Misconception patterns from students to teachers: an example for force and motion concepts

Ejemplos de ideas alternativas transmitidas de los estudiantes a los profesores: temas: fuerza y movimiento

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Abstract

To date, many investigations in physics education have been done and have revealed many things about what students know and how they learn and understand basics concepts in physics. In general, students' interactions and experiences with the real world shape their own concept about their own worlds. Mostly, these concepts contradict with scientifically accepted physics concepts taught in physics classes. This study investigates the pattern of misconceptions from high school students to prospective and in-service physics teachers about force and motion concepts. The Force Concept Inventory (FCI) test is applied to 99 high school students, 66 prospective physics teachers, and 25 in-service physics teachers working as a physics teacher in different regions of Turkey in the Anatolian Teacher High Schools. According to FCI test results, it is found that prospective physics teachers, physics teachers and tenth grade high school students have some similar misconceptions about force and motion concepts.

Key words: *in-service teachers, high school, students, physics education, FCI test, misconceptions.*

Resumen

Muchas investigaciones en educación de la física se han hecho y hay varios ejemplos acerca de qué saben los estudiantes y cómo aprenden y entienden los conceptos de principios en la física. En general, las experiencias de los estudiantes del mundo real, forman sus propios conceptos acerca de sus mundos. En su mayor parte, estos conceptos contradicen con los conceptos científicamente aceptados de la física enseñados en clase. En este trabajo se estudian los conceptos alternativos de los estudiantes de bachillerato que transmiten a los futuros docentes y a los estudiantes de licenciaturas, acerca de conceptos de fuerza y movimiento. La prueba especial sobre el concepto de la fuerza (FCI), fue aplicada a 99 estudiantes de bachillerato, a 66 futuros maestros de la física, y a 25 maestros de la física que trabajan como docentes de física en regiones diferentes a Anatolia en Turquía. Según la prueba de FCI, los futuros maestros de física, maestros de física y estudiantes de bachillerato tienen algunos conceptos alternativos similares a fuerza y movimiento.

Palabras clave: *estudiantes, bachillerato, licenciaturas, profesores en servicio, física, prueba de FCI, conceptos alternativos*

INTRODUCTION

Many investigations have been done in physics education and have revealed many things about what students know and how they learn and understand basics concepts in physics (Clement, 1982; Maloney, 1985; Halloun & Hestenes, 1985). Students' interactions and experiences with the real world shape and develop their own concepts about their own world. Students' different experiences and educational backgrounds might lead to many preconceived ideas or misconceptions about force and motion concepts (Clement, 1982; Eckstein & Shemesh, 1993a, 1993b; Halloun & Hestenes, 1985; Maloney, 1984; Palmer & Flanagan, 1997; Poon, 1993; Thijs, 1992; Tatli & Eryilmaz, 2001; Demirci, 2001). These misconceptions are resistant to change even after the students have received formal physics instruction (Clement, 1982; Driver & Warrington, 1985; Gunstone, 1987; Halloun & Hestenes, 1985a, b; McDermott, 1984; Sadanand & Kess, 1990). This resistance has been observed in both college students (Clement, 1982; Champagne, Klopfer & Anderson, 1980) and high school students (Cohen, Eylon, & Ganiel, 1983; Sadanand & Kess, 1990). Restructuring their misconceptions is required for complete and scientific understanding of physics (Nersessian, 1992).

One attempt to identify and address student misconceptions is the use of Concept Inventories. The first, and most influential of these is the Force Concept Inventory (FCI) (Hestenes *et al.*, 1992). The Force Concept Inventory (FCI) has been administered to more than 20,000 high school physics students across the United States. Designed to probe conceptual understanding of Newton's laws of motion, rather than the ability to memorize terms or manipulate equations, the use of the FCI revealed that high student grades often did not correlate with a robust conceptual understanding (Hake, 1998; Powell, 2003). Since the introduction of the FCI, other concept inventories have begun to appear in physics. Among these are the Force and Motion Concept Evaluation (FMCE) (Sokoloff & Thorton, 1998), the Brief Electricity and Magnetism Assessment (BEMA) (Ding *et al.*, 2006), the Quantum Mechanics Concept Survey (McKagan & Weiman, 2005).

One of the main responsibilities and challenges of physics instructors is to change non-scientific preconceived ideas of students. Therefore determining the patterns of misconceptions of physics students, in-service teachers and prospective physics teachers is very important and necessary for further studies to analyze in depth.

The main aim of this study was to determine, compare and evaluate high school students', in-service physics teachers' and prospective physics teachers' pattern of misconceptions (if any) about force and motion concepts in physics.

METHODOLOGY

Subjects

The subjects of this study have been chosen for convenience from three different populations.

The first sample consisted of 99 tenth-grade students from two public high schools (of the 99, 56 were female, 43 were male). All students resided in Balikesir, Turkey and volunteered for participation in the study. The average academic ability of each group was not different from the average academic ability of the students in the area. In addition, they were all from the same school district therefore they were representative of the general geographical and socio-economic background. They all took same obligatory science courses previously.

The second sample have been chosen as the 66 senior prospective physics teachers (of the 66; 35 were female and 31 were male) in the department of physics education at Necatibey Faculty of Education, Balikesir University/Turkey (in a two year period).

They were in the last semester of their education to become physics teachers. The participants, like all students in the Faculty of Education, were following a five-year integrated program. In order to complete an integrated program, for the first seven semesters, students must take physics classes in the Department of Physics. After completing these classes, in the remaining three semesters they must take courses related to the profession of teaching in the Department of Educational Sciences and the Department of Secondary Science and Mathematics Education. Upon graduation, the students are granted MSc. degrees without a thesis.

The third sample consists of 25 in-service physics teaches (of the 25; three were female and twenty-two were male) from different Anatolian Teacher High Schools from all over Turkey. The Ministry of Education has organized in-service course for Anatolian Teacher High School physics teachers to update their knowledge and new developments in physics teaching. To become a physics teacher in Anatolian Teacher High School, one has to work in public high school at least three years as a physics teacher, and pass the examination held by Ministry of Education Department. The Ministry of Education invited the Anatolian Teacher High School physics teachers to participate in an in-service course in Mersin, Turkey. Only twenty-five physics teachers have participated to this course from different region of Turkey. These participant teachers' experiences ranged between five to twenty-three years.

Instrumentation

In the study there was only one instrument, the Force and Motion Concept Inventory (FCI) test. The FCI was introduced by Hestenes, Wells, and Swackhamer (Hestenes *et al.*, 1992). This instrument evolved from the earlier Mechanics Diagnostic Test

(Halloun and Hestenes, 1985). The FCI test has high reliability and is the most used test in this area. It is designed to cover Newtonian concepts more comprehensively and facilitate the interpretation of the results (HAKE, 1998). For example, the FCI can identify students' difficulties with each of Newton's laws of motion and can help identify the common sense beliefs associated with each of these difficulties. The Newtonian force concept is decomposed into six conceptual dimensions: kinematics, first law, second law, third law, superposition principle, and kinds of force. Most physics instructors will agree that all six dimensions are required for a complete understanding of the Newtonian force concept. Each dimension is further broken down into the isolated concepts that characterize that dimension. They suggested an interpretation of FCI scores that is consistent with a three-stage model of conceptual understanding in learning Newtonian mechanics. Students who score below 60% on the FCI are classified as stage I. Stage I student thinking can typically be described in terms of the following characteristics:

- undifferentiated concepts of velocity and acceleration,
- lack of a vectorial concept of velocity,
- belief that there are other influences on motion besides forces,
- inability to reliably identify passive and active agents of force on an object, and
- fragmented and incoherent concepts about force and motion.

Students who scored between 60% and 85% on the FCI are in stage II. Hestenes and Halloun suggested that an FCI score of 60% be considered as the entry threshold to Newtonian thinking. In stage II, students are developing coherent dynamics' concepts, including vectorial concepts of velocity, acceleration, and force. An FCI score of 85% is interpreted as the threshold to stage III and mastery of the Newtonian force concept. Students in stage III develop a complete Newtonian interaction concept including a full understanding of Newton's third law. Hestenes and Halloun express confidence in "identifying students with scores above [85%] as confirmed Newtonian thinkers".

Procedures

After translating the FCI test into Turkish, the test was controlled and checked by some physics instructors and then applied to another group of prospective physics teachers (N=32). According to their responses the final FCI test was constructed to use in the study (there was not any published article related to FCI test in Turkish; therefore, this was the first time to use it). The final FCI test was applied separately to each sample (the test applied to physics teachers at the end of their in-service course program, to prospective physics teacher at the last semester of their education, and to high school students after the completing their instruction related to force and motion concepts). Then the results are compared and some conclusions drawn.

RESULTS AND INTERPRETATIONS

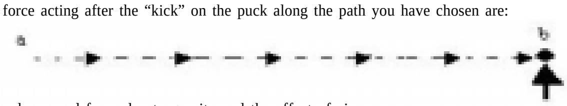
Participants' FCI test results are given in table 1. Table 1 shows that the ratio of correct answers given by all groups (high school students, prospective and in-service physics teachers) to the questions 9, 13, 15, 17, 21, 22, 24, 25, and 26 are lower than 50%. Less then 50% of prospective physics teachers gave the correct answer to fourteen questions (namely they are: 5, 6, 9, 10, 13, 15, 17, 18, 21, 22, 24, 25, 26, and 28). Prospective physics teachers' the ratio of correct answers had coincided in nine questions with in-service physics teachers. On the other hand, the high school students had only two questions with the correct answers higher than 50%. Because of the lower percentage rate, here, those coincidental questions are going to be examined first.

Table1
Participants' FCI test results

Q.		Given Answers (N)						Results	
Nº	**Participants**	**A**	**B**	**C**	**D**	**E**	**No answer**	**Number of correct answer**	**Success (in%)**
1	H. School Students	15	3	21	54	-	6	21	21,21
	Prospective Phy. Teachers	6	-	58	2	-	-	58	87,88
	In-service Phy. Teachers	-	-	25	-	-	-	25	100,00
2	H. School Students	54	6	3	9	24	3	24	24,24
	Prospective Phy. Teachers	14	2	-	-	50	-	50	69,70
	In-service Phy. Teachers	2	-	-	-	23	-	23	92,00
3	H. School Students	9	45	12	24	6	3	9	9,09
	Prospective Phy. Teachers	38	10	4	10	4	-	38	57,58
	In-service Phy. Teachers	23	-	2	-	-	-	23	92,00
4	H. School Students	9	51	6	21	3	9	51	51,52
	Prospective Phy. Teachers	2	50	4	6	4	-	50	75,76
	In-service Phy. Teachers	1	20	2	1	-	1	20	80,00
5	H. School Students	12	27	18	9	24	9	9	9,09
	Prospective Phy. Teachers	-	12	24	26	2	2	26	33,39
	In-service Phy. Teachers	-	7	4	13	-	1	13	52,00
6	H. School Students	9	27	6	27	27	3	27	27,27
	Prospective Phy. Teachers	6	30	-	2	28	-	30	45,45
	In-service Phy. Teachers	-	14	1	2	7	1	14	56,00
7	H. School Students	9	24	21	24	15	6	15	15,15
	Prospective Phy. Teachers	2	8	4	-	46	6	46	69,70
	In-service Phy. Teachers	-	2	-	1	22	-	22	88,00
8	H. School Students	15	21	18	24	12	9	15	15,15
	Prospective Phy. Teachers	34	2	10	14	2	4	34	51,52
	In-service Phy. Teachers	22	-	1	2	-	-	22	88,00
9	H. School Students	3	42	30	15	-	9	15	15,15
	Prospective Phy. Teachers	8	18	26	14	-	-	14	21,21
	In-service Phy. Teachers	8	1	6	10	-	-	10	40,00
10	H. School Students	69	21	6	-	-	3	21	21,21
	Prospective Phy. Teachers	32	20	10	-	4	-	20	30,30
	In-service Phy. Teachers	-	24	1	-	-	-	24	96,00
11	H. School Students	-	15	54	9	21	3	21	21,21
	Prospective Phy. Teachers	-	-	28	-	38	-	38	57,58
	In-service Phy. Teachers	-	-	4	1	19	1	19	76,00
12	H. School Students	3	63	18	3	6	6	63	63,64
	Prospective Phy. Teachers	-	44	20	-	2	-	44	96,96
	In-service Phy. Teachers	-	12	10	3	-	-	12	88,00
13	H. School Students	30	9	42	12	3	3	30	30,30
	Prospective Phy. Teachers	30	4	32	-	-	-	30	45,45
	In-service Phy. Teachers	6	6	12	1	-	-	6	24,00
14	H. School Students	48	3	9	6	27	6	48	48,48
	Prospective Phy. Teachers	44	-	4	-	12	6	44	66,67
	In-service Phy. Teachers	21	1	2	-	1	-	21	84,00
15	H. School Students	15	6	39	6	9	24	39	39,39
	Prospective Phy. Teachers	24	6	24	-	4	8	24	36,36
	In-service Phy. Teachers	4	12	5	-	4	-	5	20,00
16	H. School Students	-	45	48	3	-	3	45	45,45
	Prospective Phy. Teachers	-	56	6	3	-	2	56	84,85
	In-service Phy. Teachers	-	24	1	-	-	-	24	96,00
17	H. School Students	9	30	42	9	3	6	9	9,09
	Prospective Phy. Teachers	20	8	24	2	4	8	20	30,30
	In-service Phy. Teachers	11	3	4	7	-	-	11	44,00
18	H. School Students	36	30	-	-	24	9	30	30,30
	Prospective Phy. Teachers	20	28	2	-	10	6	28	42,42
	In-service Phy. Teachers	4	21	-	-	-	-	21	84,00
19	H. School Students	-	54	39	-	-	6	54	54,55
	Prospective Phy. Teachers	-	48	10	-	-	8	48	72,73
	In-service Phy. Teachers	-	23	2	-	-	-	23	92,00
20	H. School Students	9	21	30	21	6	12	6	6,06
	Prospective Phy. Teachers	14	2	2	4	34	10	34	51,52
	In-service Phy. Teachers	6	4	1	2	10	2	10	40,00
21	H. School Students	6	-	66	-	3	24	0	0,00
	Prospective Phy. Teachers	18	1	10	24	2	10	24	36,36
	In-service Phy. Teachers	2	2	11	9	1	-	9	36,00
22	H. School Students	-	30	60	-	-	9	0	0,00
	Prospective Phy. Teachers	-	8	42	14	-	2	14	21,21
	In-service Phy. Teachers	-	2	12	10	1	-	10	40,00
23	H. School Students	57	24	3	9	-	6	9	9,09
	Prospective Phy. Teachers	2	2	4	56	-	2	56	84,84
	In-service Phy. Teachers	1	1	1	21	1		21	84,00
24	H. School Students	12	18	27	12	18	12	18	18,18
	Prospective Phy. Teachers	10	14	14	6	14	8	14	21,21
	In-service Phy. Teachers	4	3	8	2	7	1	7	28,00
25	H. School Students	9	30	6	33	6	15	30	30,30
	Prospective Phy. Teachers	22	20	2	16	-	6	20	30,30
	In-service Phy. Teachers	8	9	2	6	-	-	9	36,00
26	H. School Students	18	18	15	33	3	12	15	15,15
	Prospective Phy. Teachers	6	16	26	6	2	12	26	39,39
	In-service Phy. Teachers	6	1	9	5	3	1	9	36,00
27	H. School Students	30	6	18	3	24	18	30	30,30
	Prospective Phy. Teachers	40	4	4	4	4	10	40	60,61
	In-service Phy. Teachers	20	-	4	-	1	-	20	80,00
28	H. School Students	3	9	27	9	33	18	27	27,27
	Prospective Phy. Teachers	-	4	30	20	-	12	30	45,45
	In-service Phy. Teachers	1		20	3	1	-	20	80,00
29	H. School Students	21	36	15	6	6	15	15	15,15
	Prospective Phy. Teachers	2	14	34	4	-	12	34	51,52
	In-service Phy. Teachers	-	4	19	-	-	2	19	76,00

The diagram depicts a hockey puck sliding, with a constant velocity, from point "a" to point "b" along a frictionless horizontal surface. When the puck reaches point "b", it receives an instantaneous horizontal "kick" in the direction of the heavy print arrow.

The main force acting after the "kick" on the puck along the path you have chosen are:



(A) the downward force due to gravity and the effect of air pressure.

(B) the downward force of gravity and the horizontal force in the direction of motion.

(C) the downward of gravity, the upward force exerted by the table and the horizontal force acting on the puck in the direction of motion.

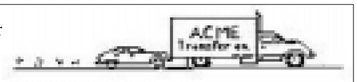
(D) the downward of gravity and the upward force exerted on the puck by the table.

(E) gravity does not exert a force on the puck; it falls because of the intrinsic tendency of the object to fall to its natural place.

Figure 1. The ninth question.

Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 15%, 40%, and 21% respectively. While seven teachers had chosen incorrect choices of B and C, 44 prospective physics teachers and 72 high school students had chosen incorrect choices of B and C. The wrong choices, B and C, are related to the misconception of "impetus supplied by hit" (HESTENES *et al.*, 1992).

A large truck breaks down on a road and r
a push back into town by a small compact



While the car, still pushing the truck, is speeding up to get up to cruising speed:
(A) the amount of force that the car pushing against the truck is equal to that of the truck pushing back against the car.
(B) the amount of force that the car pushing against the truck is less than that of the truck pushing back against the car.
(C) the amount of force that the car pushing against the truck is greater than that of the truck pushing back against the car.
(D) the car's engine is running so it applies a force it pushes against the truck but the truck's engine is not running so it cannot push back against the car.
(E) neither the car nor the truck exerts any force on the other.

Figure 2. The Thirteenth question.

Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 30%, 24%, and around 45% respectively. According to their incorrect choices, the high school students, in-service and prospective physics teachers have the following misconceptions: "the only active agents exerts forces.", "greater mass implies grater force", and "obstacles exert no forces" (HESTENES *et al.,* 1992).

When a rubber ball dropped from rest bounces off the floor, it is direction of motion is reversed because:
(A) energy of the ball is conserved.
(B) momentum of the ball conserved.
(C) the floor exerts a force on the ball that stops its fall and then drives it upward.
(D) the floor is in the way and the ball has to keep moving.
(E) none of the above.

Figure 3. The Fifteenth question:

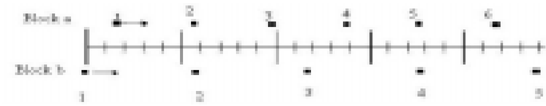
Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 39%, 20%, and 36% respectively. Another interesting result about this question was while the in-service physics teachers mostly focused on incorrect choice of B, the prospective physics teachers focused on mostly choices of A and C, and the high school students focused on the choice of A. According to these incorrect choices (applying the active force incorrectly), high school students, in-service and prospective physics teachers have misconception of "only active agent exerts force" (HESTENES *et al*., 1992).

A stone falling from the roof a single story building to the surface of the earth;
(A) reaches its maximum speed quite soon after release and then falls at a constant speed thereafter.
(B) speeds up as it falls, primarily because the closer the stone gets to earth the stronger the gravitational attraction.
(C) speeds up because of the constant gravitational force acting on it.
(D) falls because of the intrinsic tendency of all objects fall toward the earth.
(E) falls because of a combination of the force of gravity and the air pressure pushing it downward

Figure 4. The seventeenth question.

Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 9%, 44%, and 30% respectively. However, analyzing their incorrect choices, it seems that high school students, in-service and prospective physics teachers did not consider the effect of air resistance. Therefore, their incorrect choices are related to the following misconceptions: "acceleration implies increasing force", "force causes acceleration to terminal force", "gravity intrinsic to mass", and "gravity increases as objects fall" (HESTENES *et al.,* 1992).

The positions of the blocks at successive equal time intervals are represented by numbered square in the diagram below. The blocks are moving toward the right.

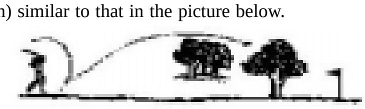


The acceleration of the blocks is related as follows:
(A) The acceleration of "a"> acceleration of "b".
(B) The acceleration of "a"= acceleration of "b".
(C) The acceleration of "b"> acceleration of "a".
(D) The acceleration of "a" = acceleration of "b"=0.
(E) Not enough information to answer

Figure 5. The 21st question.

Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 0%, 36%, and 36% respectively. Surprisingly, none of high school students gave the correct answer. However, focusing on incorrect choices by all groups was quite different. The most marked incorrect choices were A, C and D. It seems that they confused and used velocity concept instead of acceleration or one another. These incorrect choices are related to the following misconceptions: "velocity-acceleration indiscrimination", and "acceleration discriminated from velocity" (HESTENES *et al.,* 1992).

A golf ball driven down a fairway is observed to travel through the air with a trajectory (flight path) similar to that in the picture below.



Which following force(s) is(are) acting on the golf ball during its entire flight?
1. the force of gravity
2. the force of the "hit"
3. The force of air resistance

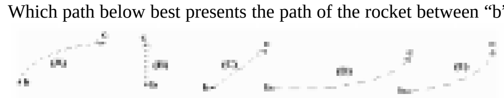
(A) Only 1 (B) 1 and 2 (C) 1, 2, and 3 (D) 1 and 3 (E) 2 and 3

Figure 6. The 22nd question:

Answers given to this question revealed that the ratio of correct answer given by high school students, in-service physics teachers and prospective physics teachers were 0%, 40%, and 21% respectively. Also, again, none of high school students did give the correct choice in answering this question. Those incorrect choices are related to the following misconceptions: "only active agents exert forces", and "impetus supplied by "hit"" (HESTENES *et al.,* 1992).

A rocket, drifting sideways in outer space from position "a" to position "b" is subject to no outside forces. At "b", the rocket's engine starts to produce a constant thrust at right angles to line "ab". The engine turns off again as the rocket reaches some point "c".

24. Which path below best presents the path of the rocket between "b" and "c"?



25. As the rocket moves from "b" to "c", its speed is
(A) constant.
(B) continuously increasing.
(C) continuously decreasing.
(D) increasing for a while and constant thereafter.
(E) constant for a while and decreasing thereafter.

26. At "c" the rocket's engine is turned off. Which of the paths below will the rocket follow beyond "c"?

Figure 7. The 24th, 25th, and 26th questions:

24, 25 and 26th questions are related to moving an object at constant speed in space, then the force acts on an object in shown direction at one instance time and then an object' motion is investigated. Those questions were answered correctly by the physics teachers around 34%, by prospective physics teachers around 30% and by high school students around 19% in average. When their incorrect choices were analyzed, it is found out that these are related to the following misconceptions: "impetus view" and "active force" and "concatenation of influences" (HESTENES *et al*., 1992).

Besides these questions, high school students had problems with almost all the questions (except only twelfth question) with all kinds of misconceptions. Prospective physics teachers had problems with answering 5th, 6th, 10th, 18th, and 28th questions. Their correct answer' ratios were 39%, 45%, 30%, 42%, and 45% respectively. These questions and their incorrect choices are related to the following misconceptions: "impetus view", "using active force incorrectly", "applying action/reaction paired force incorrect ways", and misconceptions related to "centripetal, friction, and gravitation force".

According to FCI test results it can be assert that high school students, in-service and prospective physics teachers have some parallel misconceptions about force and motion concepts, and those misconceptions have a similar pattern.

DISCUSSION

The main aim of this study was to determine, compare and evaluate high school students', in-service physics teachers' and prospective physics teachers' misconceptions pattern (if any) about force and motion concepts in physics. The Force Concept Inventory (FCI) test is applied to three different samples. First sample was 66 prospective physics teachers from the department of Physics Education, Necatibey Faculty Education at Balikesir University (in two year-periods). Second sample was 25 in-service physics teachers working in different regions of Turkey in Anatolian Teacher High Schools. The third sample was 99 10th grade students at two public high schools in Balikesir/Turkey. After analyzing FCI test results, it is found that the high school students, in-service physics teachers and prospective physics teachers have some misconceptions about force and motion concepts and those misconceptions have some similarities that could be inherited from each other.

Evaluation of all participants' force and motion concepts from high school students to physics teachers was done throughout the study using the Force Concept Inventory (FCI). The FCI test was designed to measure students' understanding of basic force and motion concepts compared with their common-sense beliefs. The FCI has played an important role of persuading the physics education community of the level of student difficulties with conceptual understanding of Newtonian force and motion concepts. Yet, while the FCI is a useful measure of students' conceptual understanding, there is a tendency in the community to rely solely on tests like the FCI. This over-simplifies the view of both student learning and evaluation. More research is needed to see how the FCI compares with measures of students thinking and reasoning using physics concepts.

According to many students' thoughts, a purpose of physics learning was to pass the examinations or to achieve high scores in tests. Studies of children's learning (see, for example, CHEEK, 1992; DRIVER *et al*., 1985; GUNSTONE *et al*., 1989; PFUNDT and DUIT, 1994) have shown that even students who are successful in examinations are generally unable to apply the concepts of physics to common everyday situations. Other studies suggested that students perceive physics as boring and irrelevant to life outside the classroom (GARDNER, 1975; LEWIS, 1975; MAUGER *et al.*, 1982; HAUSSLER, 1987; NIELSEN & THOMSEN, 1990), as well as excessively difficult (NIELSEN & THOMSEN, 1990: 68), and they persist with the subject only if it is required for their chosen course of further study. The studies by Mazur (1997), HAMMER (1989), and TOBIAS (1990) suggest that the emphasis on typical end-of-chapter problems and the structure of the traditional lecture method encourage students to see learning physics as memorizing and applying the facts and equations without understanding the underlying concepts. Therefore, the physics teachers or instructors have to remove these kinds of ideas from students "heads" with planning, implementing the original and reasonable conceptual activities. DART *et al*. (2000) found out that high school students in Australia who reported qualitative conceptions of learning (such as emphasizing understanding) tended to use deep approaches to learning, whereas students holding quantitative conceptions of learning (such as focusing on memorization) were likely to use surface approaches.

Science teachers' beliefs about learning and teaching might also play a role in students' ideas of learning physics. Although there has been no direct investigation into this research topic, it is intuitively plausible to assume that physics teachers' notions of learning (and teaching) will guide their instructional approaches and then shape students' conceptions of learning force and motion topics. DONNELLY (1999) and TSAI (2002, 2003) have shown that many science teachers may hold inappropriate conceptions about science instruction. These conceptions may influence their strategies of science instruction, and then lead them to misguide students' scientific conceptions. Physics teacher education programs need to carefully address these problems, and need to help pre-service and practicing teachers to shape more advanced ideas about teaching physics. Therefore, a study now needs to be carried out which compares physics teachers' views of learning physics with those of their students. If there is a strong correlation between these two, changing the students' conceptions may simply be a matter of changing their teachers' conceptions.

CONCLUSIONS

Prospective physics teachers and high school students do hold many incorrect ideas about the force and motion concepts which are in the primary curriculum. Evidently, physics instructors need to place as much emphasis on pre-service physics teacher' wrong ideas as on their right ones. There are many teaching methods are available to use in the classroom (for example, peer instruction, active engagement approaches, inquiry based physics activities, conceptual change approaches, etc.). If prospective teachers are better informed about the types of false beliefs students are likely to hold they will be quicker and better at identifying themand at helping students to overcome them with appropriate methods as indicated above. What the data fail to show is how many of these naive beliefs held by students are implicit, or non-verbal, since these too need to be addressed and more research into students' implicit knowledge is required. Studies on changing students' conceptions of learning may reveal some insights for this issue. For instance, BOULTON-LEWIS *et al.* (2001) have found that education at the university level, where there is some need to understand and explain phenomena in relation to a variety of theories, can probably help students construct more appropriate conceptions of learning. Likewise, if physics instruction in high schools or universities can encourage students to interpret natural phenomena or observations in terms of different theoretical perspectives, students' conceptions of learning physical topics such as force and motion subjects might be improved.

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