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REVIEW ARTICLE

How do our Students Understand Newton's Third Law of Motion? A study in a Ghanaian University Context

Victor Antwi[1], Fortune Addo-Wuver[1], Nelly Sakyi-Hagan[2]*

[1]Department of Physics Education, University of Education, Winneba, [2]Department of Integrated Science Education, University of Education, Winneba

***Corresponding Author:** maamekuumah@yahoo.com

ABSTRACT

Newton's third law of motion is probably one of the easiest and simplest laws in physics for students to recite. However, when they are given questions where they must apply the understanding of the law to solve a problem, it often becomes a challenge. They seem to forget about the fact that action and reaction are opposite and equal. In this study, five sequential activities were used in the teaching of Newton's third law of motion: Concept quiz, conceptual reasoning questions, interactive teaching, reflection, and application and problem-solving questions. Twenty 1st year University Physics students at the University of Education, Winneba, were introduced to the Newton's third law of motion using real-life examples in an interactive engagement approach. The results indicated that students could give better qualitative reasoning and verbal explanations to most of the qualitative reasoning questions that were put as an effective strategy to assess students' learning after the interactive engagement approach. It was also revealed that students were intellectually active in understanding the concept of Newton's third law of motion.

KEY WORDS: Newton's third law of motion, understand, concept, interactive engagement

INTRODUCTION

One of the simplest laws in physics that most physics or science students can recite is the Newton's third law of motion. But do students understand the concept of the law with the same ease with which they recite it? The answer to this question is revealed in the way they apply Newton's third law of motion in solving problems or real-life activities (Andy and Rudra, 2002). Specifically, to this study, many Ghanaian students in Senior High Schools, Colleges, and Universities may have Newton's third law of motion at their fingertips; however, they hardly appreciate what it really means. According to Lucas (2010), forces always occur in pairs and when one body pushes against another, the second body pushes back just as hard. Indeed, this is the gap that exists between students' comprehension in Newton's third law of motion. Hence, they often find it difficult to apply the third law of motion of Newton in solving real or daily life questions (Mateev, 1989).

In the teaching of science, we would argue that the utmost aim of the lecturer is to help students apply the knowledge they acquire to solve similar but new problems. When that is done then one can be assured of the fact that learning has taken place (McDermott, 2001). This is usually what is not observed in most of our students as they apply the law wrongly to most daily life situations, unless they are guided to become cognizance of the real understanding of the third law of motion of Newton (Zena et al., 2004).

In this study, students were introduced into the teaching and learning of Newton's third law of motion, using daily life or real-life activities in an interactive engagement manner to help their conceptual understanding (Datta, 1986). The study used a qualitative approach; hence, transcription of video recordings on the interactive engagement processes in the physics classroom on Newton's third law of motion was analyzed to explore students' initial understanding of the third law and their final conceptual understanding after they had learnt the law using an interactive engagement approach. Furthermore, pre-test and post-test on Newton's third law of motion were given to the participating students before and after the intervention to determine their performance in Newton's third law of motion (Beer and Johnston, 1962; Jegede, 1997).

POSSIBLE SOLUTIONS IN DIFFERENT WAYS OF TEACHING

In search for teaching approaches that would yield a better conceptual understanding, Hake (1998) made a survey of 62 introductory physics courses with about 6500 students, where pre-test and post-tests results were available for the conceptual reasoning tests of Hestenes and Halloun (1995) (FCI, MD and/or MBT) (Hestenes et al., 1992; Halloun et al., 1995). The measure of the average normalized gain, $\langle g \rangle$ to determine the average effectiveness of a course in promoting conceptual understanding was grouped into three:

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"High-g" courses as those with $\left(\langle g \rangle\right) \geq 0.7$

"Medium-g" as those with $0.7 > \left(\langle g \rangle\right) \geq 0.3$

"Low-g" courses as those with $\left(\langle g \rangle\right) \geq 0.3$

Looking more closely into the instructional formats of those courses, Hake (1998) grouped them into two types of teaching: (i) Interactive engagement methods and (ii) traditional methods. He found out that teachers who made considerable use of interactive engagement methods in their teaching had students achieving a gain of 0.48, about twice those who were taught with the traditional method at 0.23. He classified interactive engagement methods as those designed at least in part to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities which yielded immediate feedback through discussion with peers and/or instructors. Those reported by instructors to make little use of interactive engagement methods, relying primarily on passive-student lectures, recipe labs, and algorithmic-problem exams were classified as traditional methods.

In this study, an interactive engagement approach was used in teaching Newton's third law of motion to 1st year university Physics students (students in the 2018 year of study) to help them gain a better conceptual understanding of the third law and to improve their performance. It has been observed that the traditional approach in teaching students Newton's third law of motion does not help improve students' conceptual understanding and performance (Ezeliora, 2005). Hence, the need to introduce real-life activities in interactive engagement manner in the teaching process.

Need for Improvement

The gap between the course goals and students' achievement in Newton's third law of motion usually reflects a corresponding gap between the instructor and the students (McDermott, 2001). This calls for the need to improve students' learning because:

- The ease in solving standard quantitative problems is not an adequate criterion for functional understanding. Questions that require qualitative reasoning and verbal explanation are essential for assessing student learning and are an effective strategy for helping students to learn
- The ability to connect concepts, formal representations, and the real world are often lacking on the part of students after traditional instruction. Students need repeated practice in interpreting and relating concepts and formal representations to the real world or physical phenomena
- Some conceptual difficulties are not surmounted by the traditional method of instruction. McDermott (2001) proved that certain conceptual difficulties continue to exist in spite of instruction. Persistent conceptual difficulties must be explicitly addressed in multiple contexts
- A coherent conceptual framework is not typically an outcome of traditional instruction. Thus, many students come out of introductory physics without having developed a coherent conceptual framework for important basic topics. Students need to participate in the process of constructing qualitative models and applying these models to predict and explain real world phenomena
- The growth in reasoning ability often does not result from traditional instruction. Scientific reasoning skills must be expressly cultivated
- Teaching by telling is an ineffective mode of instruction for most students. Students must be intellectually active to develop a functional understanding
- Testing/examination should change from the more quantitative-centered problems to more conceptually-centered questions. These will reveal how well students have understood concepts.

Purpose

In this study, we investigated the effect of real-life activities, microcomputer-based laboratory (MBL), (force sensor), and animations in the context of interactive engagement teaching to improve 1st year Physics students' understanding of Newton's third law of motion in a Ghanaian University.

Research Question

To what extent does the use of real-life activities, MBL (force sensor), and animations in an interactive engagement teaching approach lead to 1st year Physics students' conceptual understanding of Newton's third law in a Ghanaian university context?

Null Hypothesis

Ho1: There is no significant difference in academic performance of 1st year physics students after using real life activities, MBL (force sensor), and animations all in an interactive engagement manner in the teaching of Newton's third law of motion in a Ghanaian University context.

METHOD

Designing an Effective Teaching Approach on Newton's Third Law of Motion

After studying the literature, the following sequence of activities was used in the teaching of Newton's third law of motion: Concept quiz, conceptual reasoning questions (CRQ), interactive teaching, reflection, and application and problem-solving questions. The purpose of using these activities is summarized in Table 1:

Twenty 1st year university students were involved in the study. Most of them were 18 years old. The students who participated were informed about the study (informed consent) and they agreed to participate with confidentiality and anonymity of their real names appearing in the study. Students were given a reading assignment on Newton's third law of motion a week before the start of the lesson. On the day of the lesson, students were asked to answer selected questions on Newton's third law of motion as a pretest. Their marks were kept as pretest scores. To test students as to whether they come to class prepared by doing their reading assignment, they had to answer a concept quiz for 10 min based on the reading assignment. The teacher

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Table 1: Designing an effective teaching approach on Newton's third law of motion

Activity	Purpose	Interactive engagement approaches used
Concept quiz	To encourage students to do their reading assignment before they come for a lecture	Teacher-student discussion
Conceptual reasoning question	To evoke students' prior knowledge and create the need for further learning	Group and plenary discussion or think-share-present
Interactive teaching	To introduce new conceptual information to students	Predictive and explanatory questions and answers; microcomputer-based lab tools; simulations and animations
Reflection	To find out how students could connect the information to their prior knowledge	Group and plenary discussion or think-share-present
Application and problem solving questions	To see whether students have acquired problem solving ability	Group and plenary discussion; student-student and teacher-student interactions

discussed the questions with the students. The next activity was the CRQ, which was to evoke students' prior knowledge and create the need for further learning. Students discussed the CRQ in groups of four. Teacher-student discussions then followed for the teacher to know the kind of misconceptions/alternative conceptions students brought to the classroom. About 20 min was used for this activity. The next activity was the interactive engagement teaching (IT). Many interactive questions which would enable students to relate Newton's third law to real world experience were introduced. The use of a MBL tool to validate Newton's third law was also used to facilitate students' conceptual understanding. To make the IT contexts more meaningful, more examples relevant to daily life activities were used. About 40 min was used for this activity. The next activity was the reflection session, where students revisited the CRQ to either maintain or change their initial ideas after they had gone through the interactive teaching. Ten minutes were used for the reflection. Answering of application and problem-solving questions were the next activity to follow (30 min was used for this activity). The pre-test questions were again given to the students the next morning to answer the questions as post-test. The students' marks were kept as posttest scores. Students used 30 min each for the pre-test and post-test. Researchers used pseudonyms to represent the actual names of the students as they were assured of confidentiality and anonymity.

CRQ

The question used for the CRQ is shown below:

While driving down the road, a fly strikes the windscreen of a bus and makes a quite obvious mess in front of the face of the driver.

i. This is a clear case of Newton's … law of motion
ii. The fly hits the bus and the bus hits the fly. Which of the two forces is greater: The force on the fly or the force on the bus?
iii. Identify the action and the reaction force pairs.

The following was transcribed from one of the group discussions (all names are pseudonyms):

1. **Ben:** I think Newton's third law is occurring. Its the third law; every action there is equal and opposite reaction
2. **Chris:** They collide then, they will stick together, but when they are not equal they collide and…
3. **Bright:** What shows they stick together?
4. **Chris:** They said it created a mess… So let's decide on one
5. **Bright:** Me, I think based on the law, we must use equal but opposite... according to Newton's third law
6. **David:** So you are saying that none of them will exert a greater force?
7. **Chris:** We are assuming the bus, but he is saying that according to the law, it should be equal and opposite, so now argue out and then tell us, because I am confused. I know that of the car *(bus instead)* to be greater…
8. […]
9. **David:** The action is the bus while the reaction is fly
10. **Bright:** Fine… I think it's like that. Group of Chris, Ben, Bright, and David

During the interactive discussions, the following discourse ensued between the teacher and the students:

11. **Teacher:**… Bismark your group.
12. **Bismark:** Newton's third law of motion.
13. **[…]**
14. **Bismark:** Yes.
15. **Teacher:** What about Sam your group?
16. **Sam:** Newton's third law of motion.
17. **[…]**
18. **Chris:** Third law:
19. **[…]**
20. **Frank:** Third law.

During the plenary session of the CRQ, it was realized that all students could affirm the collision of windscreen and fly to be an example of Newton's third law of motion.

Although students could relate the interaction between the bus and the fly to Newton's third law, it was realized that, conceptually, some of the students had difficulty with the understanding of the third law. They did not see the forces involved in the interaction to be equal in size. They assumed that the higher the mass, the greater its force would be. The following dialog is a representative exchange supporting this claim:

21. **Teacher:** The fly hits the bus and the bus hits the fly. Which of the two forces is greater: The force on the fly or the force on the bus? Bismark your group

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22. **Bismark:** Sir the bus
23. **Teacher:** The force from the bus is greater? Yes Chris
24. **Chris:** The one from the bus
25. **[…]**
26. **Sam:** The force on the fly is greater.

As the discourse continued, some of the students became conscious of the fact that if action and reaction are opposite and equal in Newton's third law then the forces should be the same:

27. **[…]**
28. **Teacher:** And we are asking which of the two forces is greater? Is it the force of the fly on the bus or the force of the bus on the fly? Which one is greater?
29. **David:** Sir, are they not the same, since action and reaction are opposite and equal?
30. […]
31. **Teacher:**… Yes Frank...
32. **Frank:** We said both are equal.

Some students did not see action and reaction as forces. They saw action and reaction as two objects involved in the interaction:

33. **David:** (In a low tone). The action is the bus and the reaction is the fly…
34. **[…]**
35. **Fred:** The fly hits the bus, so he caused the action. And the bus responded the reaction.
36. **Teacher:** Okay, it does not matter. You can take any of them,… or vice-versa.

Looking at the fragments under CRQ, it was realized that the question did serve the purpose of evoking students' misconceptions and creating room for learning. Misconception of students was clearly displayed. They had the idea that when two objects collide, the bigger one always exerts the greater force.

Interactive Teaching

The major aim of teaching was to improve teacher-student interactions in class. More questions and examples were given to students to define and relate Newton's third law of motion to everyday activities in their community. Some students were able to give some examples of everyday life applications of Newton's third law of motion. This emphasized that what we learn in class should not differ from what we see in our immediate surroundings and that real-life examples are useful for the application of physics knowledge:

37. **Fred:** Sir, nailing. If you are nailing a nail into a wood. As you nail, the nail also exerts the same force on the hammer
38. **Victus:** Sir, kneeling on the wall
39. **Smart:** When you throw a ball to hit the wall. It bounces back
40. **[…]**
41. **Isaac:** When one fires a gun. The recoil force that is the reaction…
42. **Teacher:** Yes, the bullet moves forward, but the force that the bullet used to move forward, there will be the same force that will act on the rifle to move backwards…
43. **Chris:** Paddling a canoe. When you insert the paddle into the water you push it backward, that is the action and the reaction is the force of the water on the paddle to move the canoe forward
44. **Bismark:** Sir, swimming. As you are swimming you pull the water backward with your hand and the water will also push you forward.
45. **Frank:** Birds flying. They push the wind (demonstrating with the hands) and the wind pushes them
46. **A student:** When a rocket is moving up.

The teaching was more interactive, and students participated fully by giving more situational examples and everyday life activities on Newton's third law of motion. It made the teaching lively and students had numerous examples to give. This supports the claim that students' minds are not blank slates for information to be added. Activities that promote students being actively involved in the teaching and learning process, rather than passive recipients of knowledge, should be encouraged.

Although students could state Newton's third law accurately, it was still a problem for them to believe how a collision between a heavier object and a lighter object would exert the same size of force. The use of MBL was quite helpful in explaining this to students.

Demonstration of Newton's Third Law of Motion using MBL

The demonstration below deals with two objects having (i) the same masses as shown in Figure 1 and (ii) different masses as shown in Figure 2.

47. **Teacher:**…, what explanation can you give to this (referring to diagram of Figure 1 displayed on the screen of the computer after students have collided two carts of the same mass together Chris, can you explain, can you give us what you did?
48. **Chris:** Yes sir, we collided two of the… We are trying to… we are trying to verify Newton's third law, that in a collision, two forces, the reactant force, the reaction force and the action force, are equal
49. **[…]**
50. **Chris:** (Explaining F-t graph on the screen). We could see that, the graph shows in terms of magnitude that forces are equal. That is it, so now we will erase this and then collide a heavier mass with a smaller one

The next demonstration as seen in Figure 2 was when the two objects involved were of different masses:

51. **Teacher**: So by adding a heavier mass to one of them …? What do you want to show?
52. **Chris**: We want to show different masses, and find out if they will still give us equal and opposite forces after the collision
53. **Chris:** To increase this one's mass
54. **Teacher:** So they are no longer of the same mass?
55. **[…]**
56. **David:** That both F-t graphs are the same and in opposite

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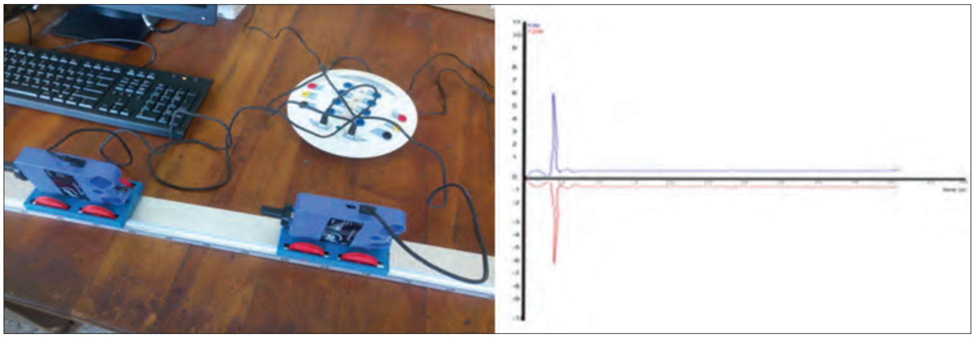

Figure 1: Two carts of equal masses are being made to collide.

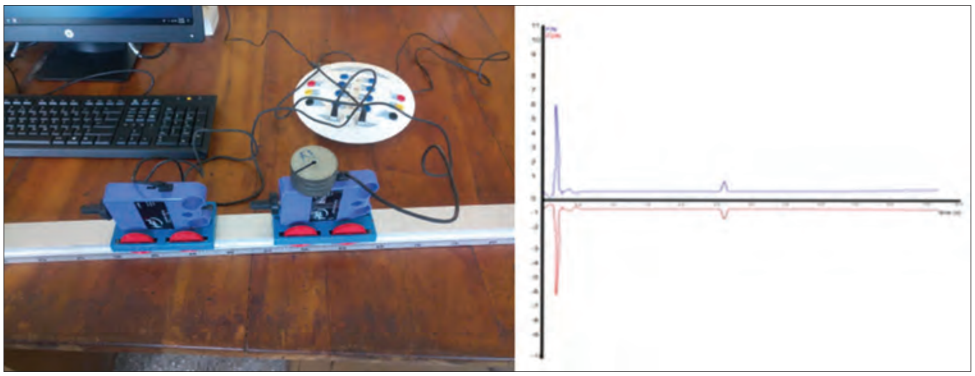

Figure 2: Two carts of unequal masses collide. One has additional mass added.

directions. That means to every action there is equal and opposite reaction

57. **Teacher:** So which one is the action and which one is the reaction?
58. **Bright:** Sir, we can take the force of this to be our action and the force of that to be our reaction (pointing to the diagrams on the screen)
59. **Some students:** Any of them can be the action and the reaction
60. **[…]**

The use of MBL to demonstrate Newton's third law to students convinced them that irrespective of the masses involved in the interaction, the size of the forces on each other would be the same:

Teacher:…, is it true that some of you were doubting initially?

61. **Some students:** Yes. (A student said, even me).
62. **Teacher:** What about this? Has this been able to convince you that the Newton's third law is true?
63. **Students:** Yes sir

At the end of the interactive teaching, it was evident that students were showing signs of understanding Newton's third law and could apply their understanding in explaining some daily life occurrences.

The demonstration on Newton's third law by the use of MBL (Coach 6 and force sensors) connected to a computer was an effective activity to support students conceptual understanding. They could see that the law was true.

Reflection

During reflection, students were very confident in responding to the CRQ. They were now convinced from what they perceived from the demonstration using the MBL. This is shown in the chorus response they made:

64. **Teacher:** (Teacher reads the CRQ again)… This is a clear case of Newton's…
65. **Students:** (Chorus answer). Third law
66. **Teacher**: …The fly hit the bus and bus hits the fly. Which of the two forces is greater; the force on the firefly or the force on the bus?
67. **Students**: (Chorus answer) Equal force

There was no major confusion during the reflection, as all the students were fully convinced of the fact that both objects exerted the same size of force.

Application Questions

In answering the application questions, some students stuck to the use of mentioning objects as action and reaction instead of "force with which one object acts or reacts on the other." Teachers need to lay emphasis on the fact that it is not the object, which is the action or the reaction, but the force of the object on another. An activity used to re-enforce this notion of forces rather than objects:

Identifying Action and Reaction Force Pairs in the following:

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(1a)

The ball pushes the stick rightwards

(1b)

Baseball pushes glove backward

(1c)

Bowling ball pushes pin backward

68. **Dan:**…, so throwing of the ball is the action and the hitting of the ball will be the reaction
69. **Teacher:** The throwing of the ball. It is not the throw. The action and reaction come into play when the two come into contact
70. **Dan:** So the ball is the action
71. **Teacher:** The force of the baseball on the stick to the right is the action and which is the reaction
72. **Dan:** The stick on the…
73. **Teacher:** The force of the stick on the ball to the left
74. **Dan:** The force of the stick on the ball to the left is the reaction

The teacher made an effort to guide students on how to explain action and reaction:

75. **Teacher:** A baseball pushes gloves backwards. So, which should be the action and which should be the reaction? Yes, another person, Bismark.
76. **Bismark:** The force of baseball is the action
77. **Teacher:** The force of baseball on what?
78. **Bismark:** On the gloves backward is the action,…, while the force of the gloves forward is the reaction
79. **Teacher:** On what?
80. **Bismark:** On baseball is the reaction
81. **[…]**

After the teacher's effort, one of the students answered the third question as they had been taught:

82. **Bright:** The force of the bowling ball on the pin backward is the action and the reaction is the force of the pin on the bowling ball forward
83. **Teacher:**… You have to explain, the force of this on that and the direction, remember the directions should be opposite, and this on that …will give you the action and reaction. I hope it is clear?
84. **Students:** Yes sir.

The questions were useful in allowing students to go a little further than the normal stating of the third law. This time the correct way of identifying action and reaction, which has been a major problem to the entire students was discussed.

Problem-solving Session

To make it more interactive, students were asked to work on the questions in the week before the session and present their solutions verbally or on the whiteboard for their peers to question, especially if they did not agree. The teacher remained as an observer and came in to clarify situations where necessary or tried to scaffold students' ideas, when he realized "bankruptcy" in their ideas, or to ask important questions sometimes.

The problem-solving session was used to supplement interactive teaching in the sense that, students who had questions during the interactive teaching period, but could not get the opportunity to ask, could bring them to the problem solving session for it to be discussed. Problem-solving questions were selected from *The Physics Classroom's* tutorials (see https://www.physicsclassroom.com).

Selected Questions on Newton's Third Law of Motion

The aim of question 1 was to find how students could apply their understanding in the demonstration of Newton's third law of motion with coach and force sensors during the interactive teaching to answer a real-life activity in a tug of war contest.

Q1. Paul and Josephine pull on opposite ends of a rope in a tug of war. The greater force exerted on the rope is by (i) Paul, (ii) Josephine, and (c) both the same.

Students could apply Newton's third law to choose the correct option of the force that is exerted on the rope by both people pulling on the rope:

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85. **Teacher:** Okay Frank, your question
86. **Frank:** It's "c"
87. **Teacher:** It's "c"
88. **Frank:** Action and reaction are opposite and …
89. **Teacher:** Equal, do you agree?
90. **Students:** Yes sir.

The aim of question 2 was to find how students could apply their understanding in Newton's third law of motion to the acceleration of a bullet and a rifle. It was expected that students would say acceleration would be equal for both the gun and the rifle.

Q2. Many people are familiar with the fact that a rifle recoils when fired. This recoil is the result of action-reaction force pairs. A gunpowder explosion creates hot gases which expand outward allowing the rifle to push forward on the bullet. Consistent with Newton's third law of motion, the bullet pushes backwards upon the rifle. The acceleration of the recoiling rifle is...

a. Greater than the acceleration of the bullet
b. Smaller than the acceleration of the bullet
c. The same size as the acceleration of the bullet.

In this question, it was realized that, some of the students thought both objects, with different masses, will have the same acceleration as expected, due to the fact that acceleration is directly proportional to force (Newton's second law), thus extending the application of Newton's third law wrongly:

91. **David:** The acceleration of the recoiling rifle is the same size as the acceleration of the bullet
92. **Teacher:** Do you agree?
93. **Students:** Yes sir
94. **David:** Sir, because the forces are the same, and since…
95. **Teacher:** If forces are the same, it does not mean that acceleration should be the same
96. **David:** Since force is directly proportional to acceleration.

The teacher capitalized on this question to explain to students why the acceleration would not be the same for cases where the masses are different:

97. **Teacher:**… Even what I have explained here should have given you the clue (Teacher was referring to an earlier explanation, so he moved to the board). Bullet and the rifle which one is heavier?

Force of rifle = Force of bullet

$$(\text{mass}_{\text{bigger}} \times \text{accel}_{\text{smaller}}) = (\text{mass}_{\text{bigger}} \times \text{accel}_{\text{smaller}})_{\text{bullet}}$$

98. **Students:** The rifle
99. **Teacher:** The rifle is heavier. (Teacher writes on the board). The mass of the rifle is bigger, so it accelerates very, very….
100. **Students:** Small
101. **Teacher:** And the mass of the bullet is…
102. **Students:** Small
103. **Teacher:** Very small, hence its acceleration is very, very fast. Do you get it? (Teacher explains it on the board).
104. **Students:** Yes sir
105. **Frank:** Even in reality it happens, you will see the bullet moving fast, while the gun moves slowly
106. **Teacher:** The "b," smaller than the acceleration of the bullet, will be the correct answer.

Students answered the first question on "tug of war" correctly. Perhaps discussions with their peers and the use of MBL to explain forces that were exerted on different masses of objects when they collided during the interactive teaching might have facilitated their understanding. However, they failed to answer the second question on "acceleration of rifle and bullet" correctly. The reason for their failure might have been that such examples were not considered in the interactive teaching.

RESULTS ON THE PRE-TEST AND POST-TEST

The pre-test and post-test scores were used to calculate for the gain that students have acquired in terms of their performance. The number of students involved in this study was 20. The average normalized gain used was

$$\langle g \rangle = [\frac{(\%\text{Posttest} - \%\text{Pretest})}{(100 - \text{Pretest})}]$$

This is shown in Table 2:

From Table 2, the average percentage pre-test score for the 100-level physics students was 32.5%. After the introduction of the real-life activities and examples in an interactive engagement manner in the teaching process, the students' average percentage post-test increased to 75.5%; average normalized gain $\langle g \rangle$ of 0.63. This normalized gain falls within the "Medium-g" as proposed by Hake (1998). Again, this value is relevant, in that it showed teachers who made considerable use of interactive engagement of students in heads-on (always) and hands-on (usually) activities which yielded immediate feedback through discussion with peers and/or teachers in their teaching helped improve students' conceptual understanding of Newton's third law of motion.

From Table 3, the result of the t-test showed that statistically there was significant difference ($t(19) = -17.403$, $\rho = 0.000$) between the pre-test and post-test mean scores. The post-test scores were gathered after the introduction of real-life examples and interactive engagement teaching. Therefore, the null hypothesis was rejected. Hence, it can be concluded that statistically there was significant improvement in students' conceptual knowledge and performance in Newton's third law of motion after using real-life examples and interactive engagement teaching.

CONCLUSIONS

Evaluation of students' in-depth analysis of classroom episodes showed that improved measures and conditions adopted in the materials and activities of the design led to an improvement in the learning of Newton's third law of motion by students.

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Table 2: Mean proportion correct scores of pre-test and post-test

Respondents	N	FCI, MBL, and physics classroom tutorial questions		
Students		% Pre (SD)	% Post (SD)	Gain (SD)
100-level Physics students	20	32.5 (3.10)	75.5 (2.10)	0.63 (0.90)

Table 3: Results of t-test analysis on paired samples of pre-test and post-test of students' knowledge in Newton's third law of motion before and after the use of interactive teaching

Test	Mean	SD	t	df	ρ
Pair 1 pre-test – posttest	–8.600000	2.21003	–17.403	19	0.000

Classroom interactions had been enhanced, mastery of content and quality of reasoning in solving qualitative problems had improved. Furthermore, students' performance in Newton's third law of motion had improved significantly.

RECOMMENDATIONS

The following recommendations were made from the findings of the study:

Interactive engagement teaching improves students' performance in Newton's third law of motion. Students were coming out with various reasons to support their responses to questions. It is, therefore, imperative as teachers to engage our students through interactions to give them the opportunity to voice out what they think about issues, rather than giving them what they need to know about concepts. When we interactively engage with our students, we easily depict their misconceptions and guide them to come out with the correct concepts.

Interactive engagement teaching improves students' performance in Newton's third law of motion. Thus, through interactive engagement teaching students get to know what concepts are supported by scientific facts, they renounce of the misconceptions they carry to class. For example, when students realized that irrespective of the sizes of the materials involved in collision, the force exerted on each other was the same, they renounced the idea that larger objects would exert greater force. Hence, they answer questions related to Newton's third law of motion with correct conceptual understanding, which goes to improve their performance

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