Remedying science student teachers' misconceptions of force and motion using worksheets based on constructivist learning theory

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Abstract

This study aims to remedy science student teachers' misconceptions of force and motion using worksheets. The study was carried out with thirty eight science student teachers (SSTs) who were in their first grade in a Faculty of Education in Turkey. The subject studied in small groups of 3-4 students. To elicit their ideas before and after intervention, interviews about instances by help of individual cards were conducted with thirteen ones who were selected by randomly. Pre-instructional interviews revealed of that SSTs thought that a force starting motion continues to act on an object during motion. However, post-instructional interviews data revealed that worksheets are effective in instructional tools on remedying their misconceptions by encouraging them to discuss and explore the force and motion subjects. It is concluded that worksheets encouraged and motivated SSTs in joining to activities. They also frankly explained their own ideas about the examined subjects by interacting with the others and also teacher.

Keywords: Worksheet; Misconception of force/motion; Science student teachers; Science education

1. Introduction

Many studies in recent years have discussed the importance of the ideas that learners bring to lessons [1, 2]. Thus, explorations of these prior ideas have become an important research focus of science education studies. The task researchers are facing about children's ideas is to describe as closely as possible the real reasons of the learner's ideas. This is not an easy task because the methods used to explore these ideas can greatly influence responses by students [3].

Individuals from all learning levels acquire non-scientific beliefs about subjects of physics as well as in other scientific areas. These non-scientific beliefs usually focus on the physics

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subjects such as overall/kinematics, falling bodies, inertia, Newton's laws, gravitation, conservation of energy, conservation of momentum, circular motion, harmonic motion and etc. These non-scientific beliefs are labeled variously as misconceptions [4], alternative frameworks [5], children’s science [6], common sense concepts [7], preconceptions [8] or alternative conceptions [9, 10]. There are a lot of studies in which some of the reasons of why students tend to acquire misconceptions and also some possible ways of students’ overcoming non-scientific concepts were investigated.

It is important to develop scientific concepts for students from all learning levels. However, students sometimes can form some sort of integration of misconceptions with newly taught science concepts, but usually their misconceptions are not altered seriously despite teaching is well established. Thus, they have the same preconceptions and misconceptions as they started [6]. Misconceptions are difficult to change and may affect how learners process new information and data [11]. Students often learn what is expected by rote learning without any understanding. So these misconceptions should be diagnosed and teaching should be designed to take students’ conceptions into account [12].

The literature shows that one possible way to improve students’ scientifically understanding about science subjects would be to implement a constructivist approach in classrooms [11]. The constructivism sees learning as a dynamic process in which learners actively construct meaning from their experiences in connection with their prior understandings [13, 14]. The constructivist view of learning argues that students do not come to the science classrooms empty-headed but arrive with lots of strongly formed ideas about how the natural world works [15], and many of these justifications and rationalizations conflict with established scientific facts. Resolving these conflicts is a difficult task, as misconceptions are deep-rooted from years of personal experience [8] and students hold on to them tightly despite their instructors’ best attempts to change them through lectures, demonstrations, and problem solving.

Traditional physics instruction is one reason of why students acquire misconceptions in science. Traditional physics instruction is a type of instruction in which an instructor spends at least half of the class period lecturing or demonstrating, presents or demonstrates key ideas before misconceptions are elicited, and designs laboratory activities to verify the principle being studied. Thus, it is too far from being sufficient in remedying students’ misconceptions which are persistent and highly resistant to change [8, 16, 17]. For this reason, common suggestions to remedy students’ misconceptions include teaching physics conceptually, and by conceptual discussion methods [18, 19].

1. 1. The misconceptions about force and motion subjects

The results of a great deal of research have shown that, prior to any formal instruction in physics, students hold scientifically incorrect conceptions about physics concepts in general, and about the force concept in particular [4-6, 20-26]. In this respect, the research into students’ misconceptions and their reasoning in mechanics has been the subject of many studies. There are a lot of studies which were established that common sense beliefs about force and motion are incompatible with scientific concepts in most respects.

The Aristotelian idea that a continuous action of a force is necessary to keep an object in motion is one alternative conception that has been intensively studied in the literature. It represents a way of thinking that has long been rejected by the scientific community, however, it has now been established that this idea often predominates among students. For example, Watts and Zylbersztajn [5] found that 85% of students aged 14 years associated force with motion; and Sadanand and Kess [27] found that 82% of their senior high school students indicated that a force is required to maintain motion.

Furthermore, it appears that students hold onto this idea tenaciously. Clement [8] found that 75% of a group of university students still indicated a force in the direction of the motion after one semester of instruction in mechanics. Even courses specifically designed to change this conception may have limited success: Thijs [28], working with secondary students, found only a 10% improvement in scores after 5 weeks of instruction, and concluded that "the course is not successful in remedying the impetus idea, that is, simply associating force and motion" (p. 166). Similarly, Gunstone et al. [29] found, after an 8-week course designed to change their students' alternative conceptions about force and motion, that "most students had not abandoned an Aristotelian view" (p. 31).

Gilbert and Watts [30] summarized the general conclusions that can be derived from the misconception studies about force and motion as follows: (a) if a body is not moving there is no force acting on it, (b) if a body is moving there is a force acting in the direction of the motion, and (c) constant motion requires a constant force. Palmer and Flanagan [31] explained that the understanding of Newton's Second Law which illustrates the relationship between force and acceleration, summarized by $F = ma$ is hindered by the misconception that "force implies motion" or that there are no passive forces and all forces create acceleration. Therefore, one must keep pushing in order to maintain a constant state of motion was examined by Clement [8]. Trumper and Gorsky [22] summarized the alternative conceptions of physics students in preservice training for high school teachers as follows: They;

- *Hold the Aristotelian 'impetus' misconception to a great extent.*
- *Believe to a great extent that the initial force exerted on an object keeps it going and gradually gets less.*
- *Think to a great extent that a force acts on moving objects resisting a push.*
- *Mostly deny the incorrect view that friction relates only to moving objects.*
- *Mostly deny the incorrect idea that gravity depends on air, on atmosphere or on a magnetic centre.*

Minstrell [32] and Terry et al. [33] studied students' explanations of bodies at rest. They found that when an object sitting on a table is considered, a significant percentage of students' were ignoring the normal force on the object due to the table. Students even considered that it was the air pressure keeping the object in place. Driver et al. [14] summarized the students' main ideas about force and motion from the research studies as follows:

- *if there is motion, there is a force acting;*
- *if there is no motion, then there is no force acting,*
- *there cannot be a force without motion,*
- *when an object is moving, there is a force in the direction of its motion;*
- *a moving object stops when its force is used up;*
- *a moving object has a force within it which keeps it going;*
- *motion is proportional to the force acting;*
- *a constant speed results from a constant force.*

Halloun and Hestenes [7] created a diagnostic instrument to evaluate students' knowledge in mechanics. They probed 22 students' conceptions through this diagnostic instrument and by means of interviews. The results helped to form a taxonomy of 27 "students' common sense concepts about motion" [7]. They reported that students' conceptions were similar to the ideas of Aristotle and Buridan (Impetus physics). The results showed that establishing a linear relationship between magnitude of force on an object and its speed was common among the students. They also tended to hold the conception that acceleration is due to increasing force.

Boeha [21] aimed to evoke students' Aristotelian-type ideas in situations involving the concept of force that they bring with them to the science classroom. Participants were 126 randomly chosen 12th grade physics students (17 or 18 years old) in a National High School or senior secondary school in a Pasific country-Papua New Guinea. The author used a mixture of pencil and paper questions and interviews similar to the interview about instances of Osborne and Gilbert [34]. This instrument took on the form of diagrams on individual cards picturing a softball on its way up and the same softball on its way down in the air. Students' Aristotelian-type ideas were summarized as simplified descriptions such as designed, motive, operative, encounter, impact, and configuration forces.

In a recent research, Bayraktar [35] detected 79 (19 first year, 21 second year, 24 third year, 15 fourth year) pre-service physics teachers' misconceptions about force and motion in Turkey. This study used FCI (Force Concept Inventory) as a diagnostic tool. The mean score on FCI was 40.89 %. The results also showed that misconceptions about force and motion were decreased through the years of education. Achievement on the test is increasing over the years suggests that college instruction has a positive effect on overcoming misconceptions although still not sufficient to help students to reach a Newtonian Thinker Level.

These studies all have shown that there is a serious discrepancy between students' understanding of force and motion and the accepted scientific conceptions. Thus, every effort must be made to help teachers and student science teachers to develop their own scientifically accepted understandings.

1. 2. Force and Motion subjects in the Turkish teaching program

In the formal education process in Turkey, students first encounter with the concepts of force and motion at 4th grade of primary schools. Later a simple relation is established between these concepts at 6th grade. This simple relation students have in their minds becomes more complicated with Newton's Laws of Motion subject in Science Schools at 9th and 10th grade.

Table below summarizes the units and inferior titles including force and motion concepts according to grades in the Turkish Science Curriculum.

Grade	The Units	The Inferior Titles
Fourth grade	Force and Motion	The basic characteristics of force
Fifth grade		Some kinds of forces
Sixth grade		Calculating velocity, measuring force, balanced and unbalanced forces, the weight as a force
Seventh grade		The force and the energy
Eighth grade		The force, the ascending force and the pressure
Ninth grade		The motion along a straight line, the basic forces on earth, Newton's laws of motion, the friction force
Tenth grade		The force and its characteristics, the motion under the influence of balanced and unbalanced forces, the action and reaction forces, the inertia
Eleventh grade		The work, the energy, the impulse-momentum, the torque, the angular momentum, the balance and balance conditions
Twelfth grade		The linear velocity, the angular velocity, the centripetal acceleration, the simple harmonic motion
First grade at the university	Newton's Laws of Motion	The forces and Newton's first law, Newton's second law, Newton's third law
	The Applying Newton's Laws	Some simple constant forces, the friction, the drag forces, the force and the circular motion, the main forces

1. 3. Using worksheets in science teaching

Worksheets are described as an effective teaching material which provides step-by-step guidance for students to discover their conceptions systematically (Proctor *et al.*, 1997). Worksheets consist of carefully sequenced tasks and questions in order to provide sufficient communication between students and worksheets. Students are expected to construct answers for themselves through discussions with their classmates and with teachers. It is considered that they construct their own correct conceptions after most of students subscribe to others by means of discussions. In this process, teachers do not explain the topic but ask questions designed to help students find their own conceptions. Worksheets contain a clear statement of objectives, directions, and materials to use, individual or group activities [36]. They can encourage students to work alone and can help students to develop sense of responsibility and confidence in individual activities [37, 38]. They also act as a classroom organizer by giving instructions and questions to initiate activity [39]. Worksheets offer useful opportunities to improve science class activities. Kurt [40] reported them as follows: worksheets;

- *are very useful to observe and obtain results,*
- *can provide opportunity to reach new knowledge by way of student's own efforts,*
- *allow students to form hypothesis and do observation and experiment about a subject,*
- *help teachers to understand students' cognitive framework,*
- *can promote learning by doing and living, and*
- *keep students on task and make the learning fun.*

The worksheets even provide all members of classroom to join in the activities simultaneously [40, 41]. Worksheets designing according to constructivist view of learning make students active to construct the conceptions in their mind [40], and decrease their misconceptions by discussing about them and living a conceptual conflict [42]. In the literature, the worksheets have usually used as a part of active learning activities [43] and propose of keeping students on the work, providing the classroom organization and improving the learning experience during the field trip [44]. Hand and Treagust [42] also developed worksheets to encourage conceptual conflict for the students holding misconceptions about acids and bases.

The aim of this study is to remedy science student teachers' misconceptions of force and motion acting on bodies in motion and to investigate the effectiveness of worksheets based on the constructivist approach on science student teachers' understanding of those concepts.

2. Methodology

The participants of the study include 38 first grade science student teachers enrolled in a Science Teacher Training Program in Turkey.

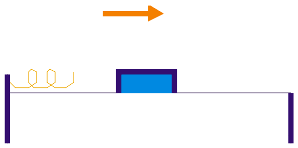
There are many techniques which are used to explore student's misconceptions about science. One is interviews about instances technique. It is described as a bright method to explore the students' ideas by Osborne and Gilbert [34]. This technique uses cards with pictures and a small amount of writing. The interview begins with a request for the interviewee to respond with his or her own understanding of a focus concept by discussing the cards as they are revealed successively. Then, follow up questions are asked to explore reasons for the initial response [45].

In the current study two cards were used to explore SSTs' pre- and post-instructional ideas about force acting on bodies in motion by means of individual taped interviews.

Two interview cards were used to reveal students' views about force acting on moving bodies. First card is about forces acting on the book which is moving on a flat with no friction. Its motion resulted from the release of a compressed spring. The main question is "After the book sets free, how forces are acting on the book?" Second card shows a ball moving in the air. It is expected from students to think about forces exerted on the body during its motion, and follow up questions provide to talk about forces more detailed.

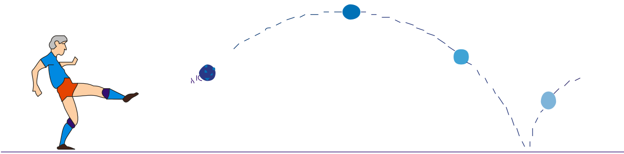
The questions on the cards asked 'Is there a force on the object?', and identify this force(s) and its direction(s). Then follow up questions such as 'Why do you think there is force acting on the object?' and 'Do you think a force gets less gradually?' were asked to seek why and how the students think so. These interviews were conducted individually with thirteen students who are selected randomly to provide more detailed information about how their images of the force concept by the first researcher.

Card 1.



A book is moving on a flat, frictionless table from left to right. The motion resulted from the release of a compressed spring and, at this motion, no physical contact exists between the spring and the book. Is there a force on the book? Identify this force (s) and its direction (s). Ignore the effects of air resistance.

Card 2.

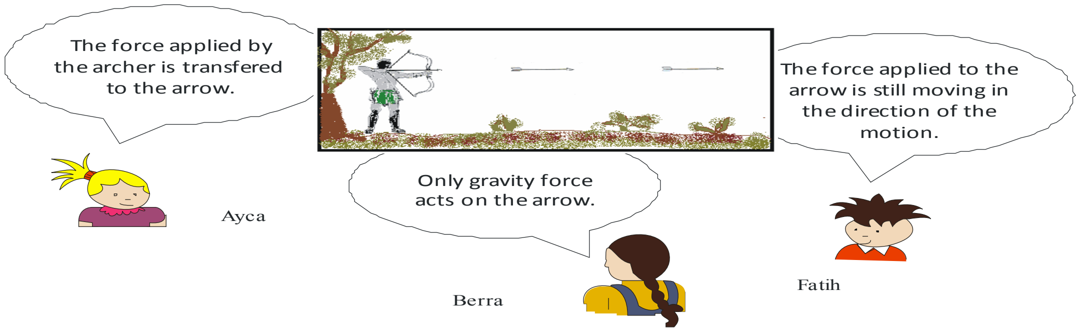


A football player hits the ball. Which forces exerted on the ball during its motion? Ignore the effect of air resistance.

2. 1. The intervention

Three worksheets including concept cartoons which were designed to encourage discussing about concepts and investigation were developed to remedy SSTs' misconceptions about forces acting on moving bodies. Each worksheet consisted of three major sections; introduction, activity and assessment. There are concept cartoons and questions to attract students' attention on misconceptions, encourage discussion about them and provide conceptual conflict to occur in the introduction section of worksheets. The concept cartoon in the introduction section invites students' meeting the ideas about force conception (See below).

A. The Introduction Section



Which balloon is true? Think about reason starting the motion of the arrow? Write your answers below
Discuss as a group weather the applied force acts on the arrow during its motion or not? Write your group conclusion below. Then explain your opinion to the classroom.
How is the direction of the net force acting on the arrow during its motion? Show the force below by drawing an arrow.

Which balloon is true? Think about reason starting the motion of the arrow? Write your answers below.

Discuss as a group weather the applied force acts on the arrow during its motion or not? Write your group conclusions below. Then explain your opinion to the classroom.

How is the direction of the net force acting on the arrow during its motion? Show the force below by drawing an arrow.

It is required that the students do simple experiments, observations and some operations about concepts in the activity section.

B. The Activity Section

Roll up a piece of paper like a ball. Throw this ball straight up into the air. Do it for three times. Write below what you observe.

Draw one or more arrows showing the directions of each force acting on the ball when it is moving upwards.

Now, hold the same piece of paper in your palm and lift it vertically upward with the former throw force. How much does the motion continuo?

Draw one or more arrows again showing the directions of each force acting on the ball when it is moving upwards.

What is the difference between two cases? Explain.

In the assessment section, there are concept cartoons and questions to reveal how students' ideas were influenced through the practices.

C. The Assessment Section

Think the net force acting on the arrow above again and explain your answer to the classroom.

The formal teaching period with participants were completed within six hours and 2 hours per week, executed by the first researcher. The SSTs studied as groups consisted of three or four bodies. Firstly, worksheets were photocopied to provide a copy for each student. Group and classroom discussions were used to provide conceptual conflicts and share their ideas. Table 1 below includes all implementations of the research. The first researcher and also the course instructor executing the lessons was an organizer to guide discussions. It was expected from SSTs' to write their individual ideas on the worksheets at the end of the discussions. This is also important for that of students' sense of responsibility is going to improve via filling out the worksheets individually as supported by Dowdeswell [37].

Table 1. Practices and conceptions in the worksheets

Worksheets	*Practices and Conceptions* *Introduction*	*Activity*	*Assessment*
Drawing a Free Body Diagram	*Drawing/Discussion: The forces acting on the stationary pendulum bob, the body staying on the flat, the box sloping down on the inclined ground and the free falling body*	*Group Working/Demonstration/ Discussion/Writing: Relations among these forces*	*Concept Cartoon/Discussion: The factors influencing the arrival of four skiers who have got different features to finish point (weight, size of the ski, etc.)*
The Force That Initiates The Motion	*Concept Cartoon/ Discussion/Drawing/Writing: The forces acting on the arrow moving in the air*	*Group Working/ Demonstration/ Discussion/Drawing/ Writing: The forces acting on the ball made from crumpling paper while the ball on the way up and first; no contact with your hand, second; when there is a contact with your hand*	*Presentation: The forces acting on the arrow*
Discovering The Net Force For The Constant Velocity	*Group Working/Planning a Hypothesis/Discussion: Planning a hypothesis about how the size of force should be to maintain its moving with constant velocity.*	*Group Working /Planning-Doing A Experiment/ Obtaining Data/Discussion: The propose of confirming the hypothesis, planning an experiment, getting data by doing the experiment and checking the data.*	*Concept Cartoon/ Writing: The motion and forces acting on the body on the skateboard moving.*

3. Data analysis

The participants' reasons obtained from interviews are presented in two ways, using the following methods. Table 2 and 3 presents the summary of responses to pre- and post-interview about instances related to cards. Furthermore, there is a comparison to reveal the effect of worksheets on students' misconceptions. Illustrations of their views, by means of extracts from the students' responses included at the end of these quotes are (in parenthesis) pre-instructional interviews (PII) and post-instructional interviews (PTII) and individual students' identification. Thus PII- S_{01} would denote pre-instructional interview and student 01.

4. Results

Table 2, includes overall responses of SSTs about first card, comparing the pre and post instructional interviews.

It can be seen from the table 2 that before intervention, eight of the SSTs think that a force is accompanies the book during its motion. They believed that the force is due to the initial impulse and its way is in the direction of the motion. Here are some of the students' justifications;

"The book accelerates because the spring pushes it continuously. So F=ma force acts on the book" (PII: S_{11})

"The spring originally has energy. There is a force from this energy. This force pushes the object. The question asks forces. So there is a force from energy of spring." (PII: S_{06})

"There is a push force of spring. Because there is not any friction force" (PII: S12)

In the PII, others state that the force coming from the spring is transformed into energy or velocity and the book is moving by means of it. Here are students' scientific justifications:

"There will be a reaction force of the spring as the object compresses the spring. The object will gain an initial

Table 2. SSTs' pre and post instructional interview data about forces acting on the book moving on the table

The statements of student science teachers	PII	PTII
The push force originally exerted by the spring continues to act on the book during its motion.	S01, S02, S04, S06, S08, S10, S11, S12	S02
The push force exerted to the book by the spring does not continue to act after it sets free because of no contact with the book.*	S05, S09, S13	S01, S03, S04, S09, S11
The book maintains its motion with the initial speed from the spring.*	S04, S07, S09	-
This push force continues to act on the book invariably during its motion because of no friction.	S04, S08, S10, S12	-
This force is the compression force of spring.	S02	-
A force from the spring energy acts on the book during its motion.	S06	-
The force originally exerted to the book by the spring gets less so it will finally become zero.	S02, S06	-
If there is no force acting on the book, it can't move.	S01, S06, S11	-
The spring gives kinetic energy to the book, and the book is moving with this energy.*	S03, S05	S03, S05, S12
There are also forces which the table and the book are acting on each other.*	S02, S08, S11	-
The book is moving under the sole influence of gravity.*	S03	S03
The force originally exerted by the spring acts instantaneously and is transformed into the energy immediately.*	-	S04, S09, S10, S11, S13
Since there is no friction, the book maintains its motion with constant velocity.*	-	S04, S05, S10
The spring transfers its energy to the book.*	-	S06
The force exerted by the spring is transformed into energy as soon as the spring becomes free. The book is moving with this energy.*	-	S01, S07, S08
Energy is stored in the spring when it is compressed. This energy is transformed into velocity as soon as the spring becomes free.*	-	S09

* Scientific answers

velocity because of this force. It continues to move with the initial velocity because of frictionless table." (PII: S_{09})
"The spring will give energy to the object. The object has to move with the steady energy because of no friction." (PII: S_{03})

From the PII, it is understood that SSTs usually use the force conception to explain the motion of the book. However, in the PTII, these students talked about the transformation of force to energy or velocity form. This view is similar to the physicists' view of the conservation of energy. It can be seen from Table II, in the PTII, there isn't any student who thinks that a force accompanies the book during its motion (except for S_{02} who isn't desirous during lessons). After intervention, they substitute energy and velocity conceptions for force conception completely, explaining the motion of the book. Here are some students' scientific explanations:

"The book maintains its motion with velocity from the spring" (PTII: S_{04})
"The spring only gives velocity to the book. Because I think the spring needs to keep in touch with the book to apply a force on the book." (PTII: S_{11})
"Now teacher, energy is stored in the spring because of its compression. Then the spring transfers its energy to object when it becomes free. So the object is moving with this energy forever because of no friction." (PTII: S_{06})
"Hımm. There is an initial force exerted by the spring. It is transformed into energy as soon as the book sets free

and moves with this energy." (PTII: S_{01})

In the PII, three SSTs think that the book can't move and stop because of no force acting on it. They have an idea that an applied force is necessary for the continuity of motion in spite of a frictionless medium (motion implies force misconception). For example:

"The spring influences the book here. The action force lasts during its motion. Moreover if there is not any influence of the spring on the book, it can't move. So I think there is force acting on the book." (PII: S_{11})

"... there is a force acting on the book, otherwise the book don't move. (PII: S_{06})

It can also be seen from Table 2, in the PII, two students think that the force acting on the book gets less or dies out during its motion. In the PTII, when asked them what happened the force from the spring, they stressed that the force is transformed into energy or velocity. For example:

"This force dies out as soon as the spring leaves the book. The force is transformed into energy, and the book is moving with this energy. (PTII: S_{01})

"The force gives energy to the book so we accept that there is no force. There is its kinetic energy. The force continues to act on the book as energy form. (PTII: S_{05})

"Action force of the spring is transformed into kinetic energy. It means that $1/2kx^2$ is transformed into $1/2mv^2$." (PTII: S_{08})

"If this force acts on the book continuously, it moves with accelerate. If it moves with influence of a force, it gains an acceleration due to F=ma formula and will be accelerated continuously. But here firstly energy is stored in the spring because of compressing. Then it is transformed into velocity (PTII: S_{09})

From Table 2, although three students think that there are forces such as the force exerted to the table by the book and the force exerted to the book by the table in the PII, there isn't any student who mentioned about these forces in the PTII. The reason of this can be students' negligence of such forces. Table 3, includes overall responses of SSTs about the second card, comparing the pre and post instructional interviews.

It can be seen from Table 3, in the PII, ten students think that the hit force from the player continues to act on the ball going in the air after the ball is set free from his foot. There is also a view that the motion of the ball is in the direction of the resultant force or net force. Here are some students' statements:

"There is the force exerted by the striker and its velocity in the horizontal way. And its weight acts in the vertical way" (PII: S_{01})

"There are an action force when the player hits the ball and a reaction force of the ball. Since the action force is greater than the reaction force the ball is going up" (PII: S_{08})

"There are the horizontal and vertical components of the hit force. Also the gravitational force is acting on the ball. The ball is moving on the way of resultant of them" (PII: S_{04})

"The ball reaches the maximum height with the push force exerted by the child" (PII: S_{07})

"While the ball is going up in the air, F_x on the horizontal way and F_y on the vertical way act on the ball" (PII: S_{06}, S_{10})

From Table 3, only one student in the PII and eight students in the PTII consider that the sole force acting on the ball is the gravitational force. The scientifically correct justification is that the force originally exerted to the ball by the player acts instantaneously. When it is asked in the PTII that what provides the ball to go up, they explain this question by using energy conception. Her are some of the students' scientifically correct explanations:

"There is the gravitational force only. I think that only the child exerts a force when he hits the ball with his foot. But this force is transformed into velocity after the ball goes on" (PTII: S_{11})

"He exerts the force instantaneously. This force again transforms into energy. Also there is the gravitational force" (PTII: S_{01})

"The force is originally exerted to the ball to provide the ball's motion. Then it is transformed into energy. Anyway it is moving by means of this energy. It maintains its motion hop hop until it spends its energy" (PTII: S_{03})

"The work done by the force is transformed into energy" (PTII: S_{04})

In the PII and PTII, some students think that the ball's energy provides its motion. At the same time they have the view of no force acting on the ball. It is comprehended that students

ignore the gravitational force.
"The object has a velocity. I don't think that a force acts on it. I think that it is moving by using present energy during its all motion" (PII: S_{05})
"We apply a force to push the ball. The force gives energy to the ball. This energy provides its motion" (PTII: S_{05})

Table 3. SSTs' pre and post instructional interview data about forces acting on the ball moving in the air

The statements of the student teachers	PII	PTII
The forces acting on the ball going up		
There are F force exerted by the player and the weight of the ball.	S02, S04, S09, S11, S12	S02**
No force	S03, S05	S03, S05, S08
There are horizontal and vertical components of force exerted by the player.	S04, S06, S10	S06***
There is a push force exerted by the child.	S01, S07, S08	
The sole gravitational force is acting on the ball. *	S13	S01, S04, S07, S09, S10, S11, S12, S13
The features of forces acting on the ball going up		
The force originally exerted to the ball by the player gets less gradually while it is going up.	S11	S02
The push force gives velocity to the ball when the child hits it.*	S13	S09
The force originally exerted to the ball by the child is transformed into energy.*		S01, S03, S04, S05, S07, S08
The forces acting on the ball at the peak point of its motion		
There is the gravitational force and the force exerted to the ball by the player.	S02, S04	
No force	S03, S05, S07	S03, S05, S08
There is the sole horizontal component of the force originally.	S06, S10	
There is the gravitational force only.*	S08, S09, S11, S12, S13	S01, S04, S09, S10, S11, S07, S12, S13
The features of the forces acting on the ball at the peak point of its motion		
The vertical component of the force is zero.	S04, S06, S10	
The effect of the force exerted by the child has expired. So the ball will drop down.	S01, S07	
The forces acting on the ball dropping down		
There is the gravitational force and the force exerted to the ball by the player.	S01, S02, S04, S06, S08, S10, S12	
No force	S03, S05, S07	S03, S05, S08
There is the gravitational force only.*	S09, S11, S13	S01, S04, S07, S09, S10, S11, S12, S13
The features of the forces acting on the ball dropping down		
The force exerted by the player is fewer than the force originally.	S02, S08, S10	
If the sole gravitational force acts on the ball, it will drop down vertically. So there must be a horizontal force that the ball moves such that.	S01, S12	
The forces acting on the ball going up after the ball crashes into the earth		
There are the gravitational force and the reaction force of the earth (the normal force)	S02, S06, S08	
No force	S03, S05, S07	S03, S05, S08
There is the reaction force exerted to the ball by the earth (N normal force).	S01, S04, S11, S10, S12, S13	
The gravitational force acts on the ball.*	S09	S01, S04, S07, S09, S10, S11, S12, S13
The features of the forces acting on the ball going up after the ball crashes into the earth		
This reaction force exerted to the ball gets less whenever it crashes into the earth.	S11	
The reaction force becomes zero when the ball arrives at the peak point.	S04	
The reaction force of the earth gives velocity to the ball and so the ball will go up.*	S09	S09, S13
The reaction force of the earth is transformed into energy. The ball can move by means of this energy.*		S01, S03, S07, S08

* Scientific answers
** That student didn't want to reply the other interview questions as telling "I have no idea".
*** This student didn't join in the activities. So no change can be determined in his ideas.

From Table 3, in the PII some students think that the force exerted to the ball dies down in the course of time.

"The force exerted by the player in the horizontal way gets less" (PII: S_{02})

"The ball will move in the direction of the resultant of the gravitational force and push force. Its size gets less because of friction" (PII: S_{08})

"I think the force exerted by the child gets less gradually" (PII: S_{11})

In the PII, two students (S_{01}, S_{07}) think that when the ball is at the peak of its motion, since the push force becomes zero or dies down the ball can't go up above. So they can say in the PII that the sole gravitational force acts on the ball at the peak since they have the idea at the former sentence.

It can be seen from Table 3 that in the PII, nine of the students express that the reaction force continues to act on the ball going up after it crashes into the earth. There isn't any student having this view in the PTII.

"The reaction force of the earth acts on the ball in the direction of the motion when it is going up" (PII: S_{13})

"There is only N (the normal force) upwards" (PII: S_{01})

"The reaction force doesn't act but gives velocity to the ball. It is again going up with this velocity" (PTII: S_{13})

It is clear that SSTs have a broader misconception about force. The great majority of SSTs consider that the force which triggers off the motion is continuously exerted on the object to keep it moving until it has been dissipated due to resistance by the medium. This force is called by them as *hit force*, *push force*, *action force*, *reaction force* and *normal force* from the earth. This transmitted motive power was called 'impetus' by Jean Buridan [46]. In addition, they believe that such a force dies out or dies down to account for changes in an object's velocity or the motionless state. diSessa called this view as the 'fading away' concept [22]. The worksheets in this study were successfully struggled with these scientifically wrong views. It was seen that the students took courage to struggle with their misconceptions by joining in activities executed in the worksheets. It is believed that SSTs' misconceptions about force acting on the bodies in motion are mostly remedied. Before worksheets students tending to associate force and motion can now imagine a force in the opposite direction to motion.

5. Discussion

Many studies in the literature, such as those by Watts and Zylbersztajn [5], Boeha [21], Palmer and Flanagan [31], Eryilmaz [24] and Jimoyiannis and Komis [2] have focused on students' conceptions about force or force and motion together. These studies suggest that students had difficulties in force and motion. In a research conducted by Watts and Zylbersztajn [4] it is documented that 85% of last grade high school students think the force exerted to throw a ball up into the air still affects the ball even after it is out of the hand. This misconception is widely recorded in the literature [30, 47, 48]. On the other hand, Brudian, who asserted that there is an affect which keeps an object in motion after it is thrown into air, called this driving force as "impetus" in the 14^{th} century [16, 46]. Thereby, impetus is such a view is supported by the work of Jimoyiannis and Komis [2], and reported similar finding to the present work that many high school students believe that net force acting on the direction of motion is necessary to maintain motion in an environment without friction. In the current study, it is observed from pre-instructional interviews that many students hold the idea that a force accompanies objects in motion is impossible without this initial force. Furthermore, they consider the force is coming from the source which starts the motion. So the worksheets contain inferior concepts about force are developed to struggle and remedy primarily this misconception.

It is defined from the pre-instructional interviews that eight students out of thirteen assume that the force exerted by the spring maintains its effect on the book during its motion (see Table 2). This assumption could be observed in their answers to the first question card. In the second question card, ten students conceive that the force starting the motion of the ball continues its effect during the motion (Table 3). In the PTII, only one student is observed to hold the same belief, possibly as a result of his unwillingness to participate in classroom activities. Besides, it is important that during the PII all students talk about "forces" to explain the motion of the book, but during the PTII none of them talk about forces but use the concept of "energy" to explain the motion of the book. This improvement in remedying this misconception may be a result of students' willingness to participate in the activities and discussions conducted with worksheets related to objects' motion with unnatural start. The other reason may be that successful students defend their ideas explaining why others are wrong in order to convince friends in their groups who hold different beliefs. Thereby, it can also be considered that discussions during the activities on the worksheets give students opportunities to evaluate the reasons and results of natural events. Thus, worksheets help students reconstruct their knowledge via they share their ideas with peers and teachers by forming a base for effective discussion.

After the worksheets, students are observed to answer questions in a more explanatory way and support their answers with scientific information. For example, the question "Does the force exerted by the spring continues to act on the the object during its motion?" is asked to S09. The answer by the student is as follows; "No, if it did, the object would move with acceleration. If the object were under the influence of an F force, it would move in a constantly increasing speed due to the formula (F = ma). But first, energy is stored when it is compressed then set free and is transformed into energy". This indicates that students can associate the event with sound scientific concept by using appropriate technical term.

It can be seen from Table 3, a few students hold the belief that the force on the ball thrown into air decreases while it is going up and becomes zero at the peak point. Furthermore, some of them consider that the vertical component of the force dies away and the horizontal component remains constant while the ball is going up to the peak point. Thereby, it is indicated that students see a direct proportion between "speed" and "force" like Aristotle. Moreover, many physics student teachers think the force accompanies a rising ball dies away with height [22]. According to Clement [8], students may think this force will increase or decrease by considering the change in the speed of the object.

It is understood from the some students' answers as can be seen from the Table 3, in the PII, that they cannot imagine that the direction of the object and the net force may be different. However, with the worksheet named "The discovery of net force for a constant velocity" the aim is to teach that motion can go on when the net force is zero or a force opposite the direction of the motion is exerted. So the students reasoned even though the gravitational force acts on towards the earth, the object can go up upwards. Hence, in the PTII, a lot of students accepted that the sole gravitational force acts on the ball moving in the air, and some still ignored such force and imagine there is no force.

It is observed during the PII conducted with the first question card; most of the students draw an arrow in front of the moving book as soon as they start imagining. In pursuit of this students say the spring when set free transfers its energy to the book. However, they show this force as a vector in the same direction with motion to ensure it and express that with concept of force, which is a vector quantity. Then they say the book has got energy and this energy is in effect as a force in this direction. From this view, it can be inferred that students consider force as a factor which is potential in objects and appears when there is a motion.

When another student is asked what the arrow he draws in the same direction with motion is, the answer is that "The spring was compressed at the beginning and has got certain energy. It pushes the object with this force. With this vector we can show the vertical force coming from the spring's energy". During the interviews students sometimes describe the force, which they think as accompanying the object and ensures the motion of the book, as "energy" or in similar way. A worksheet called "Discovery of Net Force for Constant Speed" is applied to show students that motion is possible when net force is zero or a force opposite the direction of the motion is present. During the activities in this worksheet, discussions are conducted so that students can realize the relation between "force, motion and energy". On the other hand, some students still express during informal interviews they think motion is possible with energy from the spring. It is understood after a series of questions that students know the spring transfers energy to the book but they cannot comprehend that motion cannot be without a propulsive force. The underlying reason for this belief may be that students confuse concepts of energy and force and see them as equivalent variables. Also, it is possible to consider the following ideas students have as reasons why they think a force accompanies the moving objects;

a. the sole propulsion is force
b. when the net force is zero, the motion stops
c. motion in the opposite direction to the force is impossible
d. they do not know force can act as a pushing factor or a factor ensuring move
e. they think the factor ensuring move is shown as a vector in the same direction with the motion.

As can be seen from Table 3, during PII, 9 students are observed to think that "the reaction force affects the object rising in the air even though it does not touch the ground". However in the PTII, none of the students is observed to have this misconception. A similar misconception is observed among high school students (2^{nd} grade) and even student teachers who are about to graduate [25]. In the present study, when students are asked why they think so, the explanation is "A force is necessary for the ball to rise from the ground and this force is the reaction of the Earth. Furthermore, during the activities students emphasized the statement "There is a reason for every event in nature". This statement may explain why they prefer the idea that the cause of the motion is the presence of a propulsive force. Similarly, Aristotle also asserted that a force is necessary for every motion in nature and all objects become still when force ceases. Aristotle observed a cart stopped when horse stopped pulling and inferred when there is no force there is no motion [21, 46]. It is appeared that students' conceptions are considerably in agreement with those of Aristotle.

6. Implications

During the application of the worksheet "Drawing a Free Object Diagram"; students are evaluated to be fairly successful in showing gravitation and other forces. Before worksheets are applied, they have the same idea that "No force affects the ball which is rising in the air or is at the peak point". This may be indicated they ignore the gravitational force. Similarly, Jimoyiannis and Komis [2] also state a few of student and Enderstein and Spango [49] present the students whose percentage is 78-94% ignore the gravitational force. It is inferred from some students cannot conceive of gravitation as a force [7].

Despite all the efforts against misconceptions, in the PTII, a minority continued to hold the belief that "There must be a force on objects thrown to the air. Otherwise motion in the air is Impossible." Clement has found out that 75% of university students still hold the same belief even after a semester of mechanics instruction [8]. Thijs [28] documents only a limited success is achieved through instruction aimed specifically at changing this misconception. After a five week teaching activities only a 5% percent improvement is recorded among high school students [31]. Similarly, Gunstone et al. [29] have found out that following an eight week instruction many students still keep the same ideas about force and motion as those of Aristotle.

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