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GHANAIAN STUDENTS' IDEAS ABOUT FORCE AND FRICTION

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ABSTRACT

This study was conducted to identify the misconceptions Ghanaian Secondary School students have about force and friction.

The questionnaire was administered to 90 science and 60 non-science students. The respondents were stratified samples from the first, second and third year students of Mfantsipim Secondary School in the Central Region of Ghana.

Graphical analyses of the correct scores were used to identify the existence of and the extent to which the alternate ideas persist among the students.

The study revealed that students believe

(i) that force implied motion and vice versa,

(ii) that continuous motion of a body without an external force is due to the fact that force can be transferred,

(iii) that friction is force which always opposes motion. They could, however, not conceive how friction could promote any type of motion (e.g. rotation).

These misconceptions were found persisting among all the students, irrespective or age, class or programme of study.

The paper makes recommendations for management of teaching and review of textual materials for students development of new teaching strategies and future research.

Introduction

The number of students who apply to study Physics at Ghanaian Universities has been persistently low in recent times (Crentsil, 1996). Data collected from six educationally renowned secondary schools in the Cape Coast Municipality in Central Region of Ghana, showed that the results for Physics and the other science subjects (notably biology and Chemistry) were consistently poor in almost all the schools: The results were compiled from the report of the senior secondary education terminal examinations conducted by West African Examinations Council (WAEC) in 1993.

One of the factors contributing to this trend could be poor understanding of the scientific concepts by the pupils (Nelson, 1992). Also, most students already consider Physics to be the most difficult, most boring and hence the most disliked subject within the sciences (Nachtigall, 1995). Djangmah (1988) highlighted that, "the method used in teaching scientific (and specially Physics) concepts is not in consonance with the child's cognitive and affective development". Another factor could be attributed to the findings that students hold alternate ideas about scientific phenomenon which are taught in schools; and that these alternate views persist and often interfere with correct scientific explanations in the course of the academic studies (Pope and Gilbert 1983; Driver, 1981, Erickson, 1979; Osborne and Gilbert, 1980).

The study was conducted to investigate Ghanaian students' views about the concepts of force and friction. The study investigated, as well, the effect of such factors like, age, class and course programmes, on the views the students have about the concepts. Specifically, the study sought answers to the following questions :

i. Do Senior Secondary School (SSS) students have alternate ideas about force and friction?

ii. Do SSS students' views of force and friction differ as they move from SS1 to SS3?

iii. Do SSS students of different ages have and differ in their alternate views of force and friction ?

iv. Do SSS science and non-science students have and differ in their alternate ideas about force and friction?

v. To what extent do the science and non-science students' alternate ideas of force and friction change with progression from SS1 to SS3 classes ?

Methods of Investigation

The sample for the study was made up of 90 science students (comprising 30 each from SS1, SS2, and SS3,) and 60 non-science students (comprising 20 each from SS1, SS2 and SS3) of Mfantsipim School in the Central Region town of Cape Coast. The non-science students offer only general science as a core subject. The ages of the students ranged from 15 years to 17 years. Stratified sampling method was adopted in selecting the respondents such that it covered both the science and non-science students in all the three classes whose academic achievements were above average and below average scores. Mfantsipim is a unisex (boys only) school in the Central Region of Ghana.

Instrument

A twenty-item questionnaire was used to gather data for the study. The administration of the instrument was followed by a clinical interview involving 10% of the respondents. The interview schedule was meant to tap the thinking process of the students on the concepts of force and friction.

Three physicists and one physics educator validated the instrument.

Data Collection

The instrument was administered by one of the writers. Each correct option was given a score of 1, and a wrong option scored 0. The frequency distribution of the scores was put in a tabular form. The percentages of the correct scores for the question items were presented graphically.

After the administration of the written questionnaire 9 out of the 90 science students and 6 out of the 60 non-science students were selected through stratified sampling. They were interviewed orally and audio-taped. The sampling for the oral interview was done to reflect equitably the thinking of either of the two groups (science and non-science) whose scores were above average, on the average and below average in the test questionnaire. The interview was also meant to identify the extent to which the students' thinking did reflect their self-reporting ideas and also other ideas or reasons not covered by the questionnaire.

In order to make the analysis and the discussion of the results clearer the items of the instrument are reproduced below together with the responses from the oral interview.

Questionnaire (Section ii Of Instrument)

1. Which reason explains why a stationary object remains in its state of rest on rough horizontal floor ?

   A. No force acts on it
   B. Weight of the box
   *C No unbalanced force acts on it
   D. It's weight prevents change of position

2. If a boy pushes a box along a horizontal rough floor, which force is he trying to overcome?

   *A Friction
   B. Weight of the box
   C. Perpendicular force from the floor
   D. The boy's own weight

3. According to Newton's first law of motion, if a body in linear motion does not change its direction or motion, then we can explain that :

   A. There is/are no forces on the body
   B. The path is smooth
   C. The forces acting are inside the body
   *D. There is no unbalanced force on the body.

4. What will cause a body moving linearly with constant velocity to change its direction or motion?

   A. If more forces act on it
   B. If the forces acting are removed
   *C. If an unbalanced force acts on it
   D. If the path is made rough.

5. Which statement explains why a ball continues to move long after the kick?

   A. Because the ball is round
   B. Because no force continues to act on the ball
   C. The kicking force continues to act inside the ball
   *D. The kicking force is converted to momentum

6. Which other force helps a student who pushes a book along rough horizontal surface of a table?

   A. Force from the tables
   B. Force of gravity
   C. High Friction force
   *D. No force

7. A spherical solid ball at rest is allowed to move freely on a rough inclined plane. What force will cause the motion

   A. Perpendicular force from the plane surface
   B. Inertia
   C. Friction
   *D. Force of gravity

8. After the fall of the ball (in question 7) from the inclined plane the ball continues to move freely along the horizontal floor. What force will act to stop the ball eventually?

   A. Force of gravity
   B. Perpendicular force from the floor
   *C. Friction from the floor
   D No force, but it will stop by itself

9. Which other force helps a student who rolls a drum of oil along a rough horizontal floor?

   *A Friction
   B. The drum's weight
   C. Force of gravity
   D. No Force

10. Which force causes the continuous motion of a boy riding on a bicycle when he stops pedalling for a moment?

   A. Friction
   B. Force of gravity
   *C. No force, but gained momentum
   D. Force transferred from the boy's legs.

N.B.: * Indicate the correct option to each question.

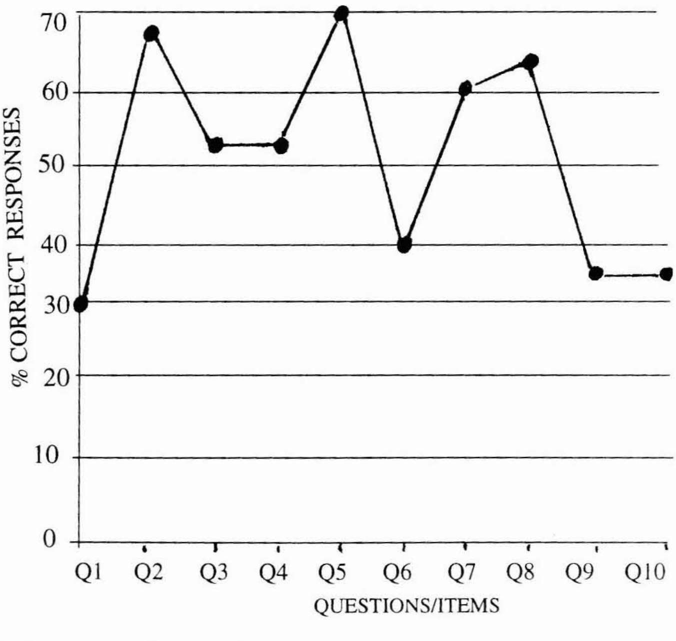
Results

Throughout the study very low scores were consistently recorded by the students on questions (1), (6), (9) and

(10) of the instrument. Hence, the discussion of the results will focus on the aforementioned questions to which majority of the student s gave wrong responses indicating some misconceptions.

***Research Question One:* Do Senior Secondary School (SSS) students have alternative idea about force and friction?**

FIG. 1
Results of Survey of Ideas Held by all the Students using the Instrument



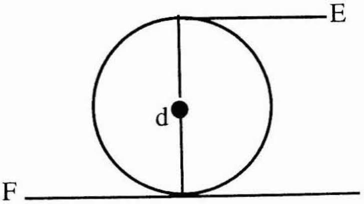
change it. This is true, however, 10.7% of the students thought that friction is the force preventing the change; while another 12.0% of the respondents also thought that the weight of the object is rather causing the body to remain at rest. Since the body does not lie on inclined plane, friction could not act to prevent any change of position.

Only 30.0% of the total respondents chose the correct response to question (1). The students' thinking is that an object at rest will remain stationary unless an unbalanced force acts to

On the other hand, as much as 47.3% of the respondents argued that since the body remained at rest then no force, at all, is acting on it.

The latter response of the students exposes their thinking that force always implies motion and vice-versa. Again, only 40.0% of the students gave correct response to question (6). They reasoned, rightly that apart from the effort force, no other force can act to help the pushing of the book. But, on the other hand, 39.3% of the students thought, rather, that the friction force would aid the sliding motion. It is right for the students perhaps to think that low friction cannot resist much linear or sliding motion. Hence whenever friction is low enough the sliding motion would still be far easier. But, on the other hand, however low the friction may be it could not act to aid the sliding motion. Secondly the surface of the table in the question was said to be rough. This indicates that the friction is not so low as the students might be thinking of.

On question (9) only 35.3% of the students chose the correct response. Equally, 30.7% of the students thought that no force would act to aid the rolling motion. This response indicates that majority of the students could not realise that rolling is motion by rotation and that in rotational motion a torque (T = Ed) is responsible. In this type of motion the floor acts as the fixed frame of reference about which the cylindrical drum rotates.



Consequently, the friction **F** force along the rough floor acts to prevent slipping of the drum, thus promoting rotational motion.

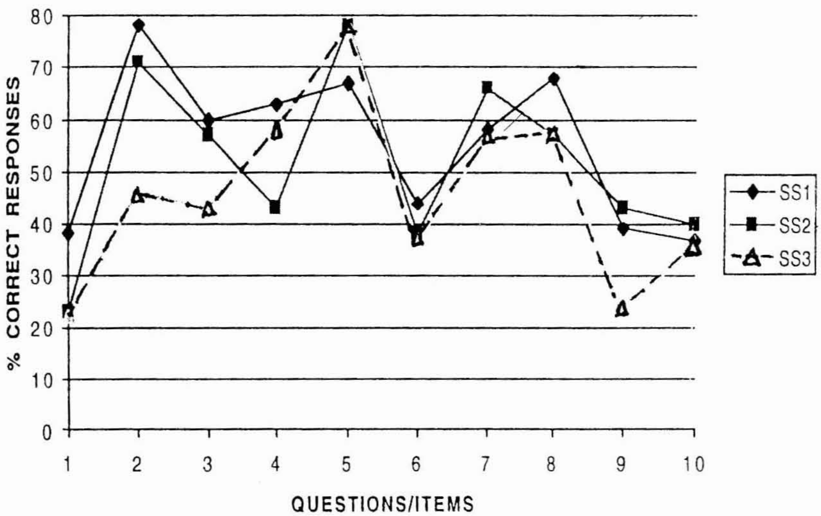
Finally, on question (10) 35.3% of the students had the correct idea. This group of students had the right conception that the continuous motion of the bicycle, after pedalling momentarily ceased, was duc to the initially gained momentum. On the other hand, as much as 44.0% of the students chose the response that the continuous motion of the bicycle was due to the fact that the initial pedalling force was transferred from the boy's legs to, probably, the wheels of the bicycle. The students' thinking is that a force is always responsible for motion; they could not conceive the idea of motion without force (Driver, 1983).

***Research Question Two* : Do SSS students of different classes have and differ in their alternative views of force and friction?**

The data were analyzed again to answer the above question and to find out if alternate views held were due to students belonging to different classes or year groups (i.e. SS1, SS2 or SS3). The analysis indicated that all students from the three classes held similar misconceptions about force and friction.

Figure 2 also illustrates the patterns of the correct responses for questions of the instrument. On question (1) 36.0% of the SS1 scored correctly; only 26.0% of the SS2 scored correctly and 28.0% of the SS3 students also had correct views. students gave the correct response. Similarly, on question (9), 38.0% of the SS1 chose the correct response; 42.0% of the SS2 also gave the correct option while only 26.0% of the SS3 students gave the correct responses. Finally, while 36.0% of the SS1 chose the correct options to question (10), and 40.0% of the SS2 scored correctly, only 30.0% of the SS3 students indicated the correct view. Fig. 2, thus portrays very low correct scores for the same questions

FIG 2.
Results of Survey of Ideas Held by Students of Different Year Groups



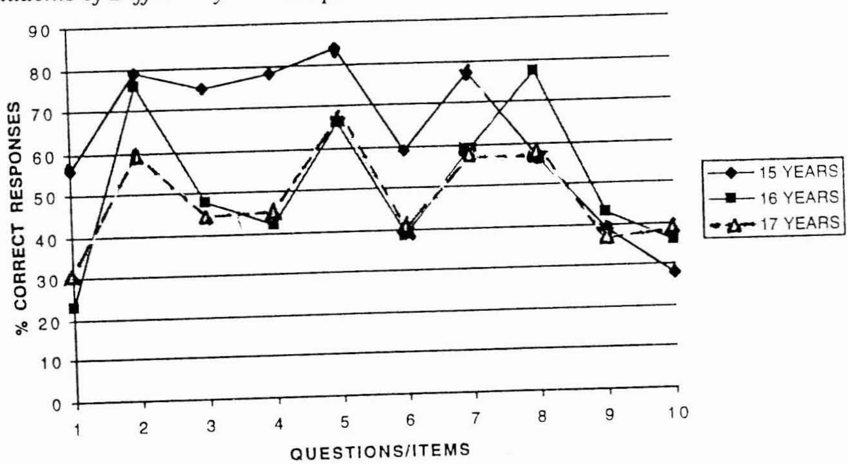
On question (6) while 48.0% of the SS1 had the correct response, only 36.0% each of the SS2 and SS3 by all the classes of students. The low scores indicate that most of the students had wrong views about force and friction. Again, the similarity of the variation of the scores show that the alternate views held by the students in each class did not differ.

***Research Question Three* : Do SSS students of different ages have and differ in their alternate views of force and friction?**

The study went further to investigate whether the alternate views held by the students were due to their age differences. Analysis of the data indicated that all the students of ages 15, 16 and 17 held the same type of misconceptions as discussed earlier. Low percentages of correct responses were recorded for all the three age groups and on the same questions (1), (6), (9) and (10) of the instrument..

Figure 3 illustrates the pattern of the scores by the students on the questions. Correct scores recorded for question (1) were 53.8% by the 15 year old , 25.0% by the 16 year old and 29.0% by the 17 year old students. On question (6), correct scores were recorded by 16.5% of the 15 year old, 38.6% of the 16 year old and 37.6% of the 17 year old students. Again on question (9), 38.5% of the 15 year old scored correctly; 43.2% of the 16 year old scored correctly; while 31.2% of the 17 year old students also chose correct options. And finally , on question (10), correct scores were obtained from 30.7% of the 15 year old, 34.0% of the 16 year old and 36.5% of the 17 year old students. The similarity of the

FIG. 3
Results of Survey of Ideas Held by Students of Different year Groups



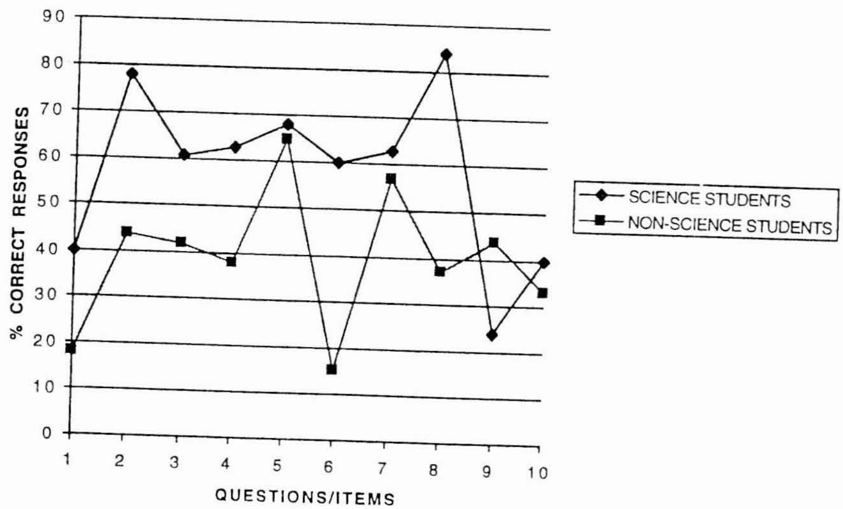
Patterns and the range of the correct responses indicate that misconceptions about force and friction exist among the SSS students, irrespective of their age differences; and also that the alternate views held by the students do not differ despite age differences.

***Research Question Four* : Do science and non-science students have and differ in their alternate views about force and friction?**

Two groups of students with different course programmes were sampled. One group study science (with elective physics) and the other representing the non-science group study only some elementary physics in a core science course. All the alternate conceptions found in the previous investigations were also identified among the students in this analysis and in similar proportions.

FIG 4

Results of Survey of ideas Held by Science and Non-Science Students



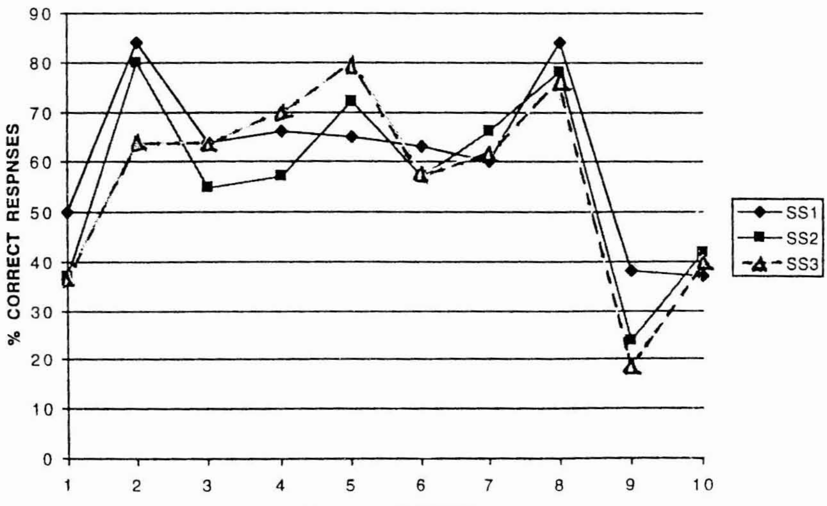
Further analysis was undertaken to investigate how the course programmes of the students would affect their alternate views about force and friction.

Analysis of the response made by students on the questions showed that 38.9% of the science and 16.7% of the non-science students respectively scored correctly on question (1). On question (6), 60.0% of the science and 10.0% of the non-science students gave correct responses. Also while 26.7% of the science scored correctly on question (9), 48.3% of the non-science students had correct view. Finally on question (10) 38.9% of the science had correct view while 30.0% of the non-science students had correct response. The relatively low scores by both groups of students on question (1), (6), (9) and 10) indicate that the science as well as the non-science students have misconceptions about force and friction. Furthermore, the similarity of the score patterns (see Fig .4) indicates that the misconceptions held by both groups did not differ. However, the science students seem to have correct views on the concepts than the non-science.

***Research Question Five*: To what extent do science and non-science students' alternate ideas of force and friction change with academic progression (i.e. from SS1 to SS3 Classes?**

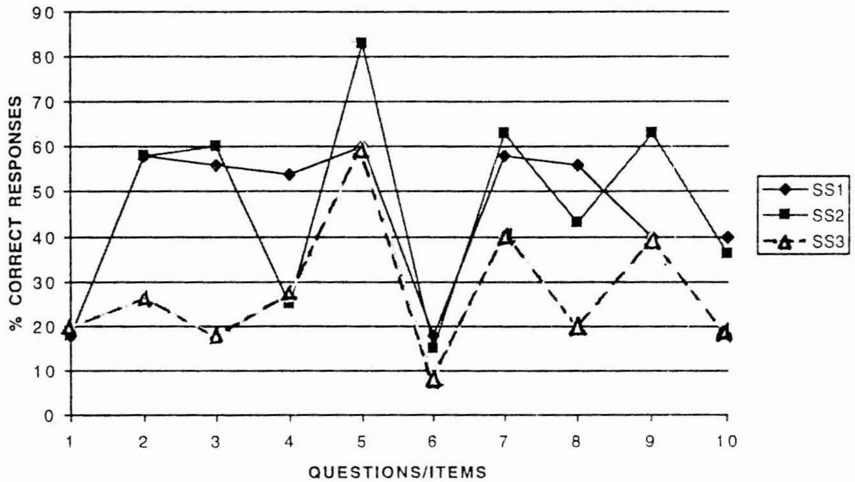
The data were further subjected to another analysis to ascertain the extent to which the alternate views held by either the science or the non-science students persisted or changed as they progressed along the academic ladder. The results of the analysis revealed no meaningful difference for the science students at SS1, SS2 and SS3; nor for the non-science students also at SS1, SS2 and SS3 (see fig.5a and 5b respectively). Low percentages of correct scores were still recorded on the same questions (1), (6), (9) and (10) for either group of students in the three course years.

FIG 5a
Results of Survey of ideas Held by Science Students in different Year Groups



The similarity of score patterns has revealed that the alternate notions held by both groups of students did not change but rather persisted throughout the three academic years, despite repeated use of concepts throughout the period.

FIG 5b
Results of Survey of ideas Held by Science Students in different Year Groups



Question 1: Could you state Newton's first law of motion?

A. *Responses* : By Above-Average students

The Interview Schedule

The following is a sample of the edited version of the interview schedule. S1, S2 and S3 refer to the three science students, N-S1, and N-S2 refer to the two non-science students.

S1, S2 and S3 : A body continues in its state of rest or uniform motion unless compelled by an external force to change.

N-S1, N-S2: A body continues to

be in motion or in a state of rest unless a force is applied to it.

B. *Responses* : By Average Students

S1, S2 and S3: I cannot remember well, but it says when a body is at rest or in motion there will be a force to change the motion.

N-S1, N-S2 : A body continues to be in motion or state of rest unless a force is applied.

C. *Responses:* By Below Average Students

S1, S2 and S3 : I cannot remember

N-S1, N-S2: No idea

Question 2: Does a body at rest have a force acting on it?

A. *Responses* : By Above-Average Students

S1, S2 and S3: Yes, it does have.

N-S1, N-S2 : No force is acting

B. *Responses:* By Average Student

S1, S2 and S3: Yes, there are forces acting.

N-S1 : No force is acting .

N-S2 : Yes, Force acts on it.

C. *Responses:* By Below-Average Students

S1, S2 and S3: No force acts.

N-S1 and N-S2: No Forces act.

***Question 3* :** Explain why the body at rest does not move.

A. *Responses:* By Above-Average Students

S1: The wood opposes it.

S2 and S3: The forces balance.

N-S1 and N-S2: It is opposed by friction

B. *Responses:* By Average Students

S1: Apart from inertia there is no other force.

S2 and S3: External forces act to make it rest.

N-S1 and N-S2: It cannot move if there is friction.

C. *Responses:* By below-Average Students

S1, S2 and S3 : Because friction and gravity oppose it.

N-S1, NS2: Because no force is acting.

Question 4: Explain why a kicked ball continues to move even after the kicking force is no more acting.

A. *Responses:* By above-Average Students

S1, S2, and S3: It has gained momentum which makes it continue.

N-S1, N-S2: The continuous motion is caused by the force which has become transferred.

B. *Responses* : By Average Students

S1 and S2: The force continues to move with it.

S3: If the kicking is strong then the motion continues until it finishes.

N-S1, N-S2: The Force goes with the ball until it reduces.

C. *Responses* : By Below-Average Students

S1, S2: The continuous motion depends on whether the ball is light or not.

S3: The kicking force goes with the ball.

N-S1: The continuous motion is caused by friction.

N-S2: The continuous motion is due to the fact that the kicking force is strong.

Question 5: What does friction do?

A *Responses:* By Above-Average Students

S1, S2 and S3: It opposes motion.

N-S1 and N-S2: It opposes motion.

B. *Responses* : By Average Students

S1. S2 and S3: It causes wear and tear of shoes.

N-S1 and N-S2: It acts to stop motion

C. *Responses:* By Below Average Students

S1, S2 and S3: It opposes motion.

N-S1, and N-S2: It opposes motion.

Question 6: Can Friction be useful? Give instance where friction is useful.

A. *Responses*: By Above Average Students

S1, S2 and S3: Yes. Useful in walking.

N-S1 and N-S2: Yes. Useful in walking.

B. *Responses:* By Average students

S1, S2 and S3 : Yes.Useful in walking.

N-S1, and N-S2: Yes. It helps us to walk.

C. Responses ; By Below Average Students

S1, S2 and S3: Yes. It is good for walking.

N-S1 and N-S2: Yes. It is good in walking.

QUESTION 7 : Give another instance where friction is useful.

A. *Responses* : By Above Average Students

S1 and S2: Writing on the board.
S3: Grinding of knives.

N-S1 and N-S2: It causes wear.

B. *Responses*: By Average Students

S1 and S2 : It wears shoes.

S3: It is useful in fixing of nails in wood

N-S1 and N-S2: No idea.

C. *Responses*: By Below Average Students

S1 and S2: No idea.

S3 : Useful in riding of bicycles .

N-S1 and N-S2: No idea.

Discussion

The study revealed the existence of some alternate views about force and friction among the senior secondary schools. This confirms the findings in similar studies conducted elsewhere (Pope and Gilbert, 1983; Driver, 1989; Erickson, 1979; Ivowi, 1984).

The low percentages of correct response to question (1) show that most students think wrongly that force always causes motion. In other words most students have the notion that motion always implies an external force causing it or vice versa. This view of students has also been reported in similar studies by Watts and Zylberstajn (1981), Clement (1982) and McCloskey (1983). This notion also made the student choose incorrect responses to explain that if a body continues to move without any visible or applied external force then the initial impelling force must have been transferred from one system to another. This is in agreement with what Driver (1983) identified in a similar study.

The students' misconception could stem from the wrong or the literal interpretation of Newton's first and second laws of motion that force is always responsible for motion. This idea or the interpretation would be acceptable if only they are thinking of force causing change of motion or state of rest. Furthermore, external forces acting on a body do not, necessarily, cause **change** in the state of rest or motion unless when they do not balance. Only a resulting unbalanced force can cause change in the state of rest or motion.

In the interview conducted two weeks after the test, it was observed that none of the students could make complete statement of Newton's first law of motion. The students had forgotten the correct statement of the law. They did not comprehend the law but rather committed it to memory, hence, making it easy to forget. On the other hand, only a few of the students could guess that forces could still act on a body at rest. However, they were not able to apply the law to explain the question of why a body at rest could still have external forces acting and yet not move. Some students in an attempt to explain that situation mentioned friction as being responsible for keeping the body at rest.

On the explanation of the continuous motion of a body without visible external force, very few of the science students in the higher achiever group could think of initially gained momentum as the cause. The rest indicated that the original impelling force was transferred to the body; that it continued with it until it finished.

Again, the low percentage scores recorded on questions (6) and (9) indicated that SS students hold some alternate view of friction. Students, however, scored highly on other questions on the nature of friction. This demonstrates that students know correctly that friction often acts to oppose motion. They could not visualize how on the other hand, friction could help to promote motion, apart from walking which is always mentioned in textbooks. The students' thinking was limited to only linear motion, even though they have learned of other types of motion (e.g. rotational, oscillatory, circular, etc.). They thus, failed to recognize the rolling motion in question (9) as rotational; and that friction provides for the torque responsible for this motion.

In the oral interview, again, all the students stated correctly that friction opposes motion. They all mentioned walking as an example of the useful application of friction. Their responses indicated only what they have exactly read in books or been taught. Most of them could not state any other advantages of friction. It is likely, their wrong thinking stems from the misconception of the general statement that "friction opposes motion". This statement does not declare which type of motion (ie. sliding), hence the naive ideas.

Analysis of the data from the students in SS1, SS2, and SS3 showed that similar misconceptions for force and friction exist among them. This result confirms those reported by Osbone and Gilbert (1980) and Nelson (1992) that misconceptions are prevalent among students at all academic levels of education.

The data collected from the students of ages 15, 16 and 17 years (or above) indicated that SSS students of all ages hold misconceptions which are not different. This finding is also consistent with those of Watts and Zylberstajn (1981), Clement (1982) and McCloskey (1983).

It was further observed that both science and non-science students have similar misconceptions about force and friction. This observation was quite contrary to expectation. Science students are expected to have better views of the concepts since they have greater opportunity to encounter scientific instances and phenomena involving the concepts. The expectation is that science students' consistent encounter with the concepts in their studies would help reduce or eliminate, to a large extent, some of the wrong ideas previously held. Nelson (1992) studied students ideas about inertia and discovered similar performance by science and non-science students. He therefore questioned the influence of our traditional teaching methods on concept development.

Further, detailed analysis revealed that the misconceptions prevalent among either the science or non-science students persisted along the academic years and proved resistant to change as reported, also, by Terrance and Wytze (1991).

On the whole, the study has revealed that SSS students have some alternate views about force and friction. The results of the interview did not reflect strongly, what was obtained using the questionnaire. This situation could be explained by the fact that the students might have had time to consult textbooks or discuss among themselves after the administration of the test.

Implication For Instructional Management

One of the important objectives of studying physics is that students would develop the ability to comprehend and relate general physics principles to everyday, natural and environmental phenomena. The results of this investigation show that many students emerge from classroom instruction in mechanics unable to associate the laws of force and friction with the change of state of rest or motion of objects they encounter in everyday life. This situation has been identified in this study as due to some misconceptions held by the students.

The possible causes of these misconceptions among the students are traceable to some statements or definitions in textbooks and also the misconceptions held by some teachers. From many of the accredited textbooks on the market, Newton's first law of motion states, inter alia, "every body continues in its state of rest or uniform motion in straight line unless compelled by an external force to change". This statement sounds a little ambiguous. It can be interpreted to mean that a body at rest will change its position only when an external force acts; or that, if the body is in uniform motion along a straight path, it is only an external force that can change the motion. This notion, if correct, presupposes that there could be no external force already acting before the change. The latter interpretation would be true only in an absolute sense; that is, it is true only in a vacuum. But in the normal physical condition there can be no situation where no external force will be acting on a body in equilibrium. For instance, a body hanging on a suspended string will have on it external forces (the tension and gravity) acting and yet be in a state of rest. The forces must balance in this case.

Hence, that statement of the law needs to be restated in a more non-ambiguous way. This can better be done by introducing the word "unbalanced" to qualify the external force needed for the change of equilibrium state. The law could rightly be stated as:

> "Every body remains in its state of rest or uniform motion in a straight line unless compelled by an external unbalanced force to change".

It is worthy to remark that some authors have attempted restating the law by introducing the concept of a "net" or "resultant" force. But a ***net*** or ***resultant*** force can be zero (or not zero); and this will, certainly, not help in the elimination of the ambiguity. An unbalanced force can never be zero to bring about any ambiguity. The introduction of this term (unbalanced) would imply that if all previously existing external forces could not cause any change in the equilibrium of a body then they balanced each other. On the other hand, one could use the term 'non-zero' resultant force in place of the concept, unbalanced (if this sounds colloquial) in the statement of the law.

On the other hand, some teachers have their own erroneous ideas about the concepts to be taught. Envisaging the difficulty in explaining facts they resort to the lecture method of teaching. They, thus, give raw scientific information by dictating notes without giving the students opportunities to observe, experiment or even read and think to discuss those facts (Mux and Shu, 1992). The teachers often, also, adopt the above inappropriate methodology, because of the (seemingly) overloaded curriculum or the heavy teaching workload. The teacher's problem may also be due to the type of terminal examination conducted by the external agency, like WAEC (Ivowi, 1984). The exams require more of declarative knowledge, i.e. description of events than analytical evidence of actual understanding.

It is suggested that a more realistic curriculum and terminal examinations emphasizing more the cognitive development and operational knowledge by the student would be developed and reviewed periodically. This study has revealed the need for educational managers at the various levels, to be organizing regular seminars and in-service programmes for science teachers to prepare them, among other things, for identifying and correcting misconceptions students often have about scientific facts. Again, in-service courses should aim at identifying the alternate views of teachers themselves about some basic physics concepts and also the procedures to remedy any such erroneous views. With their awareness of the holdings of alternate conceptions among students the teachers will, in turn, help students out of their misconceptions.

Conclusion

The findings of this study show that misconceptions about concepts of force and friction abound among SSS students in Ghanaian Schools. The study also showed that the misconceptions are similar among the students of all ages and classes irrespective of the type of course programme embarked upon; again, that the misconceptions persist and remain resistant to change. This persistence is evidence by the same misconceptions being held by all the classes (SS1 -SS3). It is expected that senior class members would exhibit better understanding after repeated use of the concepts. But this was not so.

On the basis of these findings it is envisaged that improvement of the inadequacies in human and material resource development would be addressed through effective pre-service teacher-education programmes and consistent in-service courses. The study further recommends the training of facilitators to develop and use hands-on-experiments and demonstrations (using simple local materials or exemplars) to help change the naive conceptual thinking of students to a more scientific understanding of the concepts.

This study has revealed the need for educational managers at the various levels, to be organizing regular seminars and in-service programmes for science teachers to prepare them, among other things, for identifying and correcting misconceptions students often have about scienctific facts.

The study can be adapted to identify the gender-impact of the alternate conceptions of the terms; and also the use of parametric statistical methods to test the hypothesis.

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