TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 6, Sayı 1, Nisan 2009

Journal of
TURKISH SCIENCE EDUCATION
Volume 6, Issue 1, April 2009

http://www.tused.org

Using the Anthropological Theory of Didactics in Physics: Characterization of the Teaching Conditions of Energy Concept and the Personal Relations of freshmen to this Concept

Mehmet Altan KURNAZ[1], Ayşegül SAĞLAM ARSLAN[2]

[1] PhD Candidate, Karadeniz Tech. Univ., Graduate School of Natural and Applied Sci., Trabzon-TURKEY
[2] Assist.Prof.Dr, Karadeniz Technical University, Fatih Faculty of Education, Trabzon-TURKEY

Received: 28.11.2008 **Revised:** 23.03.2009 **Accepted:** 25.03.2009

The original language of article is English (v.6, n.1, April 2009, pp.72-88)

ABSTRACT

In this article, the complex relationships between teaching conditions of energy concept and students' personal relations to this concept were investigated. The Anthropological Theory of Didactics, developed by Chevallard, has been used as a framework. In order to determine these complex relationships, first the sourcebook (Survey Physics I) used at the university has been analysed (to deduce Institutional Relation to energy concept) and secondly an achievement test has been used to collect data (to deduce Personal Relation to energy concept). The sample of the study comprised 36 first grade university students attending to the Fundamental Physics I course in the Faculty of Arts and Sciences at the Karadeniz Technical University. The praxeological approach was used to analyze the data obtained in a descriptive and qualitative way. Not only a close relationship was found between the teaching activities and the students' perception of energy concept, but also the adverse effects of institutional relations to personal relations about energy were determined.

Keywords: Energy; Teaching; Learning; Anthropological Theory of Didactics; Praxeological Approach.

INTRODUCTION

The energy is an abstract and an interdisciplinary concept between fields such as physics biology, chemistry, and geography. It can take different definitions depending on its using in different disciplines. For example: 'Energy is the potential existing in the matter and coming out in the form of heat or light; power gained by nourishment and enabling organs operate and body temperature to be sustained; ability to do work; spiritual force *etc*.'. Kruger (1990) notes that this discrepancy arises from different point of views of scientists from different disciplines (e.g. perspectives of biologists or chemists or physicists). However, one can also come across different definitions of energy in physics as '*Energy is the capacity for doing work*' (Warren, 1982) or '*Energy is the capacity to produce change*' (Chisholm, 1992), '*Energy is the capacity of a physical system to perform work*' (Hırça, 2004; Papadouris et al., 2008; Taber, 1989). That is, it is hard to find a unique, concrete and universal definition of the energy concept (Sefton, 2004). Since a common accepted scientific definition has not been generated (Domenech et al., 2007; Kurnaz & Çalık, 2009), the energy concept can be accepted in an interdisciplinary approach.

The energy concept has received much attention in science education and has been investigated in various perspectives: energy and its description (e.g. Diakidoy et al., 2003; Duit, 1987; Kaper & Goedhart, 2002a; Kruger et al., 1992), teaching and/or learning energy (e.g. Kaper & Goedhart, 2002b; Kurnaz, 2007; Kurnaz & Çalık, 2009; Papadouris & Constantinou, 2006; Trumper & Gorsky, 1993), energy and its change (e.g. Fry et al., 2003; Liu et al., 2002; Papadouris et al., 2008). Great numbers of these studies cited includes a documentation of students' conceptions about the energy concept. Among these studies; Watts (1983), Duit (1984), Nicholls and Ogborn (1993), Goldring and Osborne (1994), Trumper (1998), Küçük et al. (2005), Köse et al. (2006) have proved that the energy concept is hard to be comprehended and they also noted that students have serious misunderstandings about the nature of energy such as 'Energy is matter; Energy is a force; Energy is a power; Energy is not conserved'. In other studies aiming to remove these misconceptions, alternative learning approaches have been applied or recommended (e.g. Fry et al., 2003; Huevelen & Zou, 2001; Huis & Berg, 1993; Papadouris et al., 2008; Trumper, 1990a; 1990b; 1991). For example, Fry et al. (2003) suggest 'An Abstract Picture Language' to teach energy and conversion, Heuvelen and Zou (2001) and Mutimucuio (2003) highlight 'Multiple Representations of Energy Processes' *etc*. Meanwhile, certain recent studies have shown that students still encounter problems to perceive the energy concept (Domenech et al., 2007; Hırça et al., 2008; Kurnaz, 2007; Ünal Çoban et al., 2007). This situation indicates that the question "What are the basic reasons for the obstacles of the understanding the energy concept" keeps being update.

Reviewing the studies in this field (e.g. Duit, 1984; Küçük et al., 2005; Trumper, 1998), it can be seen that; while understanding obstacles have been determined, only learners have been taken as a source of interest. Also, researchers (Aydın & Günay Balım, 2005; Brook & Wells, 1988; Fry et al., 2003; Huevelen & Zou, 2001; etc.) have highlighted just their alternative teaching approaches and/or investigated the effectiveness of their approach by considering only students' perceptions. However, they have not taken into account their approaches (like a discipline which has its own teaching/learning environment) properly to investigate and see their own characterizations and probable (positive or adverse) effects on learning. However considering teaching-learning relation, it is obvious that the effects of learning environment on learners should be examined.

On the one hand, the usage and definitions of energy concept in different disciplines results in introducing the energy associated with the expression of the discipline's perspective to the students. Even in the same discipline; physics student may face different forms of energy such as; mechanical, nuclear, electrical *etc*. In short, because of its nature, the energy concept meets with students as a difficult concept. On the other hand, the mathematization process of Physics, started with Galileo (Sol, 1996), has escalated the effect of quantitative approach in teaching abstract concepts like the energy. The existence of this notion and its effects on student learning (*i.e*. the effects of qualitative and quantitative presentation ratio) have become outstanding topics to be examined.

Based upon related literature, the main research problem of this study was determined as; "What are the effects of institutional activities related to the energy concept on learning situations?". For this aim, the Anthropological Theory of Didactic developed by Y. Chevallard (1989) was set as the theoretical framework, since this theory, unlike other approaches, facilitates investigating the effects of teaching conditions on students' perceptions (Artaud, 2004; Chevallard, 1992; Kurnaz, 2007; Sağlam, 2004; Sağlam Arslan, 2008).

A) Theoretical Background of the Study: Anthropological Theory of Didactic

The main concepts of Anthropological Theory are **objects *O*** [object: any number, feelings (anxiety, fear…), any topic or concept (energy, cell, derivative…)], **persons *X*** [all persons can be defined as person (a boy, student, teacher, servant …)] **and institutions *I*** (an organization having its own peculiar methods and rules, imposing its ideas and knowledge to the member person) (Chevallard, 1989). In this theory, the 'relation' definition is used to explain the relations between the structural units above. And there were two different ways of defining a piece of knowledge (*i.e.* 'object'): *Institutional Relation* and *Personal Relation*.

Institutional Relation: If any object "*O*" is recognized by an institution "*I*", then "*O*" is an object in "*I*" and *I* institution has an Institutional Relation to *O* object. This relation is symbolized by *R(I,O)* or *RI(O)*. According to Y. Chevallard (1989): *"Institutional relation defines such things as; what an institution does with a certain piece of knowledge, what that knowledge is used for and how it was processed etc. All in all, it is the whole life of a piece of information spent in a certain institution"*.

Personal Relation: When an *O* object begins to exist in an *X* individual's mind, this means *X* knows *O* and *X* has a personal relation for *O*. *"Personal relation is defined as the whole collection of knowledge, skills, perceptions and abilities of a person about a subject. With a broader view; it is the whole relation between the individual and knowledge"* (Chevallard, 1989). In this theory, learning is defined as the change in *X* person's personal relation for *O*. This change means personal relation exists if it did not exist before or it changes if it already existed.

When a person (called *X*) enters to an *I* institution, *X* person's Personal Relation to an *O* object *R(X,O)* will change and improve under the Institutional Relation of *I*: *RI(O)*. In this case learning will occur when *R(X,O)* changes. In a general overview; "*personal relation forms under the influence of institutions to which the personal is presently or formerly devoted*" (Chevallard, 1989).

Within the Anthropological Theory as the theoretical framework, main elements of the research were defined as below:

Object	(*O*)	⇒	Energy
Person	(*X*)	⇒	Student
Institution	(*I*)	⇒	Fundamental of Physics I

In a given institution (like Fundamental of Physics I), to describe the origin and improvement of main components of knowledge as well as personal and institutional relations to these components, it is necessary to construct a model. This model named in Anthropological Theory of Didactic is praxeology.

Praxeology, which was contributed to didactic studies by Chevallard in 1989, can be used to determine the general characteristics of an institutional relation to an object (Bosch and Chevallard, 1999). Chevallard (1989) expressed that all activities of a person who has a position in an institution are shaped within the task system of the institution. Praxeology is formed of the two blocks: praxis (refers to the practice) and logos (refers to the theory) (Timmermann, 2005). These have 4 basic components (4T): *Type of task, Technique, Technology, Theory* (Figure 1).

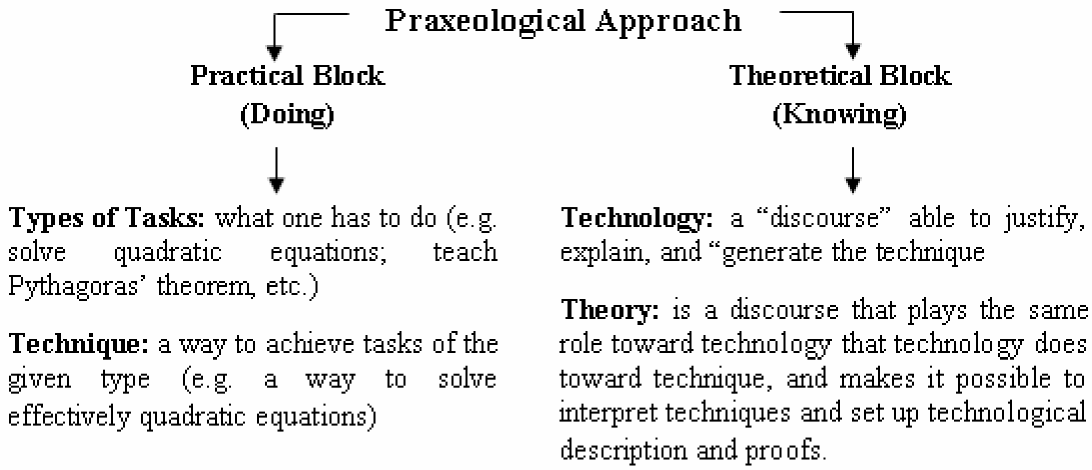


Figure 1. *Main Components of Praxeology* (Adapted from Artaud, 2004; Timmermann, 2005).

The research questions of this study based on the Anthropological Theory of Didactic which concerns teaching and learning state of the energy concept set as:

1. What are the most important characteristics of institutional relations and students' personal relations to the energy concept?
2. To what extend does personal relation coincide with institutional relations (belonging to Fundamental of Physics I institution)?
3. What are the effects of institutional relations on students' personal relations?

B) Sourcebook Analysis

According to the first research question, first of all, it is obvious that the characteristics of institutional relations should be analyzed. To determine the institutional relation, the general perspectives of the sourcebook (Physics for Scientists and Engineers, Vol. 1, 5th Edition) were determined. For a deep analysis, the obtained data were analyzed with the praxeological approach, since this approach enables revealing the general perspectives of an institution. During this process, the first component (types of task) of the praxeological approach was used to determine expectations of the institution from students.

Basic data obtained from the document analysis to determine what kind of approach is adopted for teaching the energy concept for university 1st year level (*i.e.* to determine the features of the institutional relation about the energy concept) show that the energy concept is explained be grounded on the work concept. So, in the institutional level, first kinetic energy and its change and then potential energy and its change and finally the conservation of energy, non-conservative forces and work-energy theory are explained starting from the work concept. Additionally, it was determined that in the institutional level, the topics like "energy transformation" were mentioned. There were not enough explanations and there were no emphasis on issues like energy transfer and different types of energy.

While the praxeological analyze was being conducted, 177 problems including 293 tasks in the sourcebook were considered. In this context, it was determined that the tasks were classified under 52 different types. Two different types of classification were defined to exhibit the basic features of the tasks: *Classification of types of task with respect to the status of the energy concept*, c*lassification of types of task with respect to associated activity type.*

a) Classification of Types of Task With Respect To the Status (Object-Tool) Of the Energy Concept

While the concept is classified under this title, the status of the energy concept was investigated and two different statuses were determined for this concept. If a result was reached as a result of application of the related types of task, the energy concept was classified in the object status (*e.g.* explaining or calculating the energy). On the other hand, energy was classified in the tool status if a result was reached about another issue (*e.g.* calculation of force, distance, acceleration *etc.*) by using the energy concept.

By the sourcebook analyze, it was also determined that there were types of task irrelevant from the energy concept in energy units (e.g. calculating the acceleration or the angle between two vectors *etc.*). Table 1 summarizes the distribution of the types of task in the investigated sourcebook with respect to tool, object or other types of task numbers and ratios in the sourcebook.

Table 1. *Classification of the Task Types According To Energy as a Tool or Energy as an Object*

Energy	Tasks Type	Tasks Number
As an object	21 (40.4 %)	140 (47.8 %)
As a tool	20 (38.5 %)	125 (42.66 %)
Other types of task[1]	11 (21.1 %)	28 (9.54 %)
TOTAL	52	293

As seen from the Table 1, the sourcebook does not focus on instructing the energy directly, it handles the topic with other concepts instead. For concept teaching, the main point is teaching activities to concentrate the concept of concern. However the ratio of the types of task of the energy as an object is less than all types of task in the sourcebook (40.4%). This weakens the course in terms of transmitting the conceptual nature of the energy.

b) Activity types associated with types of tasks

To find out the types of task student face, 5 different types were determined with respect to activity types. They are: calculating, explaining-interpreting, comparing, displaying with graphs and analyzing-understanding graphs (Table 2).

Table 2. *Classification of the Task Types with Respect to Activity Types*

Activity states	Types of Task Number [2]	Task Number
Calculating	44 (78.57 %)	262 (85.9 %)
Explaining-interpreting	6 (10.71 %)	25 (8.19 %)
Comparing	3 (5.36 %)	4 (1.31 %)
Displaying with graphs	2 (3.57 %)	6 (1.98 %)
Analyzing-understanding graphs	1 (1.79 %)	8 (2.62 %)

[1] The types of task belong to previous units and irrelevant from energy are classified in other tasks category.

[2] Since some task types are related to more than one activity state, 4 tasks classified under two different types of task. So, ratio calculations were made out of 56 task types.

Table 2 says that most of the types of task on the sourcebook require calculation (79%). However, the ratio of types of task requiring explanation, interpretation and interaction qualitatively is quite low (10.71%). This shows that the institution favours the activities requiring calculations and adopts a quantitative point of view.

The following classification was made to demonstrate to which issues the calculation types of task are related to in the sourcebook (Table 3).

Table 3. *Distribution of Task Types Requiring Calculations with Respect to Topics*

Task Type	Task Type Number	Task Number
Calculating velocity	6	54
Calculating distance	6	32
Calculating force	6	23
Calculating work	5	60
Calculating kinetic energy	4	32
Vector calculations	4	11
Calculating related coefficients	4	11
Calculating power	2	12
Calculating potential energy	1	11
Other calculations	6	16
TOTAL	44	262

Table 3 shows that there are few types of task in the sourcebook except for types of task requiring calculations related to work, velocity, kinetic energy and force. Additionally comparing number of types of task and number of tasks, it can be seen that certain tasks were repeated. This shows that the sourcebook presents some tasks repeatedly and so make students calculate the same variables repeatedly.

METHODOLOGY

This is a qualitative case study. Concerning peculiar structures and dynamics of contexts, it is obvious that case study is ideal for analyzing complex and dynamic events, personal affairs or other factors (Amos, 2002; Cohen, Manion & Morrison, 2000). With the frame of the research questions of the present study, it is unavoidable to take the *learning environment* and *learning situations* (in the same environments) within a holistic perspective. Based upon mentioned points, the study was carried out with an approach stemming from descriptive-interpretive analyze (Strauss & Corbin, 1990). This approach was chosen because it provides opportunity for description of the situation from institutional and personal perspective and opportunity for interpretations drawn from association of these descriptions.

a) Data Gathering Process

The study was conducted with 36 candidate teachers taking Fundamental of Physics I course in the Faculty of Science and Literature at Karadeniz Technical University. Following means were implemented to collect the data for this study:

- ~ To determine the characteristics of the personal relations of the university 1st year students' about the energy concept, an achievement test was developed in terms of the characteristics of the institutional relation (given under introduction title).
- ~ The test was applied as an examination by the lecturer in his class and the first researcher was present as the observer.

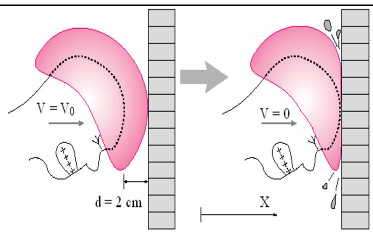
The characteristics of the open ended questions of the test are summarized in Table 4.

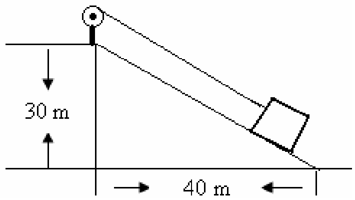
Table 4. *Identification of the Questions in the Achievement Test*

Question No	Activity Conditions
Q.1	Calculation-Confirmation
Q.2	Calculation
Q.3	Explanation-Interpretation
Q.4	Diagram or visual interpretation
Q.5	Definition and Classification

As seen from the table, the items in the data gathering tool require activities like; calculation, verification, interpretation, visual explanation/interpretation, definition, and classification to be fulfilled. The main reason of this strategy in gathering data is to determine students' ability in a wide perspective (the strong and weak aspects of the sourcebook determined from the analyses). The questions of the achievement test are below.

Q1. *Suppose that a biker hits his head against the brick wall with the velocity of 20 m/s and his head slows down and stops with a constant acceleration at 2cm (thickness of the helmet) away from the wall. Calculate the acceleration of the slowing down and explain the reason/reasons for choosing these calculations. (Ruina and Pratap, 2002)*

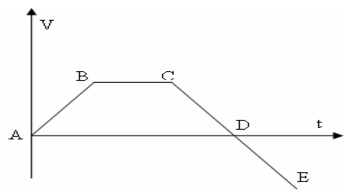




Q2. *A 400 kg granite block is being pulled upward on the inclined plane with 1m/s constant velocity by the crane in the figure. Kinetic friction coefficient between the plane and the block is 0,5. What are the works done by each force respectively affecting the block while the block is pulled 6 m up along the plane? Explain why you chose your methods.*

Q3. *What is the distance to be taken into account while calculating the potential energy of a system formed by the earth and asteroid falling onto the earth (The distance between asteroid and the surface of the earth or the distance between the asteroid and centre of the earth)?Explain.*

Q4. *The velocity of an object moving on a straight line under the influence of a single force, changes as in the velocity versus time graph. Tell the sign (+ or -) of the work done on the object by the force for each interval (AB, BC, CD and DE) and explain the reasons.*



Q5. A. *What is the energy? Explain.*
B. What kind of creatures have energy? Why?
C. Write and explain the types of energy you know?

b) Data Analyze

In this study, for analyzing the students' answers to examine the students' personal relations about the energy concept, the second and the third components of the praxeological approach were used. The first one, the technique, focuses on the method used by students to solve the questions posed, and the second one, the technology, focuses on the explanation or justification projected by students. Analyses of the obtained data were also used to see the differences between institutional relations and students' personal relations, and the negative effects caused by institutional choices on improvement of students' personal relation to the energy concept.

RESULTS

To describe the characteristics of the personal relation of 1st year university students about the energy concept, the test results were presented in this section. For this aim, concerning the data from the sourcebook analyze, the questions in the achievement test were grouped on the basis of students' encountering frequency to these questions in the sourcebook (Table 5). All the results were presented according to this grouping.

Table 5. *Classification of the Test Questions with Respect to Encounter Frequency and Status*

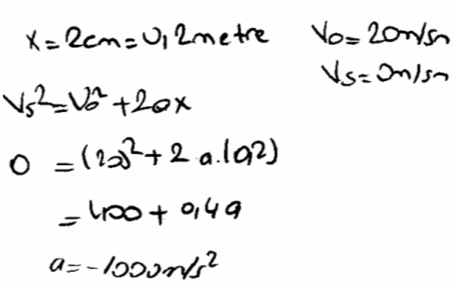
Status of Encounter	Question	Activity Conditions	Energy	
			Object	Tool
Frequently	Q.1	Calculation-Confirmation	✓	✓
	Q.2	Calculation	✓	
Rarely	Q.3	Explanation-Interpretation	✓	
	Q.4	Diagram or visual interpretation	✓	
Never	Q.5	Definition and Classification	✓	

Concerning the classification in the Table 5, the analyzes of student answers were presented in an order to reflect the effects of institutional relation on personal relations under the headings of; *frequently encountered activity conditions* (Calculation-Confirmation), *rarely encountered activity conditions* (Explanation-Interpretation; Diagram or Visual Interpretation) and *never encountered activity conditions* (Definition and Classification).

a) Frequently Encountered Activity Conditions

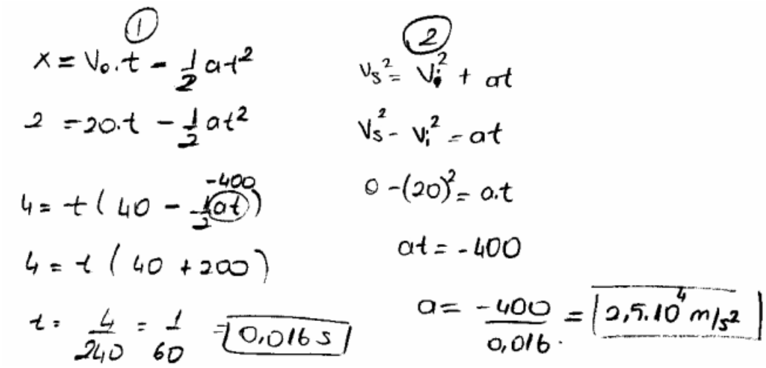
Types of task required calculation are classified under this title. For this aim, two questions, in one of which the energy is tool and in the other the energy is object, were asked to the students.

Despite there were 4 different solutions for the first question which was designed to take the energy as a tool and requires calculation of the slowing down acceleration, none of the students used the way associated with the energy. 19 of the 29 students used kinematics equation ($V_s^2 = V_0^2 + 2.a.(x - x_0)$), the easiest way to remember. However, only 9 of them could reach the right solution. One student justified the reason for using this way of solution as:



"(-) since it gets slower. I use $V_s^2 = V_0^2 + 2.a.(x - x_0)$ equation. Since we have V_{final}, $V_{initial}$ and distance covered, we can find acceleration without using any other values." (Student 7)

The quota above implies that the students endeavour to use the given data in any formula. 3 students in the other 10 submitted irrelevant answers and the rest (7) used kinematics equation ($d = x(t) = 0 + v_0.t + at^2/2$) and all failed as in the sample student answer below:



(Student 16)

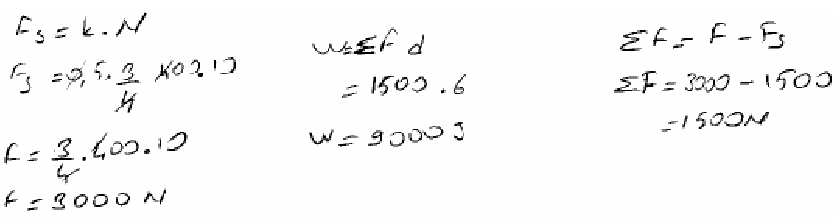
Despite the student was tried to solve the question, (s)he did not give any reasons why (s)he used this technique to solve this question as the other 6 students. This could be caused from distrust to their own knowledge.

The second question of the test, related to frequently encountered activity conditions, was requiring calculation of forces affecting an object (gravitational force, friction force, normal force, tension force). To solve this problem the students were expected to apply *W=F.d* formula in the sourcebook by concerning application angles of the forces and friction coefficients. Table 6 summarizes condition of students' application the technique (answers):

Table 6. *Student Success on Calculating Work Done By the Force Affecting the Object*

Task	Right formula	Wrong formula
Work done by gravitational force	14	1
Work done by friction force	13	9
Work done by applied force	5	1
Work done by T tension force	8	5
No answer	13	

In Table 6, there are some students who answered the question but could not remember the related formula. It was determined that despite most of the students who could not reach the right answer could draw visual diagram; they ignored the angles of the force applied on the object. This shows that students have certain weaknesses on determining/calculating work done by force; despite 'calculating work' type of task is the most frequently seen type of task in the sourcebook (see Table 3). A sample student answer is seen below:



(Student 6)

Collectively evaluating the analyses about frequently encountered activity conditions presented above, it was observed that students have tendency to reach the results straightforward. One can think that these efforts to reach the result without reasoning, is a result of student automation (in a memorized and reflex way without reasoning) on problem solving. Besides students' lack of knowledge about the formulas they used for this type of task clearly indicates that conceptual learning had not been fully attained.

b) Rarely Encountered Activity Conditions

Question 3 is the first question classified under the title of rarely encountered activities like verification, explanation–interpretation and graph interpretation requires explanation of the calculation of potential energy. In potential energy calculation for determining the distance between objects one need to choose a reference point. The analysis of the answers for this question came up with no successful student answers. The students were expected to explain that 'both of the answers can be right depending on the preference of the reference points.' But all the students chose the first way. 15 of the students argued that the distance between surfaces should be taken, 14 of the students claimed that centres should be taken as the references and the rest gave unexpected (irrelevant) answers.

The students favouring the idea that the distance between the asteroid and the earth's surface should be taken into account put forward two main arguments. The first was *h* value in "*Ep= m.g.h*" equation must be equal to the distance of initial position of the asteroid and its position at the time of collision as in the sample student answer below:

> *"It is the distance between the surfaces of the earth and the asteroid. Because when we calculate potential energy of an object we take the distance between the object and the ground as h value. It is the same for the earth as for the object. Asteroid should be considered in the same way. It must be the distance between the initial position from which it started to fall and the collision point."* (Student 19)

The second argument was potential energy is actually the gravitational force and it is valid for only the surface as in the sample student answer below:

> *"It is the distance between the asteroid and the earth's surfaces because the source of potential energy is the earth's gravitational force. So it exists only on the surface."* (Student 32)

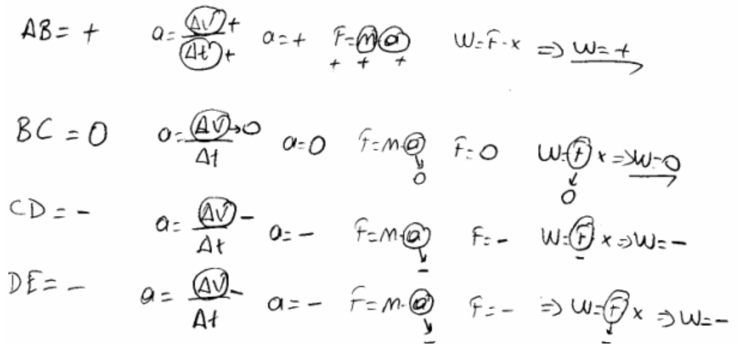
The students thinking that the distance between centres should be taken support their ideas by gravitation affecting from the centre of the earth.

> *"It is the distance between the asteroid and centre of the earth because mass is the source of potential energy. Therefore, we consider centre of mass while calculating potential energy."* (Student 12)

The situation exemplified by the quotations above can be explained by personal and institutional relation interaction. Because the potential energy calculation questions in the sourcebook generally provides students with readily given reference points and there were no expectation for reasoning about the determination of these points. None of the students mentioned reference point concept for potential energy calculation. This clearly indicates that potential energy was not perceived in the right way. The source for this problem was considered as the sourcebook's concentrating only calculation activities and not properly mentioning the determination of the reference points.

In question 4, the other question qualified as rarely encountered activity condition, the students were expected to determine change in kinetic energy (*ΔKE*) based upon velocity versus time graph (depending on time variable). But interpretation of "$F = m.a$, $x = V.t$ and $W = F.x$" formulas together can also reach to the solution.

There is a balanced student distribution in students preferring the two means: 15 students preferred using *ΔKE*; and 19 student preferred $F = m.a$, $x = V.t$ and $W = F.x$ formulas; 2 students gave no answers. But unfortunately almost none of them could carry on using techniques correctly and reach to the right solution as in the sample student answer below:



(Student 17)

The reason for this failure was concluded as students' inability of interpreting the graph correctly or their considering the work concept depending on the direction. Insufficient number of activity situations requiring explaining – interpreting or interpretation of unfamiliar visuals might be considered as at the root of the problem.

c) Never Encountered Activity Conditions

The last question of the achievement test (Question 5) was a never encountered activity condition in the Fundamentals of Physics 1 sourcebook. The question was asked to examine student perceptions about the energy concept.

There were 4 different types of definition given for item A of this question: 69% of the students make physics-bound energy definitions, 9% of them make definitions in chemistry discipline, 19% of them defined energy by associating it with daily life and finally 3% of the students submitted pseudo-scientific (Martinas, 2005) definitions (based on a mystical thought). This shows that students have not developed a general definition perspective for the energy. Besides it was observed that some of the students tried to define energy as force or power as in the sample student answer below:

"Energy is about to do work" (Student 18)

"Conversion ability of an object from power to the movement" (Student 19)

"Energy is an instant force affecting an object." (Student 27)

In item B, it was asked to the students about what creatures have energy. The data of this question tabulated in Table 7.

Table 7. *Student Ideas about Which Creatures Have Energy*

Student answers	*f*
All creatures having a mass and volume have energy.	21
Creatures having a height from the ground and/or moving creatures have energy.	5
Objects covering a distance as a result of an applied force on them have energy.	1
Other	6

Table 7 means some students have serious wrong perceptions like:

"*Energy exists in creatures which reveal a value when they are processed, moving living things and concrete objects like generator, sun, and lamp.*" (Student 13)

"Living things have energy because they move." (Student 1)

In the last item of this question prepared to reveal the student skills in terms of explaining the energy, their knowledge about the forms of energy was examined (Table 8).

Table 8. Forms of energy according to students

Forms of energy	***f***
Kinetic energy	33
Potential energy	33
Solar energy	13
Electrical energy	10
Mechanical energy	8
Heat energy	7
Nuclear energy	5
Wind energy	3
Chemical energy	3

It was observed that the most well-known forms of energy by students were the ones that are in the Physics course curriculum. Besides it was observed that kinetic and potential energies were always written together and an association was formed between these two types by students. There were only a limited number of forms of energy mentioned, which means they do not know about different forms of energy or they have difficulty to remember them.

For the same question the students were also expected to explain the forms of energy. However it was observed that they could hardly explain the forms except for potential and kinetic ones. Even more, almost the half of the students could not explain the potential and kinetic energy correctly.

"*I know there are two types of energy. One of is kinetic and the other is potential energy. Kinetic energy is caused from the change of speed of objects. Potential energy is caused from objects' position.*" (Student 27)

All these weaknesses are considered to stem from insufficient quality and quantity of conceptual inquiries in the sourcebook adopted by the institution.

DISCUSSION and CONCLUSION

In this section, frame of the discussion was constructed on comparisons of the results from both analyses to highlight the characteristics of institutional and personal relations to energy concept, since the results get more meaningful by completing each other. That is, by this way the effects of institutional relation to energy over students' personal relation to this concept could be put forward as the final results of research questions. Therefore, the results will be discussed under the titles of; 'teaching approach based on the work concept and its effects', 'restrictions of tasks and their effects', 'activity types and their effects', 'dominance of mathematical calculations and their effects'.

a) Teaching Approach Based on the Work Concept and Its Effects

One of the principal results from the analysis of the institutional relation was that the institution defines the energy based on the work concept. When the literature reviewed about the adequacy of this approach, it was found that there have been some studies both supporting and refusing the efficiency of the method. Warren (1986) argues that since the energy is a quantity obtained from the 'work' concept by physicists and since the 'work' concept is a quantity bound to the 'force' concept, teaching the energy should start with the work and the force concepts. In other words, Warren (1986) points an energy definition based on the work and force. However Sexl (1981) and Kemp (1984) reported that this definition does not work for thermodynamics since it is impossible for internal energy of a system to be completely converted to work. Duit (1986 cited in Domenech *et al*., 2007) added that this definition is not valid for non-mechanical systems, either. Hicks (1983), from another point of view, argued that the definition: 'energy is the capacity to perform work.' should not be included in the initial definitions of energy, since it is insufficient, short and easy to remember, and restricts further student learning and reasoning. Kurnaz (2007) studied with university students and confirmed the effects of these restrictions on students' perceptions. All in all, the data obtained from the present study proved the adverse effects of this approach on university students. Students' inability to comprehend the interdisciplinary conceptual nature of the energy, their equating the energy with force or power concepts, their vague ideas about what kind of things energy show that a teaching approach based on the work concept has is inadequate.

Another factor hindering students' understanding the conceptual nature of the energy is considered as not including subjects like different forms of energy, transfer, transformation and degradation of energy in the curriculum as an institution. However, Liu and McKeough (2005) emphasized that energy degradation can make simpler to understand energy conservation. Additionally most of the students can not remember other forms of energy except potential and kinetic energy. This samples another aspect of the institutional effect. The students' level about the energy did not live up to standards. Whereas, it is expected from them to give more elaborate explanations about the energy concept. However, for this, more qualified atmosphere and substructure should be presented to students.

b) Restrictions of Tasks and Their Effects

The questions and exercises assigned to the students focus on certain types of task, which cause repetitions of these tasks. And finally these repetitions make students memorize necessary techniques for the tasks without concerning the theoretical background. Actually, the students could not explain the techniques they used. Besides insufficient variety and distribution of the types of task of the institution adversely affects the students' perception of the conceptual nature of the energy. Especially, the student answers about the potential energy concept, which was poorly examined in terms of type of task variety, prove inefficiency of the institution.

c) Activity types and their effects

In an analytical perspective, the subjects of the tasks demanded by an institution are important. Besides, it is also important what kind of activities should students perform (problem solving, interpretation, explanation *etc.*) with these tasks, for the sake of skills to be gained by students. In this context, the analyze showed that the institution concentrates on 5 different activity types (calculation, explaining-interpretation, comparing, displaying with graphics, analyzing and interpreting graphs) and particularly *calculation*. It was concluded that the competency of the activities by the institution to develop students' perception of the energy can be tested by presenting students activities requiring different tasks. In that way students' ability of applying previously gained knowledge into different situations was investigated. The findings showed that students could not succeed in managing tasks including different activities.

d) Dominance of Mathematical calculations and their effects

Majority of the activities (79%) in the sourcebook require mathematical calculations, which is another reason for questioning the institution's approach to the energy concept notion. The institution is highly focused on mathematical calculations. It can be said that the institution mainly expects students to improve their calculation skills, undermining the verbal skills. In the study about student skills of using qualitative and quantitative aspects of the activities, Goldring and Osborne (1994) reported that students were successful at conducting activities with numerical calculations and failed in verbal ones. Huis and Berg (1993), Mutimucuio (2003), Heuvelen and Zou (2001) and others noted that verbal presentations improve students' calculation skills. Therefore the institution should distribute the tasks towards improving numerical skills and the tasks towards improving verbal skills in balance. It is concluded that the institution of our concern did not consider about this balance properly and this affected students negatively. The data showed that students were even unaware of why they were using a certain formula. The students admit that they only concentrated given concepts in the questions and tried to remember a formula including these values. In fact, all these proved that they devised a formula-oriented approach *i.e.;* they focus on solving problems with formulas without thinking and understanding in an automatic manner.

IMPLICATIONS

Backed with the results of the study, it is suggested that more general approaches which will reflect to conceptual content of the energy should be used for teaching the energy concept. In other words, issues like forms, transfer, and transformation of the energy should be included, easy-to-remember definitions should be avoided at the initial phases of the instruction, and an epistemological teaching strategy should also be employed in teaching approaches.

From the results, it can said that using a comparative approach comparing conceptual relations and differences of the energy with associated force and power concepts will contribute to fulfil conceptual perception.

Finally; the numerical calculation activities presented to improve student perceptions should be balanced with activities to improve the verbal skills.

REFERENCES

Amos, J. (2002). *Doing Qualitative Research in Education Settings Hatch*. Suny Press.

Artaud, M. (2004). Contributions from the Anthropological Theory of Didactics. In W. Blum and H.W. Henn (Eds), *Pre-Conference Volume of ICMI Study 14: Applications and Modelling in Mathematics Education*, Dortmund: Universität Dortmund, pp.17–22.

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.

Bosch, M. & Chevallard, Y. (1999). La sensibilité de l'activité mathématique aux ostensifs. Objet d'étude et problématique, *Recherches en Didactique des Mathématiques* 19(1) 77-123, Grenoble : La pensée Sauvage.

Chevallard, Y. (1989). Le concept de rapport au savoir. Rapport personnel, rapport institutionnel, rapport officiel, *Actes du séminaire de Didactique des Mathématiques et de l'Informatique*, LSD-IMAG, Grenoble, 211–236.

Chevallard, Y. (1992). Fundamental Concepts in Didactics: Perspectives provided by an Anthropological Approach. *Researches en Didactique des Mathematiques*, pp. 131-168.

Chisholm D. (1992). Some energetic thoughts. *Physics Education*, 27, 215-220.

Cohen, L., Manion, L. and Morrison, K. (2000). *Research Methods in Education* (5^{th} ed.). London: RoutledgeFalmer.

Diakidoy, I.A.N., Kendeou, P. & Ioannides, C. (2003). Reading about energy: The effects of text structure in science learning and conceptual change. *Contemporary Educational Psychology*, 28 (3), 335-356.

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 to the Energy Concept in School-Empirical Results from The Philippines and West Germany. *Physics Education*, 19(2), 59-66.

Duit, R. (1987) Should energy be illustrated as something quasi-material?. *International Journal of Science Education,* 9, 139–145.

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.

Hırça, N. (2004). *Ilköğretim 8. sınıf öğrencilerinde enerji kavramı ile ilgili kavram yanılgılarının tespiti ve okullar arasındaki farklılıklarının karşılaştırılması*. Unpublished Master Thesis, University of Kafkas, Kars, Türkiye.

Hırça, N., Çalık, M. & Akdeniz, F. (2008). Investigating grade 8 students' conceptions of 'energy' and related concepts, Journal of Turkish Science Education, 5(1), 75-87.

Hicks, N. (1983). Energy is the Capacity to Do Work –or is it? *Physics Teaching*, 21, 529-30.

Heuvelen, A.V. & Zou, X. (2001). Multiple representations of work-energy processes. *American Journal of Physics*, 69 (2), 184.

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

Kaper, W. H. & Goedhart, M. J. (2002a). Forms of energy, an intermediary language on the road to thermodynamics? Part I, *International Journal of Science Education,* 24(1), 81-95.

Kaper, W. H. & Goedhart, M. J. (2002b). Forms of energy, an intermediary language on the road to thermodynamics? Part II, *International Journal of Science Education,* 24(2), 119-137.

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

Köse, S., Bağ, H., Sürücü, A. & Uçak, E. (2006) Fen bilgisi öğretmen adaylarının canlılardaki enerji kaynaklarıyla ilgili görüşleri. *International Journal of Enviromental and Science Education*, 1(2), 141-152.

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

Kruger, C., Palacio, D., & Summers, M. (1992). Surveys of English primary school teachers' conceptions of force, energy and materials. *Science Education*, 76 (4), 339–351.

Kurnaz M. A. (2007). *Üniversite 1. sınıf seviyesinde enerji kavramının öğrenim durumlarının analizi*. Unpublished Master Thesis, University of Karadeniz Technical, Trabzon, Türkiye.

Kurnaz, M. A. & Çalık, M. (2009). A thematic review of 'energy' teaching studies: focuses, needs, methods, general knowledge claims and implications. *Energy Education Science and Technology Part B: Social and Educational Studies*, 1(1): 1-26.

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

Liu, X., Ebenezer, J. & Fraser, D. M. (2002) Structural characteristics of university engineering students' conceptions of energy. *Journal of Research in Science Teaching*, 39(5), 423-441.

Liu, X. & McKeough, A. (2005). Developmental Growth in Students' Concept of Energy: Analysis of Selected Items from the TIMSS Database, *Journal of Research in Science Teaching*, VOL. 42, NO. 5, PP. 493–517.

Martinas, K. (2005). Energy in Physics and in Economy. *Interdisciplinary Description of Complex Systems*, 3 (2) 44-58.

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.

Nicholls, G. & Ogborn, J. (1993). Dimensions of Children's Conceptions of Energy. *International Journal Of Science Education,* 15, 73-81.

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

Papadouris, N., Constantinou, C.P. & Kyratsi, T. (2008). Students' use of the energy model to account for changes in physical systems, *Journal of Research in science teaching*, 45(4), 444-469.

Ruina, A. ve Pratap, R. (2002). *Introduction to Statistics and Dynamics*, Oxford University Press.

Sağlam, A., *Les équations différentielles en mathématiques et en physique: Etude des conditions de leur enseignement et caractérisation des rapports personnels des étudiants de première année d'université à cet objet de savoir*, Thèse de doctorat, Université Joseph Fourier- Grenoble, 2004.

Sağlam Arslan, A. (2008). Didaktikte Antropolojik Kuram ve Kullanımına Yönelik Örnekler. *Gazi Eğitim Fakültesi Dergisi,* 28(2), 19-36.

Sefton, I. (2004). *Understanding Energy*. Proceedings of 11th Biennial Science Teachers' Workshop, the University of Sydney.

Sexl, R. U. (1981). Some Observations Concerning the Teaching the Energy Concept. *European Journal of Science Education*, 3(3), 285-289.

Sol, A. (1996). Matematik Tüm Bilimler İçin En Uygun Dil midir?. *Felsefe Dünyası* 19, 75-80.

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

Taber K. (1989). Energy-by many other names. *School Science Review*, 70, 57-62.

Timmermann, S. (2005). Undergraduates' solving strategies and teachers' practice. In C. Winsløw (éd.), *Didactics of Mathematics – the French way*, Copenhague: Center for Naturfagenes Didaktik, 71-82, Retrieved 04 March 2007, from http://isis.ku.dk/kurser/blob.aspx?feltid=52630

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

Trumper, R. (1990b). Energy and a Constructivist Way of Teaching. *Physics Education*, 25 (4), 208-212.

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

Trumper, R. & Gorsky, P. (1993). Learning about energy: the influence of alternative frameworks, cognitive levels, and closed-mindedness. *Journal of Research in Science Teaching*, 30, 637-648.

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.

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. (1982). The nature of energy. *European Journal of Science Education*, 4, 295-297.

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.