Using Real-Life Activities in an Interactive Engagement Manner in the Teaching and Learning of Newton's First Law of Motion in a Ghanaian University

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Abstract
Most Ghanaian university physics students depend on rote learning and rote problem solving, without having the conceptual knowledge of concepts that are being studied. This is so because the Ghanaian style of setting and answering of questions favour those students who have the ability to do rote memorization of learning. The instructors start physics (mechanics) teaching by first introducing the topic and lecturing on general principles. They then use the principles to derive mathematical models, show illustrative applications of the models and give students some practice question(s) in similar derivations and finally test their ability to do the same during examination. Little or no attention is paid to the question why any of that is being done, what real world phenomena the models can explain and which practical problems can be used to solve them. Ghana cannot afford to follow this trend, where the youth seem to lose their interest for understanding the concepts of physics and other science subjects in our universities and schools. The advances in physics provide human beings with the ability to achieve greater and more in-depth understanding of nature. In this study, real-life activities were used in an interactive engagement manner in the teaching and learning of Newton's first law of motion in a Ghanaian lecture room. The analyses of teaching and learning processes that were videoed and transcribed showed that students' involvement or interactive engagement in class led to enhance their conceptual understanding of the concepts of Newton's first law of motion.
Keywords: Ghanaian university, Newton's first law, interactive engagement, real-life activities

1. Introduction

Studies have shown that most students depend on rote learning and rote problem solving, without having developed the conceptual problem solving skills that all scientists value (Mazur, 1997; McDermott, 1993). Such difficulty usually goes unnoticed because students can solve many standard problems in spite of the difficulties; they are talented and have memorized rules that are often true.

Newton's three laws of motion are considered important in the teaching of the physics, especially Mechanics. Most students can easily recite the laws without necessarily understanding the concepts of these laws. Hence application or linking of the concepts of Newton's three laws of motion by students becomes a problem. Perhaps due to the traditional lecture approach which is quite often the mode of teaching in most of the Ghanaian schools (Cashin, 1990). Reports from the chief examiner of the West African Examination Council (WAEC), (2002; 2004; 2008) laid emphasis on the fact that teachers teaching the sciences, especially physics, should improve their methods of teaching. He suggested that teachers have to put in a lot more effort in their teaching methodology. They have to adopt new strategies so that physics becomes a friendly and less abstract subject. As remedies to poor knowledge of the subject, inability of the students to go beyond stating definitions and avoidance of questions requiring deductive-thinking, he said that teachers should involve students in the teaching and learning process to enhance students' understanding.

In this study, real-life activities will be used to design instructions in Newton's first law of motion on Ghanaian first year University Physics students in an interactive engagement manner. The teaching and learning process will be videoed, transcribed and analyzed to see how students' involvement or interactive engagement in class could lead to enhance their conceptual understanding of the concepts of Newton's first law of motion.

2. Related literature

2.1 Traditional approach versus Interactive engagement approach

To some educators, the traditional lecture approach to teaching is ineffective as compared to active learning methods (Marbach-Ad, Seal & Sokolove, 2001; Jungst, Licklider & Wiersema, 2003). According to Covill (2011) and Meltzer (2005), methods that promote active learning by students are based on the constructivist's view that, for meaningful learning to take place in students, they must be actively engaged with the to-be-learned subject matter through discussion, hands-on activities and problem solving.

According to advocates of the use of interactive learning methods in teaching, the lecture method is unidirectional: from the teacher to the students, and has the major weakness of allowing students to become passive recipients of information that has been rendered in a simpler form by the teacher (Hansen & Stephens, 2000). They become fully dependent on the teacher to tell them what they need to know, and as a result do not become responsible for their own learning (Machemer & Crawford, 2007). Such students by virtue of familiarizing themselves by the constant practice of being passive in class have low tolerance for challenge. And according to proponents of an active engagement style of teaching, learning on the part of students through lectures is relatively superficial and transient (Moust, Van Berkel & Schmidt, 2005). Thus teachers should adopt methods that will enhance students' participation and understanding during teaching and learning by relating physics examples to their environments and real life activities, and allowing students to have practical experience like the use of microcomputer based laboratory (MBL) tools.

2.2 Lack of students' participation

Research consistently has shown that traditional lecture methods, in which lecturers talk and students listen, dominate college and university classrooms (Bonwell & Eison, 1991). It had been once said that a foreign chemistry instructor who wanted to involve his students in one of the secondary schools in Ghana by asking so many questions, was misconstrued by students and reported to the head of the school, that the concerned instructor did not know his "stuff". They assumed that he had to ask so many questions for clarification from them.

Students usually find it quite difficult to participate in class. They prefer to receive all information from the instructor rather than to contribute. In few occasions when instructors ask questions in the lecture halls, it is likely not to get any response from students, because they either feel shy, not used to it, or afraid of getting the answer wrong, which might be felt as endangering their reputation in front of their peers. Students should not be blamed alone: the lecture method applied by most teachers does not give way to students to actively contribute or participate in class. Perhaps the risk that class time is too limited, a possible increase in teacher's preparation time, being criticized for teaching in unorthodox ways or the fear that students will not learn sufficient content, might be reasons why teachers find it difficult to allow students to participate, and thereby stick to the lecture method (Bonwell & Eison, 1991).

Research has proved that allowing students to interact or actively be engaged through discussion could promote long term retention of information, motivate students towards further learning, allow students to apply information in new settings and develop thinking skills in students (Mckeachie, Pintrich, Guan & Smith, 1986). Consequently, most students leave physics courses with no confidence that they have acquired working tools which can be flexibly put to use. They sense that they lack the flexible knowledge and skills required to put scientific training effectively to work and to use scientific knowledge productively.

2.3 What to do to improve science teaching?

According to McDermott (1991), evidence indicates that for many students the standard introductory courses are not effective in helping to achieve the kinds of intellectual objectives under discussion. Ease in using technical vocabulary does not indicate conceptual understanding. The ability to follow certain prescribed procedures for solving standard problems, which most of our students do, does not indicate development in scientific reasoning skills.

The improvement of physics and science teaching and learning at all levels of education, requires a teacher programme that emphasizes scientific inquiry and knowledge construction by students themselves as the fundamental goals of science education in Ghana. By the use of scientific inquiry we instil in students developing inquiry skills to construct their own knowledge to explain their social, physical and biological worlds (Fredua-Kwateng & Ahia, 2005; Hassard & Dias, 2009). In so doing students become part of the teaching and learning process. The focus of science instruction should be on the Ghanaian environment. This will help the students to have better understanding and apply knowledge and skills in different situations when the need arises. For example, if students understand the relation of braking distance to the speed of a moving vehicle, they could reconsider their view in unnecessary speeding when driving, especially when they do not see the relation as only a formula.

It is being anticipated that when the culture of science teaching becomes well entrenched by students' involvement at all educational levels in Ghana, it would help to remove the myth that learning science requires students to have special brains. Students would then engage in fruitful debates and discussions based on their observational findings, conjectures, and experiments. Students would be encouraged to work collaboratively. They would ask critical questions and subject claims to verification rather than absorb information pushed down their throats (Omosevo, 1999; Klem & Connel, 2004). Students would be attentive to and try to construct scientific knowledge about what their parents and relatives do at home and in their community.

3. The purpose of the study

This study is meant to design and evaluate teaching strategies in Newton's first law of motion that will make students participate in the teaching, improve interactions (student-student and teacher-student) in the teaching and learning processes and also help them to understand concepts and to improve their problem solving skills especially in qualitative questions (Chief examiner's report, 2008). The study will analyze data to see how students' involvement or interactive engagement in class could lead to enhance their conceptual understanding and qualitative problem solving skills. The focus of the study is on prospective physics teachers in Ghanaian universities.

4. Research question

"How could the understanding of Newton's first (1^{st}) law of motion be promoted using real-life activities in an interactive engagement manner among undergraduate physics students in the Ghanaian educational and cultural context?"

5. Research setting

The research was carried out in the Department of Physics Education, University of Education, Winneba (UEW). Participants in the study were all first year UEW students who took the introductory mechanics course in the first semester. There were 17 students involved. The lecture room was equipped with 16 computers and white board. The room was furnished with laboratory benches and stools that supported the number of physics students who took the mechanics course. The fixed nature of the benches made group discussions more difficult to arrange but students managed when there was the need to do so.

There was a camera assistant in the classroom who helped in videoing both plenary discussions and group work. Since there was a limited staff capacity in the physics education unit and the research was specifically about the researchers own field of teaching, the researcher was the teacher of the course.

6. Method

In the didactical structure, the following activities were considered: concept quiz, conceptual reasoning questions (CRQ), lecture/interactive teaching, reflection, application questions and tutorial/problem solving questions.

The first element of the didactical structure to consider was the concept quiz. Though it was part of the didactical structure where students answer some few questions on the topics to be considered, its major function was to encourage the students to do their pre-preparatory reading before the lecture. The next to follow was the conceptual reasoning question. It was to induce in students a sense of purpose to study the topic at hand, activate their prior knowledge and to provide them with a sense of direction as to where the study will lead them to. Next on the line was interactive teaching. In this type of teaching the teacher provided new information on real life situations to students to help them identify their wrong answers and invited their contributions. After the interactive teaching the students were allowed to reconsider their initial ideas based on the new knowledge they have gained from the teaching. This session was called the "reflection". The next stage was the application question session. Here a new task but similar to what has been taught in various activities was given to students to find how they would either apply or transfer their new knowledge to solve problems. Tutorial/Problem Solving was the last session, where selected questions on the topics treated were given to students to solve with their peers and come to class to explain or provide answers to the various questions for the teacher to see whether students had followed the right track.

7. Analysis of data

7.1 Concept quiz on Newton's first law of motion

The aim of the concept quiz was to ask some questions that students could answer successfully if they had done their homework reading. Some of the concept quiz questions were selected from Mazur (1997).

Question	Proportion correct sc.
(1) Which of these laws is identified with Newton's first law of motion? (a)Action is reaction, (b) object at rest stays at rest, (c) All objects fall with equal acceleration, (d) F=ma.	0.81
(2) The law of inertia (a) is not one of Newton's laws of motion. (b) expresses the tendency of bodies to maintain their state of motion. (c) is Newton's third law.	1.00
(3i) State Newton's 1^{st} law of motion.	0.79
(ii) A coin is held on your elbow, while the palms of your hand is open. Your arm is held in such a way that it is parallel to the floor so that the coin will not fall off. In a sudden, very quick move, the arm is dropped and your open hand snaps forward to catch the coin. Which of the Newton's laws best explains why the hand was able to catch the coin, after the arm was dropped? *(Teacher demonstrates the activity for students to see)*	0.27

The concept quiz questions on Newton's laws of motion were clear with some unequivocal options given to students to select the right answer. There were no extended discussions to cause delay. The questions did fit well with students' reading assignment, and as a result students had 0.72 mean proportion correct score. Students' low performance in question 3(ii) might be due to the difficulty in relating Newton's first law of motion to everyday activities like the one described in the question:

1. Teacher: *(Teacher reads question 1)* Which of these laws is identified …
2. A student: A
3. Most Students: *(Chorus)* B.
4. […]
5. Teacher: The law of inertia is *(Teacher reads through the answers)*… Which is which?
6. Students: *(Chorus)*. "B" *(expresses the tendency of bodies to maintain their state of motion)*.

On stating Newton's firs law of motion, it was realized that students had fair knowledge on it, as they were able to state it correctly and in different forms. This leads to suggest that, the question did fit well with the students' reading assignment. Another reason for easily stating Newton's first law could be that students are usually good in defining terms, stating laws and principles as well as quoting formulas.

7. Teacher: State Newton's 1st law of motion. Yes Isaac.
8. Alex: It states that a stationary body continues to be stationary and a body moving will continue to move with uniform speed in a straight line unless compelled by some resultant force to act otherwise.
9. […]
10. Smart: Yes, … but I wanted to find out if somebody states that "… move with uniform velocity …" to replace "uniform speed in a straight line", the person will be marked correct.
11. […]
12. One of the students: Sir what about if somebody says"… unless an unbalanced force acts on it to change its state of motion".

On question 3(ii), the real life activity on Newton's first law of motion, a student was able to use inertia to explain. There was no challenge from the other students, as they were in agreement with the answer provided by their colleague. The fragment below indicates that:

13. Teacher: *(Reads the question).* A coin is held on your elbow, while the palms of your hand is open. Your arm is held in such a way that it is parallel to the floor …?
14. Some students: *(Some said)* The 3rd law, *(others also said)* the 2nd law and the 3rd law, *(others)* all the three laws.
15. [...]
16. Teacher: Yes Smart.
17. Smart: It is the 3rd law because when the coin is placed at the elbow, the action is from the coin and the reaction is the elbow and they are in opposite direction.
18. Teacher: Do you all agree?
19. Students: *(Chorus)* Yes sir. *(Some of the students)* No sir, all the three laws will apply here
20. Bismark: Sir, I think inertia will delay the coin a bit, and it will not move with the elbow, that is why the hand was able to catch the coin. Inertia is Newton's first law of motion, so it is Newton's first law of motion.

From the answers given by the students in discussing the questions of the quiz, it was realized that students did their reading assignment and the questions did fit well within the assignment. The questions were more understandable to students with exception of the 3(ii), where majority of the students identified the activity with Newton's third law of motion and all the three laws of Newton.

7.2 Conceptual reasoning question

The conceptual reasoning question (CRQ) was intended to give the teacher insight in the current status of students' understanding in Newton's first law and to create the need for further learning.

To dislodge ketchup from the bottom of a ketchup bottle, it is often turned upside down and thrusted downward at high speeds and then abruptly halted. Which of the Newton's laws of motion explains the reason why the ketch up would still continue in motion when the bottle was halted? Explain.

In line with the aim of CRQ, it did evoke different understandings or interpretations. First of all, students creatively invoked all the three laws, but often it was hard to trace the specifics of their reasoning. The following data are from the plenary discussion that followed the groups' work:

21. **Bismark:** Sir, we chose all the 3 laws.
22. **Teacher:** … Why?
23. **Bismark:** In the first law, a body will remain at rest unless external force is applied to it. The ketchup was inside the bottle and it was at rest. So when you turn it like this *(demonstrating upside down)*, that means the first law has taken place. And then you shake, then you give the ketchup force… you have exerted force on the ketchup for the ketchup to come out. So in this case we think the first law can apply here. And the second law too, action and reaction are opposite.

24. **Students:** It's the third law.
25. **Bismark:** Okay. … And the 2nd law, …since there is a high speed and then it stops, there is a change here, so the 2nd law the rate of change of momentum ... can be applied here. And when we come to third law, ..., since we are applying force, force that we apply, the ketchup will also react by coming out of the bottle.

Others also thought the first and the third law could be applicable. They seemed to apply their previous knowledge in physics, but it did not seem to connect well, especially with the use of the third law. Frank who seemed to understand the process did invoke the wrong law:

26. **Victus:** Sir, actually we had two ideas. It's like the ketchup when it is in the container and you try to move it down *(demonstrating the process)*, and it doesn't want to come out. It's like the tendency not to move. But when you suddenly stop it, it jerks forward so comes out. So I concluded that it's the first law.
27. **Teacher:** What is the other one? You said you had two reasons.
28. **Smart:** That is the third one. In the course of the third one, we said action and reaction is equal and opposite in that, eh, when we were trying to dislodge the ketchup, you realized that as it was turned down and we exert, we move it suddenly, the bottom of the container will exert force on it, and the ketchup will also exert upward force on it. But the moment you suddenly stop, the ketchup will get dislodged. So…
29. **[…]**
30. **Smart:** And when you stop, all of a sudden it will move down. The ketchup will get dislodged.

Although the original question had been focused on the moment of halting the bottle "why will the ketchup continue its motion?" some students extended the discussion to the entire motion, thus making the discussion more confused.

However, one of the groups was able to connect the phenomenon to Newton's first law of motion. One student in the group initially connected the explanation to the first law alright, but failed to give a clear explanation of the effect of the continuous movement of the ketchup when the bottle was halted. A colleague from the same group gave a meaningful explanation to that effect. The fragments below did indicate that:

31. **Alex:** I said a body that is at rest, will stay at rest, and a body that is in motion will continue in motion in the same direction unless external force acts on it. So here when they dislodge, when they turn the bottle upside down, it will move in the same direction at constant speed. So when it is being halted it will continue to be in the same direction but the speed will not change.
32. **[…]**
33. **Sam:** As he was saying, so we took Newton's first law. The ketchup in the bottle will be moving with the same speed with the bottle. So when the bottle is halted, the ketchup will continue with the same speed that is why the ketchup gets out of the bottle to the…

From these observations, the correct answer is not evident to all. The question for a final answer remains– which is in line with the aim of CRQ. It had also revealed some misinformed knowledge from students from their senior high schools and that creates the need for further learning.

7.3 Interactive teaching

The interactive teaching started with an interactive question, asking students to state Newton's first law, which they did easily. This was not surprising because students are used to memorizing definitions, stating of laws and principles, quoting and manipulating formulas to solve for unknown variables:

34. **Amoah:** It states that an object which is at rest will always remain at rest, and then an object which is in motion will always continue in motion when a net force is not applied to it. So an object will remain at rest or continue in motion in a straight line when no external force acts on it.
35. **Teacher:** Yes, it's an object being stationary or moving, but moving with what?
36. **Amoah:** With constant speed.

The teacher showed an animation of a driver who came out of his car for failing to wear his seat belt, after hitting the car against a wall. The teacher built on this to explain Newton's first law (inertia) of motion to students.

In the next question, some of the students could develop a clear idea of what will happen but could not apply physics vocabulary correctly, there was also no explicit connection to the first law:

When you fill a cup of water to the brim, put it on cart and move around an oval track making an attempt to let it complete a lap in the least amount of time. (i)What will happen to the water in the cup?

37. **David:** When you are going round the track, since it is curved, the water will fall *(in a low voice),* maybe some of the water will split *(wanted to say spill)*... Water will split, since you are changing direction, since we are changing the acceleration... Some of the water may fall.
38. **[…]**
39. **Victus:** When you are accelerating, maybe the cup, the water does not want to come out, it wants

to stay where it is, so that when you move the cup, the cup moves forward and the water stood behind you... The water will try to move to the other side of the....

40. **Teacher:** … Yes Isaac.
41. **Alex:** Sir, I learnt since you are just moving round it and you haven't attempted to push the cup with the water, it will still remain in the cup.

However, there was one student who could correctly say what would happen to the water in the cup:

42. Chris**:** As you keep moving round the circle, the water will be spilling on the other side of the track *(using his hand to point towards the direction of a tangent).* …

On asking some daily life occurrences, students could connect the knowledge gained in understanding Newton's first law to explain both situations.

(i) Why is it that the head of a hammer can be tightened onto the wooden handle by banging the bottom of the handle against a hard surface?

(ii) Why is it that blood rushes from one's head to one's feet while quickly stopping when riding on a descending elevator ("lift")?

43. **Bright:** We are always trying to tighten the head.
44. **Teacher:** How does it get tight? I mean, ... what makes it so tight? ...
45. **Smart:** Newton's first law is implied, being that as you move it, and you are moving it downwards, both of them *(referring to the metallic part and the wooden part)* in motion, that is the same velocity, the moment it strikes the hard surface, the wood itself stops but the head would like to continue, so it moves down ...
46. **[…]**
47. **Chris:** The body contains the blood and they were all in motion with the lift at first. When your body and the elevator suddenly stop, the blood still being in that motion will try to push down as you were going downwards, so it will come down...

Here, it was realized that students had the idea, but how to put them into convincing statements was the problem. They were trying to link their previous knowledge with the situation but it hardly connected:

A man is being chased by an elephant in the forest, who attempted to photograph it. The man makes a zigzag pattern to his advantage. How does this zigzag movement help the man for not being caught by the elephant?

48. **David:** ... Because the elephant is too big, since the man doesn't have mass like the elephant, he can move in that zigzag.
49. **[…]**
50. **Dan:** He did so because as he moves this way *(demonstrating with his hand)* in a zigzag manner, the force that it will need to stop, or the time it will need to stop and change direction, he would be able to double the gap. Because the elephant will need a greater time to stop and then change...

Meanwhile one of the students was able to connect his previous knowledge on inertia to give a correct explanation:

51. **Sam:** So as we are dealing with inertia, because the elephant is more massive it will resist the change so it will move with a constant speed in a straight line, so as the man is changing its this thing *(using his hand to demonstrate the zigzag direction)*, the elephant will not be able to move in that way, because of its massive mass.

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

The interactive teaching material was good in helping students to explain some real life occurrences in relation to Newton's first law. It brought more teacher-student interactions, and students gained good understanding of the law. The questions in the teaching served as a guide to the teacher to see how students were following and understanding what he wanted to impart to them.

7.4 Reflection

The aim of the reflection was to give students another chance to either discuss CRQ in groups or provide individual answers depending on their conviction of the knowledge gained in the interactive teaching to polish up the initial answers, especially, after they had failed to provide a reasonable answer to the CRQ at the beginning.

All the students could attest to the fact that the question could be explained by Newton's first law of motion (inertia), though some could not support the answer with a correct physics explanation.

52. **Dan:** Sir, first law.
53. **Teacher:** First law, initially you said all the three laws, your group in particular; you said all the three laws. Now why are you saying it is the first law?
54. **Dan:** Sir, because the first law is saying that the body continues to be at rest and then it also,..., it

will be at rest when it is at rest and then moves in a straight line if it is moving in a straight line. It will change if only an external force is acted upon it. The ketchup was initially at rest, which means it has obeyed the first law. And it only changed the direction when the external force was acted on it that is when it was turned upside down. It followed the direction that the external force acted on. That also obeyed the first law. So I think it is the first law.

55. **[…]**
56. **Bismark**: The ketchup is inside the bottle and it is at rest, so it needs external force to exert, to force it to move.
57. **[…]**
58. **Bismark**: As it is moving, it moves with the bottle. To cause it to move it has obeyed the first law. Moving from rest to another position, the changes here...

The teacher had to use leading questions to guide (scaffolding) one of the students to come out with the reasons for the ketchup to come out when the bottle is halted abruptly.

59. **Fred**: Sir, you were pushing it down, but as you stop the ketchup in the bottle will still be in motion.
60. **Teacher:** What is in motion with the bottle?
61. **Fred:** The ketchup in the bottle.
62. **Teacher:** The ketch in the bottle is in motion with the bottle?
63. **Fred:** Yes.
64. **Teacher:** So as you stop...
65. **Fred:** So as you stop the ketchup will still be in motion.
66. **Teacher:** Because of what?
67. **Fred:** Because of inertia…
68. **Teacher:** Inertia is saying what?
69. **Fred:** Inertia is saying that an object will want to resist anything that will..., if it is motion, the tendency for the ketchup to continue in motion.
70. **Teacher:** Do you agree to Fred's explanation?
71. **Students:** Yes sir.

No major confusions appeared this time and less than the stipulated time was used. This suggests that students had changed their initial ideas.

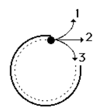
This activity was necessary to reveal to the teacher whether students would still hold on to their initial answers, which would have called for further explanation.

7.5 Application question

The aim of the application question was to allow students to try similar but new problems to see how effectively they apply the knowledge gained to solve problems.

The question used was to sharpen students mind on Newton's first law as regards motion in a circle.

A group of physics teachers are taking some time off for golf. The golf course has a large metal rim which putters must use to guide their ball towards the hole. Mr. Boakye guides a golf ball in the metal rim. When the ball leaves the rim, which path (1, 2, or 3) will the golf ball follow?



Most of the groups opted for path 2, and were able to use Newton's first law of motion to support their choice. The groups analyzed the law rightly as the ball moved through the rim and the path that it took when it came out of the metallic ring:

72. **Frank:** We said 2.
73. **Teacher:** You chose 2. Why 2?
74. **Frank:** At the first instant when the ball was kicked, it would have moved in a straight line, but since there was something to guide it as it tries to move in a straight line, the, the ring tries to change the direction of the motion. At a point in time when it gets to the point where there is nothing to guide it, it is going to move in a straight line.
75. […]
76. **Bright:** We also chose 2.
77. **Teacher:** Okay. Ben, explain why did you choose 2?
78. **Ben:** We chose 2 because the body was moving with an initial, ... We said as it continues to move, because the ring was guiding the ball, it has to move in that same direction, but when it reaches the free range, the relunctancy for it to stop or move in that circle, will not be so because the ring is no more there. It therefore continues in a straight line *(using his hand to demonstrate the straight path).*
79. **[…]**
80. **John:** Sir we chose 2.

81. **Teacher:** Why 2?
82. **John:** This is because, you know at first the ball was moving on a circular path, so it was being guided by that circular ring to have that motion. But the moment that it will reach where the ring had been cut, there is no circular ring, then it means it must move along a straight line because of that empty space over there.

However, one of the groups applied Newton's first law wrongly during the group discussion: They assumed circular motion for Newton's first law of motion:

83. **Obed:** Looking at this, the golf ball was played in a circular motion, it will continue with the same circular motion. And since it was in the same motion, and even as it is in the ring it keeps on changing direction.
84. **Dan:** Is the ring guiding it? Is the ring guiding it to be in the circular motion?
85. **Other members:** Yes.
86. **Dan:** If the ring is helping it to be in the circular motion, now the ring is not there, so what is going …
87. **Fred:** Eeh, but since it wants to obey the law of inertia, so it will continue to be in this motion. Because, it wants to obey the law of inertia.
88. **Dan:** Really, eeh, theoretically, but practically I think it doesn't happen.
89. **Obed:** Looking at the athletics game, those who throw …
90. **Fred:** Discus.
91. **Obed:** Yeah, they go round, round, round and then they release it.
92. **Dan:** But when they release it, the thing doesn't go round, or does it go round? It goes straight. It will be turning this way but it moves straight.
93. **Fred:** Yes, you see, it is still on the "round motion". When it is going…
94. **Dan:** So it is round and it will be moving down.
95. **Bismark:** Yes, so it will still be on that motion.
96. **Obed:** Or you are still arguing *(all of them laugh).*
97. **Dan:** We are not arguing, this one we are discussing.
98. **Obed:** *(Trying to explain using local language)*. This is different from shot put.
99. **Fred:** Because as for shot put it goes straight.
100. **Dan:** The shot put will go straight even though you can be doing your …
101. **Obed:** The intention is that they want it to go a longer distance…
102. **Dan:** That is why they move round?
103. **Other members:** Yes.

From the group of Obed, Dan, Bismark and Fred

They understood the first law to mean "the continuation of motion as it has assumed earlier" without considering the "… in a straight line in the absence of the external force" of the law. Below is the response of Obed's group during plenary discussion:

104. **Dan:** Sir, we chose 3.
105. **Teacher:** You chose 3, why 3?
106. **Dan:** We are looking at the fact that it will like to continue in the circular motion.
107. […]
108. **Teacher:** … when they hit the golf ball, it should have moved in a straight line with a uniform speed but because that circular ring was there it would make it move in a circular form. But when it gets to the portion where there is no ring, then in that range it continues to move in a straight line, as has been explained by the other groups. Theirs go in line with what Newton said in his first law that the object will continue to move in a straight line, when there is no external force to act on it. I hope it is clear.
109. **Students:** Yes sir.

The fragment here is informative to teachers, in the sense that they may expect this kind of thinking from their students. The teacher realizing that some students were including circular motion in Newton's first law, compared the reasonability in the views of Ben (78) and John (82) to that of Dan (106), and used their ideas to explain, laying emphasis of the straight line movement in the first law, especially with the absence of force.

Students' response to the application question was better in the sense that most of the students could choose the right path for the golf ball when it came out of the metallic rim, and could give a meaningful explanation to the choice of their answer, contrary to what happened in the first round. Only one group had it wrong. This shows that a majority of the students could apply or transfer the knowledge gained in the interactive teaching to solve similar but new problems.

The material is good in revealing how students used their understanding of Newton's first law to explain situations when something comes out of a circular motion. This idea could be transferred to explain such occurrences in real life activities, for example, the direction of motion of a substance, when the rope which is used in whirling is cut.

7.6 Tutorial/Problem solving session

Tutorial or problem solving was a session where students came to class to solve/discuss some selected problems on Newton's first law of motion, mostly on qualitative questions linking to real-life activities with the teacher.

Q1. A coin was put on a card and placed on a glass. Why will the coin drop into the glass when a force accelerates the card?

A student applied his own understanding, but did not relate it to inertia:

110. **Isaac:** I am saying, if the upward force is taken away then acceleration will act on the coin to fall.

However, the answer was improved by another student by applying Newton's first law of motion:

111. **Chris:** To add to that, the coin will like to retain its state of rest since the acceleration is applied to the card. The coin will like to remain at that state. So while it still remains here because the other force is going the other way, it will drop because the force of gravity is pulling down on the coin.
112. **Teacher:** And why will it like to stay in that position?
113. **Chris:** Because of Newton's 1st law, inertia. The tendency to resist change of motion.

Students have improved in applying inertia to real world activities. They have better linked the explanation with inertia than they did initially with the conceptual reasoning question in Newton's first law of motion. Also, their answer this time is much more improved than when it was used as one of the conceptual reasoning questions (CRQ) in the previous year.

Q2. Two bricks are resting on edge of the lab table. Victoria stands on her toes and spots the two bricks. She acquires an intense desire to know which of the two bricks are most massive. Since Victoria is vertically challenged, she is unable to reach high enough and lift the bricks; she can however reach high enough to give the bricks a push. Discuss how the process of pushing the bricks will allow her to determine which of the two bricks is most massive. What difference will Victoria observe and how can this observation lead to the necessary conclusion?

A student applied his knowledge in relationship of mass and inertia (tendency of an object to resist changes in its velocity):

114. **Rex:** So in order for her to determine the most massive one, when she gives them the slightest push,… The slight push, the one that will rise with the most opposing resistance. That will be the massive one. ...
115. **Teacher:** The one that will do what?
116. **Rex:** That will, eh, resist the greatest change, that will be the massive one.

Students have improved in their reasoning by extending their understanding in Newton's first law of motion to solve problems that require an application of the law. This reflects how students could transfer their understanding in Newton's first law to solve problems.

Q3. Supposing you were in space in a *weightless environment*, would it require a force to set an object in motion?

A student who understood "weightlessness" to mean a body without weight, answered the question wrongly. He was, however, salvaged by another student:

117. **Ben:** Sir I think weightless bodies are not affected by force of gravity.
118. **Teacher:** No, it says, supposing you were in space in a *weightless environment*, would it require a force to set an object in motion? That is the question.
119. **Ben:** My answer is no.
120. **Teacher:** Yes who has got a different answer? *(Some students raise their hands)*. Yes.
121. **Isaac:** I will say, yes, because even in space bodies have mass. So if it has mass, it will require a force to set it in motion.

Though the answers provided by students to this question in both first and second rounds were similar, students were able to argue in line with Newton's first law of motion more than those in the previous year.

Q4. If the forces acting upon an object are balanced, then the object could (a) not be moving. (b) be moving with a constant velocity. (c) not be accelerating. (d) none of these. *(Choose those that could be possible).*

Students could identify the effect of balanced forces on an object:

122. **Victus:** Sir if the forces acting on the object are balanced then the object could not be moving and I say for "a" it can be moving but not always moving. Because when you consider an object on a table, when the forces are balanced the object can be, the object would be at rest. But when you consider an object falling, when the object reaches a point when the forces on it are balanced but it is moving with a constant velocity but it is still moving. Could not be accelerating. So it is not necessarily "d". So sir, could be moving with a constant velocity.... "a", "b" and "c".
123. **Teacher:** "a", "b" and "c". Do you agree to that?
124. **Students:** Yes sir.

125. **Teacher:** Hei Evans, do you agree to that?
126. **Evans:** The "b" is correct alright, but I also think the "a" is also correct. *(He waited for a while)* Yes a, b and c.

Students could now appreciate the fact that when the total force acting on an object is balanced, the object could move with a constant velocity, which was a bit difficult for them to understand during the interactive teaching.

Students were more able to argue in line with Newton's first law of motion. They could answer questions by applying and transferring the knowledge acquired on Newton's first law of motion (inertia). However, some conceptual difficulties still remained. For example, students found it difficult to understand the "weightless environment" as they applied different interpretation to that.

8. Conclusions on Teaching Newton's first law of motion

The materials used in the concept quiz were good in assessing students' reading assignment on Newton's laws of motion. They were clear and students had explicitly understood what the questions were demanding.

The CRQ made students voice out their preconceptions. The need for further learning was created as students gave different interpretations. There were more interactions in this activity. The material created room for learning.

Teaching was interactive. Interactive questions and examples were based on daily life activities. The animation used on the motion of the driver who did not wear his seat belt after hitting a wall and what happens to passengers, when a vehicle stops, moves or negotiates a sharp curve suddenly, helped students to understand the meaning of Newton's first law of motion. More questions on real life activities and interactions guided students in relating the law to everyday life occurrences.

Though most students were able to revise their answers with regard to the type of law which explains the phenomenon of the CRQ, they could not link the explanation well to inertia. However, a student was able to do that with the guidance of the teacher and his reasoning was also understood by his colleagues. The activity was useful in helping students to fully understand how to solve such similar problems by relating it to Newton's first law of motion.

Though most students were able to apply the knowledge gained during teaching to support their answers in the application question, some students could not connect it to Newton's first law. The material was good to show students how to use Newton's first law to explain the direction of motion of an object that comes out of a circular orbit.

The aims of the tutorial/problem solving session were to encourage students to come for the session better prepared, share ideas and do more discussions with their peers. It was found that most students could answer most of the questions, indicating that students came to the problem solving session prepared and could also answer similar questions which were initially difficult through sharing of ideas with their peers. More teacher-student interactions occurred during this session. The teacher subjected students to many questions, as a way to be sure of their understanding. The materials were good practicing questions for students. They achieved the aims of making students come to the problem solving session prepared, through group discussions, sharing of ideas and cooperating with peers. The content level of students' reasoning was better and the level of interactivity was quite remarkable in the problem solving session. The questions were good in identifying remaining difficulties of students to provide the necessary solutions.

In effect the use of real-life activities in the teaching and learning of Newton's first law of motion in an interactive manner did improve students' conceptual understanding in the law. This was shown in the way students did explain the first law of Newton in relation to real-life activities.

References

Bonwell, C. C. & Eison, J. A. (1991), "Active Learning: Creating Excitement in the Classroom", *1991 ASHE-ERIC Higher Education Reports*.

Cashin, W. E. (1990), "Improving lectures. In, edited by M. Weimer and R. A. Neff, *Teaching college, College readings for the new instructor",* (pp. 59-63). Madison, Wis.: Magna Publications.

Chief Examiner (2002), "The West African Examination Council, Accra: Senior Secondary School Certificate Examination", *Annual report 2002.* Accra, Ghana: Ghana Publishing Corporation.

Chief Examiner (2004), "The West African Examination Council, Accra: Senior Secondary School Certificate Examination", *Annual report 2004.* Accra, Ghana: Ghana Publishing Corporation.

Chief Examiner (2008), "The West African Examination Council, Accra: Senior Secondary School Certificate Examination, *Annual report 2008.* Accra, Ghana: Ghana Publishing Corporation.

Covill, A. E. (2011), "College Students' Perceptions of the Traditional Lecture Method", *College Student Journal*, **45**(1), 92-101.

Fredua-Kwarteng, Y. & Ahia F. (2005), "Ghana flunks mathematics and science: Analysis (2)", [Online] Available:

http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=1463&ID=1000001762 (January 30, 2015).

Hansen, E. J. & Stephen, J. A. (2000), "The ethics of learner-centred education: Dynamics that impede progress", *Change*, **32**, 40-47.

Hassard, J. & Dias, M. (2009), "The Art of Teaching Science: Inquiry and Innovation in Middle School and High School (2nd ed.), New York: Routledge, 201 - 216.

Jungst, S., Licklider, B. & Wiersema, J. (2003), Providing support for faculty who wish to shift to a learning-centered paradigm in their higher education classrooms. *The Journal of Scholarship of Teaching and Learning*, **3**, 69-81.

Klem, A. M. & Connell, J. P. (2004), "Relationships matter: Linking teacher support to student engagement and achievement", *Journal of School Health,* **74**(7), 262-273.

Machemer, P. & Crawford, P. (2007), "Student perceptions of active learning in a large cross disciplinary classroom", *Active Learning in Higher Education*, **8**, 9-30.

Marbach-Ad, G., Seal, O. & Sokolove, P. (2001), "Student attitudes and recommendations on active learning", *Journal of College Science Teaching*, **30**, 434-438.

Mazur, E. (1997), "Peer Instruction: A User's Manual", New Jersey: Prentice Hall.

McDermott, L. C. (1991), "Millikan Lecture 1990: What we teach and what is learned- Closing the gap", *American Journal of Physics*, **59**, 301-315.

McDermott, L.C. (1993), "Guest Comment: How we teach and how students learn-A mismatch" *American Journal of Physics*, **61**, 295-298.

McDermott, L. C. (2001), "Oersted medal lecture 2001: physics education research-the key to student learning", *American Journal of Physics,* **69**(11), 1127-1137.

Mckeachie, W. J, Pintrich, P. R., Guan, L. & Smith, D. A. F. (1986*), "Teaching and Learning in the College Classroom: A Review of the Research Literature", Ann Arbor*: Regents of the University of Michigan.

Meltzer, D. (2005), "Relation between students' problem - solving - performance and representational format", *American Journal of Physics,* **73**(5), 463-478.

Moust, J. H. C., Van Berkel, H. J. M. & Schmidt, H. G. (2005), "Signs of erosion: Reflections on three decades of problem-based learning at Maastricht University", *Higher Education*, **50**, 665-683.

Omosewo, E.O. (1999). Physics educators' perception of problems militating against effective teaching of Physics in Nigerian Secondary Schools. *Journal of Educational Theory and Practice* **5**(1&2) 1-11.

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