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REMEDIATING SOME LEARNING DIFFICULTIES OF L200 SCIENCE EDUCATION STUDENTS OF MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY IN SOME PHYSICS CONCEPTS USING MULTIPLE REPRESENTATIONS

Kodjo Donkor Taale[1]

[1]*Department of Science Education, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria*

ABSTRACT

Academic performance and achievement of students is highly dependent on the approach of presenting information and how it is received. This study was an action research using the problem-solving strategy to find out the effect of multiple representations-based instruction on students' performance in some physics concepts. This was done by collecting both qualitative and quantitative data with two instruments, pre-test, to assess students' prior knowledge and post-test to determine the final state of the learners. A sample of 40 L200 Geography Education students of the Department of Science Education, Modibbo Adama University of Technology took part in the study. Descriptive statistics were used to analyze the data collected. The results obtained showed an improvement in students' achievement on basic concepts in optics, heat and mechanics. Students performed relatively better in optics (80% of the students) scoring 45% and above of the marks; followed by thermal physics (heat) (70%) and mechanics (50%). Also, effect size of 0.41calculated to see effectiveness of the treatment confirmed the improvement in the students' performance. This study suggests that it is possible to use multiple representations in physics instruction to motivate and sustain students' interest in the subject, especially those with limited physics' knowledge to apply the laws and formulae learnt to calculate and solve problems correctly.

Keywords: Learning difficulties, Multiple representations-based instruction, Physics concepts, Action research, Problem-solving strategy, Intrinsic purpose of learning.

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1. INTRODUCTION

For a country to develop it needs to strengthen its Education and the teacher is the ultimate definer of its reality. Therefore the quality of teacher education is very important if education is to enhance the country's development. (Shulman, 1987) states that teachers need to see how ideas

† Corresponding author

connect across fields and to everyday life. It is this kind of connection that will provide a foundation for pedagogical content knowledge so that teachers can make their ideas accessible to others.

To teach is to first understand purposes, subject matter structures, and ideas within and outside the discipline and teachers need to understand what they teach and, when possible, to understand it in several ways (Shulman, 1992). Hence teacher trainees must not only have adequate knowledge in the content but also methods to transmit that content for learners to understand. According to Williams (2009), teachers' knowing their subject matter is one thing, while knowing how to engage their students and transmit that knowledge is another. Especially important is content knowledge that deals with the teaching process, including the most useful forms of representing and communicating content and how best students learn the specific concepts and topics of a subject. The instructional strategies necessary for teaching Physics must have primary characteristics of giving students the freedom to build their own understanding of the concepts by actively using their imagination, their communication and thinking skills, as it has been suggested by the constructivist learning model (Llewellyn, 2004). Besides, a good problem-solving skill is the basis of learning Physics as a subject and it starts with a firm grasping of concepts. Research studies by Ainsworth (2008) and others have revealed some positive effects in the use of multiple representations (MRs) on students' performance in the teaching and learning process in Physics. This is as a result of the combination of several tools in one lesson delivery session to cater for all individual differences and also appeal to learners' imagination. Furthermore, the quality of education provided to students is highly dependent on what teachers do in the classroom.

Effective teaching involves innovative strategies based on the curriculum content, the learning needs of the students and desirable outcomes (Salim, 2006). Consequential to pre-service students' understanding of abstract scientific concepts, the functions addressed by multiple representations (MRs) are applicable. Primarily, MRs tools and activities help students bring abstract concepts into a concrete context through the use of imagination to explore and to construct an understanding of abstract ideas (McCaslin, 1996). Effective learning then occurs when students construct their understanding by active learning and by building on their prior knowledge (Yager, 1993). In addition, MRs can be useful tools for all stages of the learning cycle, providing the physics teacher an authentic assessment measure, as well as an excellent tool for engaging, explaining, exploring, elaborating and evaluating (Llewellyn, 2004). Teaching physics to all kinds of students (science and liberal arts students) can be interesting, inspirational and frustrating; frustration in the sense that there are students who seem not to know what physics is all or about or simply do not make sense of what physics is. The problem is how to reduce this frustration and find ways to reach most of the students by creating more effective learning environments in which they can learn and understand physics and science in general.

The emphasis in this study is to instill in students the importance of the *intrinsic purpose of learning* – that is shifting from extrinsic motives for learning such as getting better examination grades and marks to intrinsic motives such as belief in learning for its own sake and mastery of physics as a subject. While some research is of the view that learning for its own sake is related to better use of learning strategies and to higher achievement, Fairbrother (2000) advocates that "moving motivation in this direction is particularly difficult". Physics teachers therefore should make the subject as interesting as possible by using a variety of teaching and learning strategies and also ensure that these strategies lead to students' success in understanding physics concepts.

This study focuses on what goes on in the classroom, as far as teaching and learning is concerned and also to explore the instructional applications of MRs in facilitating and optimizing physics/science teaching and learning in Nigerian and African classrooms.

1.1. The Problem

Unlike Ghana, Integrated Science is not a compulsory subject for secondary school students in Nigeria. Research participants –L200 students of the Department of Science Education, Modibbo Adama University of Technology are made up of Physics, Chemistry, Biology, Mathematics, Statistics, and Geography Education students. Some of these students, specifically those in Geography Education have studied very little or no physics in secondary school and yet have to take the course SE 203 Integrated Science II in which they are to learn "Introduction to mechanics, heat, and optics among other topics". The study therefore employed teaching strategies that promote deeper conceptual learning by integrating multiple representations that engage students in scientific practices and facilitate their developmental change, especially in the area of their conceptual understanding of some physics concepts.

1.2. Research Question

The study was guided by the following research question: To what extent does MRs help Level 200 Geography Education students of the Department of Science Education, Modibbo Adama University of Technology, Yola learn physics?

1.3. Multiple Representations, What Are They?

Representations can be categorised into two classes, namely internal and external representations. Internal representations are defined as "individual cognitive configurations inferred from human behaviour describing some aspects for the process of physics and problem solving". On the other hand, external representations can be described as structured physical situation that can be seen as embodying physical ideas (Van Heuvelen and Zou, 2000). According to a constructivist view, internal representations are inside the students' heads, and external representations are situated in the students' environments (Meltzer, 2005). Examples of external representations in physics include words, diagrams, equations, graphs, electrical circuit diagrams, ray diagrams and sketches. Hence, the positive role of multiple representations in student learning has been suggested by many educators. By this definition therefore, almost every learning environment in a school environment offers multiple representations.

Multiple representations can overwhelm learners but this problem can be solved by the use of learning approaches and learning materials such as worked-out examples. Worked-out examples consist of a problem formulation, solution steps, and the final solution itself (Sweller and Cooper, 1985). Research has shown that learning from such examples is of major importance for the initial skill acquisition of cognitive skills and learning in well-structured domains such as mathematics, physics, and programming (VanLehn, 1996; Renkl, 2005). To benefit from the advantages of multiple representations, one challenge is to engage learners in the active knowledge construction necessary for learning (Roy and Chi, 2005) which requires considerable cognitive capacity which many of the L200 students lack. By combining different representations in a lesson, learners will take advantage and make use of the strengths and weaknesses of the various representations. Hence, it is expected that if learners are provided with a rich source of different representations of a domain, they can build references across these representations and enhance their understanding of physics (scientific) concepts.

2. METHODOLOGY

2.1. Research Design

The study used Action research methodology using the problem solving strategy advocated by Hollabaugh (2010), Johnson (2001), Reif and Scott (1999), Heller *et al.* (1992), and Heller and Hollabaugh (1992) to improve the problem solving skills of L200 Science Education students of Modibbo Adama University of Technology, Yola. According to Creswell (2008), the goal of action research is to experiment with making a positive difference in one's professional practice as the research is conducted and that teachers should reflect on what worked well and what did not, what needs adjustment, and what should be discarded altogether. This practice, he thinks, hold good promise for the academic attainment of the students.

2.2. Sample

The sample used for the study was an intact second year science education class taking the course SE 203 –Integrated Science II in the First Semester of the 2011/2012 Academic year. The participants were 139 L200 students of the Department of Science Education, Modibbo Adama University of Technology**.** The class was made up of Physics (17), Chemistry (18), Biology (33), Mathematics (18), Statistics (13), and Geography Education (40) students. However, the accessible population was the 40 L200 Geography education students in the class. This group was chosen because of their limited knowledge in physics.

2.3. Instruments

The instruments used in the study were pre-test and post-test which were teacher constructed. *The pre-test was used to determine or establish students' prior knowledge.* A short pre-test containing five problems examined the topic-specific prior knowledge to determine the initial state of the learners.

Post-test: Assessment of learning outcomes to determine the final state of the learners. The learning outcomes were measured by a post-test that contained 6 problems identical to the pre-test problems.

2.4. Intervention strategy

The following plan of action was employed:

- ❖ Obtaining constant feedback on all activities –assignments, homework and tests.
- ❖ Pairing weak students with high achievers. This was done after scoring the pre-intervention exercise.
- ❖ Providing enrichment activities for students lacking in prior knowledge.

Students were engaged in a comprehensive discussion on the steps involved when solving physics problems using the problem solving strategy during the normal lecture hours, *two hours per week* for four weeks. After each lecture, a handout containing worked examples detailing the steps in solving physics problems was distributed to students. This was done such that students could be familiar with the steps needed for solving problems in physics. The handout also included their assignment for the week which was to be handed in and graded. Test items which were used for the tests were constructed based on the activities and concepts treated within the week and the previous weeks,

2.5. Steps Involved in the Problem Solving Strategy

The problem solving strategy can be generalized into the following two steps as follows: To become a better physics problem solver, two factors can help make this possible.

1. The first is that you must know and understand the principles underlying the study of physics. The second is that you must evolve a plan for applying the principles of physics to new situations in which physics can be applied to the benefit of humans.
2. Physics problem solving can be learned just like anything that you will learn for the first time such as learning to play a guitar, or ride a bicycle.

As with all learning activities, it is always beneficial to break down the steps in the problem solving strategy into a major and a minor steps. The strategy has five major steps: *Focus on the Problem*, *Physics Description*, *Plan a Solution*, *Execute the Plan*, and *Evaluate the Solution* (Hollabaugh, 2010). According to Hollabaugh (2010), the five major steps outlined in Steps 1 to 5 can be summarized as follows:

Step 1. Problem Focus

First, ask yourself what the problem situation is. Next draw a rough, although literal, picture showing the important objects, their motion, and their interactions, and then label all known information.

Step 2. Physics Description

A "physics description" of a problem translates the given information into an idealized diagram and defines variables that can be manipulated to calculate desired quantities. One of the greatest shortcoming of beginning or novice physics problem solvers is to attempt to apply the laws of physics, that is to write down equations before starting the qualitative analysis of the problem. If you can avoid the temptation to write down equations too early when solving a problem, then you are on your way to becoming a much more effective problem solver. You will need to identify a target variable and decide what unknown quantity it is that you must calculate from your list of variables. Ask yourself now if the calculated value answers the question, and if not go over the process again.

Step 3. Plan the Solution, *that is, how do I solve the problem?*

Before you actually start to do the computation, pause and take time to make a plan. Usually when you apply the laws of physics in expressing an equation, the equation is generally a universal statement. What you now do is to construct specific algebraic equations to enable you to calculate the desired quantity or value you are looking for. Logically, start from the end and work backwards to the first step, that is, you write down the equation containing the target variable first.

Step 4. EXECUTE the PLAN *by solving the problem*

In this step, you are now ready to implement the plan. Calculate the numerical value for the variable(s) you are looking for, and make sure your final answer is clear to any evaluator who desires to check the method you used in arriving at the solution. The rule of thumb is that solve the problem algebraically first before putting in any numerical values.

Step 5. EVALUATE the SOLUTION *and check the Answer*

Finally in this step, you are ready to work out the final answer. Here, you must use your common sense about how the real world works as well as those aspects of the physical world you have learnt in your physics lectures.

It is a good idea to read through the solution you have arrived at very carefully. If your final output suggests to you that your answer is not correct or unreasonable, acknowledge your mistake and explain why you think you made that mistake.

It is important to establish a methodical approach to solving numerical examples problems. It is therefore vital to remember the first three steps, that is, in step 1, *what does the question* TELL *me*?

In Step 2, *what does the question* ASK *me*?

In Step 3, *what links these quantities*?

Hence, e*ach physics problem solution MUST have the following (using the acronym **GUESS**):*

1. *Givens*
2. *Unknown*
3. *Equations*
    - *Base Equation*
    - *Working Equation*
4. *Substitution (Equation with figures attached)*
5. *Solution with correct units attached*

Procedure for Data Collection

The data for this study was collected in three stages. The first stage involved determining the prior knowledge of students by testing them on the concepts to be learnt (pre-intervention exercise). The second stage was the weekly tests after each lesson for the four weeks' duration of the intervention. The concepts treated were on: fundamental quantities; basic and derived units; Archimedes' Principle, law of flotation, density and relative density; scalars and vectors with examples; linear motion (equations and examples); heat capacity and specific heat capacity; reflection and refraction at plane and curved surfaces. The third and final stage was the post-intervention exercise on all the concepts learnt (post-test). The results of the post-test were discussed with the participants at the end of the study.

Data Analysis

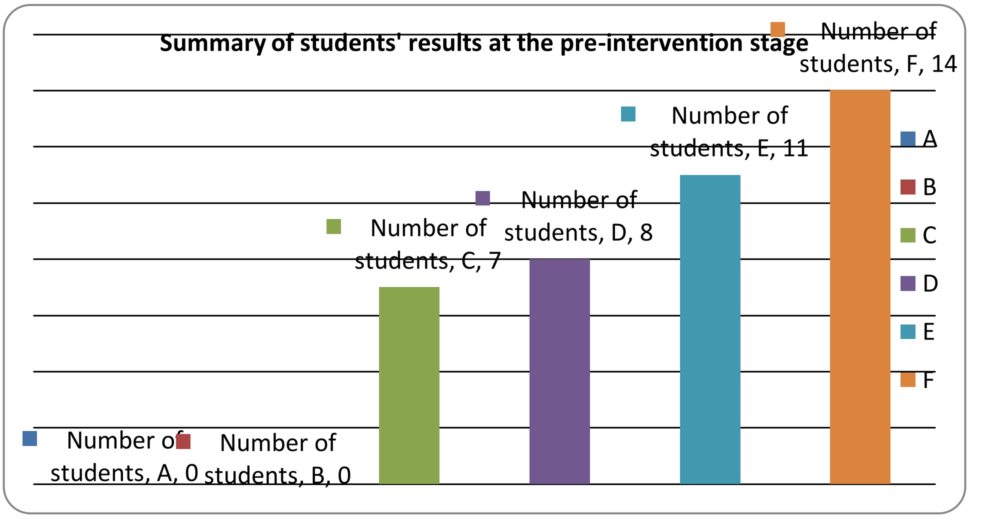
The data was analyzed using simple percentages and measures of effect size. *Effect size* refers to the magnitude of the impact of some variable on another (Cohen, 1965). The study, being an action research, reports were presented and discussed with students on each lesson taught.

3. RESULTS

3.1. Data Collected at Pre-intervention Phase

Students were tested during the pre-intervention exercise and the following results were obtained using the University's grading system, that is, [**A**: 70 -100%; **B**: 60-69%; **C**: 50-59%; D: 45-49%; E: 40 - 44%; **F**: below 40%].

Fig-1. Summary of students' results at the pre-intervention stage.



Students were then given the outline of what they are going to study for the next four weeks and day and period of tests negotiated and agreed upon.

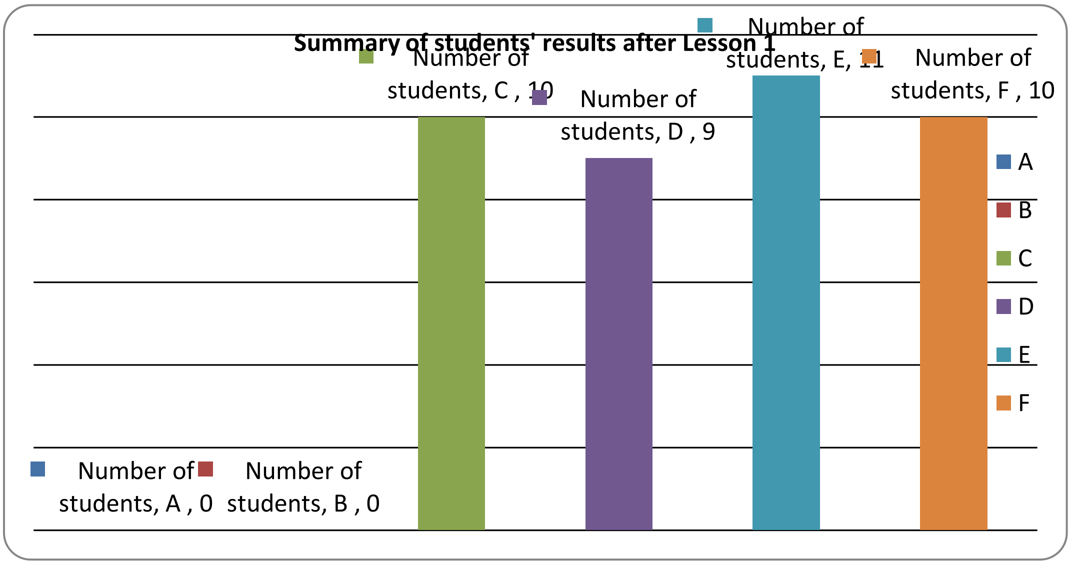
3.2. Data collected at the intervention Phase

Lesson 1

Lesson 1 was on fundamental quantities; basic and derived units; Archimedes' Principle, law of flotation, density and relative density.

Students were tested after the first lesson and the following results were obtained.

Fig. 2. Summary of students' results after the first lesson.



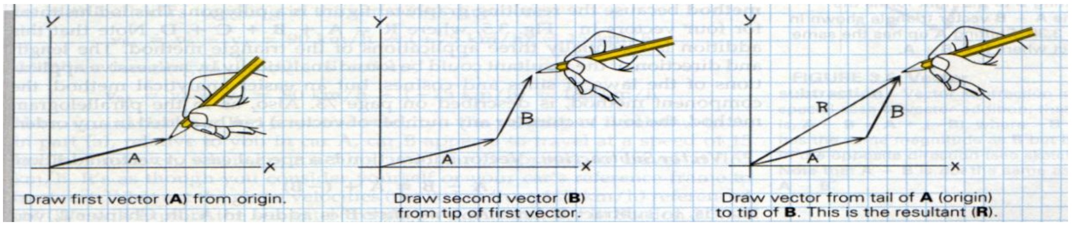
Lesson 2

The lesson 2 was on scalars and vectors with examples; linear motion (equations and examples). This lesson was taught using the following multiple representations.

A. How to determine the resultant of a vector

Scalars (quantities which are fully described by *magnitude* alone) **and Vectors** (quantities which are fully described by both *magnitude* and *direction*).

Fig-3. Finding the resultant of a vector



B. Using the Problem-solving strategy

Focus on the Problem
A car moving at 20.0 meters per second brakes at 3.0 ms^{-2} in 5.0s. Determine its stopping distance.

Describe the Physics
Read the problem. Decide what you are looking for such as: What are the units for the answer? Will the distance be in metres?, etc.

Plan the Solution, i.e., how do I solve the problem?
What data is given? Write down and label each value with a symbol and proper units. Starting velocity V_o= 20.0 m/s ; t=5.0s; final velocity, V_f= 0 m/s (stops) ; acceleration, a = -3.0 m/s^2 (it's slowing).

Execute the Plan by solving the problem
What Equations should I use? The following equations are applicable:

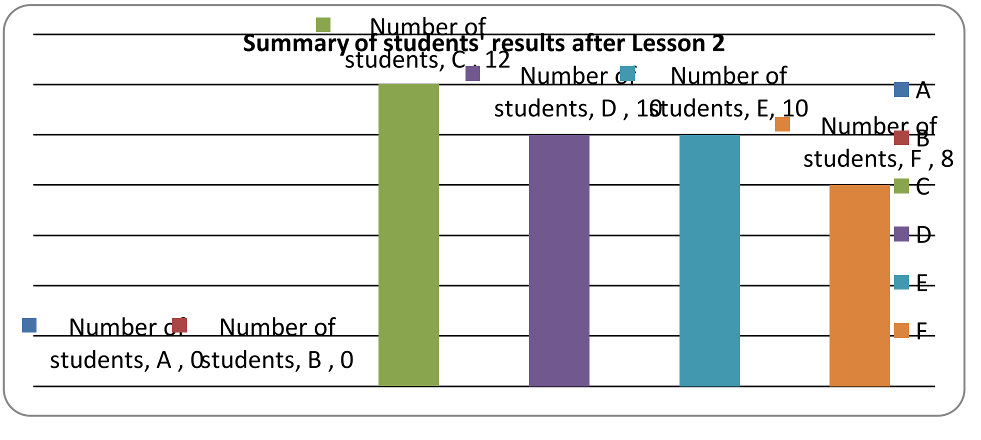
1. $v = u + at$
2. $s = \frac{(u+v)}{2}$
3. $s = ut + \frac{1}{2}at^2$
4. $v^2 = u^2 + 2as$

Both equations (3) and (4) contain our unknown (s). Since we know V, V_o , a and t, either equation will enable you to find s. Try both equations to see what you will get.

Evaluate and check the Answer. Did you get 62.5 m? If not, try again and check your steps.

Students were tested after the second lesson and the following results were obtained.

Fig. 4. Summary of students' results after the second lesson.



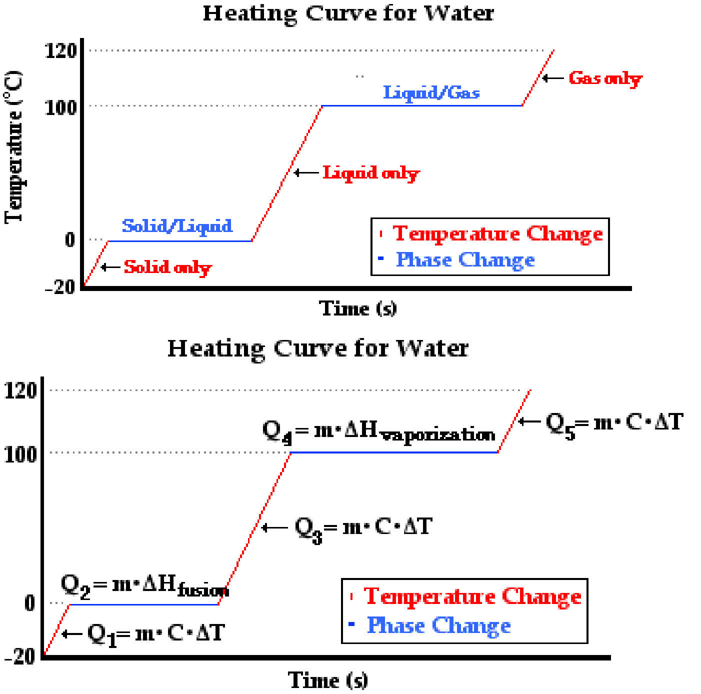
Lesson 3

The lesson 3 was on heat capacity and specific heat capacity using the following multiple representations.

Heating curves of water heated from -20ºC to 120ºC

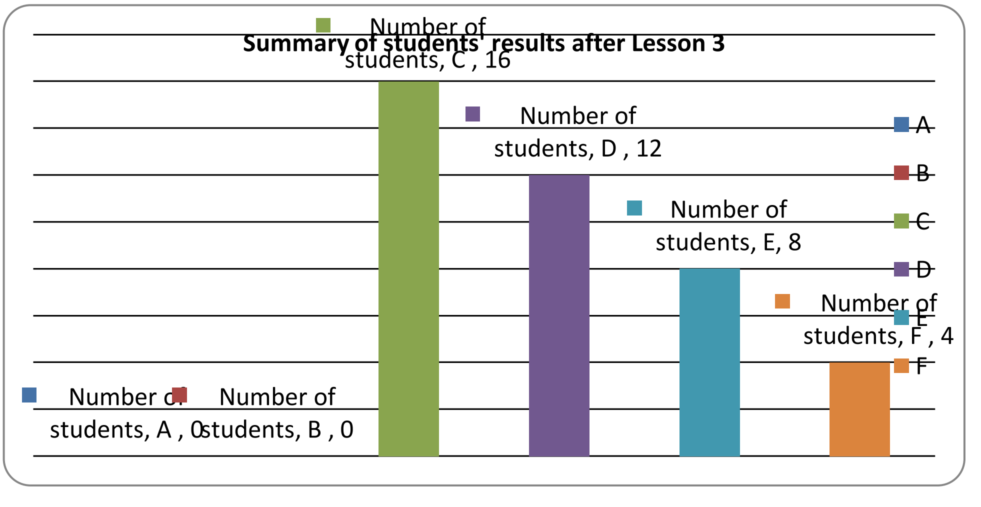
The heating curves represent changes in temperature as time changes for a sample of water to which heat is transferred from **-20ºC to 120ºC** showing the various phase changes.

Fig-5. Heating curves for water showing 'sensible' and latent heats.



Students were tested after the third lesson and the following results were obtained.

Fig. 6. Summary of students' results after the third lesson.



Lesson 4

The lesson 4 was on reflection and refraction at plane and curved surfaces using the following multiple representations.

(a) Determining an image formed in a curved mirror

Fig-7. Formation of a virtual image in convex and concave mirrors.

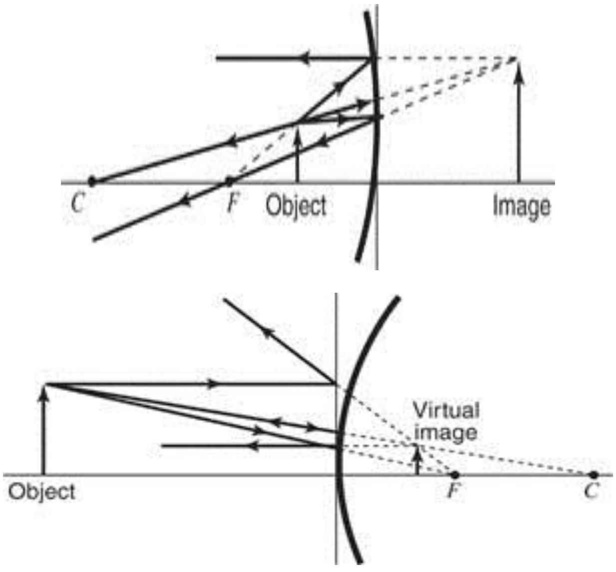


Fig. -8. Thin lenses function by refracting light (a) converging lens, (b) diverging lens.

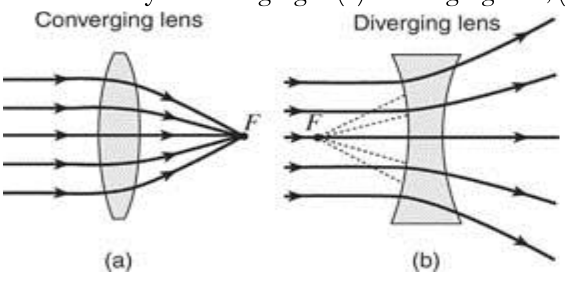
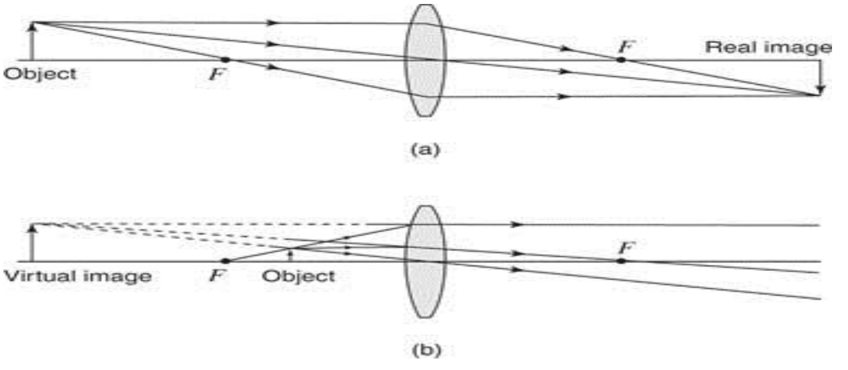
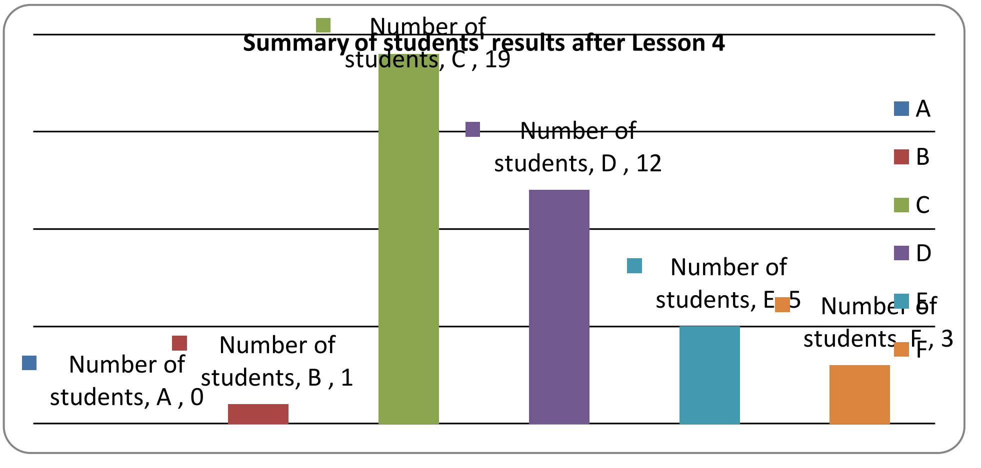


Fig- 9. Ray diagrams for a converging lens, showing the formation of (a) a real image or (b) a virtual image.



Students were tested after the last lesson and the following results were obtained.

Fig-10. Summary of students' results after the fourth lesson.

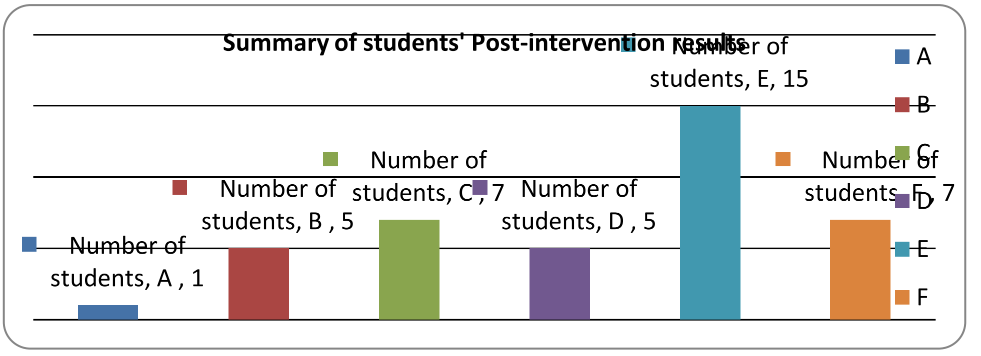


3.3 Post-intervention stage

This stage was to find out the effect of the intervention lessons on students' achievement on the concepts learnt.

Students were tested during the post-intervention exercise and the following results were obtained.

Fig-11. Summary of students' results after the post-intervention test.



Estimating Effect size using Cohen's d – Differences between Means

Table-1. Data used to estimate effect size using Cohen's *d*

Pre-test	
Mean	41.125
Standard Deviation	8.284021
Sample Variance	68.625
Sum	1645
Count	40
Post-test	
Mean	45.275
Standard Deviation	11.57359
Sample Variance	133.9481
Sum	1811
Count	40

variance = (68.625 + 133.9481)/2 = 101.28655

Pooled Standard Deviation (s_p) = √ (101.28655) = 10.0641

Cohen's d, = $d = \dfrac{\bar{X}_1 - \bar{X}_2}{s_p}$ = (mean of Post-test - mean of Pre-test) / s_p = (45.275 - 41.125) / 10.0641

= **0.41**

4. DISCUSSION OF RESULTS

The following research question was posed in the study –"To what extent does MRs help Level 200 Geography Education students of the Department of Science Education, Modibbo Adama University of Technology, Yola learn physics"? The question sought to determine the impact of the intervention on students' understanding of some basic concepts in mechanics, heat and optics.

From the Pre-test and Post-test (Figs. 1 & 12), students who scored C and above, that is above 50% were 7 and 13 respectively, meaning there was almost 50% increment in students' comprehension after the intervention on the average. Also, the number of students who failed, that is had less that 40% (F) halved from 14 to 7 students. However, there was no improvement in students' grades within the D and E bracket (19 and 20) students respectively.

The individual lessons were on different concepts with differing levels of difficulty. Lessons 1 and 2 were on mechanics where students scoring 50% and above (C to A) were on the average 11 (27.5%), between (D & E), 20 (50%) and F (9) (22.5%) (see Figs. 2 & 4). Lesson 3 was on heat and students' performance here was quite good. Sixteen students (16) (40%) scored 50% and above, 20 students (50%) scored 40-50% of the marks with 4 students (10%) failing (see Fig. 7). In Lessons 1 to 3, no student had grades A or B, that is, 60% and above. In Lesson 4, which was on optics, 20 students (50%) scored 50% and above, with 1 student (2.5%) obtaining B (60-69%); 17 students (42.5%) (D & E) and 3 students (7.5%) failing (see Fig. 11). Of the four lessons, students performed relatively better in optics (32 students) (80%) scoring 45% and above of the marks; followed by thermal physics (heat) (28 students) (70%) and mechanics (20 students) (50%). Literature shows that mechanics is one of the difficult and abstract conceptual areas of physics to learners which has been proved in this study. This is because in the context of introductory mechanics, misconceptions arise from the everyday observations and generalizations, beginning in childhood, that everyone needs in order to toss a ball, walk down a street, or chew his or her food (Styer, 1996). The lectures in the lessons focused on using various representations (see Figs. 3- 4; 6; & 8-10) to minimize students' misunderstandings, hence the improved performance of the students as demonstrated in the post-test. Comparatively, from the post-test scores (see Fig. 11), only 18 students (45%) (A: 1; B: 5; C: 7; D: 5) who scored 45% and above can be said to have understood the concepts taught them using multiple representations. The rest 55% of the students' performance was below average in the post-test, and this is a clear indication that the concepts taught were not well understood by majority of the students. However, this is a marked improvement from where the students were before the intervention, for only 15 students (37.5%) (A: 0; B: 0; C: 7; D: 8) scored 45% and above. Also, effect size (degree of precision) as a confidence interval around a point estimate of a population parameter calculated to see the effectiveness of the treatment was 0.41. According to Cohen (1969), some rules of thumb of interpreting effect sizes is as follows: if the effect size is 0.2, then it is small, 0.5 medium and 0.8 large. Also, an effect size of 0.5 is described as 'medium' and is 'large enough to be visible to the naked eye'. However, Cohen (1969) does acknowledge the danger of using terms like 'small', 'medium' and 'large' out of context. Glass *et al.* (1981) are particularly critical of this approach, arguing that the effectiveness of a particular intervention can only be interpreted in relation to other interventions that seek to produce the same effect. Glass *et al.* (1981) also point out that the practical importance of an effect size depends entirely on its relative costs and benefits, since in education, if it could be shown that making a small and inexpensive change would raise academic achievement by an effect size of even as little as 0.1, then this could be a very significant improvement, particularly if the improvement applied uniformly to all students, and even more so if the effect were cumulative over time. Therefore, the effect size of 0.41 obtained indicates that the use of MRs to increase students' conceptual understanding of basic concepts in optics, heat and mechanics, showed an improvement in their understanding of the concepts. According to Sutherland and Wehby (2001), students who are actively engaged and are given frequent opportunities in the same ideas in different modes may demonstrate improved academic skills. Hence, the treatment offered the students opportunities to learn and understand the concepts taught them from different angles.

This research study has lent credence to the fact that multiple representations-based instructions did make a significant influence on the performance of students if they are diligent in their studies. The results of this study is supported in the literature by researchers such as Brenner (1995), who although her treatment took short period of time, significant difference was found between pre-test and post-test in favour of the students' performance in the post-test. There might be various reasons to result in positive influences of multiple representations-based instructions on students' performance. As suggested in Swafford and Langrall (2000) study; multiple representations-based instruction promotes conceptual understanding and makes students conceptualize symbols, objects and ideas. The findings of this study is also consistent with the findings of previous studies (Ozgun-Koca, 1998; Pitts, 2003) that provided evidence for the effectiveness of multiple representations- based instruction in engaging students in meaningful learning. From the classroom observations, it can be implied that after introducing multiple representations-based instruction, students are better able to establish connections between varieties of representational modes. Generally, students perceived that equations are the last achieving point, and all other representational modes can only be used to reach this representational mode. However, the students noticed the fact that equation is one of the most common representational modes, like graphs or tables. Another attainment from the treatment was that multiple representations-based instruction made students better problem solvers (Yerushalmy, 1997; diSessa and Sherin, 2000; Renkl, 2005; Berthold *et al*., 2007) since they were dealing with the thematic activities and every activity had a problem situation. Furthermore, the results of this study are in alignment with the theoretical views of multiple representation-based instructions on some articles (Klein, 2003; Mayer, 2003; Waldrip and Prain, 2004). Klein (2003) argued that multiple representations promote students` recall and understanding of the concepts learnt.

5. CONCLUSION

Comparing the pre-test and post-test scores and effect size of 0.41, although only 45% of the students scored 45% and above as against 37.5% of the students at the pre-intervention stage, there was an improvement in students' achievement in basic concepts in optics, heat and mechanics. This indicates the effectiveness of MRs to increase students' conceptual understanding of the physics concepts taught. The treatment offered the students, the opportunities to learn and understand the concepts taught them from different angles. To determine an appropriate final state of intellectual performance for students in any physics course of study, the most important goals for students to: (1) learn the fundamental principles of physics; (2) learn general qualitative and quantitative problem-solving skills that they can apply to new situations. To attain these goals, students must restructure their pre-existing knowledge so the fundamental concepts and principles of physics can be remembered and appropriately retrieved for problem solving. Some of these principles of physics processes required for problem solving are generating a description of the problem that makes it easier to solve physics problems, making prudent decisions in arriving at a solution, and testing and evaluating the solution.

5.1. Implications for Physics Teaching

Effective physics instruction needs more than lecturing or any single representation method of instruction. Effective teaching therefore does not simply teach students what is correct- it also ensures that students do not believe what is incorrect (Styer, 1996). It requires active involvement of the students in the learning process. Multiple representations-based instructions meet this need in the physics classroom. As noted by Monk (2004), the aim should be to teach students to use multiple representations in a particular scientific context and to use variety of representations at the same time, rather than to use only one representation for all situations. In physics classrooms, teachers are responsible for designing constructivist situations and concrete connections for students so that scaffolding of knowledge can be achieved. Teachers should also encourage students to think about connections between multiple representations. Laughbaum (2003) claims that teachers should spend some time of the physics lesson on the relationships between manipulative and abstract symbols and emphasize applications of multiple representations. Moreover, using multiple representations in teaching of physics should be emphasized in pre-service teacher education programs, as well as in in-service teacher education seminars. One further implication can be suggested for the physics textbooks and other teaching materials. In traditional physics classroom, there is a need to encourage students to think more deeply on physics concepts, to intrinsically motivate for learning, to make students appreciate the nature of physics by getting rid of rote memorization, and to avoid overemphasizing rules and algorithms. In fact, new instructional methodologies like multiple representations-based instructions might address this need.

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6. REFERENCES

Ainsworth, M.D.S., 2008. Attachment: Retrospect and prospect. The place of attachment in human behaviour. New York: Basic Books.

Berthold, K., M. Nückles and A. Renkl, 2007. Do learning protocols support learning strategies and outcomes? The role of cognitive and metacognitive prompts. Learning and Instruction, 17: 564-577.

Brenner, M.E., 1995. The role of multiple representations in learning algebra.

Cohen, J., 1965. Some statistical issues in psychological research. Handbook of clinical psychology. New York: Academic Press.

Cohen, J., 1969. Statistical power analysis for the behavioral sciences. NY: Academic Press.

Creswell, J.W., 2008. Educational research: Planning, conducting, and evaluation. Croom: Helm.

diSessa, A. and B. Sherin, 2000. Meta-representation: An introduction. Journal of Mathematical Behaviour, 19: 385-398.

Fairbrother, R., 2000. Strategies for learning Good practice in science teaching –What research has to say. Open University Press: Buckingham . Philadelphia.

Glass, G.V., B. McGaw and M.L. Smith, 1981. Meta-analysis in social research. London: Sage.

Heller, P. and M. Hollabaugh, 1992. Teaching problem solving through cooperative grouping. Part 2: Designing problems and structuring groups. American Journal of Physics, 60(7): 637-644.

Heller, P., R. Keith and S. Anderson, 1992. Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving. American Journal of Physics, 60(7): 627-636.

Hollabaugh, M., 2010. Problem solving in physics. Available from http://faculty.normandale.edu/~physics/Hollabaugh/probsolv.htm.

Johnson, M., 2001. Facilitating high quality student practice in introductory physics. Phys. Educ. Res., Am. J. Phys, 69(7).

Klein, P.D., 2003. Rethinking the multiplicity of cognitive resources and curricular representations: Alternatives to `learning styles` and `multiple intelligences. Journal of Curriculum Studies, 35(1): 45-81.

Laughbaum, E., 2003. Developmental algebra with function as the underlying theme. Mathematics and Computer Education, 37(1).

Llewellyn, D., 2004. Teaching high school science through inquiry. A Case study approach. Corwin Press.

Mayer, R.E., 2003. Multimedia learning. Cambridge: Cambridge University Press.

McCaslin, N., 1996. Creative drama in the classroom and beyond. 6th Edn: Longman Publishers; USA.

Meltzer, D., 2005. Relation between students, problem-solving performance and representational format. American Journal of Physics, 73: 463-478.

Monk, S., 2004. Representations in school mathematics: Learning to graph and graphing to learn. A Research Companion to Principles and Standards for School Mathematics. Reston, VA: NCTM, Inc.

Ozgun-Koca, S.A., 1998. Computer-based representations in mathematics classrooms. The effects of multiple-linked and semi-linked representations on students, learning of linear relationship. Published PhD dissertation. Ohio: Ohio State University

Pitts, V.R., 2003. Representations of functions: An examination of pre-service mathematics teachers' knowledge of translations between algebraic and graphical representations. Unpublished PhD Dissertation. Pittsburg: University of Pittsburg.

Reif, F. and L.A. Scott, 1999. Teaching scientific thinking skills: Students and computers coaching each other. Am. J. Phys, 67: 819-831.

Renkl, A., 2005. The worked-out example principle in multimedia learning. Cambridge handbook of multimedia learning. Cambridge, UK: Cambridge University Press.

Roy, M. and M.T.H. Chi, 2005. The self-explanation principle in multi-media learning. Cambridge handbook of multimedia learning Cambridge, UK: Cambridge University Press.

Salim, S.A., 2006. Strategies for curriculum innovation and development Deliberation Student, Participation and Context Relevance.

Shulman, L., 1987. Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1): 1-22.

Shulman, L., 1992. Ways of seeing, ways of knowing, ways of teaching, ways of learning about teaching. Journal of Curriculum Studies, 28: 393-396.

Styer, D.F., 1996. Common misconceptions regarding quantum mechanics. American Journal of Physics 64: 31-34.

Sutherland, K.S. and J.H. Wehby, 2001. The effects of self-evaluation on teaching behaviours in classrooms for students with emotional and behavioural disorders. Journal of Special Education, 35: 161-171.

Swafford, J.O. and C.W. Langrall, 2000. Grade 6 students' preinstructional use of equations to describe and represent problem situations. Journal of Research in Mathematics Education, 31(1): 89-112.

Sweller, J. and G.A. Cooper, 1985. The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction, 2: 59-89.

Van Heuvelen, A. and X. Zou, 2000. Multiple representations of work-energy processes American Journal of Physics, 69: 184-194.

VanLehn, K., 1996. Cognitive skill acquisition. Annual Review of Psychology, 47: 513-539.

Waldrip, B. and V. Prain, 2004. Enhancing learning through using multi-modal representations of concepts. Paper presented at the annual meeting of the American Education Research Association (AERA), 2004.

Williams, B., 2009. Teaching the teacher. Available from http://www.nwitimes.com/news/locap/porter/article_7722fb0d-e8-5459-be6b-c99023c5173b.html.

Yager, R.E., 1993. The constructivist learning model. The Science Teacher, 60: 27-31.

Yerushalmy, M., 1997. Designing representations: Reasoning about functions of two variables. Journal of Research in Mathematics Education, 28(4): 431-466.