' understanding of the science concepts in measurement (Cardamone, 2007). For example pure science, science education and engineering students are trained yearly. The training is given to the science students so that they would be able to view physical situations with an analytical eye in order that they would be able to acquire a qualitative understanding of physical situations, and thus would be able to make quantitative predictions of observable results arising from the physical situations (Cardamone, 2007). However, many pure science, science education and engineering students perceive measurement as a difficult subject, because to them measurement deals with abstract laws or principles, concepts and models (Schauer, Ozvoldova & Lustig, 2007).

Although practical work forms part of the senior high school physics curricula in Ghana (physics syllabus, 2007), it is not clear as to the level at which senior high school physics students in category A, category B, category C, and category D senior high schools in the Volta region of Ghana understand the basic ideas of data comparison of physical quantities and the appropriateness of the data treatment procedures that they learn to use (WAEC, 2000, 2002 and 2006). All what is usually expected is that after the senior high school physics laboratory course, physics students should able to use an array of data analysis techniques, such as calculating the mean, standard deviation of the mean of physical quantities (physics syllabus, 2007) but not the understanding of the concepts of measurement (Anamuah-Mensah, Mensah, & Otuka, 2001).

However, while the Physics Syllabus of Ghana for senior high schools and some researches in pure sciences, applied science and science education strongly subscribed to the use of the set paradigm concept (i.e. all available data are used to construct distributions from which the best approximation of the scientist and an interval of uncertainty are derived) by science students and scientist the world over (Allie, Buffler, Campbell & Lubben, 2003; Bassarath & Whiteley, 2009; International Organization for Standardization (ISO), 2003; Physics Syllabus, 2007; Wilson, 2009) when it come to measurement of physical quantity, yet many science students in Ghana still made deductions after taken one measurement (WAEC, 2000).

The July/August, 2002 and 2006 Physics Chief Examiner's reports revealed further that, many science candidates did not repeat experimental readings so that two sets of values could be obtained and a mean taken. This implies that the Physics Chief Examiner's reports of 2002 and 2006 expected science students to repeat their experimental readings so that two or more sets of data can be obtained for the calculation of mean (average). This assertion is in line with the set paradigm concept of measurement of physical quantities where by experiments are to be repeated to get means, standard deviation of the mean and variance of the mean (Allie et al, 2001) in order to reduce or minimize random errors or any other errors aside random errors in measurement of physical quantities. This is because, one experiment cannot give the 'true value', unless that experiment is performed several times, and the mean of the numerous data collected is estimated to eliminate uncertainties in measured results (Wilson, 2009; Bassarath & Whiteley, 2009).

These lapses enumerated by the Physics Chief Examiner's report of the West African Examination Council of Ghana (WAEC, 2000, 2002 and 2006) of both physics-1 (theory) and physics-2 (practical) could either be due to anxiety of physics students during the examination or the type of examination questions set by the West Africa Examination Council or the lack of understanding of data comparison of physical quantities or the holding onto either the set paradigm concept or the point paradigm concept or the mixed paradigm by some science students or the students own conception.

It is therefore worthwhile to investigate into physics students understanding of data comparison of length and time in SHS3 in category A, category B, category C, and category D senior high schools in the Volta region in order to understand the causes of these confusion and misunderstanding by science students so that instruction on this subject can be improved.

Purpose of the Study

The purpose of this study is to explore SHS3 physics students' understanding of data comparison of length and time in category A, category B, category C, and category D senior high schools in the Volta region.

Research Questions

This study will attempt to answer the research question of length and time i.e. what is SHS3 physics students' understanding of data comparison of length and time in category A, category B, category C, and category D senior high schools in the Volta region?

Significance of the Study

The findings of the study would be significant in the following ways:

It could help provide some guide to physics teachers and students in order to assist and improve students' skills in practical activities involving measurement of length, and time. It could provide information to physics teachers on students' difficulties in data comparison of length, and time, so that teachers would find appropriate method of approaching the measurement concepts. It could also provide information to the Ministry of Education, policy makers and the general public on students' difficulties in data comparison of length and time, so that the Ministry of Education, policy makers and the general public would design appropriate educational policies of approaching the measurement concepts.

Delimitation

This study used only SHS3 physics students in data collection; this was because, by the time the physics students from SHS2 get to SHS3 in their various schools, they might have been taught measurement of physical quantities as has been specified in the physics syllabus, 2007. Thus, SHS3 physics students would be in the best position to respond meaningfully to the closed and opened ended questionnaire items and structured interview items of the study.

This study also considered only length and time aspect of measurement of physical quantities. This was because, these two physical quantities i.e. length and time, are fundamental quantities and also it form daily measurements that students undertake either in their schools or homes.

This study also considered only the understanding of SHS3 physics students in data comparison of measurement of length and time

Limitation

Some of the students were absent on the agreed day for the administration of the closed and opened ended questionnaire item in the rest of the selected category of schools.

REVIEW OF RELATED LITERATURE

The Concept of Data

Data is a term normally used for the recording of numerical values (Cardamone, 2007). Numerical values could be numbers, figures and facts. Data is information, often in the form of facts or figures obtained from experiments or surveys, and used as a base for making calculations or drawing conclusions or inferences (ISO, 2003). This shows that data could be facts, clinical observations, and measurements

Data Comparison

Comparison deals with examining or judging two or more things order to show how they are similar or different from each other (Plachouras & Ounis, 2007). This implies that science students in the classroom or the laboratory handling any type of data should be able to interpret the data by looking at the similarities and differences in the data he or she is handling or is dealing with such as a primary data, a secondary data, and a processed data among others.

Empirical Studies on Students' Understanding of Scientific Measurement

Masnick and Morris (2002) surveyed the way in which the comparison of two data sets is influenced by the characteristics of the sets. In interviews with individual students, they presented tables of data related to the achievement of two athletes. They varied the data sets systematically in size (from one to six data points), the frequency of overlapping data points (from zero to two) and the variability, or range, relative to the mean. American undergraduates were asked the conclusions they could draw from the information, the reasons for these conclusions and how certain they were. They were also asked to predict the next data point for each athlete, and how certain they were about the difference between the two predicted values. The results indicate that judgements were highly sensitive to sample size (for a larger sample size students were significantly more certain of their conclusions and predictions), and to the number of overlapping data points (fewer overlapping data points resulted in a significantly higher certainty of difference between the athletes' performances). Apart from sample size and overlapping data points, conclusions were based on criteria related to comparison between data points (as frequency, or proportion) and the means of the sets of data points. Only a small minority of students suggested being influenced by variability or outliers within the data sets, or by characteristics of the experimenter, or the apparatus.

In 2004, Allie, Buffler, Campbell and Lubben conducted a research on The Influence of Context on Judgements of the Quality of Experimental Measurements. The research reports on differences in perceptions of measurement in everyday and scientific situations such as in the kitchen, pharmacy and university laboratory. Open -ended scenario-based questionnaires were used for surveying university entrants. Analysis was based on students' views on the acceptability of readings deviating from target measurements and on the report format of measurements.

The findings from a constant comparison method analysis show that judgements on the quality of measurements are unrelated to the context of measurement. This indicates that dichotomous reasoning in everyday and scientific domains does not direct students' perceptions. Instead, most students base their judgements, in each context, on the perceived purpose of the measurement. Judgements are related to individuals' consistent epistemological views of the nature of experimentation. Based on these findings, a teaching sequence was suggested for developing students, i.e. understanding of measurement in a set paradigm concept instead of a point paradigm concept.

Pillay (2006) carried out a study on the evaluation of a research-based curriculum for teaching measurement in the first year physics laboratory. The sample cohort comprises approximately 150 GEPS students. These students are primarily from educationally disadvantaged backgrounds. Students' responses to diagnostic probes administered before and after participation in the course, are analysed in terms of the point and set paradigm concept framework. The findings indicate a significant shift in students' understanding of measurement and uncertainty, across all aspects of measurement, to the set paradigm concept perspective. Only 2 of the 76 students surveyed (3%) are consistently identified as point-reasoners before and after the laboratory course, and 16% of students initially classified as point-thinkers shifted to set-based reasoning in their post-instruction responses. A quarter of the sample cohort (25%) went from using mixed paradigms (22%) and unclassifiable paradigms (3%), prior to instruction, to the set paradigm concept after instruction.

Kung and Linder (2006) used an open-ended survey to investigate students' ideas about data processing and data comparison before and after laboratory course during their study of University students' ideas about data processing and data comparison in a physics laboratory course. This study focuses on how students use the ideas of measurement and uncertainty to process and compare experimental data, showing that these ideas are not necessarily understood as they should be even by university science students in their second year. For example, 11 out of 41 students failed to apply the basic idea that uncertainty must be used to compare the results of two sets of data, even after a specially-designed laboratory course. It appears difficult to adequately promote an appropriate understanding of measurement even through a specially-designed laboratory course has been constructed. This contradicts a frequently-heard opinion that one laboratory exercise is sufficient to teach uncertainty effectively. This suggests that these ideas must be continuously revisited and explored as a fundamental part of all undergraduate laboratory experiences.

METHODOLOGY

Research Design

The design of this study was a mixed method research design. It is a combination of qualitative and quantitative techniques (Ary, Jacobs & Razavieh, 2002; Ray, 2003). The quantitative technique was used to test the research questions of the study on SHS3 physics students' understanding of data comparison, of length and time.

Cross-sectional survey (Ary, Jacobs & Razavieh, 2002; Ray, 2003) was used in this study with SHS3 physics students. The SHS3 physics students were randomly selected from category A, category B, category C, and category D (Ghana Education Service, 2009) schools in Volta region. The close and opened ended questionnaire items was adapted from Allie, Buffler, Campbell and Lubben, (2003) and used to gather data from SHS3 physics students on their understanding of measurement of length and time.

All the intact class of SHS3 physics students in each of the categories of schools were involved in the study. The close and opened ended questionnaire items were based on SHS3 physics students understanding of measurement of length and time i.e. data collection of length and time; data processing of length and time; data comparison of length and time; and measurement uncertainty of length and time

The use of the adapted close and opened ended questionnaire items (Allie, Buffler, Campbell & Lubben, 2003) from Department of Physics of the University of Cape Town, South Africa and University of York, UK was appropriate in this study because it helped the researcher in his work.

In addition to the close and opened ended questionnaire items of the cross sectional survey design, structured interview of the SHS3 physics students was also conducted to elicit further information from physics students which might not have appeared on the questionnaire items and to also validate the written responses of the students on the questionnaire items.

Population

The population of the study was 642 SHS3 science students in Volta region. These SHS3 science students were selected from eleven (11) SHS and one (1) SHTS in Volta region (Ghana Education Service, 2009). The twelve SHS and SHTS were categories into category A, category B, category C and category D (Ghana Education Service, 2009).

Sample and Sampling Procedure

The sample for the study was 422 SHS3 and SHTS3 science students. This sample size of science students were simple randomly selected from the population. Within this 422 science students, 20 students were again sampled purposively and interviewed. The 20 students were purposively selected based on how they responded to the questionnaire items of the study. The 422 sample size of SHS3 and SHTS3 science students formed 65.73% of the 642 of SHS3 and SHTS3 of science students in the eleven SHS and one SHTS in the region. The 65.73% sample of the population in this study was more than 10% sample of the population as indicated in (Ary, Jacobs & Razavieh, 2002; Ray, 2003); they argued that for a descriptive research, it is convenient to select 10 to 20 percent of the population. A sample of 65.73% of the population was therefore appreciably adequate for this study.

Simple random sampling method was used to select the sample for the study. This was done in order to get an appreciable representation of students in each category of schools i.e. category A, category B, category C and category D (Ghana Education Service, 2009). A total of four hundred and twenty two (422) SHS3 and SHTS3 physics students were sampled for the study. These total numbers of four hundred and twenty two (422) SHS3 and SHTS3 physics students were made up as follows;

The first SHS was a category A school. It had Forty nine (49) students present in class at the time of administration of the test.

The second SHS was a category A school. It had Forty nine (49) students present in class at the time of administration of the test.

The third SHS was a category B school. It had forty six (46) students present in class at the time of administration of the test.

The four SHS was also a category B school. It had thirty seven (37) students present in class at the time of administration of the test.

The five SHS was also a category B school. It had thirty nine (39) students present in class at the time of administration of the test.

The sixth SHS was a category C school. It had thirty eight (38) students present in class at the time of administration of the test.

The seventh SHS was a category D school. It had forty (40) students present in class at the time of administration of the test.

The eighth SHS was also a category C school. It had twenty three (23) students present in class at the time of administration of the test.

The ninth SHS was also a category A school. It had thirty six (39) students present in class at the time of administration of the test.

The tenth SHS was also a category D school. It had thirty eight (38) students present in class at the time of administration of the test.

The eleventh SHS was also a category D school. It had thirty seven (37) students present in class at the time of administration of the test.

The twelfth SHS was also a category C school. It had twenty six (23) students present in class at the time of administration of the test.

Eleven SHS and one SHTS offering physics in the various categories of schools by the Ghana Education standard were randomly selected from the thirty 32 SHS and SHTS (Ghana Education Service, 2009). All the twelve SHS and SHTS were selected from the categories based on classification of Ghana Education Service, which is Category A, Category B, Category C and Category D (Ghana Education Service, 2009). The selections of the eleven SHS and one SHTS were done by using Microsoft Excel software. A list of names of category A, category B, category C, and category D were obtained (Ghana Education Service, 2009). These names of schools in their categories were imputed into Microsoft Excel software. All the schools in the categories were highlighted, and then sort ascending in the tool bar of Microsoft Excel software clicked. This was done to arrange the schools in each category in alphabetical order. Rand also in the tool bar of the auto sum of Microsoft Excel software was clicked to assign random numbers to each of the schools in each category. Since this study looks at physics students understanding of measurement of length and time, but not physics students' performance in senior high schools, the use of the classification of Ghana Education Service is appropriate for this study. The reason being that the classification (Ghana Education Service, 2009) was based on the availability of facilities (i.e. boarding or day, and classrooms among other facilities) in the senior high schools of Ghana, but not on performance of students and students' entry behaviours.

With this 65.73%, three SHS or SHTS were selected from the category A schools, three SHS or SHTS from the category B schools, three SHS or SHTS from the category C schools and three SHS or SHTS from the category D schools. The reason for these 65.73% selection of physics students from each category of schools was based on the assumption that the sample size of a population should not be less than 10% (Ary, Jacobs & Razavieh, 2002; Ray, 2003). Thus selecting 65.73% sample size from each category would give a fare representation of SHS3 or SHTS3 of physics students to be included in the study. Each selected school was identified by a confidential code alphabet. Also each student in the selected school was identified by their names thereafter and throughout the study. Students' names were used in the study in order to identify them for interviewing. Table 4, shows the coding of both senior high schools with the size of the participated SHS3 and SHTS3 physics students in each of the school.

Table 4: Alphabet Codes of Senior High Schools and Number of participated SHS3 Physics Students

Category A

School code	Students codes	Number of participated SHS3 physics students
A_1	$A_{1\,(1)}$-$A_{1\,(50)}$	49
A_2	$A_{2\,(1)}$-$A_{2\,(50)}$	49
Total		**98**

Category B

School code	Students codes	Number of participated SHS3 physics students
B_1	$B_{1\,(1)}$-$B_{1\,(50)}$	46
B_2	$B_{2\,(1)}$-$B_{2\,(50)}$	37
B_3	$B_{3\,(1)}$-$B_{3\,(50)}$	39
Total		**122**

Category C

School code	Students codes	Number of participated SHS3 physics students
C_1	$C_{1\,(1)}$-$C_{1\,(50)}$	38
C_2	$C_{2\,(1)}$-$C_{2\,(50)}$	23
C_3	$C_{3\,(1)}$-$C_{3\,(50)}$	26
Total		**87**

Category D

School code	Students codes	Number of participated SHS3 physics students
D_1	$D_{1\,(1)}$-$D_{1\,(50)}$	40
D_2	$D_{2\,(1)}$-$D_{2\,(50)}$	38
D_3	$D_{3\,(1)}$-$D_{3\,(50)}$	37
Total		**115**

Instruments

The research instrument (close and opened ended questionnaire) was adapted from (Allie & Buffler, Campbell & Lubben, 2003) for the study. This was accompanied with a structured interview for respondents to give opinions on each item in the close and opened ended questionnaire items. The close and opened ended questionnaire items was adapted (Allie, Buffler, Campbell & Lubben, 2003) for this study because it was the most appropriate instrument in view of the purpose of the study considering the financial and time constraint of the study.

The close and opened ended questionnaire items were of four dimensions. Dimension one dealt with SHS3 physics students understanding of data collection of length and time. It was comprised of three close ended or multiple-choice items and its corresponding three easy or opened ended items (Repeating Time, Repeating Distance, and Repeating Distance Again). Dimension two dealt with SHS3 physics students understanding of data processing of length and time. It was comprised of three close ended or multiple-choice items and its corresponding three easy or opened ended items (Using Repeat, Anomaly in data set and Straight Line Graph). Dimension three dealt with SHS3 physics students understanding of data comparison of length and time. It was comprised of four close ended or multiple-choice items and its corresponding four easy or opened ended items (Same Mean but Different Spread, Different Mean but Similar Spread, Different Mean but Overlapping Spread, and Different Mean but Same Uncertainty). Dimension four dealt with SHS3 physics students understanding of measurement uncertainty of length and time. It was comprised of two close ended or multiple-choice items and its corresponding two easy or opened ended items (No Uncertainty-1 and No Uncertainty-2). The corresponding easy or opened ended items of the close ended or multiple-choice items was for the SHS3 physics students to illuminate their reasoning of each of the option selected in the close ended or multiple-choice items. Each of the items in the questionnaire under the four dimensions was targeted at a particular aspect of measurement and seeks to determine students' decision and at the same time illuminated students reasoning.

The four dimensions have been put into twelve questionnaire items. All the items under the dimensions in the questionnaire had the same form. A brief stem of text posited a situation where decisions had to be made concerning the experimental procedure (Appendix A). A number of options were presented in each item of the questionnaire by cartoon characters, purposely included to avoid gender and race bias in influencing the respondent's choices. The questionnaire items called for an explanation of each choice made by the physics students in each item.

The questionnaire item was in two parts i.e. part one and two. Part one consisted of five items. These four items elicited information on physics students' background, which were students surname, students' first name, location and type of school. This student's background was used to help identify each student for interviewing. Part two consisted of four dimensions, which were students understanding of data collection, data processing, data comparison and measurement uncertainty (Appendix A).

The close and opened ended questionnaire item was of duration of sixty five minutes. Five minutes was allowed for the students to read through the given questionnaire items and for any further questions and further clarification before the commencement of the questionnaire items. Sixty minutes for the actual answering of the given close and opened ended questionnaire items by the students. The sixty minute time was allowed in order that the students would have ample time to respond to the close and opened ended questionnaire items, since the questionnaire items was not a speed test but rather an understanding of measurement of distance and time, thus the questionnaire items requires much time for the students to respond since it involves much reasoning and thinking by the students.

The Interview Guide

A variety of interview methods exist (Ary, Jacobs & Razavieh, 2002; Ray, 2003), they are standardized (structured), semi-standardized (semi-structured), and un-standardized (unstructured). The decision to use the structured interview as a follow up data gathering method to the questionnaire item was influenced by (Ary, Jacobs & Razavieh, 2002; Ray, 2003). They maintained that structured interview allows respondents to freely speak for themselves in order to provide their perspective in words and other actions, and that it usually involves personal visit to respondents at home, at school and at work.

In this study, the interview guide schedule was made up of four items (i.e. SMDS, DMSS, DMOS, and DMSU) see Appendix B. The twelve interview schedule items were comprised of five questions each. Two questions went for students who had the questionnaire items wrong, and three questions went for students who had the questionnaire items right. Even though structured interview usually involves much cost on the part of the researcher such as it took a great deal in meeting the students, interviewer bias which is due to the interviewer own feelings, attitudes, gender, race age and among others which might influence the way and manner the questions were asked, and social desirability which occurs when respondents want to please the interviewer by giving acceptable responses that might not have necessarily be given on the questionnaire items and also time consuming when it comes to the transcribing of the interview responses (Ary, Jacobs & Razavieh, 2002; Ray, 2003). However, its use in this study allowed the researcher enough flexibility in re-wording questions that would fit into the interview, it was more conversational, and it made the interviewee saw, and felt the need to be interviewed on items in the questionnaire (Ary, Jacobs & Razavieh, 2002; Ray, 2003). Also it enabled the researcher find the target sample to be interviewed and most importantly it served as a backup instrument to the close and opened ended questionnaire items. This back up instrument enabled the researcher to cross examine the physics students who had earlier responded to the close and opened ended questionnaire items (Ary, Jacobs & Razavieh, 2002; Ray, 2003). The cross examination enable the researcher to verify whether the students responses to items in the close and opened ended questionnaire were really what they meant or otherwise or whether the written responses of the physics students were interpreted in line with the ideas the physics students wanted to communicate (Ary, Jacobs & Razavieh, 2002; Ray, 2003).

The responses from the students involved in the interview were hand written by the researcher. Audio taping might have been better but because audio taping of responses from respondents may possibly make the students nervous, less apt to listen and less apt to respond freely because students responses would be recorded (Ary, Jacobs & Razavieh, 2002; Ray, 2003) it was better for the researcher to write their responses down with the use of pen and paper. The structured questions were focused on SHS3 physics students understanding of data comparison of length and time in category A, category B, category C, category D schools in Volta region.

Validity and Reliability of the Instrument

The instrument of the study had already been validated with 230 South African freshmen undergraduate students (Allie & Buffler, Campbell & Lubben, 2003). Allie et al, (2003) developed a range of items on a questionnaire for use in their investigation. Each of the items in the questionnaire was targeted at a particular aspect of measurement and sought to determine students' decision and at the same time illuminated students reasoning. This questionnaire was validated by giving it to other research members to independently look at. This was done in order to identify different categories of reasoning. They further went ahead to interview thirty (30) volunteered students for about thirty (30) minutes. The interview allowed (Allie et al, 2003) to further validate the close and opened ended questionnaire items by checking on students understanding of the questionnaire items and the interviewers' interpretation of their responses.

However, since the same instrument was used in this study with Ghanaian SHS3 physics students, face and content validity were again assessed by given the questionnaire item to three SHS physics teachers from the pre testing school (University Practice Senior High School) in Cape Coast, and two colleagues who majored in physics. They were given the close and opened ended questionnaire items and were asked to assess the quality of each item of the questionnaire. This was done in the context of ambiguity of item, clarity of item and generality of item. The three physics teachers and the two colleagues of physics worked independently on evaluation of the close and opened ended questionnaire items. They independently approved on the questionnaire items adapted from Allie et al, (2003). This meant that all the items of the questionnaire were clear, not ambiguous and every SHS3 physics students in Ghana can respond to it. However, the reliability of the research instrument was ignored, since the internal consistence value (i.e. Crombach alpha) was too small i.e. 2.6, so the researcher rather concentrated on triangulation of research instrument i.e. validity of the research instrument, since validity is the most important aspect of testing a research instrument (Ary, Jacobs, & Razavieh, 2002).

The validity of the instrument was improved by conducting a pretest using an intact class of SHS3 physics student of in University Practice Senior High school (UPSS) in the Cape Coast municipality. The questionnaire item was distributed personally by the researcher to the SH3 physics students in their science classroom. The SHS3 physics students responded to the questionnaire items in the presence of the researcher. The questionnaire items were collected after completion, personally by the researcher and then analyzed. The intact class was made up of forty six (44) SHS3 physics students. The mean of the intact class was 32.00; the standard deviation was 24.83; and variance 616.56. The pre-tested school was randomly selected from six (6) schools. The pretest was done so that the ambiguous items in the questionnaire could be removed or reworded so that they would have the same meaning for the respondents. The validity of the instrument was further enhanced by conducting personal interview with twenty SHS3 physics students purposively selected by the researcher. The twenty physics students were purposively selected because of the way they responded to the questionnaire items. The twenty physics students that were involved in the interview were spread into the four categories of schools i.e. category A, category B, category C and category D. This means that five physics students were interview from each of the categories of schools.

Data Collection Procedure

Before the research data were collected from SHS3 physics students, an introduction letter was first taken from the head, Department of Science and Mathematics Education of University of Cape Coast and sent to the selected categories of schools. Initial visits were made to the selected categories of schools in order to meet the heads, deliver the research visit introductory letter from the Department of Science Education and to familiarize with the SHS3 physics students and the subject tutors. The meeting of the heads of schools, teachers and students enabled the researcher an opportunity to explain the objectives of the study and to seek their consent to conduct the research in their schools. It also helped the researcher the opportunity to agree on the day(s) and time for the administration of the research instruments. It also gave the schools and SHS physics students the opportunity to decide on when to respond to the closed and opened ended questionnaire items; whether to respond to the questionnaire items before the normal hours, during the school hours or after the school hours.

On the actual day for the data collection in the schools, the researcher re-explained the rationale of the study to the SHS physics students and assured them of confidentiality of their responses. The researcher with the help of the subject tutors administered the closed and opened ended questionnaire to the SHS3 physics students on the same day. An intact class of SHS3 physics students was used throughout in each of the selected schools. Each of the closed and opened ended questionnaire lasted for sixty minutes. The instrument did not require the use of gender (Allie et al, 2003). It took the researcher duration of two weeks to move round the twelve (12) selected schools to collect data.

Data Analysis

Research question i.e. what is SHS-3 Physics understanding of data comparison in category A, category B, category C, category D schools in Volta region? Was analyzed using frequency distribution by the use of SPSS 16.0. The criteria that was employed to determine students understanding of data comparison was 50% using frequency distribution by the use of SPSS 16.0. Thus below 50% students understanding was with the point paradigm concept and above 50% students understanding was with the set paradigm concept. Correct option went for 'set paradigm concept'; wrong option went for point 'paradigm concept', unclear students written response went for 'Not Classified' and a mixer of correct option but wrong written response and vice versa went for 'mixed paradigm state' and any other written response which is not either right or wrong went for 'confusion / own paradigm state . Determination of range of values with calculation of mean went for internalized set paradigm concept. Determination of range of values without the calculation of mean went for consistent set paradigm concept.

RESULTS AND DISCUSSION

Students' Understanding of Data Comparison

The research question sought to find out SHS-3 physics students' understanding of data comparison. Students' understanding of data comparison was tested on four items i.e. same mean different spread (SMDS), different mean same spread (DMSS), different mean overlapping spread (DMOS) and different mean same uncertainty (DMSU).

The Same Mean Different Spread (SMDS)

The SMDS item sought to find out from the students whether there was a spread in the individual data recorded even though the two groups had the same mean. The expected response required from students is option (A); our results are better. They are all between 424 mm and 444 mm yours are spread between 410 mm and 460 mm.

The reason is that though the two groups had the same mean, the individual results of group B are much wider from each other to that of group A. Thus group A results could be said to be within the same range, than that of group B.

The percentage number of students that selected option (A) was 63.2%. This selected option (Table 17) is in line with the set paradigm concept; hence the students seemed to understand same mean but different spread.

Table 17: Students' selected options on SMDS (N=422)

Items	Paradigm Type	Frequency	Percentage
Same Mean Different Spreads (SMDS)	Point Paradigm concept	155	36.8%
	Set Paradigm concept	267	63.2%

Students' written responses were coded 'Not Classified' meaning students' responses were not clear to the researcher; and 'No Explanation' meaning students were not able to give any response or explanation to their selected options.

Students were expected to respond to the option (A) on same mean different spread. The responses of the students to option (A) would show whether their reasoning is in line with the reasoning of the set paradigm concept on same mean different spread. Thus by the set paradigm concept, the reason for comparing means of different data is to see whether the range difference between average value and the individual values are wide or close and the same applies to the range difference between the individual values in a data set.

The number of students that could be said to have internalised the set paradigm concept was 1.3%. However, 83.5% of the students (Table 18) were consistently with the set paradigm concept. Also 4.5% of students were observed to be confused (i.e. not classified) and 8.9% of students were not able to explain the option they selected. However, the findings of this study on same mean but different spread does not agree with Allie, Buffler, Campbell and Lubben, (2003) in the sense that most of the students as at the time were classified as subscribing to the point paradigm concept prior to instruction.

Table 18: Students' written response on Same Mean Different Spread (SMDS) item (N = 224)

SMDS (B) written Response	Frequency	Percent
No Explanation	20	8.9
Not classified	10	4.5
Because the average of group A and group B are the same. This implies that using average to answer practical question is better than using only one outcome. Hence both group values are correct	187	83.5
Because the distance obtained depends on how each group released the ball	1	.4
Because group A and group B had the same average but just that both group individual measurements are different.	3	1.3

The Different Mean Same Spread (DMSS)

The DMSS item sought to find out from the students whether the spread in the individual data of the two groups are the same even though the groups have different mean. The expected response required from students is option (B); No, your results do not agree with ours.

The reason is that the range difference in group A results is 18 i.e. (444-422) mm while that of group B is 16 i.e. (444-426). However, the difference between the two spread results is 2 mm i.e. (18-16) mm. this range difference between the two groups is greater than +/- 0.1 mm or +/- 0.5 mm; it implies that the spread between group A and B were not the same (Appendix A).

The percentage number of students that selected option (B) was 58%. This selected option (Table 19) is in line with the set paradigm concept; hence the students seemed to understand the spread in the two groups were not the same.

Table 19: Students' selected options on DMSS (N=422)

Items	Paradigm Type	Frequency	Percentage
Different Mean Same Spread (DMSS)	Point Paradigm concept	177	42.0%
	Set Paradigm concept	245	58.0%

Students' written responses were coded 'Not Classified' meaning students' responses were not clear to the researcher; and 'No Explanation' meaning students were not able to give any response or explanation to their selected options.

Students were expected to respond to the option (B) on different mean but same spread. The responses of the students to option (B) would show whether their reasoning is in line with the reasoning of the set paradigm concept on different mean but same mean. Thus by the set paradigm concept, for any two values to be considered almost the same, then the difference between the two values should be within +/- (0.01-0.05) mm.

The responses from students on different mean same spread were expected to be that the two group ranges were not the same, since the difference between the two group ranges was 2 mm which is far wider than the range difference of +/- (0.01-0.05) mm. With this response, the students could be said to have internalise the set paradigm concept. The number of students that could be said to have internalised the set paradigm concept was 52.4%. Also 1.9% of students were observed to be confused (i.e. not classified). However, the findings of this study on different mean but same spread does not agree with Allie, Buffler, Campbell and Lubben, (2003) in the sense that most of the students in their study as at the time were classified as subscribing to the point paradigm concept prior to instruction.

Table 20: Students' written response on Different Mean Same Spread (DMSS) item (N = 224)

DMSS (B) written Response	Frequency	Percent
No Explanation	12	5.0
Not Classified	7	1.9
Because the value of group A is far more consistent and accurate than group B	1	.3
Because there was error in their readings	1	.3
Because the average of group A and group B are the same, since they only differ by 2mm	5	1.4
Because the average of group B is not correct but that of group A is correct	2	.5
Because the average of group A does not agree with that of group B. However, group B's average is the correct answer	1	.3
Because the average of group A and group B are not the same, so the results do not agree with each other	191	52.4
Because group B is correct but group A is not correct	2	.5
Because the average distance of the two groups is not the same. It means therefore that the two groups' ball moved with different velocities and time when released	2	.5

Different Mean Overlapping Spread (DMOS)

The DMOS item sought to find out from the students whether the spread in the individual data of the two groups have overlapped even though the groups have different mean. The expected response required from students is option (B); No, your results do not agree with ours.

The reason is that the individual data set of the two groups did not overlap. This is because there was no intersection of values between the two groups (Appendix A).

The percentage number of students that selected option (B) was 81.0%. This selected option (Table 21) is in line with the set paradigm concept; hence the students seemed to understand different mean but overlapping spread.

Table 21: Students' selected options on DMOS (N=422)

Items	Paradigm Type	Frequency	Percentage
Different Mean Overlapping Spread (DMOS)	Point Paradigm concept	80	19.0%
	Set Paradigm concept	342	81.0%

Students' written responses were coded 'Not Classified' meaning students' responses were not clear to the researcher; and 'No Explanation' meaning students were not able to give any response or explanation to their selected options.

Students were expected to respond to the option (B) on different mean overlapping spread. The responses of the students to option (B) would show whether their reasoning is in line with the reasoning of the set paradigm concept on different mean overlapping spread.

The number of the students that could be said to have internalised the set paradigm concept was 73.6%. However, 17.9% of the students (Table 22) were with the point paradigm concept. Also 4.4% of students were observed to be confused (i.e. not classified). However, the findings of this study on different mean but overlapping spread does not agree with Allie, Buffler, Campbell and Lubben, (2003) in the sense that most of the students in their study as at the time were classified as subscribing to the point paradigm concept prior to instruction.

Table 22: Students' written response on Different Mean Overlapping Spread (DMOS) item (N = 224)

DMOS (B) written Response	Frequency	Percent
No Explanation	41	17.9
Not Classified	16	4.4
Because the difference of the two groups averages is 15, which is too wide making the two averages inconsistent with each other	165	73.6
Because the average of the two groups do not agree since the velocities and distances of the ball is not the same	1	.3
Because there is a wide difference between the average of group A and group B. it implies that the ball was released from different angles	2	.5
Because some of the two groups did not calculate the accuracy of the measured results well, hence the great difference between the two group results	1	.3

Different Mean Same Uncertainty (DMSU)

The DMSU item sought to find out from the students whether the comparison of mean and standard deviation values of the two groups were the same. The expected response required from students is option (B); No, your results do not agree with ours.

The reason is that adding and subtracting 5mm from each group distance will not give the same result. That is for group A, d = 436 mm + 5 mm = 441 mm; d = 436 mm – 5 mm = 431 mm, while that of group B, d = 442 mm + 5 mm = 449 mm; d = 442 mm – 5 mm = 437 mm (Appendix A).

The percentage of students that selected option (C) was 60.7%. This selected option (Table 23) is in line with the set paradigm concept; hence the students seemed to understand different mean same uncertainty.

Table 23: Students' selected options on DMSU (N=422)

Items	Paradigm Type	Frequency	Percentage
Different Mean	Point Paradigm concept	166	39.3%
Same Uncertainty	Set Paradigm concept	256	60.7%

Students' written responses were coded 'Not Classified' meaning students' responses were not clear to the researcher; and 'No Explanation' meaning students were not able to give any response or explanation to their selected options.

Students were expected to respond to the option (B) on different mean same uncertainty. The responses of the students to option (B) would show whether their reasoning is in line with the reasoning of the set paradigm concept on different mean same uncertainty.

The number of students that could be said to have internalised the set paradigm concept was 49.5%. However, 40.6% of the students (Table 24) were not able to explain the option they selected. However, the findings of this study on different mean but same uncertainty does not agree with Allie, Buffler, Campbell and Lubben, (2003) in the sense that most of the students in their study as at the time were classified as subscribing to the point paradigm concept prior to instruction.

Table 24: Students' written response on Different Mean Same Uncertainty (DMSU) item (N = 224)

DMSU (B) written Response	Frequency	Percent
No Explanation	91	40.6
Not Classified	9	4.1
Because the mean and standard deviation of the two groups are not the same, since increasing and reducing the values both groups by 5 does not give the same results	111	49.5
Because the difference between the two groups mean and standard deviation is 6 plus 10, hence 16 is too wide	3	.8
Because the means and standard deviations of the two groups are the same	2	.5
Because the means of the two groups are not the same but their standard deviations are the same	4	1.6
Because the range between the standard deviations of the two groups is great so the two groups' results are affordable	1	.3

Five physics students were interviewed on data comparison items i.e. same mean different spread (SMDS), different mean same spread (DMSS), different mean overlapping spread (DMOS) and different mean same uncertainty (DMSU). These five physics students were conveniently selected based on the way they responded to the SMDS, DMSS, DMOS and DMSU items. This was done in order to validate the written responses of students.

The following interview questions went to the physics students who had the item correct.

Researcher: "You chose option A under SMDS; why was this option the correct answer?"

Student 1: "You see looking at the individual values of group A and that of group B, even though the two groups have the same average, yet the values of group A is closer than the values of group B. so to me the value of group A is far more consistent and accurate than group B".

Student 2: "This is because the range value of group A is smaller than group B. Thus to me, group A values are closer to each other than group B. this implies that group A mean will give a more accurate representative value of the values of group A than that of group B even though the two groups had the same mean at the end".

Student 3: "This is because group A and group B had the same average but just that both group individual measurements are different"

The three students have internalized the set paradigm concept because they were able to acknowledge the spread in individual data of the two groups and also showed that the two groups spread of data was wide even

though their averages were the same.
Researcher: "Why did you not choose option A under SMDS item?"
Student 1: "I think option B is still the correct answer. This is because the average of group A and group B are the same. This means that the measurement of the two groups did not spread but rather are in the same range".
Student 2: "Because the average of group A and group B are the same. This implies that using average to answer practical question is better than using only one outcome. Hence both group values are correct"

These two students' responses are consistently with the set paradigm concept. This is because they only looked at the average results of the two groups but were not able to critically look at the spread in the individual results of the two groups. However, comparing these students selected option to their oral responses; they could be in a mixed paradigm state.

The following interview questions went to the physics students who had the item correct.
Researcher: "You choose option B under DMSS; why was this option the correct answer?"
Student 1: "I chose option B because looking at the result presented, the average of group A and group B are not the same. However, for these two group averages to be the same, then their individual results must be of a difference of +/- 0.1mm".
Student 2: "Well, group A has an average of 433 mm and group B 435 mm. Now considering the mean error which is within +/- 0.1 mm and +/- 0.5 mm, then it is clear that the average value of group B is different from group A by 2, and this difference of 2 is far more bigger than +/- 0.1 mm and +/- 0.5 mm; hence the two group average are not the same".
Student 3: "This is because both groups will obtain different but close values when they should add or subtract 5"

The first two students' responses were with the set paradigm concept. Hence these students have internalized the set paradigm concept. However, student 3 was confused, because there was no +/- 5 mm on the DMSS item.
Researcher: "Why did you not choose option B under DMSS item?"
Student 1: "Because the average of group B is not correct but that of group A is correct"
Student 2: "The average of group A does not agree with group B. Yet, group B's average is the correct answer"

These two students were confused. This is because there was nothing to show whether group A average results was the most correct or that of group B average result.

The following interview questions went to the physics students who had the item correct.
Researcher: "You choose option B under DMOS; why was this option the correct answer?"
Student 1: "The difference between the two group averages is 15; this 15 difference is too wide and it has made the two group averages inconsistent with each other".
Student 2: "The two group averages do not agree with each other, since the interval between the two groups averages is very wide. So even if there is a range, one of the groups may lie outside the range".
Student 3: "The vast difference between the two average results leaves a whole lot of uncertainty. This is because the 458 mm and 462 mm in group B are more than the rest of the values. This has made the average of group B far larger than that of group A".

The responses of these three students clearly showed that they have internalized the set paradigm concept.
Researcher: "Why did you not choose option B under DMOS item?"
Student 1: "My understanding is that one of the two groups may be was not able to record exactly some of the results well or was not able to read the results carefully from the measuring instrument, hence the great difference between the two group results. Based on this response, student 1 could be said to have internalized the set paradigm concept. However, comparing his oral response to the selected option, he could be said to be in a mixed paradigm state".
Student 2: "This is because external forces acted on the rolling ball".

The following interview questions went to the physics students who had the item correct.
Researcher: "You chose option B under DMSU; why was this option the correct answer?"
Student 1: The mean and standard deviation of the two groups are not the same, since increasing and reducing the average values by 5 does not give the same results.
Student 2: "This is because the two groups' averages do not agree since there is a wide difference of 5 in their standard deviations".
Student 3: was not able to give any response.

The first two students have internalized the set paradigm concept. However, student 3 might have gotten the answer by guessing.

Researcher: "Why did you not choose option B under DMSU item?"

Student 1: "This is because the means and standard deviations of the two groups are the same".

Student 2: "To me, I think the difference between the two groups mean and standard deviation is 6 plus 10, hence 16 is too wide".

These students were completely confused. This is because for student 1, there was no way where the mean and standard deviation of the two groups were the same and also for student 2 the two groups mean and standard deviation was not 6 plus 10.

Key findings

With students understanding on data comparison, all the four items on data comparison of students (i.e. SMDS, DMSS, DMOS and DMSU) were in line with the set paradigm concept of measurement. Furthermore, with the DMOS item, 73.6% of students internalised the set paradigm concept. Finally, with the DMSU item, 40.6% of the students were not able to explain the option they selected.

Recommendation

Based on the findings of this study it is recommended that physics teachers should make effort to make scientific measurement by the set paradigm concept relevant to all senior high school science students in Volta Region of Ghana.

Suggestions for Future Research

The use of the set paradigm concept in teaching and learning of scientific measurement has been approved to be an effective tool in Ghana and advanced countries such as USA, Australia, Netherland and South Africa. The current study was carried out with 364 sample size of SHS3 physics students.

It is suggested that this research can be carried out in other subject areas such as Chemistry, Mathematics and Biology in a wider perspective.

It is also suggested that this study should be given a nationwide dimension; this will enable policy makers to observe the true picture of science students towards their understanding of scientific measurement in order to obtain and employ professional physics science teachers at the Senior High Schools.

It is also suggested that any other study on students understanding of scientific measurement should rather be conducted on physics teachers' since some physics teachers could hold onto the point paradigm concept of scientific measurement.

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Appendix A
Instrument-1 of the study
A 4 Item Questionnaire on Students' Understanding of Data Comparison
Senior High Schools Physics Students' Understanding of Measurement
SHS Students' form
Part 1: Background Questionnaire
Surname: ……………………………………………………………………
First name: …………………………………………………………………….
School ……………………………………………………………………….
Location of School / District: ………………………………………………
Type of School [SHS] [SHTS] [BUSINESS] [VOCATIONAL]

Part 2: Laboratory Procedures Questionnaire
Instructions

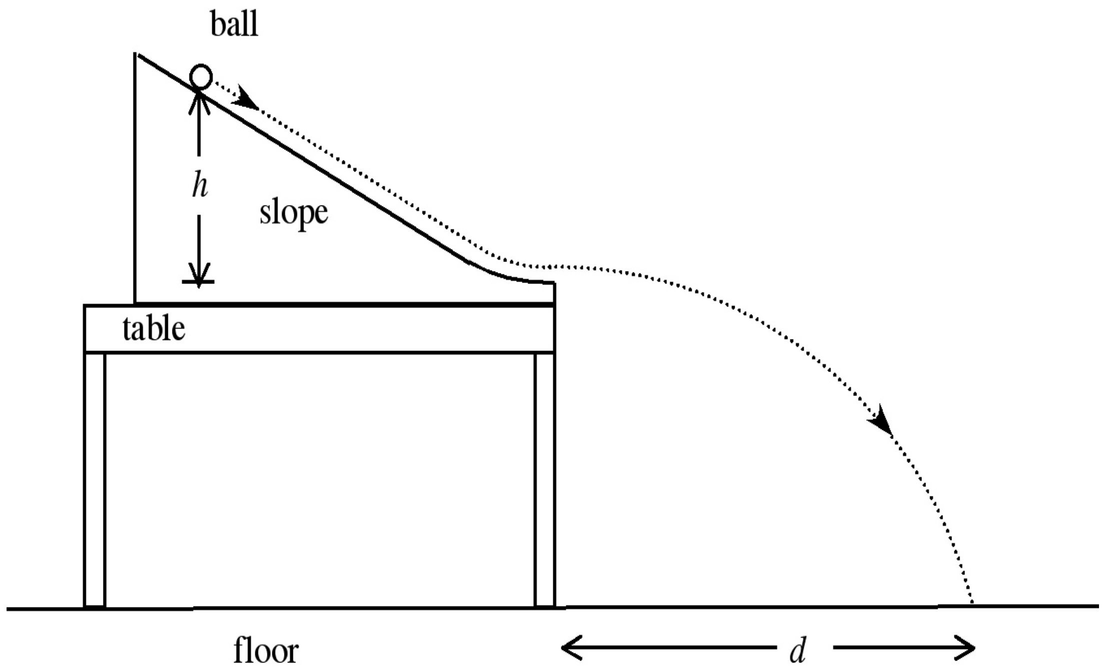
Write your name in the box above.
Inside this envelope there are pages numbered up to page 17.
Read the text below and answer the questions on each sheet.
If you need more space for your answers, then use the backs of the sheets.
It should take you about 5 minutes to answer each question.

Answer the questions in order and do not skip any sheet.
When you have completed a question, put the sheet inside this envelope and do not take it out again, even if you want to change your answer.

Note: It is possible that some answers may be similar or exactly the same as others. Please write all answers out in full, even if you feel that you are repeating yourself.

Experimental Context
An experiment is being performed by students in the Physics Laboratory.
A wooden slope is clamped near the edge of a table. A ball is released from a height h above the table as shown in the diagram. The ball leaves the slope horizontally and lands on the floor a distance d from the edge of the table. Special paper is placed on the floor on which the ball makes a small mark when it lands.

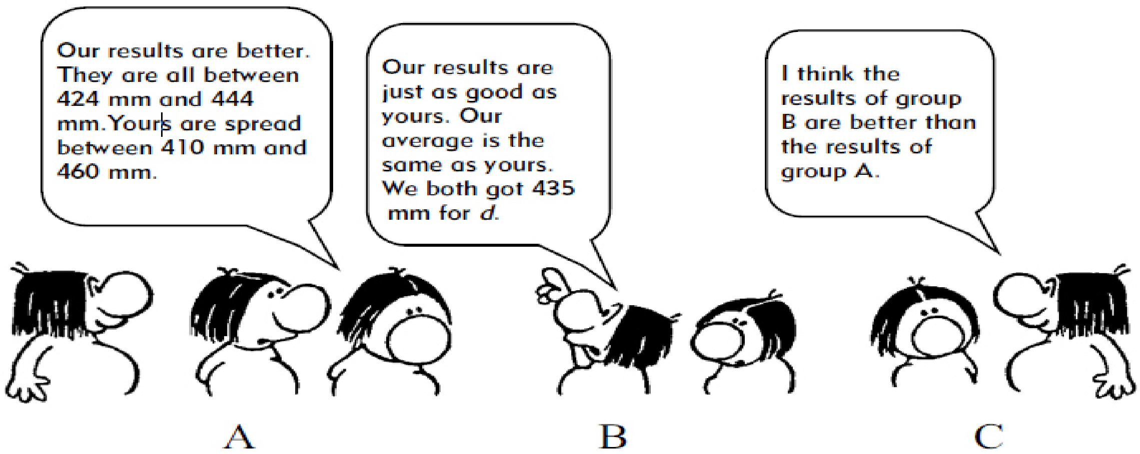
The students have been asked to investigate how the distance d on the floor changes when the height h is varied. A meter stick is used to measure d and h.



SMDS

Two groups of students compare their results for d obtained by releasing the ball at h = 400 mm. Their results for five releases are shown below.

Release	Group A d (mm)	Group B d (mm)
1	444	441
2	432	460
3	424	410
4	440	424
5	435	440
Average	435	435



With which group do you most closely agree? (Circle ONE): | A | B | C |

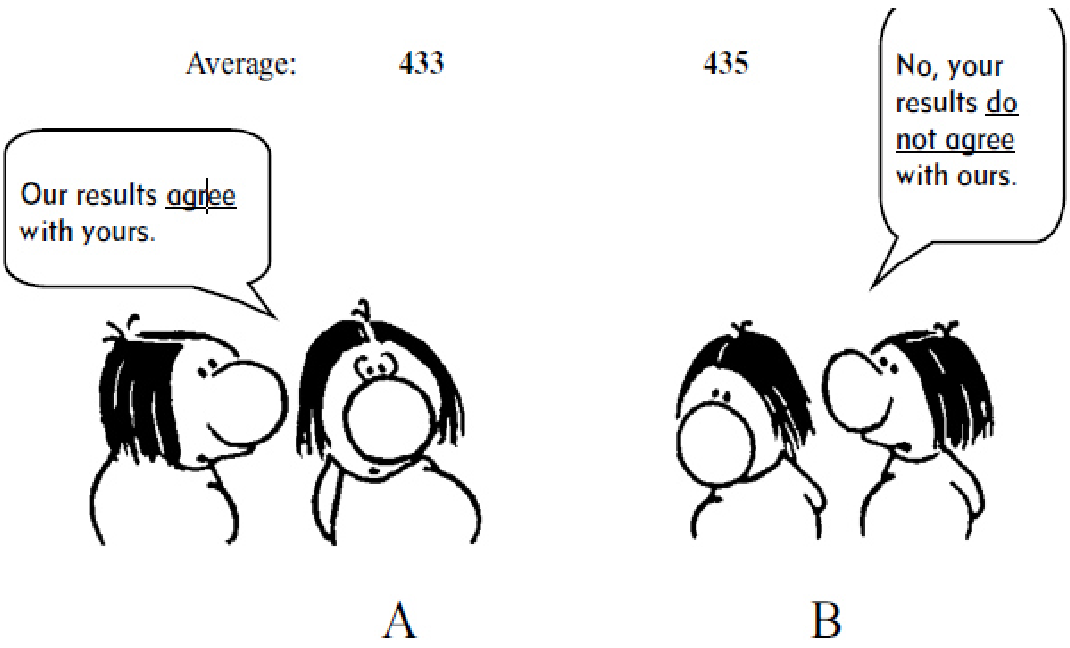
Explain your choice. Do not use the word “results” in your explanation.

……
……
………………………

DMSS

Two other groups of students compare their results for d obtained by releasing the ball at h = 400 mm. Their results for five releases are shown below.

Release	Group A d (mm)	Group B d (mm)
1	440	432
2	438	444
3	433	426
4	422	433
5	432	440
Average	433	435



With which group do you most closely agree? (Circle ONE): A B

Explain your choice. Do not use the word "results" in your explanation.

DMOS

Two groups of students compare their results for d obtained by releasing the ball at h = 400 mm. Their results for five releases are shown below.

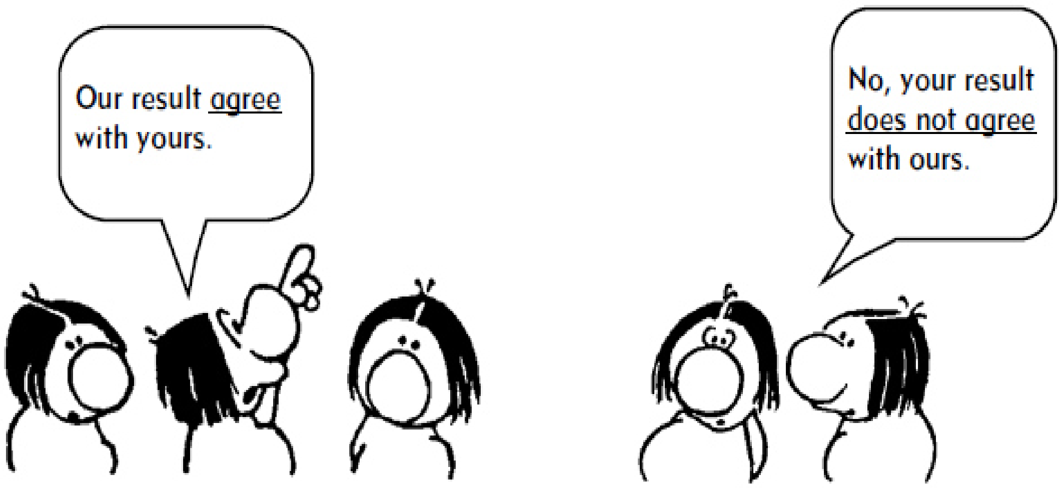
Release	Group A d (mm)	Group B d (mm)
1	444	458
2	435	438
3	424	462
4	440	449
5	432	443
Average	435	450

A B

With which group do you most closely agree? (Circle ONE): | A | B |

Explain your choice. Do not use the word "results" in your explanation.

DMSU
Two other groups of students compare their results for d obtained by releasing the ball at h = 400 mm. Their means and standard deviation of the means for their releases are shown below.
Group A: d = 436 ± 5 mm
Group B: d = 442 ± 5 mm



A B

With which group do you most closely agree? (Circle ONE): | A | B |

Explain your choice. Do not use the word "result" in your explanation.

Appendix B
Instrument-2 of the study
Interview Guide on Students' Understanding of Data Comparison
NB: before the interview, the SHS3 physics students would be made to respond to closed and open-ended questionnaire items which focus on students' reasons for their choice of responses to the questionnaire items.
SHS3 physics students' understanding of data comparison of **length** and **time**.

The following questions will be asked in respect of student's responses to questions on SMDS, DMSS, DMOS and DMSU.
Question one is for students who got the item correct
You chose this response under SMDS, DMSS, DMOS and DMSU; why was this response the correct answer?
Question two is for students who got the item wrong
Why did you not choose option B under SMDS, DMSS, DMOS and DMSU?

Appendix C
Coding Scheme of Students' Responses
Same Mean Different Spread.
SMDS $_{(A)}$: Our results are better. They are all between 424 mm and 444 mm.
Yours are spread between 410 mm and 460 mm.
Not classified.
No explanation given.
Because the average of group A and group B are the same. This implies that using average to answer practical question is better than using only one outcome. Hence both group values are correct.
Because the distance obtained depends on how each group released the ball.
Because group A and group B had the same average but just that both group individual measurements are different.
Because the average of group A and group B are the same. This means that the measurement of the two groups did not spread but rather are in the same range.
Different Mean Similar Spread
DMSS $_{(B)}$: No your results do not agree with ours.
Not classified.
No explanation given.
Because the average of group A and group B are the same, since they only differ by 2mm.
Because the average of group B is not correct but that of group A is correct.
Because the average of group A does not agree with that of group B. However, group B's average is the correct answer.
Because the average of group A and group B are not the same, so the results do not agree with each other.
Because group B is correct but group A is not correct.
Because there was error in their readings.
Because the value of group A is far more consistent and accurate than group B.
Because the average distance of the two groups is not the same. It means therefore that the two groups' ball moved with different velocities and time when released.
Different Mean Overlapping Spread
DMOS $_{(B)}$: No your results do not agree with ours.
Not classified.
No explanation given.
Because some of the two groups did not calculate the accuracy of the measured results well, hence the great difference between the two group results.
Because the difference of the two groups averages is 15, which is too wide making the two averages inconsistent with each other.
Because the average of the two groups do not agree since the velocities and distances of the ball is not the same.
Because there is a wide difference between the average of group A and group B. it implies that the ball was released from different angles.
Different Mean Same Uncertainty
DMSU $_{(B)}$: No your results do not agree with ours
Not classified.
No explanation given.
Because the mean and standard deviation of the two groups are not the same, since increasing and reducing the values both groups by 5 does not give the same results.
Because the difference between the two groups mean and standard deviation is 6 plus 10, hence 16 is too wide.
Because the means of the two groups are not the same but their standard deviations are the same.
Because the range between the standard deviations of the two groups is great so the two groups' results are affordable.
Because the means and standard deviations of the two groups are the same.

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