An Analysis of 6th Grade Science Topic on Levers Tested to Teacher Training College (TTC) Students in Papua New Guinea

Hellen WAMINGI

Naruto University of Education

Abstract

Lever concept like other primary science courses places a challenge for many pre-service student teachers and even the lecturers teaching the course at the teacher training college in Papua New Guinea though it is the fundamental of future science learning. Many recent findings have revealed that both the lecturers and student teachers in Papua New Guinea teacher training colleges have difficulty understanding lever concept.

This study is based on a grade 6 content comparison test that was administered to student teachers of one of the teacher training college in Papua New Guinea (PNG). The purpose of this study is to comprehend the effectiveness of the science curriculum at the teacher training colleges in PNG. A test consisted of four lever concept questions were administered to a total of 41 year 3 student teachers from two separate classes. The study engaged both qualitative and quantitative method of data analysis collection. The findings exposed student teachers' limited understanding of lever concept and common misconceptions. Hence, the study proposes more effective ways to improve the standards of science education at the teacher training colleges in PNG.

Keywords：Papua New Guinea, Pre-service student teachers, lever concepts, Misconceptions

1. Introduction

Papua New Guinean Science curriculum begins at Primary Education level and progresses to higher levels with complex content and context. The country uses 3, 6, 4 education system from elementary, primary, junior high school and senior high school then into the tertiary level. The education system will be 1, 6, 6 beginning 2019 and still continue with the three years diploma program at TTC. Science subject is compulsory from elementary till the end of high school but optional into secondary education. However, in the teacher training colleges, science courses (living things& environment, physical science and earth &space) are inclusive in the training. About 10% of the intakes are science major while the rest are social science students.

This study contains information about the sample science test conducted in one of the teacher training college in Papua New Guinea. The study is part of the program sponsored by JICA under the long term study program "Improvement of Quality of Teaching Materials for Mathematics and Science". Hence, the sample acts as a tool to guide curriculum planners and educators about the difficulties and misconceptions of teaching and learning in science education as well as the effectiveness of the newly introduced curriculum so that applicable measures can be taken to improve the standard of science education at the teacher training college level in PNG.

Enga Teacher College is in an urban setting but unlike Scared Heart teachers college in Port Moresby city where student teachers are from all provinces of PNG enrol there. Most of the students are from the Highlands provinces with various social-demographic backgrounds and with a range of ability levels. The teacher training colleges can be classified as government, church or privately run colleges and are in the urban setting per the provinces. Hence this sample study can signify efficiency of science education at TTC level in PNG.

2. Participants

The sample includes two separate classes of year three student teachers with ages ranging from 21-27 years old in Enga teachers college, one of the governments owned TTC and is an hour by plane and about 4 hours drive by road from the Nation's capital city of Port Moresby, Papua New Guinea. The sample of 41 students from two classes (21 males and 20 females) participated in this survey.

3. Instruments

The main source of data collection was through the four (4) lever concept questions used in the test purposely to gather information about student teachers' understanding of lever concepts. The test required students to use their prior knowledge to solve problem questions by circling their choice from the multiple choices or to give answers in written/diagram form with reasons on the spaces provided on the test. Their application of the content knowledge and scientific inquiry skills were tested during the test. Thus the study engaged both the qualitative and quantitative method of data collection.

Table 1   Lever concept as questions used in the test

Question	Difficulty Index	Pre-test Content	Lever Concepts
1A	0.02	Lever (load, fulcrum and effort)	Lever as an experimental lever
1B	0.05	Lever at Equilibrium	All possible conditions for the experimental lever to be horizontally balance
2A	0.17	Lever at Equilibrium	Application of Law of Equilibrium of levers Weight x distance (right arm) = Weight x distance (left arm)
2B	0.00	Lever at Equilibrium	Stating the problem/key question on the scenario with a derived summary {Weight x distance (right arm) =Weight x distance (left arm)} given
3A	0.00	Tong, class 3 lever	Usage of tools (class 1, 2 and 3 levers) depends on the load distance and effort distances from the fulcrum.
3B	0.02	Tong, class 3 lever	Usage of tools (class 1, 2 and 3 levers) depends on the load distance and effort distances from the fulcrum.
4A	0.34	Lever as a scale	Using the law of lever and mechanism of scale to weigh objects (registered mail).
4B	0.24	Lever as a scale	Using the law of lever and mechanism of scale to weigh objects (the registered mail).

Table 2: Item difficulty Index Range (P value- Probability of getting the item correct by examinee)

Range	Interpretation	Notes
0.00-0.30	Extremely difficult	Examinees are at chance level or even below, so the item might be miskeyed or have other issues
0.30-0.50	Very difficult	Items in this range will challenge even the top examinees, and therefore might elicit complaints but are typically very strong
0.50-0.70	Moderately difficult	These items are fairly common and a little on the tough side
0.70-0.90	Moderately easy	These are the most common range of items on most classically built tests, easy enough that examinees rarely complain
0.90-1.0	Very easy	These items are mastered by most examinees, they are actually too easy to provide much into on examinees thought and can be detrimental to reliability

Source: http://www.assess.com/classical -item-difficulty-p-value/
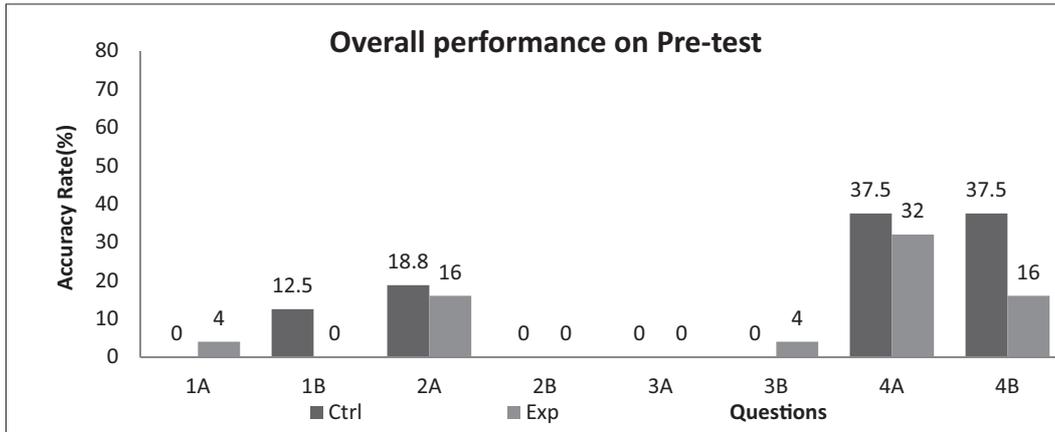
4. Results

4.1 Quantitative Analyses

Figure 4.1   Showing overall performance on the Pre-test Questions

4.2 Analyses of Misconceptions

Misconception 1 (MC1): Viewing load and effort in levers as force

Misconception 1 was due to student teachers unable to relate the idea of force in a new situation/context. In this situation, force refers to load and effort on either sides of the fulcrum in the concept of a lever. The weights are actually the concrete materials (objects) when levers become an experimental lever and these weights are placed on the left and right side of the beam to balance it. The word familiar to them is force and only force can replace effort and load when it comes to the idea of levers. With this concept, students are not able to clearly see that the representation of the arms of the lever in the process of investigating it to be a lever with objects in place of weight, force, effort and load.

Figure 4.3 shows almost 68.8-76% of the sample population on both the control and the experimental classes of student teachers made Force (B) as the choice while 31% of the control class and 16% of the experimental class taught Effort (C) their choice. And none from the control class population made Load (D) as their choice; still 4% of the experimental class chose D. About 98% of student teachers had the question 1A incorrectly done; implying that Misconception 1 (MC1) is obvious.
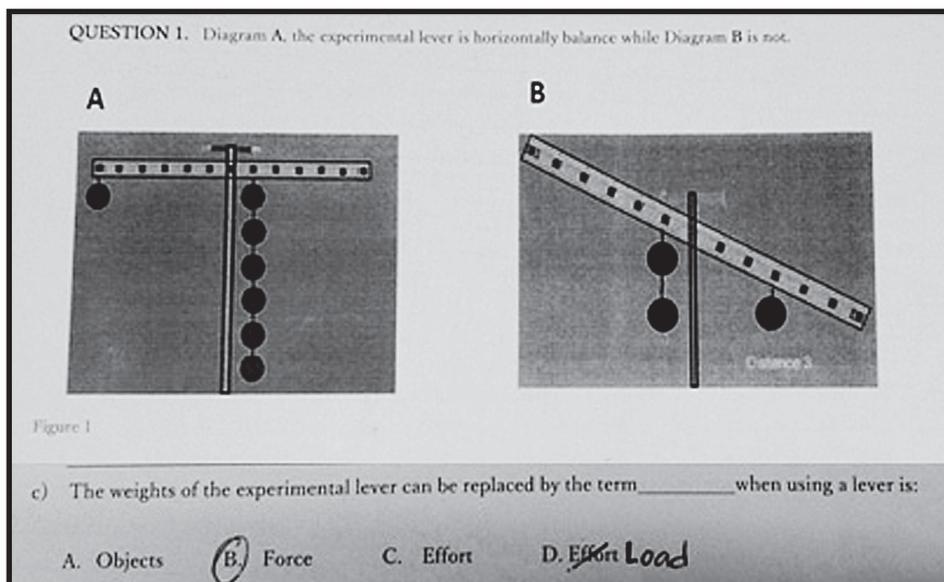

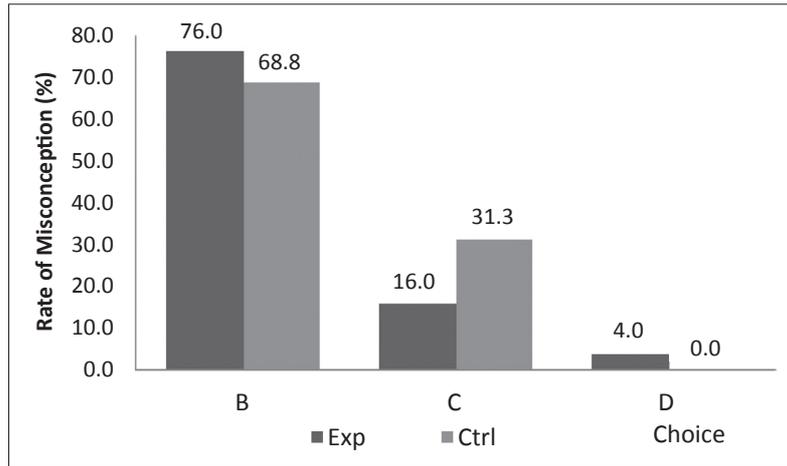Figure 4.2   Sample evidence of Misconception 1 (MC1)

Pre-test

Figure 4.3　Rate of Misconception 1 (MC1)

Misconception 2 (MC2): Viewing Weights as the key factor to keep the lever at Equilibrium

Misconception 2 was due to student teachers believe that in order to balance the lever, smaller weights must be placed away from the pivot while the bigger weights be placed closer to the pivot and same weight and distance on either sides of the pivot. In order to balance the lever, the placement and movement of weights determines the balance position of the lever.

Figure 4.5 shows 50% and 76% of the sample population on the control and the experimental classes of student teachers there only 2 conditions for the experimental lever to be horizontally balance that's why they chose B as their answer. Other student teachers in the control and the experiment class taught there is one possible condition for the experimental lever to be horizontally balance and so choice B as their choice. None of the student teachers from both the control and experimental class left question 1B unanswered. About 95% of student teachers did question 1A incorrectly; implying that Misconception 2 (MC2) is evident.
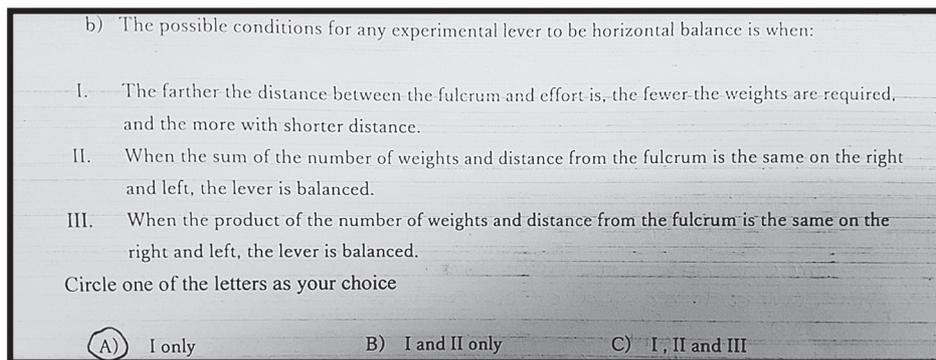
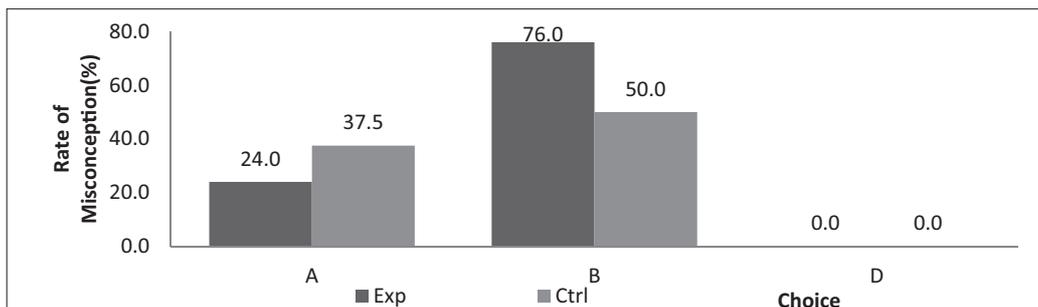Figure 4.4　Sample evidence of Misconception 2 (MC2)

Figure 4.5　Rate of Misconception 2 (MC2)

Misconception 3 (MC3): Visco Spatial, partly visualization of the complete concept of the law of equilibrium of levers.

Misconception 3 was due to student teachers find it difficult to relate the information in the statement form into the numbers and information on the table form based on partial visualization. Also they are unable to see the information clearly when different representations of the same information is presented, for example, from a statement to a numbers in the table. Understanding and seeing the law of equilibrium of levers with limited exposed to the application of the formula to everyday activities with this idea student

teachers are unable to interpret the information in the table. Therefore, they are unable to figure out the correct information provided on the table although the procedure was provided.

Figure 4.7 shows 28% and 6.3% to 18.8% of the sample population on the experimental and the control classes, student teachers chose the distracters (A, B and D) as their answer. Most student teachers (43.8%) in the control class left the question unanswered but none in the experimental class. About 83% of student teachers did question 2A incorrectly; implying that Misconception 3 (MC3) is observable.

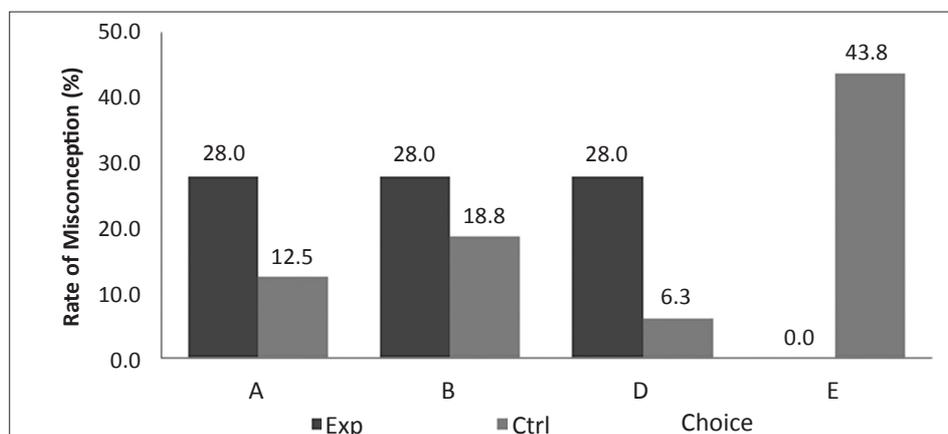Figure 4.6　Sample evidence of Misconception 3 (MC3)

Pre-test

Figure 4.7　Rate of Misconception 3 (MC3)

Misconception 4 (MC4): Viewing law of Equilibrium of levers as balance of LHS = RHS. Misconception 4 is due to student teachers lack creativity skills. Given a scenario, student teachers are unable to make a prediction based on the information provided, nor derive a hypothesis or even a problem question for investigation process to take place.

Figure 4.9 above shows 60% and 62.5% of the sample population on the experimental and the control classes, most student teachers left the question

unanswered and if answered, then the answers are out of content, e.g. "find the areas of the lever given?" Some of the student teachers, 25% and 28% in the control and experiment class the problem question as "the law of equilibrium" while the remaining student teachers, 6.3% and 4-8% wrote answers under the categories of balancing of lever, weight and distance. All their answers to question 2B were incorrect showing that Misconception 4 (MC4) is apparent.
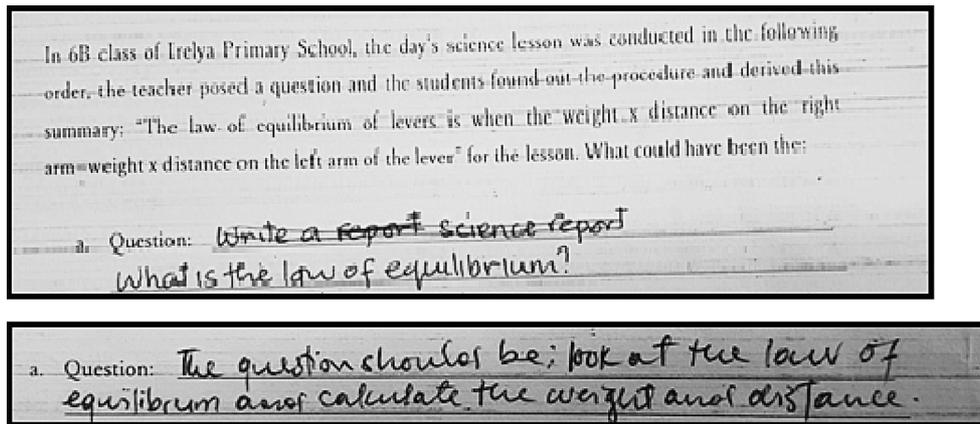

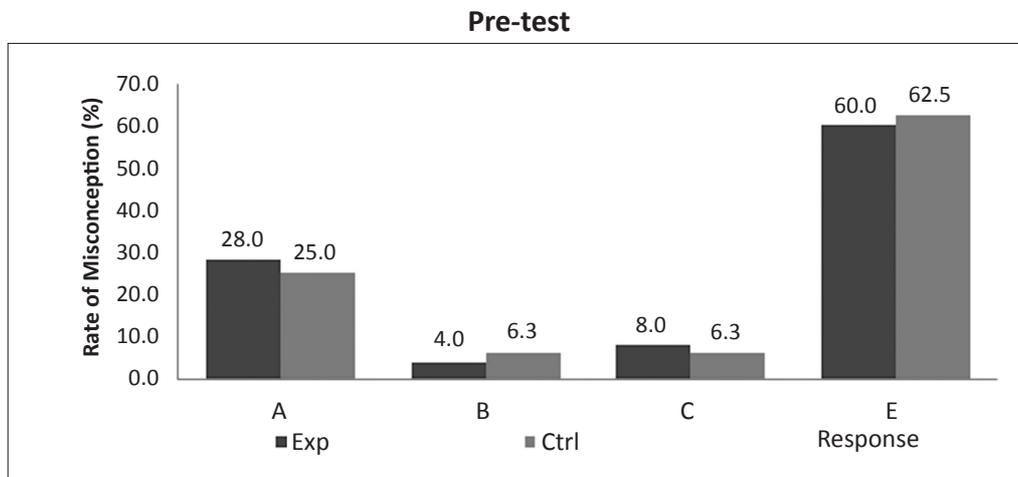Figure 4.8   Sample evidence of Misconception 4 (MC4)

Figure 4.9   Rate of Misconception 4 (MC4)

Misconception 5 (MC5): Viewing fulcrum as always at the center of lever.

Misconception 5 was due to student teachers view levers as having a load and effort on each sides of the fulcrum. The fulcrum is always in the middle of the load and effort. They lack the skill of identifying levers based on the effort distance and load distance and relating it to its usage rather than the positions of the fulcrum to determine the usage of the lever.

From Figure 4.11 above, 52% and 62.5% of the sample population on the experimental and the control classes, most student teachers left the question unanswered. Other student teachers, 20-28% and 12.5 to 25% in the experiment and control class chose Class 1 and Class 2 lever by circling the choices given. All of them answered question 3A incorrectly which implies that Misconception 5 (MC5) is obvious.
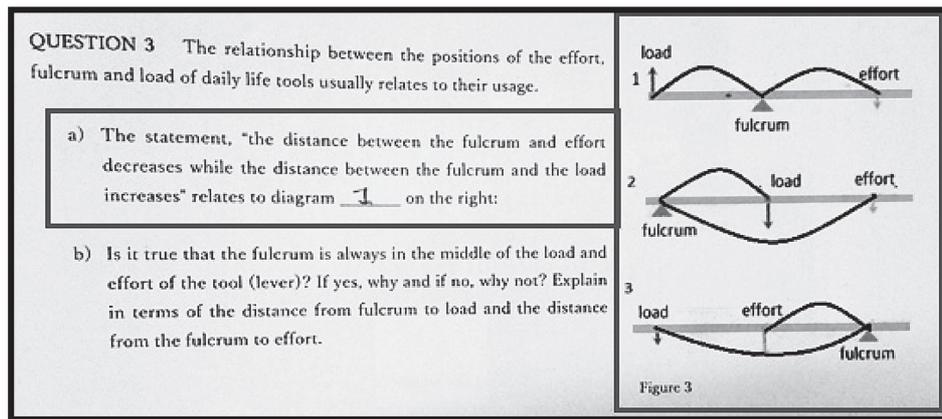
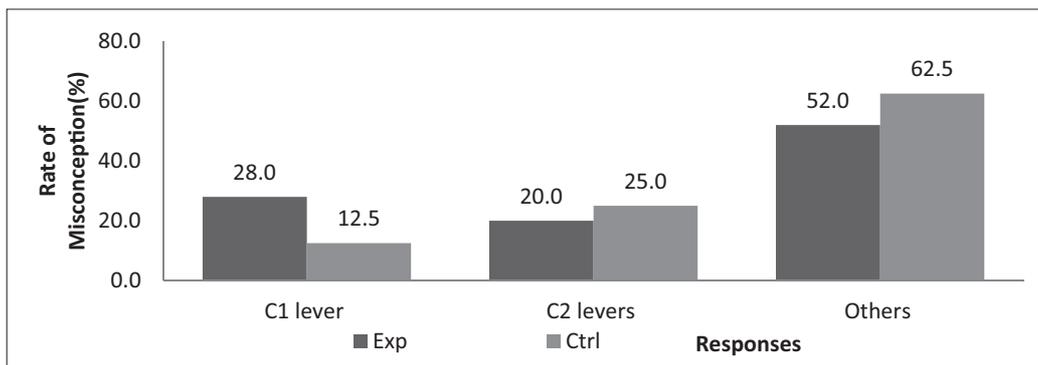Figure 4.10   Sample evidence of Misconception 5 (MC5)

Figure 4.11   Rate of Misconception 5 (MC5)

Misconception 6 (MC6): Viewing the mechanism of scale to weigh objects in isolation with the law of equilibrium of lever

Misconception 6 was due to student teachers are unable to combine the idea of weighing objects using a scale with the law of equilibrium of levers. They are not able to see clearly that the scale used to weigh objects are based on the idea of the lever at the balance position so the weight be measured.

Figure 4.13 shows that 56% and 50% of the sample population on the experimental and the control classes, most student teachers decided on the A choice, a distracter while 28% and 12.5% of the remaining student population on choice C, a distracter as their answer. More than half of their answers to question 4B were incorrect which implies that Misconception 6 (MC6) is evident.
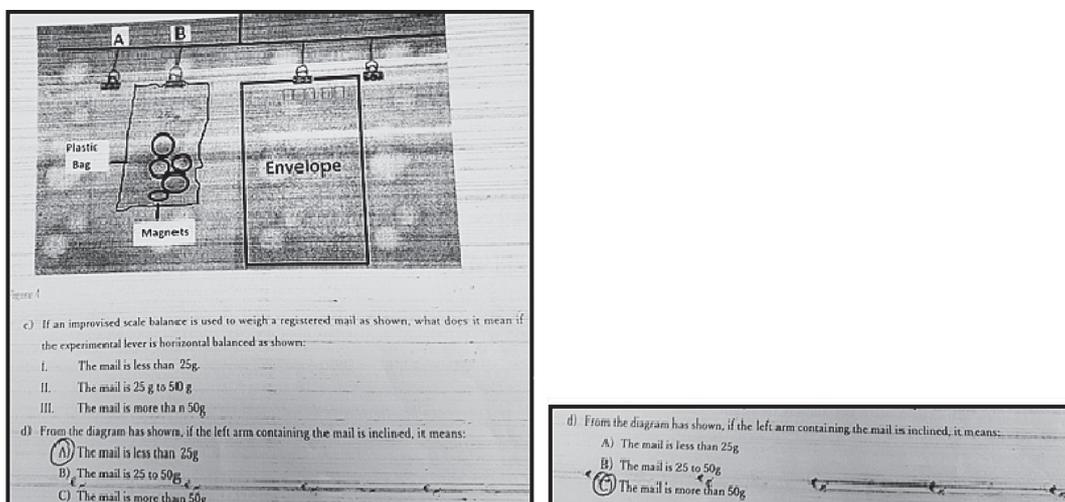

Figure 4.12   Sample evidence of Misconception 6 (MC6)

Pre-test
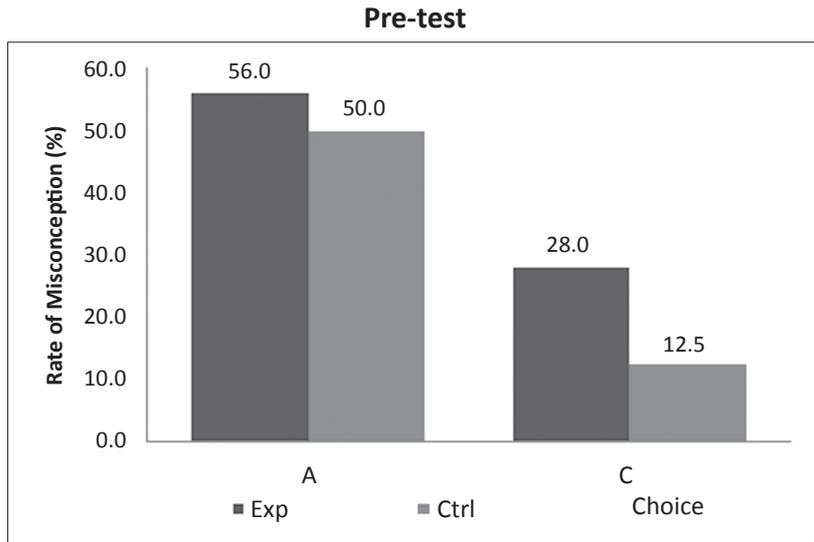
Figure 4.13　Rate of Misconception 6 (MC6)

Misconception 7 (MC7): Incorrect reasoning and scientific diagrams of tong, a class 3 lever.

Misconception 7 was due to student teachers limited exposure to classroom activities based on the practical application of the law of lever and the usage of levers. Students visualize all levers as having a fulcrum in the middle with load and effort on either side of the fulcrum. Students are unable to differentiate a scientific diagram of a lever to drawing the actual tool shown.

1. Scientific diagrams

Figure 4.14　Sample evidence of Misconception 7 (MC7)

2. Incorrect Reasoning

Figure 4.15　Sample evidence of Misconception 7 (MC7)

Figure 4.16 above shows 20-56% and18.8 to 43.8% of the sample population on the experimental and the control classes, student teachers drew scientific diagram of a tong as a class 1 or 2 lever and with

an incorrect reasoning. Others left the question unanswered or answered with drawings showing experimental levers, non-scientific diagrams of tong,

etc. Almost all answers to question 3B were incorrect which implies that Misconception 7 (MC7) is clear.

Figure 4.16   Rate of Misconception 7 (MC7)

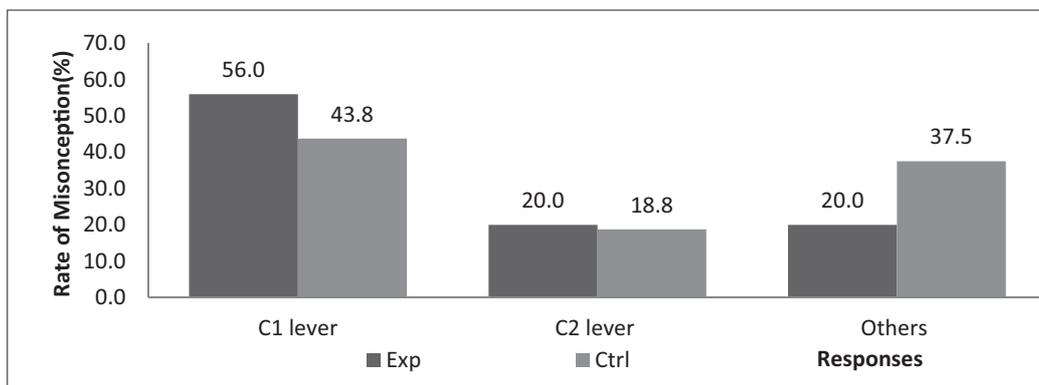## 5. Discussions and Implications

The overall performance by the sample population was extremely poor on the test exposing the difficulties student teachers have on lever concepts. The worst performed questions were Q2B and 3A with none of the student teachers had a correct answer. Then Questions 3B and 1A with an accuracy rate of 2.4%, followed by questions 1B, 2A, 4B and 4A having accuracy rates of 4.9%, 17%, 24.4% and 34%. The question difficulty indexes ranged from 0.00 to 0.34, implying that the questions were extremely and very difficult for the student teachers at the TTC level.

The further qualitative analyses identified five common misconceptions for the eight questions on lever concepts in this study. The most common misconception was viewing law of Equilibrium of levers as balance of LHS = RHS. Student teachers lack the skill of prediction to state the problem question which is the key question. Provided with the derived summary, student teachers have limited exposure to structured problem solving base lessons where a problem question paves way for making hypothesis and prediction and then to test during teaching and learning of science.

The next most common misconception was viewing fulcrum as always at the center of lever. They lack exposure to practical activities in class to understand that the load distance and the effort distance from the fulcrum determines the usage of the tool. For class 2 &3 levers, the effort and the load distance decreases from the fulcrum unlike class 1

levers where the load and effort distance from the fulcrum are the same. And so, a tong is a class 3 lever because the effort distance decreases with increase in the load distance from the fulcrum.

The next common misconception was viewing load and effort in levers as force. The load and effort are forces and the fulcrum is the pivot of any lever but student teachers are unable to clearly see the representation of the effort and load for objects having weight when a lever is an experimental lever. They are still used to the facts and with less exposure to activities involving an experimental lever to see all the possible ways for it to be horizontally balanced.

The next common misconception was viewing the mechanism of scale to weigh objects in isolation with the law of equilibrium of lever. Student teachers are used to weighing objects using the standard balances, unable to combine the two ideas together and clearly see what it means when the lever (improvised scale balance) is horizontally balance, and then one of the scales given signifies the weight of the object hanging. They are unable to see that when the lever is horizontally balance, it means the weight on the right arm is equal to the weight of the left arm; the arm containing the mail has the same weight as the sample bag of 20t coins. Remembering facts and with less exposure to practical activities in class is a result of such misconception.

The last common misconception was incorrect reasoning and scientific diagrams of lever concept. Student teachers are unable to a give correct reasoning and be able to draw scientific diagram of a lever (tong).

They are unable to distinguish between diagrams or sketch of a lever with correctly representing it as a scientific diagram and labels. They are unable to clearly outline the key factor due to the fact of less exposure to classroom activities involving scientific reasoning, explanations and diagrams.

6. General Conclusion

The primary purpose of this study was to identify the effectiveness of PNG science curriculum at the teacher training colleges so that appropriate measures can be taken to address the findings highlighted in the study. The study was successfully carried out in one of the teacher training colleges in Enga, Wabag province of PNG. There was a fair (50% males and the other 50% females) participants from both genders from the 41 students. The sample science tests consisted of questions taken from 6th grade Japanese Curriculum on the content of levers, specifically on the lever concept.

The results of the test administered showed majority of the student teachers fell short of demonstrating mastery of the 6th grade lever concept at the teacher training college level in PNG. Student teachers exposed very limited understanding of lever concept, its practical application and scientific inquiry skills to solve problems. The qualitative analysis exposed five areas of misconceptions on lever concepts based on the student teachers exposure to these problem solving skills which are; application, interpretation, prediction, reasoning and representation. Henceforth, in light of the findings revealed in this study, the following recommendations need careful attention in order to raise the standards of science at the teacher training college level in PNG.

Firstly, having accepted the constructivist philosophy in education, the primary aim of the instruction must to help student teachers acquire skills rather than gain scientific knowledge (MEB, 2005), and there must be more emphasis on the scientific inquiry skills as stated by Driver, 1985. Teaching methods be shifted from lecture-based towards student-centered approaches and that student teachers be provided opportunity to carry out investigations to test their ideas and construct their own knowledge, making inquiries as scientists as emphasized by Filiz 2010.

Secondly teaching through problem solving approach can be more effective in helping students to acquire scientific inquiry skills. Students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills (NRC, 1996). Scientific experiments are, by nature, inquiry-based activities; students must learn to propose hypotheses, design experiments, and select appropriate materials (Correiro, Griffin & Hart, 2008) and with all of these activities will certainly contribute to not only students' scientific inquiry skills but also their understanding of science concepts. Likewise, student teachers must be exposed to structured problem solving lessons during the teaching and learning of primary science. In previous findings done by Dadavana et al (2015) corresponding to the test items required content and the skills for cognitive domain suggested that the sample population had problems with reasoning, analyzing and applying appropriate skills for different science domains presented. The signs generated from the results of the sample test imply that the primary students and including the student teachers generally lack the necessary knowledge and skills to connect scientific concepts to daily situations as reflected in item two, three and item eight of that test items. On the same note, the eight questions on levers used to test conceptual understanding and the scientific inquiry skills showed similar results and the difficulties student teachers face without the exposure of structured problem solving lessons in TTC in PNG.

Finally, teaching and learning of lever concept with understanding requires more effort from the lecturers. Lecturers must help student teachers to realize that levers are tools and that the learning of this concept is applicable to daily use of simple tools such as tong, staplers, hole puncher, wheelbarrow and etc. It is also important to incorporate variety of representations of science concepts in real objects, photos, drawings/diagrams, graphs, tables, formulas and text according to 'The Science Representation Continuum' (Pozzer and Roth 2003). Finding the right balance of science representations is key to lasting understandings for students as specified by Olson 2008. She also stated that 'choosing representations is important for helping students to understand science concept and if representations are clear, accurate and focus students attention to the phenomena being studied help students to construct more accurate ideas'. In addition, (Apule et al 2017), the order in

which we use representations also impacts student learning, the beginning with concrete representations prior to the use of abstractions is more likely to result in accurate understanding of abstract concepts like the law of equilibrium of levers. That can only be achieved if teaching materials such as student worksheets, models/teaching aids and black board plan are accompanied by the structured problem solving lesson in teaching and learning.

To conclude, lever concept is fundamental for future science achievement and for ability to succeed in many professions. On the contradictory, these problems solving skills in the form of scientific inquiry skills seems to be difficult for many student teachers and lecturers. Hence, it is weighty to evaluate and pinpoint as to why and how learning lever concept is so problematic for student teachers at TTC level in PNG. It is better to look into the present performs and norms and identify correct interventions to help student teachers to overcome the challenges of mastering the lever concept.

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