Students' Alternative Conceptions in Force and Motion

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Abstract

The main purpose of this study was to find out the students' alternative conception in force and motion. The Force Concept Inventory (FCI) was used as tool to find out the alternative conceptions of the students. There were twenty six (26) alternative conceptions which were identified by the FCI. The sample was senior secondary students with physics as one subject of their study.

Keywords: Conceptual understanding, Alternative conceptions, Force Concept Inventory (FCI), Everyday experiences

Introduction

Science uses scientifically accepted ideas, concepts and frameworks which are used to conceptualize the physical worlds. In physics, there are scientifically accepted ideas of force, motion, Heat, works, energy and power. At time of argument, whatever reason a person give to defend him/her idea/ beliefs demonstrate that the particular belief/ ideas are well founded and anyone can easily prove it by pointing out where this particular ideas/beliefs are located and from where it got necessary support in entire construction. If these ideas/ belief is not according to the expert's views labeled as misconceptions as discussed in earlier heading. Thus the term 'misconceptions' is often used when students seemed to have understood differently, what teachers have tried to teach them? The term misconception denoted that the learner understanding is not correct and need correction. Besides this it is also appears that the teachers and brighter learners can correct the errors (Kumar.2013). But students have their own explanations which have some base embedded in their prior knowledge; therefore the

term misconception is not fit properly to denote their knowledge so we should use Alternative conception in place of misconceptions. An alternative conception implies that students have constructed and ordered the information received and their personal experiences in such a way that they have come up with a serious alternative to the scientific conception (Kuiper, 1994). According to Taser (2001) Alternative conception is defined as;

Alternative Conception refers to experience-based explanations constructed by a learner to make a range of phenomena and objects intelligible, but also confers intellectual respect on the learner who holds those ideas: it implies that alternative conceptions are contextually valid and rational and can lead to even more fruitful conceptions (e.g. scientific conceptions)

All children's conceptual frameworks develop from their experiences and change as they mature. However, frequently their intuitive understanding of the world around them does not agree with the scientific explanation. It is important in planning instruction to know how these naïve conceptions differ from the scientific explanation, and why children construct these ideas. The reason for exploring learners' ideas parallels the theory that students' ideas constrained and channeled learning, so knowledge of students' ideas should inform teaching. Development of complex concepts takes place in many small steps. Missing steps can make the correct explanation illusive or downright unattainable. This makes high-quality, age appropriate instruction at each grade level vital to the development of children's understandings of key science concepts. Osborne, Bell and Gilbert (1983) reported three main factors which caused the origin of alternative conceptions in learners.

1) Concepts which have no directly observable instances (Atom) and physical reality (Potential Energy). They are outside of students' experiences.
2) Everyday observable phenomena are connected to abstract theories by increasingly complicated reasoning.
3) In developing a coherent view of the world, scientists have evolved a technical vocabulary where words have specific, unambiguous meaning. Students do not realize this.

Student's Alternative Conceptions about Force and Motion

Students enter introductory physics courses with preconceived ideas that are often misconceptions, in that they do not provide a correct description of

the behavior of the physical world that is consistent with the laws of physics (Demirci-2003). They use primitive formula-centered problem-solving strategies. They have very limited number of concepts related to the phenomena; their knowledge consists of a small number of facts and equations stored randomly in the mind. Many studies indicate that students leave courses in about the same status as they entered. They have the same preconceptions and misconceptions/ alternative conceptions as when they started. They still use formula-centered problem solving methods. They see physics problems as springs, inclined planes, ropes and pulleys, whereas experienced physicists see the problems in terms of basic physics concepts (Tasar-2004). The concept of force is the most fundamental concept yet the most misunderstood in physics. The students across different levels (Elementary, Secondary, senior secondary, and college) have a wide variety of vague and undifferentiated ideas about force and motion which are incompatible with Newtonian mechanics. According to Halloun and Hestenes (1985), impetus (i.e., a force has to be exerted on an object in order to keep it in motion), and dominance (i.e., in an interaction a greater or a more active object exerts a greater force on the other) are the two most frequent beliefs about force. According to Clement (1982) the Newton's second law ($F=ma$) contradicts the students' intuitive ideas because in real world situations friction always exists. Therefore, one must keep pushing in order to maintain a constant state of motion. The learners always come across this situation in their daily life and they developed their understanding which always emphasize on presence of external force for continuous motion. This alternative conception is not automatically replaced by the scientific conception simply because students take a physics course.

Methods and Procedures

This study was administered to with 23 students of senior secondary schools. These students were studying physics as one of the subjects in their class XI. The whole class was taken as a sample. They were handed over the FCI tool and asked to respond according to their understanding on each items. 50 minutes were given to each student to respond the FCI.

Force Concept Inventory (FCI)

The Force Concept Inventory (FCI) is a multiple-choice test which probes students' conceptions on Newtonian mechanics, especially the concept of force, as well as the students 'ability to apply basic concepts and laws of

Newtonian mechanics in various contexts (Hestenes et al. 1992). The FCI contains 30 qualitative, multiple-choice questions about the mechanics. The choices in each question have been designed so that the students have to decide between a common-sense and a Newtonian conception. The inventory suggested five responses for each question but only one is correct according to Newtonian mechanics. The questions in the FCI are formulated so that they are understandable to students without formal knowledge of mechanics. According to Hestenes et.al. (1992) technical language is avoided in order to explore students' genuine thinking.

According to Hestenes et al.(1992), the Newtonian force concept comprises the following dimensions:

- **Kinematics**: position, velocity and acceleration discriminated from each other
- **Newton's First Law**: with no force, velocity direction and speed constant
- **Newton's Second Law**: constant force implies constant acceleration
- **Newton's Third Law:** with an action there is always a reaction
- **Superposition Principle**
- **Kinds of Forces**: solid contact, fluid contact, gravitation

In FCI, for each correct answer the student gets one mark. Since there are 30 questions, the maximum score is 30 marks. The authors (Hestenes et al. 1992) of the FCI have suggested the Newtonian conceptual threshold, i.e., a minimum level of understanding of the Newtonian mechanics to be 60% score. 80% score can be regarded as a threshold for mastering the basic concepts of Newtonian mechanics. Students with 80% correct response of FCI can be regarded as Newtonian thinkers (Hestenes et al. 1992).

Results and Discussion

Students' Responses on Force Concept Inventory

During the interaction period, just after completing the learning module and explanation of the causes behind the alternative conceptions, researcher probed the students conceptual frameworks related to the some concepts through open ended questionnaire contained eight questions. These were selected from the force concept Inventory (FCI). The analyses are given here.

Initially investigator conducted a pilot study to find out the expected alternative conceptions and alternative frameworks in force and motion.

There were twenty six (26) alternative conceptions identified on the basis of pilot study. These are:

1. In linear motion, position and velocity are the same phenomena.
2. In linear motion, velocity and acceleration are the same phenomena
3. In linear motion, resultant velocity of an object is the result of arithmetic sum of the forces applied to it.
4. An object falls straight downwards when dropped from a moving object.
5. A moving object carries the force supplied by the throw/hit and this force dissipates after travelling some distance (Impetus).
6. A moving object carries the force supplied by throw/hit and this force start losing just after throw/hit (Impetus).
7. An object in circular motion follows a circular path once it is released from the effect of centripetal force in circular motion.
8. In a collision of between two objects, only the active agent exerts force.
9. If an object is in motion means a force is acting on it.
10. The velocity of a moving object is directly proportional to the applied force.
11. The acceleration of an object is the result of continuously increasing force acting on it.
12. In the absence of air, an object dropped from a height reaches its maximum velocity immediately after the release and then drops with constant speed
13. In a collision between two objects, heavier object exerts more force on lighter one.
14. In a collision between two objects, the object moving with greater speed exerts greater force on the object moving with lesser speed.
15. If more than two forces are acting on an object, then the direction of the largest force determines the direction of motion
16. The force acting on an object thrown upwards is continuously increasing while force carried by the object is continuously decreasing.
17. The direction of a motion of a moving object being acted upon by two or more than two forces is determined by last applied force.
18. In circular motion, Centrifugal force determines the direction of motion

19. Motion of an object is unaffected by any obstacle in its path.
20. An object dropped from a moving body is dragged backward because of air resistance.
21. There is no force acting on an object lying rest on the earth's surface.
22. Two objects of different masses dropped from a height, the object with greater mass falls faster.
23. During the fall of an object, the force of gravity continuously increases as the object falls.
24. An object is thrown from a height carried forces supplied which run out after a while and then force of gravity began to work.
25. No force is acting on an object which is rest.
26. In collision between two objects, only the heavy object exerts force.

Causes of these Alternative Conceptions

It is very difficult to determine the source of alternative conceptions in science. Misunderstanding, miscommunication, mis-education and even a misapplication of well-established physical principles lead to the alternative conceptions (Wenning, 2008). Following sources may be a source of alternative conceptions:

Everyday Experiences

We generally form ideas from our everyday experiences. Sometimes, the ideas or concepts developed on the basis of everyday experiences are not correct with respect to the most recent scientifically accepted ideas or concepts. Everyday experiences involving sensual impression encountered in natural phenomena such as heat, sound, light, force and motion, combustion, growing plants and animals, and many others are major source of alternative conceptions.

Everyday Language

Everyday language is another source of alternative conceptions. Everyday language holds many conceptions that have been outdated in science for centuries, for example, the sun rises –means sun revolving or sun moving not earth. In similar way, thrown object carry the supplied force (Impetus theory). These types of languages create confusion among the learners and a base for alternative conceptions.

Learner's Social Environment

Students in their daily life interact with friends, parents, relatives and other peoples in society. Teacher's Instruction. In these interactions, students may pick up both scientifically acceptable conceptions and alternative conceptions. These interactions may also influence by mass media i.e. TV programme, videos programs, computer game and Comical books. These sources may be more influential in science education more than the simple instruction because only a small number of hours is dedicated to the science instruction, whereas the rest of the time students encounter other sources of information.

Teachers Instruction

Teachers' instruction is a source of alternative conceptions among the students. A large number of literatures are available which support that the alternative conceptions arise due to the false instruction provided by the teachers or text books (Sharma, 2004; Jadav & Parida, 2008). Sometime teachers misinterpret the correct information; this is also causing alternative conceptions among the students.

Conclusion

The study reveals that the students hold a number of alternative conceptions related to the force and motion. These alternative conceptions are very rigid and have a number of sources i.e. focus only one parameter on solving of a problem, limited perspective of concepts, sensual impression, everyday language, and students' social environment and teachers instruction from which it can be generate. The sources mentioned above so far leads to very deep rooted alternative conceptions. These alternative conceptions are supported continuously in everyday experiences and they are very difficult to change by simple science instructions.

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