Prospective physics teachers' level of understanding energy, power and force concepts

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Contents

Abstract

The aim of this **study is to** determine prospective physics teachers' level of understanding of the concepts of energy and the related concepts of force and power. The study was carried out with the participation of 56 physics education department students at a university in Karadeniz region. All participants had previously taken an introductory physics course. To reach the aim of the study, an achievement test with 5 questions was formed for each concept and the collected data was analyzed using the description method. The data analysis revealed that majority of the students were not at the intended level in defining and explaining the energy, power and force concepts scientifically, and they could not associate these concepts with their daily life. Backed by the available results, utilizing associations of these concepts and using conceptual change texts were suggested for effective teaching of the concerned concepts.

Keywords: Energy, Power, Force, Prospective Physics Teachers, Level of Understanding

Introduction

Even though it has been known only as a physics subject, the concept of energy has an interdisciplinary background and it has been subjected to lots of studies because of its complex nature. Boyes and Stanisstreet (1990), Domenech *et al*. (2007) and Trumper (1998) reported that students mentioned the energy as a difficult concept to learn. Some other researchers (e.g. Solomon, 1983; Warren, 1983; Watts, 1983) studied the difficulties of teaching about the concept of energy. The difficulties associate with teaching and learning these concepts oriented some researchers to devise effective approaches to teaching.(e.g. Brook & Wells, 1988; Kirkwood & Carr, 1988; 1989; Trumper, 1990a; 1990b; 1991; Huis & Berg, 1993; Gürdal *et al*., 1998; Heuvelen & Zou, 2001; Fry *et.al*., 2003; Mutimucuio, 2003; Aydın & Balım, 2005; Tsagliotis, 2005; Papadouris & Constantinou, 2006). For teaching the concepts of energy, some approaches were put forward including, "Abstract Picture Language" (Fry *et al*., 2003), "Multiple Representations Approach" (Heuvelen & Zou, 2001; Mutimucuio, 2003), "A Systems Approach" (Huis & Berg, 1993).

In spite of the existence of such different approaches, a work concept-grounded approach has been suggested and most adopted for teaching the concepts of energy (Warren, 1986; Küçük *et al*., 2005; Kurnaz, 2007). When one realizes the associations between work, distance and force concepts, then it is obviously meaningful that to a large extent learning the concept of energy depends on the force concept, which is one of the principal concepts of physics. Certain studies focusing on this relationship determined that students confuse these concepts with each other and could not state the difference between them (Duit, 1984; Goldring & Osborne, 1994; Küçük *et al*., 2005; Ünal Çoban *et al*., 2007). Additionally, it was determined that this confusion obstructs students ability to develop alternative ideas related to the concept of energy and truly understand the conceptual nature of it (Duit, 1984; Goldring & Osborne, 1994; Trumper, 1998; Gürdal *et al*, 1999; Kurnaz, 2007; Küçük *et al*., 2005; Ünal Çoban *et al*., 2007). Whereas, according to Domenech *et al*. (2007), the basic barrier for students to perceive energy arises because they do not know how to define energy. The studies about the issue have shown that students tried to define energy based on only a single discipline, they could not associate meanings of energy in different disciplines and they had difficulties understanding energy related terms like power and force (Hırça *et al*., 2008; Kurnaz, 2007; Küçük *et al*., 2005).

It is known that determining students' probable weaknesses and mistakes about conceptual perceptions in advance is helpful in terms of providing students and teachers with necessary information to solve and to develop solution strategies for scientific or daily life problems related to these concepts (Küçük *et al*., 2005; Trumper, 1990a). Therefore, in order to tackle probable problems faced while teaching the closely interrelated terms, power, force and energy, the first thing one should determine is how much students know about these concepts and to what extent they can differentiate between them. Most of the studies about this issue were carried out at the primary school level. In this context, researchers have investigated the students' levels of understanding of energy and related concepts. Watts (1983) carried out a study with primary school students of different grades; Duit's study examined (1984) primary and secondary school students (6^{th} to 10^{th} grades) from different countries; Goldring and Osborne (1994) studied 6^{th} graders; Küçük *et al*. (2005) studied 7^{th} grades; Ünal Çoban *et al*. (2007) and Hırça *et al*. (2008) studied 8^{th} graders. The striking findings of the research related to students' alternative conceptions and learning difficulties are presented below.

Alternative conceptions	Only living organisms have energy.	Watts (1983), Ünal Çoban et al. (2007) and Hırça et al. (2008)
	Non-living things do not have energy because they do not move.	
	Moving/activity means energy.	Watts (1983)
	Energy can be generated.	
	Energy is a kind of matter.	Küçük et al. (2005)
	Energy can not be stored in objects such as oil, coal and books. They have energy when they burn or move.	Watts (1983) and Küçük et al. (2005)
Learning difficulties	Students do not have proper information about energy forms.	Watts (1983), Ünal Çoban et al. (2007) and Hırça et al. (2008)
	Students confound the concept of energy with force, power and electric concepts.	Küçük et al. (2005)
	Students mostly define energy in colloquial terms rather than in a scientifically meaningful way.	Duit (1984)

	Students can not explain the meaning of energy conservation.	Duit (1984), Goldring & Osborne (1994)
	Students generally fail to determine the unit of energy or power.	Goldring & Osborne (1994)

There have been not enough studies examining students' perception of energy and related terms with university students. Thus, this study was aimed at determining prospective physics teachers' level of understanding of energy, power and force concepts and how these concepts are primarily associated in relation to physics. As a result, it is believed that instructors may use students' alternative frameworks related to energy, power and force to construct a meaningful understanding of students in a scientific manner.

Subjects

The present study was carried out with a qualitative point of view which aims to perform research without manipulating the situation. The study sample consisted of 56 students enrolled in an introductory physics course in the physics education program in a university in the Karadeniz region of Turkey in 2007.

The sample had taken several courses related to the concepts of energy as 5th grade students through university. During this process, students were expected to learn energy concepts based on energy transformations associated with macro-level work concepts and micro-level heat concepts. The students also recognized force and power concepts related to the concept of energy. Furthermore, students were expected to learn about the conservation of energy by making associations with daily life experiments. In introductory physics courses at the university, students encountered similar topics once more within a more scientific manner. In summary, students learn mechanical energy concepts.

Instruments

A comparative achievement test was developed to reveal students' understanding of energy, power and force. The test was applied just after the instruction of the related concepts. The test included 5 open-ended questions for each of the three concepts (a total of 15 questions). Students were expected to realize the differences between the three concepts and to answer the questions up to a certain level. The first three questions required defining and stating characteristics of the energy, power and force concepts. And the last two required explanation of some attributions of these concepts, for example being a source of movement for an object and being a property of an object. The questions of the achievement test are below:

Q1	What is energy in a scientific point of view?
	What is power in a scientific point of view?

	What is force in a scientific point of view?
Q2	What kind of quantity is energy? Why?
	What kind of quantity is power? Why?
	What kind of quantity is force? Why?
Q3	What are the units of measurement of energy?
	What are the units of measurement of power?
	What are the units of measurement of force?
Q4	Is energy a result of movement? Why?
	Is power a result of movement? Why?
	Is force a result of movement? Why?
Q5	Can energy be a property of an object? Why?
	Can power be a property of an object? Why?
	Can force be a property of an object? Why?

Data Analysis

In order to analyze the collected data, four levels were determined based on levels of understanding developed by Abraham *et al*. (1994).

- [0]: Unanswered questions, repeating questions, unclear response or short answers with no explanation
- [1]: Answers far from being scientific information
- [2]: Answers not fully coinciding with scientific information but having proper attributions
- [3]: Answers complying with scientific definitions

The collected data was analyzed according to the levels described above by both of the researchers. Answers from certain levels were sub-categorized when necessary and these sub-categories were presented in the related tables. In the analysis process, inferences were made with respect to these tables and supported with necessary descriptions.

Results

First, summary tables and relevant explanations were given, then characteristics of the answers were examined, principally with respect to the four levels of understanding and then the subcategories related to these levels were created based upon the characteristics of the students' answers. In addition, findings were classified under these titles:

- Energy, power and force as concepts

- Energy, power and force as physical quantities
- Measurement of units of energy, power and force
- The relation between movement and energy, power and force
- Energy, power and force as a property of an object

Energy power and force as concepts

The level distribution of the answers given for the first question is presented in Table 1.

Table 1 *The level distribution of the student answers related to definition of the energy, power and work concepts.*

Concepts	Frequency Percentile	Levels				Number of sub-categories belonging to the levels			
		[3]	[2]	[1]	[0]	[3]	[2]	[1]	[0]
Energy	f %	6 11	6 11	13 23	31 55	1	2	6	-
Power	f %	8 14	9 16	17 31	22 39	1	3	6	-
Force	f %	9 16	5 9	8 14	34 61	1	2	7	-

To answer this questions, students were expected to define energy as "an invented entity in the context of a theoretical framework for explaining changes encountered in physical systems" (Papadouris & Constantinou, 2006), power as "the amount of energy consumed/used in unit time or the rate of energy transmission in unit time" and force as "the interaction between two physical bodies causing push or pull" (Serway, 2002; Crowell, 2006).

When the student answers about energy concepts were grouped based on their characteristics (see Table 1), the majority of them (approximately 80%) fell within the first two levels (0, 1). That is, they were unable to submit any definitions for the related concepts or gave answers other than scientific ones. Half of the remaining students responded to questions scientifically (level 3), and the remaining students gave answers not completely true, but partially applicable in a scientific point of view (level 2) (11% and 11% respectively).

Similarly, the majority of student answers (70%) about power fell into the first two levels (0, 1), and only 30% of them complied with scientific definitions as presented in Table 1. Answers for force demonstrated a similar distribution. Only one-forth of the students gave answers that can be classified in level 2 and 3, and the rest either gave no answers or disclosed incorrect definitions for the concept.

The sub-categories of the levels are given in the table below.

***Table 2** The sub-categories of the student answers related to definition of the energy, power and work concepts.*

Level 3	Energy	Capacity for doing work
	Power	Amount of work done per unit time
	Force	A dynamic vector quantity that changes a body from a state of rest to one of motion, stops or redirects a moving body
Level 2	Energy	The quantity possessed by a body because of its position or movement It is spent while an object is being carried
	Power	Energy that is spent to do something It is the velocity of energy It is work per time
	Force	Influence that is applied to give an object velocity Vector quantity necessary for doing work
Level 1	Energy	It is the power consumed while work is being done The conversion of force into movement or velocity The rate of power over time It is velocity multiplied by mass It is the raw material used to get power
	Power	The ability to do work The force possessed, Stored energy The velocity of a mass
	Force	Velocity applied on an object Change in the position of an object with respect to velocity and time The ability for using muscle power It is power The associate of energy and power Ability for doing work

Considering this table, the content of the answers classified in the level 2 showed that the students had appropriate perceptions about the energy, power and force; however, they had difficulties in expressing their knowledge. And the expressions considered in level 1, on one hand, shows that the energy, power and force concepts were not perceived scientifically by students and also there were confusions over the meaning of these concepts.

Energy, power and force as physical quantities

The classifications given as responses to the second question, which was asked to determine knowledge of quantities of energy, power and force concepts, were presented in Table 3.

Table 3 *The distribution of the student answers related to the kind of quantity (Vector/Scalar) of energy, power and force.*

Concepts	Frequency Percentile	Levels				Sub-categories of the levels			
		[3]	[2]	[1]	[0]	[3]	[2]	[1]	[0]
Energy	f %	11 19	2 4	3 5	40 72	1	1	2	3
Power	f %	18 32	- -	8 14	30 54	2	-	3	3
Force	f %	19 34	1 2	4 7	32 57	1	1	1	2

The students were expected to answer this inquiry by stating concepts, for example, normally force is vector, but energy and power are scalar quantities. In addition to such an answer, students were also expected to write an explanation. For example, energy and power are not quantities with direction and magnitude, however, force is a quantity with direction and magnitude.

As seen from Table 3, a considerable majority of the students were at the level 0(72% for energy, 54% for power and 57% force), since they did not give any answers for the question or only responded, "it is a scalar/a vector quantity." On the other hand students gave answers coinciding with scientific facts and qualified as level 3; 19% for energy, 32% for power and 34% for force, respectively. Regarding energy (4%) and force (2%), a minority of students gave answers that did not fully match, but were compatible with scientific facts. Finally, Table 3 also shows that for energy (5%), power (14%) and force (7%) slightly more students gave answers that did not match the scientific facts at all and were classified as level 1.

The sub-categories related to the kind of quantity of the concepts considered are listed below.

Table 4 *The sub-categories of the student answers related to the kind of quantity (Vector/Scalar) of energy, power and force*

Level 3	Energy	Direction is not important
	Power	Direction of power is not important Power is scalar
	Force	Force has direction and magnitude

Level 2	Energy	It is scalar because it has a magnitude
	Force	It is vector because it depends on velocity
Level 1	Energy	Since force is vector, energy is also vector It is a magnitude with direction, it is important towards which way it is applied
	Power	It is the product of two vectors (*Fx*) It affects in a certain direction Since force has direction
	Force	It has three dimensions
Level 0	Energy	Energy is scalar Energy is a vector quantity No answers
	Power	Power is a scalar quantity Power is a vector quantity No answers
	Force	Force is a vector quantity No answers

Some of the students fell into the level 2 and reported that energy is scalar and force is a vector quantity and most of them could not explain their answers in a scientifically acceptable way. The students classified in level 1 and figuring energy and power as vector quantities can be said to have significant misconceptions. In spite of the fact that the rest of the students in this group reported that force is a vector quantity, their explanations were not valid from a scientific point of view.

Considering level 0, Table 4 shows that three types of answers are considered in this level: correct answers with no explanation, wrong answers with no explanation and no answer. For the concept of energy, most of the students placed into this category (65%) said that energy is scalar without providing any explanations; 2% claimed that energy is a vector quantity without any explanation; and the rest (33%) submitted no answers. For the concept of power, 63% of the students evaluated in this level noted that power is a scalar quantity and put forward no explanations; 1% said it is vector quantity; and the rest (26%) left the question unanswered. As for the concept of force, 56% of the students in level 0 argued that force is a vector quantity, and the remaining 44% did not respond the question in any way.

When we try to evaluate all the categories collectively, it can be said that the students did not have adequate and correct information about whether the energy, power and force concepts are vector or scalar quantities. However, the students were relatively successful at determining that the force concept is a vector quantity.

The Measurement of Units of Energy, Power and Force

Table 5 presents the classification of the student answers given for question three inquiring about the students' state of determining the measurement of units of energy, power and force. Based upon this data, more than half of the students were classified in level 3 as a result of their answers matching the scientific facts (56% for energy, 54% for power, 57% force). For this question, related to energy, only 5% of the students gave answers that did not match the scientific facts and placed at level 1. However, there were no students at this level for the other concepts. Additionally, Table 5 presents that students could not write the measurement units and they were classified as level 0 (for energy 39%, for power 46% and for force 43%).

Table 5 *The distribution level of the student answers about the units of energy, power and force*

Concepts	Frequency Percentile	Levels				Number of sub-categories belonging to the levels			
		[3]	[2]	[1]	[0]	[3]	[2]	[1]	[0]
Energy	f %	31 56	-	3 5	22 39	4	-	-	-
Power	f %	30 54	-	-	26 46	2	-	-	-
Force	f %	32 57	-	-	24 43	3	-	-	-

The answers, about the units of energy, power and force, related to the mentioned four levels are presented in Table 6.

Table 6 *The sub-categories of the student answers related to the units of energy, power and force*

Level 3	Energy	Joule Erg Calorie Nt.m
	Power	Watt J/s
	Force	Newton Dyne $kg.m/s^2$
Level 1	Energy	km/s It has no unit

The relation between movement and energy, power and force

Under this title, student views about the relation between movement and energy, power and force were examined.

***Table** 7 The distribution level of student answers about the relation between movement and energy, power and force*

Concepts	Frequency Percentile	Levels				Number of sub-categories belonging to the levels			
		[3]	[2]	[1]	[0]	[3]	[2]	[1]	[0]
Energy	f %	7 12	3 6	7 12	39 70	1	2	2	3
Power	f %	-	3 6	19 34	34 60	-	1	8	3
Force	f %	6 11	2 4	7 12	41 73	1	1	4	3

As seen from Table 7, the vast majority of student answers fell into level 1 and 0 for this question (i.e. answers did not match the scientific facts or no answer). Similarly, for the energy and force concepts (12% of students) and for power concepts (34% of the students), students gave answers that did not match scientific facts (level 1). It was determined that the rest of the students failed to answer (70% for energy, 60% for power, 73% force). They did not submit any answers aiming to explain the relationship between the related concepts and movement (level 0). However, only 12% of the students for energy and 11% for force could give answers matching the scientific facts and were classified as level 3. None of the students could give scientific answers about the concept of power. 6% of the students for energy and 4% of the students for force gave answers not matching, but agreeable with scientific facts and qualified as level 2.

The table below summarizes the sub-categories related to this issue.

***Table 8** The sub-categories of the student answers about the relation between movement and energy, power and force*

Level 3	Energy	The movement is done by energy
	Force	Force generates movement
Level 2	Energy	Energy can neither be created nor be destroyed Potential energy can come out without movement
	Power	Movement requires power to be created
	Force	Movement comes out by energy but not force

Level 1	Energy	No energy comes out without movement or action Energy is ability for doing work. No energy is generated if there is no movement
	Power	We lose certain amount of energy to do a work or action It is a result of energy in an engagement Power is spent or generated if something happens Power is the force which is necessary to perform a movement," Power can not be spent without energy consumption It is not possible without interaction, power is needed to generate movement Movement is a kind of power Since there is no self-generated force, no power can come out without movement
Level 0	Energy	Energy is a result of movement Energy is not a result of movement No answers
	Power	Movement is the source of power Power is the source of movement No answers
	Force	Movement is the source of force Force is the source of movement No answers

The answers categorized in level 3 shows that there were no answers for power in this level. The students were observed as having difficulties especially on whether the power concept has a role in generating movement. The answers qualified as level 2 were true but not adequate answers to the question asked. And the answers categorized in level 1 showed that students had some misperceptions about the generation of movement.

There were different types of answers classified in level 0 . For energy, more than half of the students that fell into this category (54%) reported that energy is a result of movement with no explanation. Again, 10% argued that energy is not a result of movement with no explanation, and the rest (36%) did not answer this question. Concerning the power concept, the majority of the students evaluated in this level either said that movement is the source of power without explaining (68%), or stated that power is the source of movement with no explanation (6%). The rest of the students (26%) did not answer the question. For the concept of force, 34% of the students placed into this category stated that movement is the source of force with no supporting explanation, 15% of them again reported, with no explanation, that force is the source of movement and the rest of the students (51%) left the question unanswered.

Energy, power and force as a property of an object

Classification and distribution of student answers regarding the relationships between the concepts of energy, power and force as properties of an object are presented in Table 9.

Table 9 *Classification and Distribution of the Student Answers about the Relationship between the Energy – Power – Force Concepts as Property of an Object*

Concepts	Frequency Percentile	Levels				Number of sub-categories belonging to the levels			
		[3]	[2]	[1]	[0]	[3]	[2]	[1]	[0]
Energy	f %	-	1 2	3 5	52 93	1	-	3	3
Power	f %	-	2 4	4 7	50 89	-	2	4	3
Force	f %	-	-	5 9	51 91	-	-	5	3

As seen in Table 9, none of the participants gave answers matching the scientific facts related to the question about the state of the energy, power and force concepts as a property of an object. Moreover, only 2% of the students for energy and 4% for power gave answers partly coinciding with scientific facts. These students were classified in level 2. Furthermore, for energy (5%), for power (7%) and for force (9%), a minority of the students submitted non-scientific information to explain the relationship between the concepts and objects; they were labeled as level 1. And finally, the vast majority of students fell into level 0 by either giving short answers with no explanation or not answering the question (respectively; 93%, 89% and 91%).

The table below summarizes the students' answers about the relationship between the energy - power - force concepts as property of an object.

Table 10 *The sub-categories of the student answers about the relationship between the energy - power - force concepts as property of an object*

Level 2	Energy	Objects are those provide energy
	Power	Everything that has energy has power as well Power belongs to the object
Level 1	Energy	Energy is changeable Everything has energy in different quantities Energy comes from the position of molecules or objects
	Power	Everything in nature is object based Every object has different capacity Power is ability to do something Power does not depend on the object it depends on the magnitude
	Force	Action-reaction requires this Force is the indicator of power It depends on the position of objects

		We apply force to the matter from the outside Everything that has mass has force
Level 0	Energy	Energy can be a property of an object Energy cannot be a property of an object No answers
	Power	Power can be a property of an object Power cannot be a property of an object No answers
	Force	Force can be a property of an object Force cannot be a property of an object No answers

Considering level 2 and level 1, Table 10 shows that students' answers don't coincide with the correct knowledge regarding the relationship between the energy-power-force concepts as property of an object. The rest of the answers are classified in level 0. Associated with the energy; 31% of the students in this category noted that energy can be a property of an object and gave no supporting explanation. 11% said energy cannot be a property of an object, again with no explanation, and the rest (58%) gave no answer. For power, 24% of the students remarked that power can be a property of an object, 22% argued that it cannot be a property of an object with no explanation and the rest (54%) left this question unanswered. Finally, for force, 22% of the students put forward that force can be a property of an object, 20% said it cannot be; both were without explanations. The rest (58%) gave no answers.

Conclusion and Discussion

Analyzing the data obtained in this study, carried out to examine the prospective physics teachers' understanding levels of the concepts of energy, power and force, it was determined that the level of understanding of the participants did not live up to expected standards. In other words, the data analysis showed that the participant students had difficultly defining and explaining the meaning of the concepts. It is obvious that such weaknesses of prospective teachers, who will play the leading role in the distribution of instructional activities, will adversely affect the learning of their students.

The analysis of the available data indicated that the energy, power and force definitions of the bulk of the sample did not match the scientific facts. It was noticed that the students confused the concepts of energy, power and force with each other or with the concept of force while they were trying to define them. That is, they were in the state of a true contradiction of terms. It can be assumed that the students were in the state of wrong perception about the mentioned concepts, since the concept of power relies on the concept of energy, and the concept of force is one of the fundamental concepts used while the concept of energy is being explained. On the other hand, the fact that these concepts are referred to as if they were alternatives of each other in daily life can be considered as a factor causing this situation. The similar remarks in Duit (1984), Kruger (1990) and Küçük et al.(2005) have supported these conclusions. However, as Aycan and Yumuşak (2003) mentioned, prospective physics teachers should exhibit the skill of utilizing and referring to the concepts by differentiating between them in both contexts (in scientific and daily life contexts). Analyzing the data and considering the teacher skills in pre-service education period, it can be said that the prospective physics teachers did not possess these skills or they had difficulties in demonstrating these skills. The situation is similar to the results of Trumper's study (1998) subjecting the conceptual development states of the university students about the concept of energy.

As another result of the study, it was determined that most participants were not at an intended level to state, explain, and recall measurement units. Students were expected to explain that energy and power are not quantities defined with direction and magnitude in space, whereas force is a quantity that has a direction and magnitude. Among the three concepts, the students were rather successful at explaining that the force is a vector quantity, but they still had difficulty explaining the reason. Additionally, parallel to the results of the study by Goldring and Osborne (1994), even though the students were more successful in determining the units of the concepts than they were in the other questions, they were still below the intended level. Even though they had been instructed about the units of these concepts since primary school, most of the students could not answer this question correctly. This can be evidence of not learning the related concepts and their properties correctly. According to White (1992), students care for formulas involving these concepts but they have a tendency to learn their properties superficially, although they are frequently faced with these concepts. That is, students give priority to learn the quantitative aspects of the concepts, while they hardly consider the qualitative ways. Moreover, it is known that this situation negatively affects these concepts to be learned (Goldring and Osborne, 1994; Kurnaz, 2007).

Besides the definition and properties of energy, power and force, associating skills of theoretical gains with daily life experiments of prospective physics teachers were also investigated, since there are vital relations between the related concepts and daily life experiences. While the term energy is used with no borders in daily life experiences, it has strict borders in scientific field, as McClelland (1989) noted. Students should direct daily usage starting from scientific usage (Aycan & Yumuşak, 2003). The findings of this study implied that the participants had difficulties associating the situations that they experienced with the energy, power and force concepts in a scientific manner. Almost all of the students left the question inquiring about the relationship of the three concepts and related object unanswered. This shows that students could not comprehend the state of related concepts being/not being a property of an object. The simplicity of the answer for this question suggests that this fundamental incompetence of the prospective teachers is a significant case to be examined. This situation is thought to arise from immature knowledge of the students about the concepts. Backed by available data, we could say that this is the same for the relations between movement-energy, movement-power and movement-force. By reviewing student answers, we can voice an overall failure, and we can notice that the least scientific answers were given for power out of the three concepts. The reason for the students' inability to draw such relationships is because the instructional process of these concepts was implemented without qualitative inquiries. Similar results were found in Kurnaz's study (2007) of first year university students.

The agreement between the results of the present study and the studies involving primary school students (Küçük et al., 2005; Hırça et al., 2008) actually implies that learning difficulties associated with the concerned concepts are valid for all age groups. Taking into account the profile of the sample of this study, it can be said that such difficulties can also be valid for teachers, as well as students, as Kruger (1990) and McClelland disclosed.

Supported by the result indicating prospective physics teachers were not at the adequate level in defining the energy, power and force concepts scientifically and their inability to state the characteristics and explain the situations in relationship to their environment, it can be suggested that the three concepts should be given in coherence (i.e. concerning the relations, restrictions, and differences between them) in an instructional situation. For instance, in a conceptual manner, the three concepts can be presented comparatively. Comparative presentations will be effective when the students have difficulties in referring inter-conceptual relations. For such an organization to be practiced, we also think that concept maps and conceptual change texts will be useful and we suggest them.

References

Abraham, M. R., Williamson, V. M. & Wetsbrook, S. L. (1994). A Cross-Age Study of the Understqnding of Five Chemistry Concepts. *Journal of Research in Science Teaching*, *31*(2), 147-165.

Aycan, Ş. & Yumuşak, A. (2003). Lise Müfredatındaki Fizik Konularının Anlaşılma Düzeyleri Üzerine Bir Araştırma. *Milli Eğitim Dergisi*, *159*, 171-180.

Aydın, G., & Günay Balım, A., (2005). Yapılandırmacı Yaklaşıma Göre Modellendirilmiş Disiplinler Arası Uygulama: Enerji Konularının Öğretimi. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Dergisi*, 38(2), 145-166.

Brook, J. A. & Wells P. (1988). Conserving the circus? An alternative Approach to the Teaching and Learning about Energy. *Physics Education*, *23*(2), 80-85.

Boyes, E. & Stanisstreet, M. (1990). Pupils' Ideas Concerning Energy Sources. *International Science Education*, *12*(5), 513-529.

Crowell, B. (2006). *Conservation Laws*, *2. Edition*, Light and Matter, Fullerton, California.

Domenech, J. L., Gil-perez, D., Gras-marti, A., Guisasola, J., Torregrosa, J.M., Salinas, J., Trumper, R., Valdes, P. & Vilches, A. (2007). Teaching of energy issues: A debate proposal for a global reorientation. *Science & Education*, *16*, 43-64.

Duit, R. (1984). Learning the concept of energy in School-Empirical Results from The Philippines and West Germany. *Physics Education*, *19*(2), 59-66.

Fry, M., Dimeo, L., Wilson, C., Sadler, J. & Fawns, R. (2003). A new approach to teaching "energy and change": using an abstract picture language to teach thermodynamic thinking in junior science classes, *Australian Science Teachers Journal*, 49 (1).

Goldring, H. & Osborne, J. (1994). Students' Difficulties with Energy and Related Concepts. *Physics Education*, *29*(1), 26-32.

Gürdal, A., Şahin, F. & Bayram, H. (1999). İlköğretim Öğretmen Adaylarının Enerji Konusunda Bütünlüğü Sağlama ve İlişki Kurma Düzeyleri Üzerine Bir Araştırma. *D.E.Ü. Buca Eğitim Fakültesi Dergisi*, *10*, 382-395.

Heuvelen, A.V. & X. Zou (2001). Multiple representations of work-energy processes. *American Journal of Physics*, *69*, 184.

Hırça, N., Çalık, M. & Akdeniz, F. (2008). Investigating Grade 8 Students' Conceptions of 'Energy' and Related Concept. *Journal of Turkish Science Education*, *5*(1).

Huis C. & Berg E. (1993). Teaching energy: a systems approach. *Physics Education*, *28*(3), 147-153.

Kemp, H. R. (1984). The Concept of Energy without Heat or Work. *Physics Education*, *19*(5), 234-240.

Kirkwood, V. & Carr, M. (1988). Final report: Learning in Science Project (Energy). Centre for Science and Mathematics Education Research, University of Waikato, Hamilton.

Kirkwood V. & Carr M. (1989). A valuable teaching approach: some insights from LISP (Energy). *Physics Education*, 24, 332-334.

Kruger, C. (1990). Some Primary Teachers' Ideas about Energy. *Physics Education*, *25*(2), 86-91.

Kurnaz, M. A. (2007). Enerji Kavramının Üniversite 1. Sınıf Seviyesinde Öğrenim Durumlarının Analizi. *Yüksek Lisans Tezi*, Karadeniz Teknik Üniversitesi, Trabzon.

Küçük, M., Çepni, S. & Gökdere, M. (2005). Turkish Primary School Students' Alternative Conceptions about Work, Power and Energy. *Journal of Physics Teacher Education*, *3*(2), 22-28.

McClellard, G. (1989). Energy in School Science. *Physics Education*, *24*(3), 162-164.

Mutimucuio, I. (2003). Multiple representations of energy processes in mechanical energy systems. Research and quality of Science Education, ESERA Conference, Netherlands, http://www1.phys.uu.nl/esera2003/programme/pdf%5C164S.pdf.

Papadouris, N. & Constantinou, C. P. Design, development and validation of a teaching proposal for energy: results from a pilot implementation, GIREP, Amsterdam, 2006.

Serway, R. A., Fen ve Mühendislik için Serway Fizik 1, Çeviri Ed. Çolakoğlu, K., 5. baskı, Palme Yayıncılık, Ankara, 2002.

Solomon, J. (1983). Is physics easy?*Physics Education*, *18*, 155-160.

Strauss, A. L. & Corbin, J. (1990). *Basics of Qualitative Research*. Newbury Park, CA: Sage.

Trumper, R. (1990a). Energy and a constructivist way of teaching. *Physics Education*, *25*, 208-212.

Trumper, R. (1990b). Being constructive: An alternative approach to the teaching of the concept of energy, part one. *International Journal of Science Education*, *12*, 343-354.

Trumper, R. (1991). Being constructive: An alternative approach to the teaching of the concept of energy, part two. *International Journal of Science Education*, *13*, 1-10.

Trumper, R. (1998). A Longitudinal Study of Physics Students' Conceptions on Energy in Pre-Service Training for High School Teachers. *Journal of Science Education Technology*, *7*(4), 311-318.

Tsagliotis, N. (2005). Hands-on science activities for the teaching and learning of mechanical energy with 6th grade primary school children in Greece. Hands-on Science: Science in a changing Education, University of Crete campus at Rethymno, Greece, July 13 -16.

Ünal Çoban G., Aktamış H. & Ergin Ö. (2007). İlköğretim 8.Sınıf Öğrencilerinin Enerjiyle İlgili Görüşleri. *G.Ü. Kastamonu Eğitim Dergisi*, *15*(1), 175-184.

Warren, J. W. (1983). Energy and Its Carriers: A Critical Analysis. *Physics Education*, *18*(5) 209-212.

Warren, J. W. (1986). At What Stage Should Energy Be Taught? *Physics Education*, *21*(3), 154-156.

Watts, D.M. (1983). Some Alternative Views on Energy. *Physics Education*, *18*, 213–217.