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Abstract The main purpose of science education is to enable students to connect concepts with daily life and establish relations between the concepts. Thus, many implementations related to constructivism have been carried out. The aim of the study is to explore how students' conceptual perceptions related to "Force and Motion" subject changed with meaningful learning. Pre-test -post test single group design, one of the experimental research designs, were used in the research. In order to interpret the students' results in meaningful learning process, Conceptual Perception Test related to Force and Motion subject (CPTFM) was developed and the test was composed of five open-ended questions. The content of the items in the test was developed in such a way to include "Action-Reaction Law", "Gravity", and "Pairs of Balanced Forces." The points obtained from the evaluation instrument were evaluated according to the levels created by the researcher. 35 students in their third year of study in the Department of Science Teaching participated in the study. The results of the study revealed that meaningful learning activities made positive contributions to pre-service teachers' conceptual perceptions related to force and motion concepts.

Key words: conceptual learning, force and motion concepts, meaningful learning, science teaching.

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EFFECTS OF MEANINGFUL LEARNING ON CONCEPTUAL PERCEPTIONS RELATED TO "FORCE AND MOTION": AN EXPERIMENTAL STUDY FOR PRE-SERVICE SCIENCE TEACHERS

Murat Demirbaş

Introduction

Science teaching aims at training science literate students, constructing the knowledge they learn, and adapting the acquired knowledge to daily life. In this respect, it is important that the knowledge students learn must be meaningful to them. Constructivist approach which defends that student must play an active role during the learning process suggests that active learning environments must be created.

In constructivist approach, students are asked to construct the knowledge they have acquired in the external world via active learning (Kurt, 2006). Students' accumulation of knowledge is important in meaningful learning. If the learned knowledge does not overlap with the prior knowledge, understanding the knowledge will become difficult. Memorizing the concepts will have negative effects on permanent knowledge. If the learned knowledge is associated with the knowledge stored in the brain for a long time, learning will become more meaningful. While teachers present knowledge in learning environments, they must also help their students to construct the knowledge. Therefore, they must offer a lot of examples and students must be made to think about them (Gürten, 2012).

Science Teaching and Meaningful Learning

Learning is defined as acquisition throughout the process, memorization, behaviour change, development of the skills, or meaningful learning (Caine & Caine, 2006). Meaningful learning was basically founded on constructivist approach and developed according to cognitive theory of learning. In meaningful learning the information to be learned takes on meaning with their latest version. The prior information considerably determines the planning of the instruction. Learning occurs when a connection between the existing information of the student and the new information is established. Another important point in meaningful learning is that the prior knowledge is learned correctly and completely (Ausubel, 1968; cited: Çakıcı, Alver & Ada, 2006).

Meaningful learning is frequently used in learning environment. Students who are at abstract operational stage realize the relations between



the concepts and they are able to connect them by organizing these relations (Ausubel, 1968; cited: Çakıcı, Alver & Ada, 2006).

Snowman and Biehler (2003) offer a few techniques which make meaningful learning easy (cited: Çakıcı, Alver & Ada, 2006).

- Introductory activities which will provide meaningful qualities to the new information are used.
- Concrete examples are offered to explain abstract ideas.
- Information is presented via visual methods such as graphics, and three dimensional models.
- Information is transferred to the other subjects.

Meaningful learning declares that the individual can learn the essential information without learning it via discovery process. Students are actively engaged in the learning environment via discovery method and meaningful learning, prior learning functions and changes are tried to be made in students' mind. It is accepted in meaningful learning that knowledge is formed in a deductive process (Senemoğlu, 2001).

Three stages are mentioned in meaningful learning (Senemoğlu, 2001);

1. *Presentation of pre-organizers (Introduction):* A general framework for the knowledge to be presented is introduced and a structure to embed details about the subject is created. The important points of the knowledge to be presented here are emphasized. A conceptual bridge is composed between the knowledge to be given and the existing knowledge.
2. *Presentation of the subject and the material to be learned (Development):* In this stage, the knowledge to be learned requires to be presented from general to specific, exemplified, and discussed. From then on, concrete examples are given and similarities and differences between the old and new concepts are presented.
3. *Reinforcing cognitive organization (Accomplishing a result):* In this age, the relationship between detailed knowledge and general situation is explored. The realization of conceptual learning is tried to be determined with the questions. If there is insufficient learning or mislearning, they are discovered.

Kara and Özgün Koca (2004) came up with an explanation about meaningful learning as below:

Qualities	Meaningful Learning
Basic Goal	Constructing knowledge
Creating knowledge	Attaching it to previous knowledge
Activity	Student- teacher interaction
Process	Deductive (From rules to examples)
Equipment and Tools	Not required.
Interaction between the students	Not required.
Time	Many subjects and examples in a short time
Transfer	Important.
Learning environment	Carefully organized and constructed: organizers and examples Comparative and expository organisers Emphasising similarities and differences

While implementing meaningful learning approach in the classroom, organizers which will draw the attention of the students and remind them of their prior knowledge must be used. All the details of the new knowledge must be presented incrementally, the subject must be practiced with various examples so that students must be given opportunities to expand their prior knowledge and eliminate their wrong knowledge and conflicts (Çepni, Ayas, Johnson & Turgut, 1997).

When a relation between the concepts is not established and the concepts explained are not understood very well, learning will not be attained at a desired level. It is found that the subjects related to force and motion concepts were among the concepts which students had misconceptions or they could not connect to daily life. Nuhoğlu (2008) explored the primary school students' knowledge related to the motion and force. It was revealed in the study that students had misconceptions about subjects such as the relation between force and motion,



friction force, gravity and balanced force. Eryılmaz and Tatlı (2000) in their study developed a test to determine the misconceptions of university students in their first year of studies and at the same time determined students' misconceptions. It was found that students developed misconceptions about mechanical concepts. Moreover, it was stated that misconceptions showed parallelism with concepts' historical development. Kocakulah and Kenar Açıl (2011) determined the misconceptions of 8th grade students about gravity in their study. The results of the study revealed that students did not differentiate force and motion, confused mass and weight concepts, and thought that there was no gravity in the space and on the moon. Demir and Çökelez (2012) explored the 6th grade students' conceptual change about mass, weight, and gravity concepts before and after instruction. The results of the study revealed that students still had misconceptions at the end of the instruction. Ateş and Karaçam (2008) examined the different assessment techniques on knowledge level about force and motion laws in terms of gender differences. The study conducted on high school students determined that there was a difference between the male and female students' conceptual knowledge level which was assessed via multiple choice tests. Dikici, Türker and Özdemir (2010) explored the effect of 5E learning cycle on students' meaningful learning. The study carried out with primary school students was conducted within the framework of force and motion unit. It was found that changes emerged with students' misconceptions related to force and motion. Palmer and Flanagan (1997) used refutation texts to eliminate misconceptions related to force and motion in their study. Elimination of these misconceptions was analyzed based on age. According to the research results, it was determined that misconceptions of students in older age group could be removed.

When the results of the studies carried out were investigated, it was found that students had many misconceptions about force and motion and their conceptual perceptions were not at a desired level. In this respect, the more the students are engaged in learning environment, the more the instruction will become more meaningful and permanent (Gençtürk & Türkmen, 2007). Environments which will engage students should be provided and meaningful learning situations must be introduced.

Purpose of the Study

It is important that learning environment where students will detect the relations between the concepts should be created. In this respect, students must construct the existing knowledge in their mind on their own and meaningful learning conditions must be actualized while doing this. In this study, meaningful learning activities were implemented to develop students' conceptual understanding related to force and motion subjects. The following questions are sought answers within this framework:

1. At what level are the pre-service science teachers' conceptual understanding pre-test scores related to force and motion subject?
2. Have the pre-service science teachers' conceptual understanding post-test scores related to force and motion subject developed with meaningful learning activities?

Methodology of Research

Pre-test-post test single group design, one of the experimental designs, were used in the research. The effects of experimental operation are tested with a study carried out on a single group. The measurements of the subjects related to dependent variable are obtained by using pre-test before the implementation and post-test after the implementation with the same subjects and assessment tools (Büyükoztürk and et al., 2010). Both quantitative and qualitative methods were used together in the research. The responses of the students to open ended questions composed the qualitative side of the research. The students' responses were analysed via content analysis. While students' responses were quoted, students' names were not written and abbreviations such as student 1 (S1), student 20 (S20) were used.

Implementation Stages of the Research

1. Before progressing to experimental implementations, an assessment tool to determine the actualisation of students' meaningful learning was developed.
2. 35 students in their third year of study in the Department of Science Teaching included in the study based on their voluntary participation and the implementations were carried out in spring term of



2012-2013 education year.

3. Conceptual Perception Test related to Force and Motion subject (CPTFM) was implemented as pre-test. Then, the lectures related to meaningful learning lasted three weeks in two course hours.
4. The stages of pre-organizer, presentation of the subject to be learned, and reinforcing cognitive organization, important components of meaningful learning, are paid attention during lecturing (*Appendix 2: Sample Lesson Activity*)
5. Conceptual Perception Test related to Force and Motion subject (CPTFM), which was used as pre-test, was implemented as post-test at the end of the process.
6. The results obtained were evaluated using qualitative and quantitative data analysis and interpreted.

Assessment Tools and Data Analysis

While the assessment tool was being developed in order to determine the conceptual perceptions of students towards force and motion subjects, the literature was analysed and the subjects which students had difficulty in learning and actualizing meaningful learning were determined. Conceptual Perception Test related to Force and Motion subjects (CPTFM) consists of 5 open ended questions (*Appendix 1: Assessment Tool*). Which subjects the questions are related to were explained below;

Question number	Related Subject Content
Question 1	Action-Reaction Law
Question 2	Gravity
Question 3	Pairs of Balanced Forces and Action-Reaction Force Pairs
Question 4	Gravity
Question 5	Gravity

The questions created were finalized in terms of their intelligibility and having a purpose by taking the views of two experts from science education field and two science teachers.

The responses of the students to the criteria were graded according to the rating criteria generated by the researcher. Performance levels range from the lowest (0) to the highest (2) on the rating scale. To determine the reliability of the students' scores identified with the rating scale, a piloting was carried out. The responses of 10 non-participant students in the study were graded by five science teachers individually using the rating scale during the piloting. A consistency between the teachers' grades was calculated to be 85%. When the results of the experimental study were evaluated, the levels detected by two different researchers were considered and evaluated. The levels where each student's responses were displayed were compared and whether they matched with each other or not was considered. The answer sheets were re-examined in case of displaying the responses in the levels which were incompatible with each other and then they were tried to be displayed in the suitable levels. Thus, subjectivity which resulted from the evaluations carried out by different people was tried to be eliminated. The level points used while doing an evaluation was given below.

Level	Point	Criteria
<i>True</i>	2	Descriptions and explanations are done as desired. Illustrations and examples were used.
<i>Partly true</i>	1	Descriptions were made but lack of knowledge exists. Examples were missing.
<i>False</i>	0	Explanations are either false or unacceptable.

Sample evaluations related to the scoring were given below;



True Answer, Assessment Sample for Post -Test Answer to Question 1(Student 1)

① Elimiz duvara dayayıp duvara bir kuvvet uyguladığımızı varsayalım. Sürekli arka bir kuvvet uygulayalım. Bir değişiklik oluyor mu? Ayağlarımız geriye doğru kayıyor değil mi? Bu durumda ayaklarımızın altında bir kaykay olsaydı geriye doğru daha hızlı kayardık. Biz elimizi duvara dayadığımızda duvara bir kuvvet uygularız. Bu bir etkidir. Duvar da bize aynı büyüklükte zıt yönlü geriye doğru kaymamızı neden olan bir kuvvet uygular bu da "tepti" kuvvetidir. Gözlenirse de gözlenirse de her etkinin bir tepkisi vardır. Bu tepki etki ile aynı büyüklükte ancak ters yönlüdür.

Figure 1: An example of "Correct Answer" for the evaluation of criteria items (The answer was written in Turkish).

The English version of the statement expressed in Figure 1 is given as follows: "Suppose we put our hand on the wall and exert a force on the wall. Does a change occur? Our legs slide back, don't they? If there were a skateboard under our legs, we would go backwardly faster. When we put our hand on the wall, we exert a force on the wall. This is an action. The wall exerts a force at the same magnitude in the opposite direction which causes us to slide back and this is a reaction force. Whether it is observed or not, each action has a reaction. This reaction has the same magnitude as the action but it is in the opposite direction to action."

Partly True Answer, Assessment Sample for Pre-test Answer to Question 2 (Student 6)

2) Dünyanın bir yerçekimi olduğundan dolayı elma, Dünya'ya doğru düşmektedir. Ancak Elma "g" yerçekimi kuvvetiyle Dünya'ya hareket eder.

Figure 2: An example of "Partly True Answer" for the evaluation of criteria items (The answer was written in Turkish).

The English version of the statement expressed in Figure 2 is given as follows: "Due to the gravity force of the Earth, an apple falls towards the Earth. In my opinion, an apple moves toward the Earth with the acceleration of "g" gravity."

Wrong Answer, Assessment Sample for Post-test Answer to Question 4 (Student 15)

4) Dünya yüzeyinden bir kılın cisimlerin kütleleri değişmez. Ancak ağırlıkları değişir. Dünyadaki cisimlerin ağırlıkları fazla olan daha kısa sürelerde düşer.

Figure 3: An example of "False Answer" for the evaluation of criteria items (The answer was written in Turkish).

The English version of the statement expressed in Figure 3 is given as follows: "The masses of the objects left on the surface of the earth do not change. However, their weights change. The objects with greater weight on the Earth fall in a shorter time."

Sampling

Students studying in the 3rd grade of Science Teaching department of Education Faculty in Kırıkkale University compose the population of the research. The distribution of the students participating in the research in terms of their gender was presented in Table 1.

Table 1. Distribution of students in terms of their gender.

Gender	N	%
Female	31	89
Male	4	11
Total	35	100

Results of Research

The findings obtained in line with responses to the questions in the research were presented below, respectively.

Question 1: One of the *fundamental laws of Newton is Action-Reaction Law. Explain the action-reaction with examples*".

Table 2 presents the analysis related to the students' responses to the question.

Table 2. Pre-test and post-test results for Question 1.

QUESTION 1	Pre-test						Post-test					
	True		Partly true		False		True		Partly true		False	
	N	%	N	%	N	%	N	%	N	%	N	%
	12	34	16	46	7	20	20	57	10	29	5	14

When Table 2 was examined, it was revealed that according to the pre-test results 34% of the students correctly answered the first question which asked the students to explain action-reaction law with examples. While 46% of them gave partly true responses and 20 % of them false responses, the same question was answered correctly by 57% of the students, partly true by 29% of them and false by 14% of them in the post-test. When the pre-test and post-test results were evaluated together, it was found that there was an increases in the number of the students who answered the question correctly and decrease in the number of the student who gave false responses. Examples were given for the student answers below;

Student 4 (S4) answered the questions with the following response in the pre-test: "When you push the table on your own, you will see that it does not move. But when a friend of yours moves from the opposite side of the table and applies the same force with you, the force acting on the table is an equal and opposite force, so the resultant force is zero and the table does not move." According to the response, the student showed confusion about action-reaction and balanced forces. The same student answered the question correctly in the post-test: "If a force is exerted on a body, the body exerts a force equal in magnitude but opposite in direction. This is called action-reaction law. A person pushes a wall with a force of 10N. The wall exerts a force of 10N but in opposite direction. The answers given in Turkish by Student 4 for Question 1 in pre-test and pos- test were introduced in Figure 4 and 5.



1) Bir masayı sadece kendiniz ittiğinizde hareket ettiğini göreceksiniz. Masanın karşı tarafına bir arkadaşınız geçtiğinde ve sizlerle aynı kuvveti uyguladığında masaya uygulanan kuvvetler eşit ve zıt yönlü olacaktır birleşke kuvvet sıfırdır ve masa hareket etmez. Bir başka şekilde duvar iterken uyguladığınız kuvvetin eşdeğeri duvardan da size doğru uygulanacağından duvar hareket etmez.

Figure 4: An example answer given by Student 4 for Question 1 in pre-test (The answer was written in Turkish).

1- Eğer bir cisme F kuvvet uygulanırsa cisim de eşit miktarda ve zıt yönde bir kuvvet uygular. Buna etki tepki prensibi denir. Bir kişi duvarı 10N'lık bir kuvvetle itiyorsa duvar da 10N'lık bir kuvvetle fakat zıt yönde bir kuvvet uyguluyor.

Figure 5: An example answer given by Student 4 for Question 1 in post-test (The answer was written in Turkish).

Student 1 (S1) stated the following answer in the pre-test: 'For example, suppose that there is a dark setting and you are in this setting. If we consider it as a system, in this system you give reaction when a light is flashed on your face. There is action-reaction between such materials.' In the post-test, the same student expressed the following statement: 'When we put our hand on the wall, we exert a force on the wall. This is an action. The wall exerts a force equal in magnitude but opposite in direction which causes us to slide back. Student 10(S10) answered the same question in the pre-test as follows: 'Suppose that a force of 30 N acts on a body is 30 N, the body weighs 20N, and the body will react to an action of 30N with a force of 20N.' However, in the post-test the student gave the following response: 'It is a force applied by the body against the force acting on the body t. For example, action upon a wall by pushing it does not move with the reaction applied greater by the wall.' It is revealed with student's both responses that the student associated reaction with the weight of the body and he thought that action-reaction forces were not equal.

While student 4 (S4) used the following statement in the post-test 'When we, ourselves, push the table, you will observe that it moves. If your friend takes position opposite the table and exerts the same force, the forces applied on the table are equal and opposite, so the resultant force is zero and the table does not move' in the post-test he answered the same question like that 'if a force acts upon an object, the object exerts a force equal in size but opposite in direction and this is called action-reaction law'. Whenever one thing exerts a force on another, an equal amount of force is exerted back on it.

Question 2: As it is known, two masses exert gravitational force on each other ($F=G \cdot (M_1 \cdot M_2 / R^2)$ In other words, whenever the large mass exerts force on the smaller force, the smaller force will exert the equal amount of force on the large force. Thus, when we consider the apple which fell on Newton's head, does the apple fall toward the earth? Or else, is the earth moving up towards the apple? Explain your answer with your reasons.' The responses of the students to the question were analyzed and the findings obtained were presented in Table 3.



Table 3. Pre-test and post-test results for Question 2.

QUESTION 2	Pre-test						Post-test					
	True		Partly true		False		True		Partly true		False	
	N	%	N	%	N	%	N	%	N	%	N	%
	0	0	22	63	13	37	7	20	23	66	5	14

When Table 3 was examined, it was revealed that according to the pre- test results 63% of the students answered the second question partly true but 37% of them false. There are no students who answered the question correctly in the pre-test. According to the post-test results, it was revealed that 20% of the students answered the question correctly, 66% of them partly true and 14% of them false. Pre-test and post-tests pointed to an increase in the number of the students who answered the question correctly and a decrease in the number of the students who gave false responses. The following examples were given for the student answers;

The response of the student 20 (S20) in the pre-test was: 'In this event an apple moved towards the earth due to the gravity of the earth. The life continues due to the gravitational force of our planet. Everything on the earth is under the effect of this gravitational force.' In the post-test S20 stated, 'Because the mass of the Earth is much larger than the mass of the apple, the apple accelerates towards the Earth.'

Student 19 (S19) in the pre-test said, 'The apple attracts the Earth and also the Earth attracts the apple but due to the small mass of the apple, it is regarded that the Earth attracts it', but in the post-test S19 stated, 'Both the apple and the Earth attract each other; however, because the Earth has a larger mass, it causes the fall of the apple toward the ground to be seen.'. The answers given in Turkish by Student 19 for Question 2 in pre-test and post-test were introduced in Figure 6 and 7.

2- Dünya da dünyayı çekmekte, dünyada elmayı çekmektedir. Fakat elmanın kütlesi küçük old. için dünya çekiyor muş gibi algılanır

Figure 6: An example answer given by Student 19 for Question 2 in pre-test (The answer was written in Turkish).

2- Yüce dışarı elmanda dünya ve elma birbirlerini çekiyor fakat dünyanın kütesinin fazla olması elmanın kütesinin göçülmesine sebep olur. $F_{\text{dünya elmaya}} = G \cdot \frac{m_1 m_2}{r^2}$ $F_{\text{elmanın dünyaya}} = G \cdot \frac{m_1 m_2}{r^2}$ ← ağırlık dünyayı göre çok az old. fark edilmez.

Figure 7: An example answer given by Student 19 for Question 2 in post-test (The answer was written in Turkish).

Student 28 (S28) in the pre-test stated, 'Due to the force of gravity, the Earth pulls down each body because they have specific weights. That's why the apple falls toward the Earth.'. In the post-test S28 said, 'The apple is attracted



towards the Earth and the Earth is attracted towards the apple. Because the force applied by the apple on the Earth is large, the apple will fall toward the Earth."

Student 30 (S30) in the post-test stated, "...The large mass applies a force of gravity on the small mass. In the same way the small mass applies a force of gravity on the large mass, but the magnitude of these forces of gravity differ due to difference in masses.' In the post-test S30 answered, '...The Earth's gravitational force is in the central field of the Earth. In other words, the apple which fell on Newton's head falls toward the Earth due to the force of gravity.

Question 3: What do you understand from the concepts of pairs of balanced forces and action-reaction force pairs? Explain your answer with your reasons. The responses of the students to the question were analyzed and the findings obtained were presented in Table 4.

Table 4. Pre-test and post-test results for Question 3.

QUESTION 3	Pre-test						Post-test					
	True		Partly true		False		True		Partly true		False	
	N	%	N	%	N	%	N	%	N	%	N	%
	14	40	6	17	15	43	17	49	7	20	11	31

When Table 4 was examined, it was revealed that according to the pre- test results 40 % of the students answered the third question correctly, 37% of them partly true and 43 of them false. However, according to the post-test results for the same question, 49 % of the students answered the question correctly, 20% of them partly true and 31 % of them false. When the results were evaluated, it was discovered there was an increase in the number of the students who answered the question correctly and a decrease in the number of the students who gave false responses. The following examples were given for the student answers;

Student 24 (S24) in the pre-test stated, '...The forces applied in pairs of balanced forces produce action-reaction on each other and if the forces are equal, they are balanced.' In the post-test, S24 answered, 'For example, Ali pulls a table with a force of 5N and Ahmet pulls the table from the opposite side with a force of 5N, so the table is at equilibrium. ... What I understand from action-reaction force pairs is that for action there is reaction force. If an action occurs, there is absolutely reaction force.' The answers given in Turkish by Student 24 for Question 3 in pre-test and post-test were introduced in Figure 8 and 9.

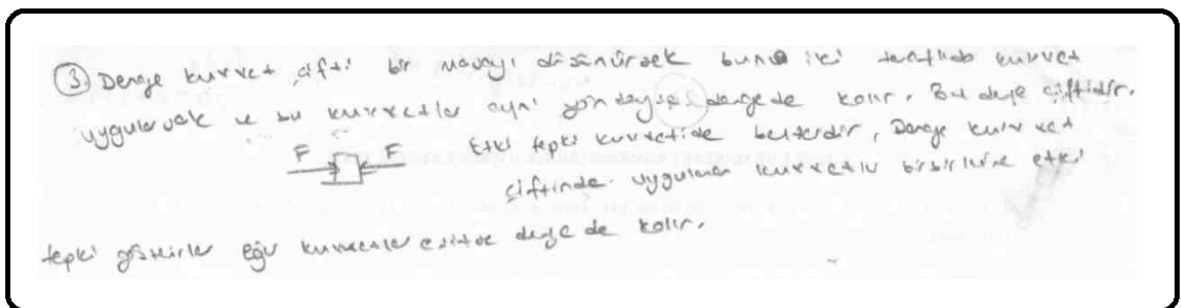


Figure 8: An example answer given by Student 24 for Question 3 in pre-test (The answer was written in Turkish).

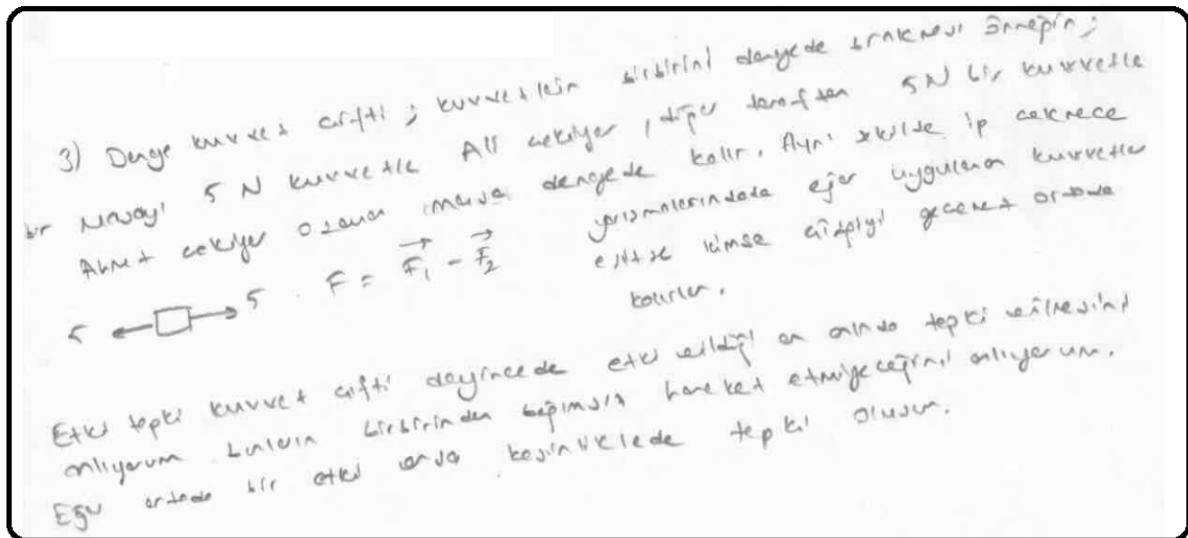


Figure 9: An example answer given by Student 24 for Question 3 in post-test (The answer was written in Turkish).

Student 4 (S4) in the pre-test established the relationship between the forces and the angles in his response: 'A pair of balanced forces provides the force acting upon the objects at an angle and also the object will be at equilibrium. Action-reaction pairs are acting upon a body at an angle of 90° '. S4 in the post-test used the following statements, '... If two people pull a table equally with the same force, the table does not move... In action-reaction pairs, the force which is equal but opposite in direction is exerted on a body.'

Student 30 (S30) answered the question correctly in the pre test: 'To exemplify action-reaction pairs, we tie a rope to a tree and try to pull on the rope. F action force acts upon the rope but the force exerted by the tree on us is a reaction force in $-F$ value. To exemplify pairs of balanced forces, when Eren pulls a suitcase towards right with a force of 5N and Mete pulls it towards left with a force of 5N, because their force values are equal but opposite in direction, the resultant force acting on it is zero and the suitcase is at rest. S30 in the post-test stated, 'Balanced force is the resultant force acting upon an object. Balanced force is a single force creating action instead of all the forces. Action-reaction is equal but opposite in direction. Hitting a wall is action and feeling pain on our hand is reaction.' According to the response, the student tries to define resultant force and balanced force.

Student 14 (S14) stated in the pre-test, 'Action-reaction force pairs are equal to balanced force. Because action-reaction forces are equal in magnitude and opposite in direction, they form balanced force by eliminating each other. S14 in the post-test stated, 'In other words, pairs of balanced forces can be action-reaction pairs because the resultant force of pairs of balanced forces is zero..... Action-reaction pairs exert another force on the force acting upon a body in equal magnitude and reaction occurs. In other words, the bodies are at equilibrium.

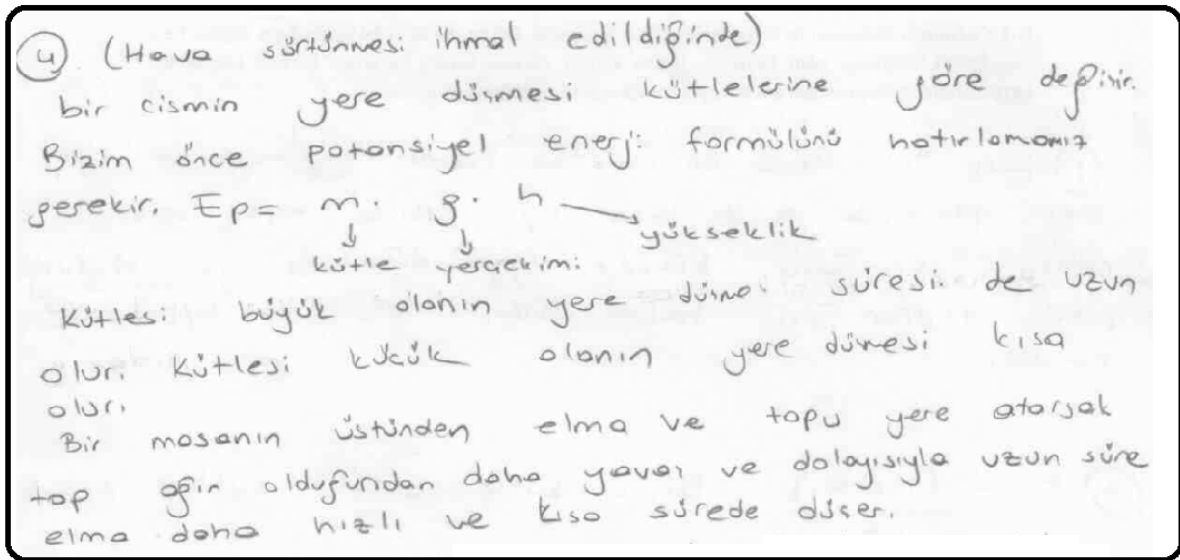
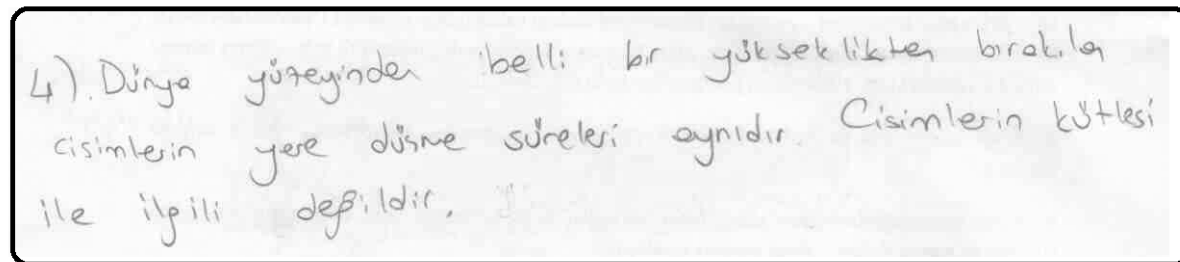
Question 4: When different masses of bodies are dropped from a height, how is their elapsed time associated with their masses? (Do not consider air resistance) Explain your answer with your reasons. The responses of the students to the question were analyzed and the findings obtained were presented in Table 5.

Table 5. Pre-test and post-test results for Question 4.

QUESTION 4	Pre-test						Post-test					
	True		Partly true		False		True		Partly true		False	
	N	%	N	%	N	%	N	%	N	%	N	%
	11	31	9	26	15	43	9	26	12	34	14	40

According to Table 5, 31% of the students answered the question correctly, 26% of them partly true and 43% of them false. However, according to the post-test results for the same question, 26% of the students answered correctly, 34% of them partly true and 40% of them false. It was suggested that pre-test and post-test results were quite close to each other. The following examples were given for the student answers;

Student 26 (S26) gave the following answer in the pre-test: 'When air resistance is ignored, a body that is falling downward may change according to its mass.The larger masses the body has, the longer time it takes to fall downwards.' In the post-test S26 stated, 'Bodies will fall at the same time when they are dropped from the same height. It is not related to the masses of the bodies.' The answers given in Turkish by Student 26 for Question 4 in pre-test and post-test were introduced in Figure 10 and 11.

**Figure 10: An example answer given by Student 26 for Question 4 in pre-test (The answer was written in Turkish).****Figure 11: An example answer given by Student 26 for Question 4 in post-test (The answer was written in Turkish).**

Student 16 (S16) responded to the question in the pre-test in this way: 'When two bodies with different masses are dropped at the same height, the one with a larger mass falls faster. For example, the falling of a plastic ball and a stone is not the same.' In the post-test S16 stated, 'Mass has no effect on the bodies when they are dropped in an environment where there is no resistance.'

Student 6 (S6) gave the following answer in the pre-test and formed a relationship between the falling time and energy: 'Different masses could fall at different rates.' For example, when we drop a marble and feather at the same height, the marble will fall faster than a feather. Potential energy is $PE=mgh$ where m depends on the mass, so their rates will be different. Different masses could fall at different rates.' In the post-test S6 gave the following answer, '...For instance, when we drop a stone and feather from the same height, the stone falls faster than the feather. Because the stone has a larger mass, it moves faster.'

Student 4 (S4) associated the falling time with the mass and force of gravity with his answer in the pre-test: 'With $G=mg$ formula, if one of the bodies dropped at a certain height has a larger mass than one of the other, the gravity force exerted will be greater and the body will fall at a faster speed. The body with a smaller mass will fall at much slower speed because the force of gravity is weak.' S4 in the post-test stated, 'When a stone and a piece of paper are dropped at the same height, we see that the stone reaches the ground first. The heavier objects fall at a faster speed.'

Question 5: A jeweller wants to weigh gold in different places on the earth. The jeweller has a shop both on the mountain and in the valley, so where should he buy gold and where should he sell it? The responses of the students to the question were analyzed and the findings obtained were presented in Table 6.

Table 6. Pre-test and post-test results for Question 5.

QUESTION 5	Pre-test						Post-test					
	True		Partly true		False		True		Partly true		False	
	N	%	N	%	N	%	N	%	N	%	N	%
	23	66	6	17	6	17	20	57	6	17	9	26

When Table 6 was examined, 66 % of the students answered the question correctly, 17% of them partly true and 17 of them false in the pre-test. However, according to the post-test results, 57 % of the students answered the question correctly, 17% of them partly true and 26 % of them false. Although the pre-test and post-test results are close to each other, it was discovered that there is a slight decrease in the number of the students who answered correctly and a slight increase in the number of students who gave false answers. The following examples were given for the student answers;

Student 15 (S15) answered the question in the pre-test as follows: 'The gravitational acceleration of the Earth is greater than a valley or a mountain. The Earth has a much greater mass. The gravitational acceleration is the same in a valley or on a mountain because the gravitational acceleration is constant. It is the same everywhere. The jeweller can sell or buy gold both in the valley and on the mountain.' S15 in the post-test stated, 'The bodies' masses do not change. Selling and purchasing have nothing to do with mass. The force of gravity weakens as you get farther away from the Earth's centre. The jeweller must both buy and sell the gold on the mountain.'

Student 32 (S32) stated in the pre-test, 'The gravitational force weakens as you get farther away from a place.That's why the jeweller must both buy and sell the gold on the mountain.' However, S32 in the post-test stated, 'As you go up above the ground, the gravitational acceleration increases. That's why the jeweller must buy the gold in the valley and sell it on the mountain.'

Student 26 (S26) replied in the pre-test, 'The jeweller must buy the gold in the valley and sell it on the mountain because a pressure acts upon the gold in open air. Atmospheric pressure weakens as you go up above the Earth's surface and the mass of the bodies decreases. Because the density is the same, the masses of the bodies increase. As it has greater mass on the mountain, it weighs heavy. If he sells it on the mountain, it is more profitable.' S26 gave the following answer in the post-test, 'The weight of the gold on the mountain and in the valley change according to the location of the jeweller because the gravitational acceleration is effective. The jeweller must buy the gold on the mountain and sell in the valley.' The answers given in Turkish by Student 26 for Question 5 in pre-test and post-test were introduced in Figure 12 and 13.



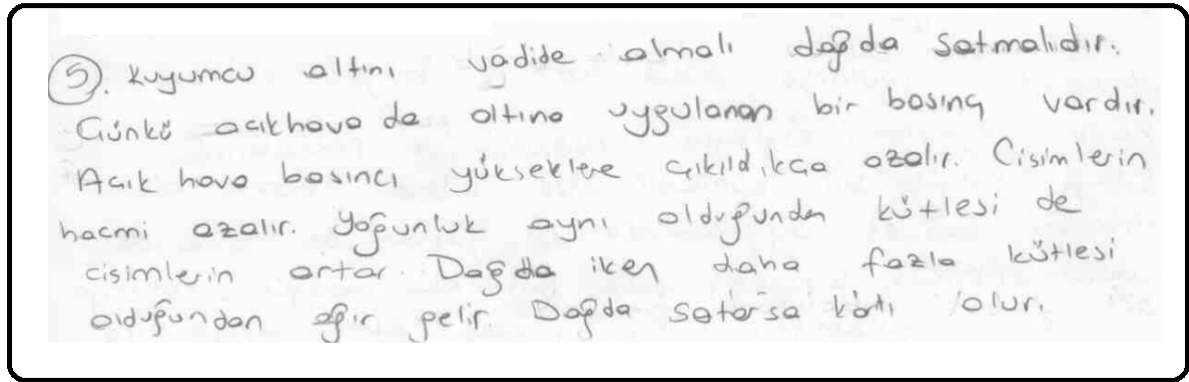


Figure 12: An example answer given by Student 26 for Question 5 in pre-test (The answer was written in Turkish).

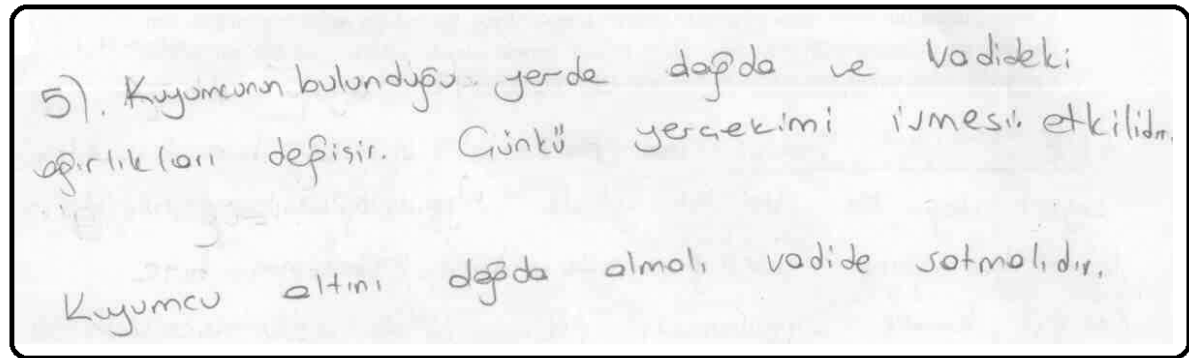


Figure 13: An example answer given by Student 26 for Question 5 in post-test (The answer was written in Turkish).

Student 36 (S36) gave the following answer in the pre-test: 'The jeweller must weigh the gold while selling it in the valley and buying it on the mountain. The force of gravitation is different in the valley and on the mountain. Because the gravitational force is greater in the valley, it will weigh more, in other words, while selling it he will make more profit. His gold will weigh less on the mountain and he will buy it more cheaply.' S36 used the following expression in the post-test: 'The jeweller must weigh the gold on the mountain when buying it and in the valley while selling it. Because the gravitational force is weak on the mountain, the gold will weigh less. But as he has weighed it in the valley, it will weigh more while selling it and he will make profit.In other words, he will pay 100 TL for 10 gram gold on the mountain and the gold which weighed heavy in the valley (10 gram gold become 11 gram) will weigh more and he will make profit.'

Discussion

The results obtained with the study are explained as follows:

It is revealed that there was an increase in the students' post-test results related to the explanation of action-reaction law. Moreover, it was discovered that the students got confused about action-reaction force pairs and pairs of balanced force at the beginning, but the differences between two force pairs were clarified and understood as a result of the meaningful learning activities (Table 2). Eryılmaz (2002) developed an academic achievement test in order to determine the misconceptions of high school physics students related to force and motion unit in his study. Discussions on conceptual change were carried out during the implementations and an effort was made to have the students learn the concepts meaningfully. At the end of the process, it was reported that misconceptions were eliminated and their achievement levels increased. In addition, Tao and Gunstone (1999) in their study determined the misconceptions about mechanics and they carried out computer assisted instruction for 10th grade students. The study was designed according to the activities of prediction- observation-explanation and it was revealed



that they were effective in eliminating students' misconceptions. Demirci (2005) in his study emphasized many student misconceptions about force and motion and implemented web-assisted physics programs to eliminate them. The results of the research revealed that web-assisted physics programs carried out by the experimental group were effective in eliminating the misconceptions. Halloun (1996) presented the importance of creating schematic modelling and stated that schematic modelling explained the state of acquiring scientific knowledge. Moreover, Halloun (1996) added that schematic models created by the students explained the construction and development process of the knowledge within the students. The experimental study conducted by Halloun introduced that teaching activities based on the schematic modelling approach actualized meaningful learning in a more profound way. Marshall and Carrejo (2008) in their study examined the students' mathematical modelling and formulating conditions about motion and they found that students had difficulty in making mathematical modelling while explaining the concepts such as velocity and acceleration. Chen, Hand and Dowell (2013) in their study explored the students' conceptual understanding about force and motion. Students' level of understanding the force and motion concepts at the beginning, during the process and at the end of the process were examined in the implementation. The implementations carried out were based on the questions asked to the students, assertions, and evidence. The results of the study revealed that the implementations enabled the concepts about force and motion to be understood better. It can be suggested that the results of the study obtained is compatible with the conditions of actualization of meaningful learning.

When the students' responses related to the force of gravity are examined, it is found that none of the students could explain how the apple was pulled downward by the Earth (Table 3). 20% of the student gave correct explanations at the end of the meaningful learning activities, but it was identified that there were about 14% of the students who gave false answers. It is concluded that although they are few in number, some students could not understand that the apple would be accelerated toward the Earth due to the differences in mass.

When the results related to the students' explanations about action-reaction force pairs and pairs of balanced force are examined, it is reported that there was an increase in the number of students who gave correct answers (Table 4). It can be suggested that meaningful learning activities contributed students to understand the differences between pairs of balanced force.

When the students' results related to the force of gravity are examined, it is observed their conceptual perceptions of this subject remained at similar levels at the beginning and at the end of the process. It is revealed that some students could not actualize meaningful learning and they stated that the falling rate of bodies in space would be proportional to their weights (Table 5). Alonzo and Steedle (2009) developed a concept test composed of multiple choice and open ended questions related to force and motion subjects in order to reveal students learning in their study. Implementations obtained from the test were given. Kanter (2010) designed a project-based instruction to promote meaningful learning and carried out implementations. Özsevgeç (2006) examined the 5E implementations developed according to the constructivist approach for force and motion subjects and also explored its effect on students' attitudes and achievement. It was reported that the implementation carried out yielded positive results. It can be stated that the studies carried out to facilitate meaningful learning were compatible with the results obtained from the study.

When the students' responses related to the question which examined the relationship between the mass and height for the force of gravity are explored, it is detected that there was a considerable increase in the post-test and students actualized meaningful learning. It was revealed that students' understanding of the relationship between the weight and height was facilitated with meaningful learning (Table 6). Göksun, George, Pasek and Golinkoff (2013) explored the conceptual perceptions of young children about force and motion subjects. The results revealed that pupils defined force in terms of its effects and different aspects of student thinking were also included in the study.

When the results obtained were examined, meaningful learning activities carried out with the pre-service teachers yielded effective results in terms of understanding action-reaction law on students, introducing the differences between action-reaction force pairs and pairs of balanced force, and presenting the relationship between force and gravity and mass and weight. Thus, situations in which students can introduce the relationship between the subjects explained conceptually must be provided. Students must not learn the subjects separately, a connection must be established between the subjects told, and the conditions whether they are similar or not must be introduced. Environments where students can think deeply must be provided and a careful attention must be paid on students' learning meaningfully while learning the subjects. Students' lack of knowledge or misconceptions must be identified and activities to eliminate them must be designed and developed.



Conclusions

The study aimed at students' learning the subjects in detail such as action-reaction law, pairs of balanced forces, the relationship between mass and weight, which they only know conceptually at knowledge level. It was revealed in the study that the meaningful learning activities promoted students' conceptual understanding. Thus, it can be suggested that students' misconceptions and mislearning, if there are any, can be corrected. The activities developed for meaningful learning can make contributions to the future studies. Moreover, the researchers will be able to conduct similar studies on different subjects in the science field. Therefore, this demonstrates the authenticity of the study carried out. The assessment tool used in the study consists of interesting questions and also it presents the students' conceptual understanding about force and motion. The assessment tool is considered to lead the way for similar studies. It is important that meaningful learning activities should be used with other topics in the science field and their results should be viewed.

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APPENDIX 1: CONCEPTUAL PERCEPTION TEST RELATED TO FORCE AND MOTION SUBJECT (CPTFM)

1. One of the fundamental laws of Newton is Action-Reaction Law. Explain the action-reaction principles with examples.
2. As it is known, two masses exert gravitational force on each other [$F=G \cdot (M_1 \cdot M_2) / R^2$]. In other words, whenever the large mass exerts force on the smaller force, the smaller force will exert the equal amount of force on the large force. Thus, when we consider the apple which fell on Newton's head, does the apple fall toward the earth? Or else, is the earth pulled through the apple? Explain your answer with your reasons.
3. What do you understand from concepts of balanced force pairs and action-reaction force pairs? Explain your answer with your reasons.
4. When different masses of bodies dropped from a height, how is their elapsed time associated with their masses? (Do not consider air resistance) Explain your answer with your reasons.
5. A jeweller wants to weigh gold in different places on the earth. The jeweller has a shop both on the mountain and in the valley, so where should he buy gold and where should he sell it? Explain your answer with your reasons.

APPENDIX 2: A SAMPLE LESSON ON ACTION-REACTION PAIRS AND BALANCED FORCE PAIRS FOR MEANINGFUL LEARNING

I. Preparation

Course Name: Physics (Within the Content of Special Education Methods)

Name of the Subject: Action-Reaction Pairs and Balanced Force Pairs

Strategy: Meaningful Learning

Resources: PowerPoint presentations about the subject, white board and worksheets

II. Teaching the course

a) Presentation of Pre-Organizers (Beginning):

Students are asked what action-reaction pairs and balanced force pairs are.

They are asked to exemplify them. Examples consistent or inconsistent with action-reaction pairs and balanced force pairs are given. A discussion is carried on them. In this stage prediction-explanation-observation and explanation (PEOE) activities can be given.

The students can be asked the question "What kind of force is the forward force which accelerates you as well as the car and the car exerts on your seat?" Whether this force is an action or reaction is discussed with its reasons.

Another question which can be asked is "What kind of force is a backwards force acting upon the car and keeping you in the seat? Whether this force is an action or reaction force is discussed by giving reasons.

The following question is asked. "Does the state of a stationary body reflect upon us the special case of having a constant speed? Explain." With such questions as "What are the conditions of being at equilibrium?" students' views about action-reaction force pairs and pairs of balanced force are discussed.



b) Presentation of the Subject to be Learned (Development)

In this section, what action-reaction force pairs and pairs of balanced force are identified and explained in detail.

About action-reaction force;

When we push the wall with our fingers, it is explained that the wall will also push our fingers. When we kick a soccer ball, it is mentioned that the soccer ball will exert a force equal but opposite in direction. At this point, Newton's third law is explained: "If object A exerts F force on object B, object B applies $-F$ force which is equal to F in magnitude but in opposite direction on object A. Examples are given for the sample situations.

While explaining pairs of balanced force, the following information is given:

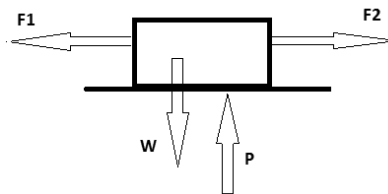
When a body is at rest and tends to remain stationary, it is called static equilibrium. Newton's first and second laws suggest that the net force acting upon the body is zero. It is explained that this condition is a "must" for equilibrium.

1st Condition for equilibrium: The vector sum of all forces acting upon a body is zero.

2nd Condition for equilibrium: The sum of clockwise and counter clockwise torques in acting on a body is zero.

c) Reinforcing Cognitive Learning (Accomplishing a Result)

Different examples are given for the connection of the subjects told with each other. The diagram given below explains the differences between the action-reaction force pairs and pairs of balanced force.



It is emphasized here that the sum of vertical and horizontal forces is separately zero as the box remains stationary.

$$F_1 - F_2 = 0 \text{ and } P - W = 0$$

It is also explained that pairs of balanced force act on the same bodies, but action reaction force pairs act on different bodies. Examples suitable to the content of the subject are done for the students and lecturing ends.

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