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To Assess The Concept Of Force Of The Students Studying Physics By Force Concept Inventory

K. N. Chattopadhyay And Papiya Upadhyay

Asstt. Professor, Department of Education, Burdwan University, Burdwan, W.B
Faculty (Contractual), Dept. of Education, Burdwan University, Burdwan, W.B

Abstract: The aim of physics education is the development of conceptual understanding of the natural world in which we live. Physics is an experimental science and force is the central part of it. To study the conceptual understanding of physics, it is necessary to study the concept of force of the students. In this paper, the concept of force of different students are assessed using force concept inventory (FCI) developed by Hestenes, D et al. In this paper, it is also studied that whether the concept of force differs for male and female students or for urban and rural students or for science and engineering students or for B.Sc. and M.Sc. students. The misconceptions about force of the students of different categories are also discussed.

Keyword: Force, Concept of force, Force concept inventory

INTRODUCTION:

Physics is an experimental science and mechanics is the base of physics. Force is the central part of mechanics and it is a such physical quantity which is experienced by every child from his childhood and forms a conception about it. This conception may not be right always, because it is formed from his commonsense. Actually when a student begins to study physics then he already possess well-established system of commonsense beliefs about force and these beliefs play a dominant role in introductory physics. It is noticed that the students of our country are not comfortable in mechanics. So, it is necessary to know the level of conception (and also the misconception) of force of our students. Hestenes et al (1992) have designed an Inventory about force concept, known as Force Concept Inventory (FCI) to know the students' Newtonian concept of force. From this inventory a clear picture of students' misconceptions about force can also be obtained. FCI helps the teachers to raise their awareness of misconceptions among their own students as misconceptions are more informative than the conceptions. And this awareness is necessary to construct a suitable instructional strategy. In this study an attempt has been made to find out the conceptions of force and obviously the misconceptions of force among the students (using FCI) who have already gathered a general knowledge of introductory physics. To frame instructional strategy it is also valuable to know whether the educational level of a student has any effect on the concept of force. Will the concept of force differ for male and female students or for urban and rural students or for science and engineering students? These questions arise. The investigators have tried to find out the answer of these questions as there is yet any study in this regard.

OBJECTIVES OF THE STUDY

The following objectives are laid down in this study:
(i)This study aims to find out the level of conception of force of students who have studied physics as a major subject in higher secondary.
(ii)To find out if there is any difference between male and female students regarding the conception of force.
(iii)To explore whether education level of students has any effect on the concept of force.
(iv)To find out if the medium of instruction has any role on the misconception of force.
(v)This study investigates whether the students who have scored high marks in class XII physics have better conception in force.
(vi)To study whether science and engineering students differ in their force conception.
(vii)To know if there is any difference between urban and rural students in their force conception.

HYPOTHESES

The following hypotheses are framed for the study –
H1:The concept of force of male and female students differs significantly.
H2:The concept of force of urban and rural students differs significantly.
H3:The concept of force of English medium and Bengali medium students differs significantly.
H4:The concept of force of science and engineering students differs significantly.
H5:The concept of force of the students having > 80% marks and the students having
< 80% marks in class XII physics differs significantly.
H6:The concept of force of under graduate and post graduate science students differs

significantly.

DELIMITATION OF THE STUDY

Taking into consideration the time in hand, scope and finance available the present study was delimited in terms of scope, area, sample etc.

(i)The study is limited to 199 students selected by random purposive sampling methods due to short stipulated time.

(ii)The study is confined to the M.Sc.(Physics) & B.Sc Honours(Physics) and B.E.students.

(iii)The study is performed to the students of Burdwan city only.

(iv)Economic status of the students is delimited in this study.

(v)The physics teachers are excluded from this study.

RELATED STUDIES CONDUCTED ABROAD

Many professors and scientists e.g. Hestenes, D(1992), Halloun, I et al (1985), Carvalho, P S et al (2005), Savinainen, A et al (2002) etc. have studied regarding conception of force, motion and frictional force on large number of students in different countries. Malone, K L (2008) has published a paper in Physical Review on correlations among knowledge structures, force concept inventory and problem-solving behaviours.

RELATED STUDIES CONDUCTED IN INDIA

Sharma, S V , RIE (NCERT) in 2005, conducted a project on investigation into understanding the concept of force at different levels of students.

· Sharma, S V , RIE (NCERT) in 2006, conducted a project on investigation into understanding the concept of frictional force at different levels of students.

· Sharma, S V et al in 2007 published a paper in Physics Education (UK) on Force Concept Inventory and Frictional Force Concept Inventory. They have administered FCI and Frictional FCI followed by practical activities on number of students to know their understanding regarding force and frictional force. They have found a significant difference between expected and actual learning outcomes.

METHODOLOGY OF THE STUDY

Tools used

There are different techniques for the collection of data. The investigators have taken the 'Force Concept Inventory' (FCI) , originally designed by Hestenes et al (1992), as the tool for the collection of data. FCI is a well proved test and Hestenes et al (1992) have discussed in details about the test validity and reliability of FCI.

Samples

In the present study on understanding of concepts of force, the sample consisted of 199 students of B.Sc.(Physics Hons.) 1st year, B.E. 1st year and M.Sc.(Physics) 1st year. The details of the samples are given in Table 1.

Table 1: Details of the samples for FCI

Sl. No.	Sample	Size of the Sample	Level of the Sample
1	B.Sc.(Physics Hons) 1st year Students	23	Under Graduate
2	B.E. 1st year Students	115	Under Graduate
3	M.Sc.(Physics) 1st year Students	61	Post Graduate

Total = 199

Area of the Study

The present study was conducted among the students of different colleges like M.U.C. Women's College, Raj College, University Institute of Technology of Burdwan city and in the Physics Department of Burdwan University in West Bengal.

Administration of FCI and Collection of Data

After selection of the sample the important aspect of the study is the administration of FCI and collection of data. The FCI test was administered to 199 under graduate and post graduate students of Burdwan city by purposive random sampling method. The investigators went to the above said institutions, took permission from the Head of the institution for administering the FCI. After introduction the investigators explained the instructions of this test before the students and then supplied the question paper containing 29 multiple choice type questions i.e. the FCI to them. They were allowed maximum 45 minutes to answer the questions. The students wrote their answers (by giving a tick to each question) on the same question paper and returned it to the investigators.

Scoring technique

There are 29 multiple choice type questions and each question has five options. Among the five options one is correct answer according to Newtonian concept and the other four options are designed on the basis of misconceptions. The students were asked to tick one option on the basis of their own thinking. Wrong response or more than one response or no response was treated as incorrect answer. There was no negative marking. A correct response was scored as +1 and an incorrect response was scored as 0. So a student's maximum score could be +29 and minimum be 0.

ANALYSIS AND INTERPRETATION

The sample size of this study is 199. The samples are the under graduate and post graduate students of Burdwan city. To find the acceptance or rejection of the hypotheses they are classified into different groups as given in the following Table 2.

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Table 2: Size of different groups of the samples

Sl. No.	Variables	No. of Samples
1	Male Students	136
	Female Students	63
2	Rural Students	71
	Urban Students	128
3	Medium of instruction : English	48
	Medium of instruction : Bengali	151
4	Science Students	84
	Engineering Students	115
5	Students having > 80% marks in XII std. Physics	75
	Students having < 80% marks in XII std. Physics	124
6	Under graduate Students	138
	Post graduate Students	61

Each sample got a score and the scores obtained by each group are analysed as follows.

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Table 3: Comparison between Male and Female students towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
Male	136	10.60	3.54	3.67	Significant at .01 level
Female	63	8.51	3.84		

Table 4: Comparison between Rural and Urban students towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
Rural	71	9.44	3.49	1.45	Not Significant
Urban	128	10.22	3.88		

Table 5: Comparison between English Medium and Bengali Medium students towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
English Medium	48	10.58	4.10	1.27	Not Significant
Bengali Medium	151	9.74	3.63		

Table 6: Comparison between Science and Engineering students towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
Science	84	9.42	3.77	1.67	Not Significant
Engineering	115	10.32	3.72		

Table 7 : Comparison between students having >80% marks and < 80% marks in XII std. physics towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
>80% marks in XII std. Physics	75	9.60	4.00	0.97	Not Significant
<80% marks in XII std. Physics	124	10.14	3.60		

Table 8 : Comparison between under graduate and post graduate students towards Concept of Force

Group	Sample No. (N)	Mean Score (M)	SD (σ)	t-value	Level of significance
UG	138	9.76	3.92	1.05	Not Significant
PG	61	10.34	3.37		

Analysis of data relating to Hypothesis no.1

H1: The concept of force of male and female students differs significantly.

The mean score of male students is 10.60 with standard deviation 3.54 and the mean score of female students is 8.51 with standard deviation 3.84. To find out the significance of difference between two means 't' value is calculated and it is found to be 3.67. From the t-table it is seen that the value 3.67 is significant at .01 level. From this statistical analysis we may conclude that the concept of force of male students and female students differs significantly.

Analysis of data relating to Hypothesis no.2

H2: The concept of force of urban and rural students differs significantly.

The mean score obtained by urban students is 10.22 with standard deviation 3.88 whereas the mean score of rural students is 9.44 with standard deviation 3.49. The computed 't' value is 1.45 and from t-table it is verified that this value is insignificant. From this statistical analysis we can say that the concept of force of urban students and rural students does not differ significantly or in other words null hypothesis is retained.

Analysis of data relating to Hypothesis no.3

H3: The concept of force of English medium and Bengali medium students differs significantly.

The mean score of English medium students is 10.58 with standard deviation 4.10 and the mean score of Bengali medium students is 9.74 with standard deviation 3.63. To find out the significance of difference between two means 't' value is calculated and it turns out 1.27. From the t-table it is seen that this value is insignificant. So we may conclude that the concept of force of urban students and rural students does not differ significantly.

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Analysis of data relating to Hypothesis no.4

H4: The concept of force of Science students and Engineering students differs significantly.

The mean score obtained by science students is 9.42 with standard deviation 3.77 whereas the mean score of Engineering students is 10.32 with standard deviation 3.72. The 't' value is calculated to find out the significance of difference between two means. The value of 't' is found to be 1.67 and this value of 't' is insignificant. This statistical analysis shows that the concept of force of science students and engineering students does not differ significantly.

Analysis of data relating to Hypothesis no.5

H5: The concept of force of the students having >80% marks and the students having < 80% marks in class XII physics differs significantly.

The mean score of the students having > 80% marks in XII std. physics is 9.60 with standard deviation 4.00 and the mean score of the students having < 80% marks is 10.14 with standard deviation 3.60. 't' value is calculated and is found to be 0.97. From the t-table it is seen that this value is insignificant. So we may conclude that the concept of force of the students having >80% marks and the students having < 80% marks in XII std. physics does not differ significantly.

Analysis of data relating to Hypothesis no.6

H6: The concept of force of under graduate and post graduate students differs significantly.

The mean score obtained by the under graduate students is 9.76 with standard deviation 3.92 whereas the mean score of the post graduate students is 10.34 with standard deviation 3.37. The computed 't' value is 1.07 and from t-table it is verified that this value is insignificant. From this statistical analysis we can say that the concept of force of the under graduate students and the post graduate students does not differ significantly or in other words null hypothesis is retained.

Analysis of data pertaining to Conceptions and Misconceptions of Force In the force concept inventory there are 29 questions and each question has five options (except question no. 16). Among the five options one option is correct according to Newtonian concept and others are designed on the basis of commonsense beliefs i.e. misconceptions. The response of the students is listed in the following Table no. 9.

Table 9: Response frequencies for the students

Item No.	Correct Option	No. of students opt for					
		Option A	Option B	Option C	Option D	Option E	None
1	C	5	11	134	36	5	8
2	E	61	15	5	4	104	10
3	A	29	26	15	42	24	63
4	B	9	157	3	5	6	19
5	D	7	59	83	38	1	11
6	B	25	65	7	29	63	10
7	E	14	34	23	12	91	25
8	A	69	13	14	71	18	14
9	D	13	43	77	15	9	42
10	B	28	107	20	9	7	28
11	E	9	3	23	39	119	6
12	B	22	107	54	2	10	4
13	A	56	30	61	21	0	31
14	A	45	17	55	15	4	63
15	C	29	88	65	1	8	8
16	B	3	93	83	4	0	17
17	C	24	64	74	4	25	12
18	B	96	33	7	4	34	25
19	B	4	105	51	4	0	35
20	E	47	7	12	46	43	44
21	D	11	7	68	54	19	40
22	D	6	31	117	23	2	20
23	D	52	22	11	92	2	20
24	E	44	23	54	19	31	28
25	B	43	31	22	49	27	27
26	B	7	16	30	72	8	56
27	A	74	16	43	11	14	41
28	C	5	17	42	77	7	51
29	C	5	61	65	8	13	47

From the above table it may be noted that:

i)The overall percentage of correct and incorrect response is only 34.3% and 65.7% respectively.

ii)In some cases there were very few correct responses e.g. question numbers 3, 5, 9, 18, 20, 22, 24, 25, 26 & 28.

iii)Question number 4 is answered correctly by 78.9% students, whereas question number 9 is answered correctly only by 7.5% students.

CONCLUSION

From the present study the investigator may conclude that:

i)There is a significant difference of the concept of force of male and female students.

ii)There is no significant difference of the concept of force of urban and rural students.

iii)There is no significant difference of the concept of force of English medium and Bengali medium students.

iv)There is no significant difference of the concept of force of science and engineering students.

v)There is no significant difference of the concept of force of the students having > 80% marks and < 80% marks in XII std. physics.

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vi)There is no significant difference of the concept of force of under graduate and post graduate students.
vii)The overall conception of force of the students is poor. Only 34.3% questions are answered correctly by them. This data strengthens the fact that commonsense beliefs play a dominant role in the concept of force. The main cause of poor performance in FCI can be discussed as follows:

As physics is an experimental science, this conceptual understanding can be obtained through hands-on activities of the students. The national curriculum framework prepared by NCERT for school education has also emphasized more on practical work and activity oriented teaching of science. But in our country, almost in all states, importance is given in the teaching of theoretical portion of physics and the experimental portion is neglected. The main reason behind this attitude of the institutions is that most of them don't possess sufficient equipment and apparatus. The another reason is that the students of +2 level are not careful to perform the practical works. Most of the students who study science in +2 level are much interested to prepare themselves for entrance examinations conducted for medical and engineering courses. For this purpose they need only the theoretical knowledge of the subject and thus the experimental portion is neglected. Obviously, the students are not getting the right concept of the science subjects.

SUGGESTION FOR FURTHER STUDY

i)This study will be more valuable if it is extended to the other students of different colleges and Universities of West Bengal.
ii)The concept of force of the Physics teachers of schools, colleges and Universities can be studied.
iii)The study will be more fruitful if the misconceptions of the students are analyzed in details.
iv)Other variables like economic status of the students can be included.
v)There is a scope to find out the reasons behind the difference in acquisition of the concept of force of male and female students.
vi)Other concepts of physics like mechanics baseline, friction etc. may also be studied.

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