REVIEW OF RESEARCH

AN INVESTIGATION ABOUT STUDENT'S MISCONCEPTIONS ON THE CONCEPT OF FORCE IN A CONSTRUCTIVIST LEARNING ENVIRONMENT

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ABSTRACT:

This study is an analysis of the NCERT science textbook from the primary level to the secondary level with regard to the concept of force. The kind of treatment given to this important concept at the lower level leads to the formation of popular misconceptions regarding force in higher classes. A force concept inventory was made, which helped in identifying the student's misconceptions in force at the secondary level. On the basis of this inventory, 5E model of constructivist learning was planned and executed on a selected group of students. The achievement level of both the groups was checked and the difference was found statistically significant. This shows that the constructivist approach is effective to dispel student's misconceptions in physics and improve their academic performance. The aim of this study was to use the constructivist approach of learning to the normal traditional approach and study the student's misconceptions in the concept of force in physics.

KEYWORDS: *Force, Misconceptions, Constructivism, Curriculum.*

INTRODUCTION:-

Force is a term which we often use in our daily life. "Water is coming from a tap with a great 'force', 'force' pulls the stone down, the police 'forced' the door open, in spite of applying great force the lid of the tin is not opening are some common sentences. When students move from their daily life experiences to the scientific concept of force, they inherently develop many misconceptions. The concept of force at the school level is introduced in Class VIII and then in Class IX in NCERT Science Textbooks. The learning outcomes, as defined by NCERT mention that students should be aware of the contact and non-contact forces in Class VIII. Some idea about net force is also given. When students are confronted with the Newtons Laws of Motion in Class IX they are still confused about the concept of force because they have been taught to interpret force as merely push or pull. It is hard for them to realize that that there does not exist any definition of a force independent of Newton's laws of motion. Another interesting thing to note is that in class VIII some elementary ideas about force and friction are given. But the description of friction and its examples are limited. So all the examples given to explain the concepts seem to be artificial. The question arises whether the constructivist learning environment can help the students in clearing their misconceptions about the concept of force. The concept of force poses you difficulty and, at the same time, gives an opportunity to put forth ideas, debate on them and reach conclusions. Can we plan, design, and think about some experiments which can help our students in getting rid of their misconceptions. Can we put forth some problems on the concept of force which, when solved, will help our students to dispel their misconceptions about force and to understand the concept better. Constructivist learning environment has the potential to confront our students with these misconceptions and help them in removing them in an active learning environment. In the past, some studies indicate that students of different age groups have different misconceptions about force (Clement, 1982, Demirci, 2001, Poon, 1993, Brooke & Etkina, 2009, Fadaei and Mora, 2015). They have suggested different strategies to dispel away the misconceptions regarding the concept of force and Newtons and Laws of Motion. Research shows that students have some alternative concepts or incorrect ideas about the force. Students apply these ideas in different contexts in the physical world. Some researchers have suggested the use of a web-assisted program to normal traditional classroom instruction to remove students' misconceptions about force.

In view of the existing variety of concepts, which may not be in accordance with scientific ideas, it is necessary to adopt strategies to bring out necessary conceptual change. For a conceptual change, the necessary conditions are:

1. The learner must encounter such a situation which he is not able to understand using existing knowledge
2. The learner must come across some knowledge which is intelligible to him and seems plausible
3. The new knowledge helps the learner to understand some new situations which were beyond his reach earlier.

Driver and Oldham have suggested the constructivist teaching sequence consisting of five phases: 1) Orientation, 2) Elicitation of children's ideas, 3) Restructuring of children's ideas through (i) clarification and exchange (ii) exposure to conflict situation (iii) construction of new ideas (iv) evaluation of new ideas, 4) Application of new ideas, and 5) Review of change in ideas and comparison with previously held ideas. To reconstruct children's ideas various strategies can be used. These include demonstration, discussion, debate, experiment etc. A constructivist classroom environment is democratic and student's ideas are paid adequate attention.

In this paper, the researcher has used the constructivist approach of learning to dispel away student's misconceptions regarding force.

METHODOLOGY

This quasi-experimental research was conducted in Demonstration Multipurpose School in Bhopal. The respondents of the study were the two sections of the Class 9th students, wherein the researcher conducted the constructivist approach-based sessions. A total of 47 students were selected for the study, out of which the control group comprised of 23 students and experimental group comprised of 27 students. The test instruments used were: (a) The Force Concept Inventory pre-test (c) The Force Concept Inventory post-test, which were developed by a team of experts in the related area. Before the experimental study, the pre-achievement test was administered to the two groups of respondents to find out their preconceptions and misconceptions in selected topics of science and likewise to measure their achievement level.

The treatment for the experimental group differs from that of control group in only one aspect. During the period of study, the experimental group was exposed to the constructivist approach of learning based on the 5E model.

At the end of the study, a post achievement test was again administered to measure the achievement level of the students.

The t-test was used to determine if there was a difference between the experimental and control groups in their:

a) Pre-achievement scores
b) Post-achievement scores

RESULTS

A pretest consisting of situations which revolved around eight items as listed in Table-1 was administered to a group of 45 students of Class IX. The items were selected from Hapkiewicz, A. (1992). The questions of the pretest included several situations related to the misconception items. Questions were multiple choice in nature. However students were asked to explain the reason of their answer along with a diagram of the situation.

Table 1: Common Misconceptions Detected from Force Concept Inventory Pre-Test

S.No.	Misconceptions	Situation	Percentage of Students with Correct Answers
1	If an object is at rest no forces are acting on it.	A book resting on a table, A man standing on a floor	15%
2	Force is a property of an object. An object has force and when it runs out of force it stops moving.	A ball rolling on a horizontal floor comes to a stop after some time	30%
3	A force is needed to keep an object moving with a constant speed constant motion requires a constant force	A car traveling at a constant speed in a straight line	10%
4	Forces acting on bodies/objects are associated with living things	A book resting on a table	20%
5	Force is always in the same direction as the velocity of the body.	A ball thrown vertically upwards	23%
6	The product of mass and acceleration is force	A stone falling on the ground	12%
7	Forces applied by, say a hand, still acts on an object after the object leaves the hand.	A ball thrown vertically upwards	5%
8	The action-reaction forces act on the same body.	A student pushing the wall, a player hitting a football, a bullet released from a gun	10%

Pre-test was administered on 47 students of Class IX, out of which control group comprised of 24 students and experimental group comprised of 23 students. Results of pre-test are presented in Table-2. It can be seen from the table that control group had a mean score of 26.67 and a standard deviation of 3.28 while that of experimental group had a mean score of 24.31 and a standard deviation of 3.987. The t-test was performed to find out whether there is a significant difference between the two means. It has been assumed that the distribution of the achievement scores of control and experimental group were sufficiently normal for the purpose of conducting a t-test. The assumption of homogeneity of variances was tested and satisfied via Levene's F-test, $F(35)=.021$, $p=.885$. The t-ratio of 1.607 has an associated probability of .122. The obtained t-value is less than the table t-value at 0.05 level of significance. This means that the null hypothesis is accepted. Hence, there is no significant difference between the pre-test mean scores of the two groups of respondents.

Table 2: Difference between Pre-Achievement Scores of Experimental and Control Groups

Group	Mean	SD	Df	t-value	p-value
Control	26.67	3.284	45	1.607	.122
Experimental	24.31	3.987			

After the study, the effect of constructivist approach and traditional approach in teaching was determined. The actual scores of the two groups were treated. The null hypothesis states that there is no difference between the post-achievement scores of Experimental and Control groups. As shown in the table, the students exposed to constructivist approach-based learning had a post-test mean score of 25.44 and a standard deviation of 3.787 while the group exposed to traditional experiments had a mean score of 17.23 and a standard deviation of 6.070. The t-ratio of 5.636 has an associated probability of .000. The t-value obtained is greater than the table t-value at 0.01 level of significance hence the null hypothesis is rejected. Hence, there is a significant difference between achievement scores of the two groups after the study. It can be concluded that constructivist approach is effective in improving student achievement and in dispelling the misconceptions related to the concept of force.

Table 3: Difference between Post-Achievement Scores of Experimental and Control Groups

Group	Mean	SD	Df	t-value	p-value
Control	17.23	6.070	45	5.636	.000
Experimental	25.44	3.787			

The pre- and post-achievement scores of experimental and control groups are compared in Table-4. The table also reveals that the t-ratio is 4.134, which has a probability of 0.000. The obtained t-value is greater than the table t-value at 0.01 level of significance. Hence, there is a significant difference between the pre and post achievement scores of the students exposed to constructivist learning situations and we reject the null hypothesis. It also suggests that constructivist learning situations in different subjects did enhance achievement.

Table 4: Difference between the Pre and Post-Achievement Scores of the Experimental Group

Achievement	Mean	SD	Df	t-value	p-value
Pre	19.95	5.744	21	4.134	.000
Post	25.50	3.419			

DISCUSSION

Force lessons in the classroom should be planned to target the common misconceptions and also there is a need to utilize different teaching strategies to overcome them. The lessons utilized in this study were structured around the 5 E model of lesson planning (Bybee & Landes, 1988). The lessons were structured around the 5 E model of lesson planning for science instruction. The five E's, utilized were: Engage, Explore, Explain, Extend and Evaluate.

Item No. 1, 2, & 3 relate to the following misconceptions; force is always associated with a body in motion, the force would be zero if the velocity of the body were zero, and the direction of force is that of the velocity. The concept of force as push or pull introduced in the earlier classes is the beginning of these misconceptions. Examples given in the book are related to living beings who are exercising some kind of push and pull (Item 4). So, the student reverses the argument in his mind and thinks that as 'continuous force is required for an object to be in motion'. We should emphasize while giving the above example that force is needed only to change the velocity of the body, and no force is needed to maintain its constant velocity. In everyday life, we do need a steady force to maintain a constant velocity of our bicycle or moped to counterbalance the frictional force arising due to the relative motion of the two surfaces in contact. When Newtons First Law of Motion has introduced a discussion about balanced and unbalanced forces is essential. Having understood the concept of balanced and unbalanced forces, students can now write Newton's first law of motion in their own words. While discussing the examples mentioned above, the teacher can explain to the students to consider a body on which no net force acts. If the body is at rest, it will remain at rest. If the body is moving with constant velocity, it will continue to do so. An important word here is NET. It means "total" or "sum of all" (forces). It is not that no force at all can act on the body. It is just that all the forces must add to zero (cancel each other out).

Therefore Newton's First Law of Motion can be written as:

Every object persists (stays) in its state of rest or uniform motion in a straight line unless it is compelled (made) to change that state by forces impressed (acting) on it.

If a ball is thrown vertically up by the hand, the push force exerted at the time of throw remains in the body during the entire flight (Item 7). If students are asked to label all forces during the flight of a ball right from the point when the ball is released from hand and until reaches the floor they have an inherent confusion that a muscular force acts on the ball until it reaches the highest point of its flight and while its journey back this force ceases to act and now it is the gravitational force that takes over. Examples of ball thrown upwards, downwards and at an angle were discussed. A free body diagram was then drawn.

Discussing Newton's second law of motion teacher can draw the attention of the learners to the example of a stone thrown from a height. If you allow stone to fall and if its acceleration is observed as 'a' then 'ma' gives us the net force acting on the stone (Item 6). This net force is the combination of the force due to earth and the opposing force due to the surrounding air.

So, Newton's second law of motion is commonly shortened to "F=ma". (Valid for a single force) Correctly, it is :

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}, \qquad \vec{\mathbf{a}} = \frac{\sum \vec{\mathbf{F}}}{m} \qquad \text{(For Multiple forces)}$$

The significance of the third law of Newton is much deeper than the action and reaction it talks about. It states a very important characteristic of force, namely that forces always occur in pairs. When we are interested in the accelerated motion of only one body, we may not consider the other paired force, but it does exist. Thus, the third law states that a force is the result of interaction between two bodies. The misconception often quoted is students' thinking that the action and reaction forces act on the same body (Item 8).

The most effective way of curbing this misconception is not to give the third law in its briefest form, namely "Action and reaction are equal and opposite". It should rather be stated as "Mutual action and reaction between two bodies are equal and opposite". The book 'Fundamentals of Physics' (Halliday, Resnick and Walker, 1994) gives a good number of examples illustrating action-reaction pairs of forces. The common examples given while teaching this law are 'ball and bat', 'bullet and rifle' etc. Even in these cases, forces are neither properly identified nor described verbally in a pedagogically correct manner. For example, it is stated that the bullet goes forward and the gun comes backward; one is action and the other is the reaction. We forget that action and reaction refer to forces and not motion. If we persist in this way, the misconception of the students equating force with motion is likely to be strengthened. We should rather say that "The rifle acts on the bullet" (action) and "The bullet reacts on the rifle" (reaction). So, whatever example we give of action-reaction pair, we must identify 'by whom' and 'on what'. In the case of the ball-bat example, stating the pair won't be enough. The bat either does not seem to move or move in a direction opposite to that in which the force due to the ball is exerted on the bat. One comes to know of the existence of this reaction as an experience of the batsman who feels a pain in his hand.

More interesting and also more confusing in terms of students' responses are situations where nothing moves, but action-reaction forces are present. In this category, let us cite the example of a boy sitting on a chair. The boy acts on the chair and the chair reacts to the boy. The physical cause for the boy's action on the chair is the gravitational pull of the earth on the boy. This is also action the opposite paired reaction for which is the force with which the boy attracts the earth. The 'pair' of forces acting on the boy by 'the earth and the chair' is equal and opposite (why?) but is not an action-reaction pair because both members of the pair are acting on the same object that is the boy! And in this case, three objects are involved: the earth, the chair, and the boy. So, it should be clear that the action and reaction, which the third law talks about, describe, in fact, the physical interactions between objects taken two at a time.

CONCLUSION

The development of alternative frameworks or misconceptions is from the same mechanism that leads to the development of conception. In addition, some modes and sequences of presenting information during teaching may result in the development of misconceptions. In the context of constructivist approach students' errors are recognized as a part of the developmental phenomena and not due to misunderstanding of the concept. Students understanding of the concept of force as they move from lower to higher level may be influenced by their daily life experiences. The content knowledge given in books is not sufficient to dispel away the misconceptions. Supplementary knowledge and examples need to be given. It is important that teachers plan and design some experiments and conduct discussions in the classroom. Using active learning strategies, such as brainstorming techniques can also help.

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