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Use of the FAR Guide in Alternative Teaching Models Developed on Structuring the Topic of Energy

Enerji Konusunun Yapılandırılmasında FAR Rehberliğinde Geliştirilen Alternatif Öğretim Modellerinin Kullanımı

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Abstract

The objective of this study is to determine the impact of the use of alternative teaching models, under the leadership of the FAR Guide, on the ability of students to comprehend the topic of energy. After the experiment done related to each subject, modelling was performed to provide the students to configure such an abstract concept as 'energy' in their minds. The participants of the research was consisted of ninth grade students (n=52) existing in Aydin Province, Turkey. In the research, the pre-test post-test experimental model with a control group was used. The data collection tools were interview questions about energy, multiple choice energy achievement scale and the role of scientific models scale. At the end of the research, it was found that there is an increase in the physics achievement level and scientific models attitudes of students.

Keywords: scientific modelling, energy, the FAR guide,

Özet

Bu çalışmanın amacı FAR rehberliğinde geliştirilen alternatif öğretim modellerinin kullanımının öğrencilerin enerji konusunu yapılandırmalarına etkisini belirlemektir. Çalışma öntest-son test kontrol gruplu yarı deneme modelinde yapılmıştır. Çalışmada deney grubundaki öğrencilere enerji konusunu yapılandırmaları için FAR rehberliğinde geliştirilen alternatif öğretim modelleri konu ile ilgili yapılan her deneyden sonra kullanılmıştır. Araştırmaya Aydın ilinden dokuzuncu sınıf öğrencileri katılmıştır (n=52). Araştırmada veri toplama araçları olarak; enerji başarı testi, enerji ile ilgili görüşme soruları ve bilimsel modellerin rolü ölçeği kullanılmıştır. Araştırmanın sonunda deney grubundaki öğrencilerin enerji ile ilgili başarı düzeylerinde ve bilimsel modellere yönelik tutumlarında bir artma bulunmuştur.

Anahtar Kelimeler: bilimsel modelleme, enerji, FAR rehberliği,

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I. INTRODUCTION

The general aim of modelling is to test an idea-represented as a system of related processes, events, or structures-against observations in the real world and to assess the adequacy of the representation against standards of evidence. The most important overall goal of scientists is the development of an understanding of how the natural world works. In all scientific disciplines, this understanding is most often accomplished through the conceptualization of models of various natural processes. The term 'model' is often used to describe physical replicas of objects or systems. Models are important in science because they can be used as instruments to help in the construction of theories (Vosniadou, 2002; Greca and Moreira, 2002). Modelling is a crucial method, for scientists and physicists, to put order to form and apply scientific theories (Greca and Moreira, 2000). Scientists create models in the forms of analogies, conceptual drawings, diagrams, graphs, maps, physical constructions, and computer simulations. Authorities in areas as diverse as geography, economics, technology, mathematics, and history use models to make sense of phenomena in their respective domains (Windschitl and Thompson, 2006).

1) The Scientific Modelling

Scientific modelling is different from, for example, a model spacecraft or clothing model. A model spacecraft, for instance, is crafted to reduce the size of the object, in order to be able to see it in its entirety. In using this type of model, one hopes to reproduce via a copy (model spacecraft) or advertise a specific item (clothing, car, etc) (Durmus ve Kocakulah, 2006). A scientific model is a set of *ideas* that describes a natural *process* (For example, meiosis model). A 'scientific' model so conceived can be mentally run, given certain constraints, to explain or predict natural phenomena (such as the atomic model). It is in this way that scientific models are both desirable *products* of scientific research and useful as *guides* to future research (such as the Rutherford atomic model, Bohr atomic model) (Cartier, Rudolph and Stewart, 2001). Scientific models are representations of how some aspect of the world works.

Models play an important role in teaching and learning science (Harrison and Treagust, 1998; Heywood, 2002). In science education, it is sometimes be difficult to make concrete subjects as well as abstract concepts accessible and comprehensible for the student. The abstract structure of sciences enlarges functions and usage areas of models within science classes.

At the same time NRC (1996) expresses the models as follows:

''Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists'' (NRC, 1996).

Experiences of students relating to the scientific models help them develop their own mental models relating to the scientific concepts. The experience of a student in relating to a scientific model is invaluable in helping them develop their own mental models relating to scientific concepts.

Cartier (2000) represented the characteristics of the scientific models, and students' alternative concepts related to the scientific models, as a table in his study;

Table 1. Features of scientific models and alternative conceptions (quoted from Cartier, 2000).

Features of Scientific Models	Alternative Conceptions of Models
explain data/phenomena are conceptual entities (ideas) are consistent with other ideas are agreed upon by a community can be used to predict account for a wide variety of phenomena and /or lead to reproducible results change over time	are demonstrations or proof of an idea are physical replicas visually represent an idea serve as visual or conceptual teaching tools

If a student learns scientific/curricular model successfully, he/she will have an understanding of both the scientific theory and the nature of the model; and he/she will come experience the presented phenomenon fully; he/she gains awareness of the importance of learning the model and the reasoning behind its construction; understands simulation process, and has information of source from structured target model or / and teaching model. In order for learning to take place, the teacher must be able to effectively communicate these ideas (Justi and Gilbert, 2002).

Harrison and Treagust (1998) classified the models used in science classes as follows;

1. Scale models: frequently used to portray colour, appearance and structure of animals, plants, cars and boats.

2. Pedagogical analogical models: They are the physical models used by teachers to portray abstract or unobservable entities such as atoms and molecules.

3. Abstract models arranged for theoretical relation of iconic and symbolical models: Chemical formulas and equations are relational arrangements of chemical reactions and symbolical models.

4. Mathematical models: Physical possession, changes and processes (e.g. k= PV, F = ma), conceptual relations (e.g. Boyle's law, Newton's law).

5. Theoretical model: Analogical presentations of forces and photons via electromagnetic lines are theoretical, because models are human configuration expression of theoretical entities with a good basis. Theoretical expressions, kinetic theory model in volume, heat and pressure of gases are included in this category. Kinetic theory particles are simply described as pedagogical and analogical models.

6. Description of models as multi-concepts and processes, maps, diagrams and tables: Students easily visualize examples, ways and relations via these models. Examples include: Periodic table, phylogenetic trees, air maps, circuit schemes, metabolic ways, blood circulation, nervous systems, genealogical trees, food chains, nets and pyramids.

7. Concept-process model: The concept-process model allows students to apply what they learn. While the most abstract models are concept-process models, these models we models are the ones used to understand and put into action important concepts like physical and chemical balance, the current flow in circuits and biological classifications. Most science concepts are processes rather than objects. Teachers explain the intangible processes to students (most of whom think in concrete terms) using concept-process models - like the multiple models of acid and bases and oxidation reduction. The analogical, concrete, and dynamic nature of these analogies mean that they can integrate multiple pedagogical analogical, symbolic, theoretical, and mathematical models.

8. Simulations: The only category of multi-dynamic models is simulation. Simulations are subtle processes like model plane flight, global warming, nuclear reactions and accidents and population fluctuations. Simulations are staged for the inexperienced, and researchers gain experience by developing skills without taking vital risks.

2) Educational Use of the Model

Scientific models are accepted as useful tools that enable learning. Students will often model at a level below teachers' expectations. Primary and secondary school students, in general, pay less attention and tend to focus on superficial similarities in the models. Most primary/secondary school students will accept scientific models as actual copies of the real things while just a few students seem able to visualize models as presentations of abstract entities or ideas (Harrison and Treagust, 1998). Scientific models are tools of estimate and relationship, though their potential is not completely maximized in class (Treagust, Chittleborough and Mamiala, 2002). Experiments conducted in science classes are important in terms of verifying modelling process and content of the modelling. It is important that students understand the role and the nature of the models that play a key role in developing specific themes in science (Coll, France and Taylor, 2005). Thus, multiple models support a social learning environment; and when used properly, students will surprise their teachers; their creativeness and imagination will increase (Harrison and Treagust, 1998).

With regard to the use of models in the class, Harrison and Treagust (2000) and Treagust, Harrison and Venville (1998) propose the Focus, Action and Reflection (FAR) approach for model and analogy use of teachers in the lesson. In this approach, also underlying this study; *Focus* involves pre-lesson planning, where the teacher focuses on the concept's level of difficulty, the students' prior knowledge and ability, and the analogical model's familiarity. *Action* deals with the in-lesson presentation of the familiar analogy or model and stresses the need for the teacher and students to co-operatively map the shared and unshared attributes. *Reflection* is the post-lesson evaluation of the analogy's or model's effectiveness, and identifies qualifications necessary for subsequent lessons or modifications next time the analogy or model is used. Three features of the FAR approach are given in Table 2 (extracted from Harrison and Treagust, 2000).

Table 2. The three aspects of the FAR approach

Focus	Concept	Is it difficult, unfamiliar or abstract?
	Students	What ideas do the students already have about the concept?
	Analog	Is it something your students are familiar with?
Action	Like	Discuss the features of the analog and the science concept. Draw similarities between the analog and target.
	Unlike	Discuss where the analog concept is unlike the science concept.
Reflection	Conclusions	Was the analogy clear and useful, or confusing?
	Improvements	Refocus as above in light of outcomes.

The FAR Guide is recommended for use in the following way:

1. Focus: A teacher will evaluate a particular analogy, and whether students are familiar with the scientific concept and the related analogy. If the teacher believes that students are unfamiliar with the analogy, he/she may use a different example.

If the teacher's objective is to explain the similarity between electric current and the water flow through a pipe, he should take into consideration the students' learning and grade level, and select an analogy suitable for students at that level.

Using analogies that are incompatible with students' ability to understand them may cause a contradiction in terms.

2. Action: When the teacher is introducing the analogy in the classroom, he presents the attributes common to the analogy and that particular scientific concept of science. He offers and discusses the similar and different aspects of the analogy and the scientific concept. For instance, the teacher will illustrate the similarities and differences between water flow and the electric flux through a cable, in the classroom, to explain the analogy. He explains the similarities between water flow in a pipe and electric current.

3. Reflection: The teacher evaluates the practicability of the analogy and whether it effectively explains the scientific concept. He adjusts his presentation according to feedback from the students before and after the class; if necessary, he will present a different analogy or modify the existing one. The aim of the FAR Guide is to enable teachers to maximize the benefits of analogies and to minimize their deficiencies. Results from using the FAR Guide indicate that students and teachers like, and benefit from, the use of analogies when learning or teaching science. (Treagust et al., 1998).

In this study, the data submitted was on the use of alternative teaching models with the guidance of the FAR Guide was conducted according to the requirements related to the subject titles in the chapter 'Energy' on the 9th Grade Physics.

3) Research Questions

In this study, results indicate that the use of models with the guidance of FAR Guide is helpful in enabling students to understand the role of models in science. Energy and the transfer, transmission and transformation of energy are abstract and unobservable subjects. The teacher uses examples from daily life to explain these subjects in the classroom, but these examples are not effective in ensuring that students fully comprehend these subjects. The students will often confuse the transfer and the transmission. The literature does not contain any concrete teaching models for teachers to use. This study examined which alternative teaching models, with the guidance of the FAR, are most effective in conveying the concepts to the students.

The objective of this study is to determine the impact of the use of alternative teaching models, under the leadership of the FAR Guide, on the ability of students to comprehend the topic of energy. In accordance with this purpose, the following questions were presented:

1. Does the use of alternative teaching models with the guidance of the FAR Guide have any impact on how students perceive the topic of energy?

2. Does the use of alternative teaching models with the guidance of the FAR Guide lead to a significant difference in students' understanding of the role of models in science, in terms of how students perceive energy?

3. Does the use of alternative teaching models with the guidance of the FAR Guide lead to a significant relationship between a student's understanding of the role of models in science and academic achievement, in terms of how students comprehend the topic of energy?

II. METHOD

In this study, the pre-test post-test experimental model with a control group was used. When random assignments cannot be made, true experimental research cannot be done. In its place, quasi-experimental research is used, which embodies the characteristics of experimental research, excluding random selection and assignment of participants (Charles, 1998:308). The semi-experimental model was used, with the students' score averages used to determine the control and experimental groups.

The participants of the research was consisted of ninth grade students (n=52) existing in Aydin Province, Turkey. The research subjects consisted of students in a control group (N=26; 12 of the students who participated into research are male, and 14 of them are female), and in an experimental group (N=26; 13 of the students who participated into research are male, and 13 of them are female). All students are fifteen years old and in 9th grade level of high school.

1) Activities Related to the Energy Concept

By researching existing resources available in field literature related to the sub-titles within the chapter of "Energy" (Solomon, 1982; Ogborn, 1990; Stylianidou, 1997; STTIS Project, 2000), activities providing experimental and alternative models were prepared. The sub-titles included in the prepared activities were discussed as energy forms, energy transformation, difference between the transformation and the transition, comparison of energy forms and energy transformations, energy transition from hot to cold, insulation, self-generated energy transformations, non-self-generated energy transformations, energy storage, fuels and energy in foods. Examples were drawn from daily life and experiments conducted related to these subject titles. After each related subject experiment was completed, the use of alternative teaching models with the guidance of the FAR Guide was presented, to provide the students with a method of configuring the abstract concept as 'energy'. These activities were given to the group designated the experimental group in the 9th grade.

Activities were also prepared for each subject title mentioned above. In these activities, students were at first asked to complete an experiment related to the subject, and then alternative teaching models were offered to reinforce the energy concept, which is an abstract concept. For the alternative teaching models, the alternative teaching model examples in STTIS (2000) Project were used. Students were instructed to use the alternative model in relation to the given example, in order to determine whether they understood; these examples were drawn from daily life as well as from the experiments they had conducted.

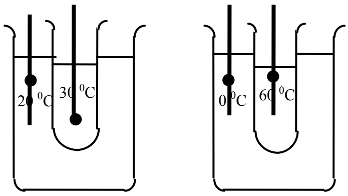
2) Conducting the Study

During this study, the researcher participated in the experimental and control groups as an observer. The allocated time for the chapter is 12 weeks. The chapter was taught to the control group using class book and curriculum. In the same semester, the teacher taught both the experimental group and the control group.

In the control group, the instructions were given by the text book. The lecture was conducted by instructing having to ask introductory questions about the subject at the beginning of the lecture, and ended with teacher's problem solving activity with his students. In addition to these activities, he did the demonstration experiments in the classroom.

In the experimental group, the students were divided into groups according to activity. Examples from daily life were examined and experimental activities conducted with the students. The students were categorized into the groups according to the activity done to represent the transfer of the energy from one matter to another during the heat transfer among the matters, and these groups were done an experiment related to two different situations:

Experimental stage. In the 1st case, the students were given a small beaker having 30 ^{0}C and a big beaker full of water in room temperature 20 ^{0}C. And the students were wanted to measure the temperatures of the water in the beakers by means of a thermometer. Then, they were wanted to put the smaller beaker into the bigger one, and to wait for 10 minutes, and then to measure the temperatures of the waters in the beakers again, and to write down onto the given table. And in the 2nd case, the students were given the smaller beaker full of water in 60 ^{0}C temperature, and the bigger beaker full of iced water in 0 ^{0}C. The students measured the temperatures of the waters by thermometer, and wrote down onto the table. The students put the smaller beaker into the bigger one, and waited for 10 minutes, and then measured the temperatures of the waters in the beakers, and wrote down onto the table.



1st case 2nd case

		Initial Temperature	Temperatures after 10 minutes
1st case	Small beaker		
	Big beaker		
2nd case	Small beaker		
	Big beaker		

Figure 1. Insulation experiment

Additionally, the use of alternative teaching models with the guidance of the FAR Guide was presented to the students.

The teaching models represent stage in the Far Guide:

1. Focus: Is the concept difficult, unfamiliar, or abstract?

It is an abstract concept and difficult to understand. The concepts of transformation of energy and transition of energy are often confused.

What ideas do the students already know about the concept?

The students learned about energy transmission from high temperature objects to lower temperature objects in previous classes, but they have not had an opportunity to use these concepts in new and different situations.

Is (the analog) something your students are familiar with?

No, they weren't familiar with the cards analogy so I decided to demonstrate it.

2. Action: to display the energy transfer, black cards representing hot, white cards representing cold and grey cards representing room temperature were prepared. One of each card (3 cards in total) was given to each student in the classroom. Arrow-shaped cards representing energy transfer were also prepared. There were two types of energy-transfer cards: the first was a thin arrow, representing a low energy transfer; the second was a thicker arrow, representing a high energy transfer. The cards and their meanings were explained to the students. Students were asked to place these cards correctly in the first experiment conducted.

The teacher aided the students in these activities. The first experiment was demonstrated by the teacher. The teacher asked students what the black card represented in the 1st case. Most of the students responded that this card represented the water in the smaller beaker. Correspondingly, they responded that the grey card represented the water in the bigger beaker. The teacher then asked students to assess the direction of the transfer, determining whether a thick or thin arrow should be used. After discussion, it was determined that the correct arrow was the thin arrow, and the correct direction was from the black card to the grey card. The modelling for this experiment is given in the figure 2 below.

1st case 2nd case

Figure 2. Model cards

At the final stage, sample figures from daily life related to the energy transfer from hot to cold were presented to the classroom, and students were asked to place the cards on their desks in the correct order according to the examples in these figures. During this time, the teacher observed the students and assisted those who were placing the cards incorrectly.

And at the end of the applications, it was seen that hardly any of the students performed wrong cards arrangement. An example from daily life related to the experiment given above was given at the figures below;

3rd Figure: represents the case when the man who wears a coat wandering on a cold winter day sat on the bench.

4th Figure: represents the case when the man who just came out from his warm home on a cold winter day sat on the bench.

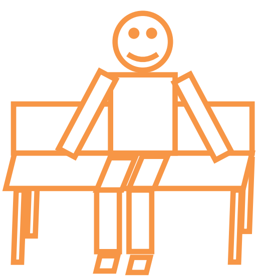


Figure 3

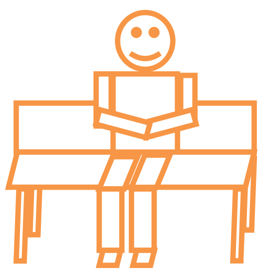


Figure 4

3. Reflection: At the end of this session, most of the students had arranged the cards correctly. The analogy was clear and the students loved it. They all wanted to do it again. The analogy appeared to be motivational and entertaining.

Another Experiment: Making a simple calorimeter

You can make a calorimeter pot. For this, it is enough to have two foam cups, and a material to close on them. When you put the cups one within the other, and close the brim, then we can say you obtained a calorimeter. And you can put your thermometer and stirring rod on the holes that you opened on the top into the pot.

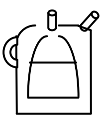
3) Data Collection Tools

The data collection tools were interview questions about energy, multiple choice energy achievement scale and the role of scientific models scale.

Energy achievement scale

This scale contained, in total, twenty questions. This scale was given to 9th grade students for reliability studies (n=200). After the scale questions were answered, the discrimination indices, difficulty of the items, and the reliability coefficient of the scale were calculated. Questions having a discrimination index below 0.20 were removed from the scale. The chapter achievement scale containing 20 multiple-choice items was created. The Reliability Coefficient (KR–20) of the achievement scale was 0.72. These scale questions included energy transformations, transition, energy conservations, insulation, fuels and energy in foods, energy storage and energy forms. Sample question:

There are two cans nested below. A student wants to keep the tea warm in the K part. which item can we put the L section, If we want to keep warm the tea?



a) Alcohol in room temperature
b) Hot sand
c) Cold water
d) Water in room temperature

Interview Questions

The interview questions as a part of the qualitative study are semi-structured questions and they were used to assess or to support the results of the energy achievement scale. Questions shaped by Unal Çoban, Aktamış and Ergin (2006) were used for each one of the sub-titles determined with regard to the topic of energy. There were 8 questions in the interview form. The opinions of 5 field experts were taken so as to ensure scope validity of the questions, and necessary corrections were made in accordance with their suggestions. After converting data into written text, a reliability study was conducted. Reliability of the interview was conducted by calculating correspondence percentage of interviews recorded on paper. While calculating correspondence percentage, data were recorded on paper and coded two-month intervals. Finally, both of the texts were compared, and the correspondence percentage between the codes given by the researcher was found to be .95. Interview questions were given in part of results.

The Role of the Scientific Models Scale

When forming items in the scale of models used in the research, Treagust's (2002) study called '*Students 'Understanding of the Role of Scientific Models in Learning Science'* along with items taken from the scale used by researchers (2004) were used to adapt this scale. In addition to these operations, the validity and reliability studies of the questionnaire prepared by the researchers were conducted, and the questionnaire was integrated into the scale. The students were asked to mark any of the best applicable choice for themselves, ranging in degrees of acceptance from 'strongly disagree', 'disagree', 'partly agree', 'agree', and 'strongly agree' for each item of the scale.

As a result of the reliability and validity studies conducted during the research, new names were given to items categorized under the factors determined as different from the names in the original form of the scale. Reliability and validity analyses were conducted for the 'the Role of Scientific Models Scale' and this consists of five factors and 21 items. The Cronbach's alpha reliability coefficient of the scale was found to be 0.86. By taking into consideration the items which were contained in five dimensions, the names given to these dimensions, number of items within each dimension, Cronbach Alpha Reliability Coefficient belonging to each dimension, and sample items were given in Table 3.

Table 3. Names given to the factors related to ms, number of items, results of reliability study, and sample items

Sub Dimensions	Number of Items	Cronbach Alpha	Sample Items
Abstractness of the models	5	0.69	The Newton's Laws; Archimedes' principle, Evolutionary theory, and Pythagoras' theorem are the samples of the model.
Content of the models	4	0.66	A model can be a diagram, a figure, a map, a graphics or a picture.
Structure of the models	4	0.68	The models can explicitly display the correlation between the opinions.
Changeability of the models	3	0.77	A model can change if new theories or phenomena verify the different facts.
Being realistic of the models	5	0.66	A model should exactly resemble the real object except for its size.

4) Data Analysis

In this study, students were assessed in a semi-structured interview and given an achievement test as pretest-/post test relating to the topic of energy to determine how the use of models with the assistance the FAR Guide affects how student perceive the topic of energy. While determining how much of the energy model was retained by students, the interview/test also measured the impact of models on the student's achievement levels, relating to the subject of energy, in class. Quantitatively determined constructing models were verified qualitatively. The results of the energy achievement test (before and after), sample answers from the interview and the number of students in each section, as determined by the researcher, are given.

Quantitative Data

In the quantitative data analysis of, students' answers were evaluated using statistical techniques, including as mean, standard deviation, independent samples t-test, regression analysis and paired sample t-test by SPSS 11.0 statistical program.

Qualitative Data

The following steps were followed in analysing quantitative section of data;

- Generating natural units of meaning.
- Classifying, categorizing and ordering these units of meaning: students' written answers were re-examined by the researcher at two-month intervals, and each question was divided into categories by giving a title to the same answers given by students for each question. At the end of each categorization process conducted at the two-month interval, correlation between these two categorization processes was .95. Each category was coded according to the answers given in it.
- Structuring narratives to describe the interview contents: when recording the research results, certain student quotes which were characteristic of the quotes in general were supplied as samples, for these category definitions. In addition, frequency (n) of the student responses was presented. The categories and coding of student responses are presented in Table 4.

Table 4. Categories and coding - from interviews

Energy as the main source of life	Nature-Environment
	Energy
Qualities of the energy	Visibility of the energy
	Everything's having energy
	Storage of the energy
Types of the energy	Energy types
	Energy sources
Transformation of the energy	Energy events
	How transformation takes place

- Interpreting the interview data and reporting (Cohen, Manion, and Morrison, 2008).

III. FINDINGS and COMMENTS

1. First sub-problem: Does the use of alternative teaching models with the guidance of the FAR Guide have any impact on how students perceive the topic of energy?

In this study, the first priority was to determine the impact of using alternative teaching models with the FAR Guide on how students perceive energy; before and after the sessions, The Achievement scale was administered to experimental and control groups. Each correct response in the scale was scored as one point.

Comparisons were made in terms of the experimental and control groups' pre-post test achievement score means with t-test analyze.

Table 5. Comparison of mean scores of control group (CG) and experimental group (EG) in energy achievement scale given as a pre-test and post test.

	Groups	N	$\overline{X}$	Ss	t	p
Pre-test	EG	26	13.385	1.699	1.348	p>.05
	CG	26	12.692	1.892		
Post-test	EG	26	15.231	1.451	2.529	P<.05*
	CG	26	14.153	1.376		

*Significant at the .05 level

Table 5 shows that there was no statistically significant difference between the mean scores of students in the control and experimental group with respect to the Energy Achievement Scale before the instruction. The two groups were equivalent in this dependent measure; students both groups had similar knowledge about as it was examined in this study.

Results in Table 5 show a statistically significant difference between the mean score of the students instructed with alternative teaching model activities and that of students taught with traditional methods, in favour of the experimental group. We can conclude that the achievement level of these students increases with the prepared materials and activities. In addition, the experimental and control group pre- and post- test scores were compared and the scores for both groups are higher than before the research (experimental group t=8.12, p=.000, control group t=3.262, p=.003).

Interview questions used in the research Examples are given from the answers (from interviews with students in the experimental group), using the coding for each of the 8 questions relating to daily life. One related to energy as "the main source of life". Three questions related to the existence and quality of energy, and having energy. One question related to the types of energy and two questions related to the transformation of energy, below.

"*What do you think is the basis of life on the* earth", asked in order to discover student opinions about necessity of energy as the main source of the energy. Four students considered energy as the basis of life before the experiment, this number rose to 11 after the administration. For the question "*What do you think is the* energy", asked in order to discover how the students define energy: while 5 students believed energy is a "*skill to perform an* action" before the administration, this number rose to 10 after the administration.

For the question "*Can you show the* energy", relating to the visibility of energy (in the category for energy qualities); Pre-administration, seven students answered that energy could not be shown. After the administration, 6 students said that energy could be shown.

For the question "*Does everything in nature have energy?*" asked in order to discover what students though about "having energy", while 6 students believed that everything has an energy at the beginning, this number rose to 9 after the administration. When they were asked how they would show energy, students gave the following answers after the administration: "*transformation of potential energy in the iron to heat through friction*", "*energy of vase*", "*sun power*", "*in my stomach*" and "*when I point to the pencil on the table, I come to show it*"

For the question "*do you have energy*" asked with regard to "having energy", eight students responded, before the administration, that they had energy. This number rose to 9 students, after the administration. Before and after, only one student answered "*in my* cells" to the question of where the energy is stored in the body. Some of the other answers were "*in my body*" and "*in every piece of my body*".

For the question "*Can the energy of the same mass of coal and apple be the same? If yes, in which condition can they be equal?*" , asked in order to reveal student opinions with regard to the storage of the energy; eight students responded at both the beginning and end of the administration that the energy of the two substances could not be equal; 5 students answered that they did not know. The explanations given by students for their answers, after the administration, were *"coal is a heat source, but an apple is not", "the matter is different from one another, so they cannot be"; "it can be possible as a result of energy transformation".*

For the question "*How many types of energy are there*" asked in order to discover what students understood about types of energy; while most of the interviewed students could not distinguish energy types before the administration, 6 students noted the existence of just one or two types of energy after the administration, and 6 students answered with specific types, including "*kinetic, nuclear, luminous, mechanical, electrical, heat, potential* energy". Pictures (i.e. glass of water, a running man and a sound) portraying different types of energy were shown to the students; and the question "*Do the following matters have energy? If they have, what kind of energy can they have? (A glass of water-sound-battery-buzzer)*" was given to the students.

For this question, while a couple of the students were able to recognize energy types pre-test, more students were able to identify energy types from the pictures correctly after the administration.

For instance, only two students were able to recognize "sound energy" from the loudspeaker/sound picture, before the administration, while 8 students recognized it as "*sound energy*" after the administration. 4 students recognized that the energy in a glass of water is "*potential* energy" at the beginning, the number of students answering *"potential* energy" rose to 10 after the treatment.

For the question "*Rub your hands together very quickly for a while. Then stop. What kind of a change did you feel in your hands? What Why did you feel this change? Please try to explain using energy transformation.*" Eight students answered, pre-administration, that their hands became warm and the cause was friction; it turned into heat as a result of friction. Post administration, every student answered that their hands became warm as a result of friction and motion energy transformed into heat, because of friction. While one student answered "*friction turned into heat* energy" before the administration, the same student said afterwards, "*potential energy turned into kinetic energy as a result of friction, and it turned into heat energy through getting warm*. Another student said before the administration, "*it turned into heat energy*", the same student said afterwards, *"my hand got warm…through friction…motional energy turns into heat energy.*"

For the question "*A man cold because of cold weather sits opposite the electric stove which is switched on in the figure. After a while, the man gets warm, and takes off his cardigan. According to what is expressed, what are the energy events here? How does the man get warm?*" asked in order to discover what students know about interpreting an event using a picture, with regard to energy transformation: Pre-administration, Six students answered that the man got warmer with heat energy. Afterwards, 10 students answered that the man warmed up with heat energy and 2 students answered that he warmed up with transmitted heat. Pre-test, 4 students answered that there was a transformation from electric energy to heat energy, 5 students answered that electric energy turned into heat energy. Post-administration, 4 students answered that electric energy turned into heat and luminous energy, and 3 students could not explain the transformation. One of the answers at the end of the administration was "*electric energy turned into heat and luminous energy. Heat waves spread around the room*", while another student said "*electric energy was transformed into heat and luminous energy. Light and heat were transferred to the human being, and the man got warm*".

Evaluation of student interviews indicates that using alternative teaching models with the assistance of the FAR Guide does affect how students perceive and construct the topic of energy; students were able to provide examples from daily life and, as a result, were able to give detailed explanations.

2. Second sub-problem: Does the use of alternative teaching models with the guidance of the FAR Guide lead to a significant difference in students' understanding of the role of models in science, in terms of how students perceive energy?

In order to determine whether using alternative teaching models with the FAR Guide could lead to a significant difference in students' comprehension of the role of models in science, the role of the scientific models scale was administered both before and after the treatment, to both the experimental and control groups. Each response in the scale was scored as likert type. Comparisons were made in terms of the experimental and control groups' pre-post test score means with t-test analyze.

Table 6. Comparison of mean scores of control group and experimental group in the role of scientific models scale given as a pre-test and post-test

	Groups	N	$\overline{X}$	Ss	t	p
Pre-test	EG	26	82.846	7.519	.911	p>.05
	CG	26	80.308	12.052		
Post-test	EG	26	84.115	8.406	2.930	P<.05*
	CG	26	78.038	6.415		

*Significant at the .05 level

Table 6 shows that there was no statistically significant difference between the mean scores of students in the control and experimental groups in terms of the role of scientific models scale before the instruction. The two groups were equivalent in this dependent measure and both groups had similar attitudes.

The figures in Table 6 indicate that there was a statistically significant difference between the mean of score of the students taught with the experiments/alternative teaching model and that of the students taught by traditional methods, in favour of experimental group. We can conclude that the perspective of these students increases with the prepared materials and activities. Pre-test and post-test scores of the experimental and control groups were compared. While the perspective of students in the experimental group grew broader, no such significant change was observed for the students in the control group, compared to pre-test (experimental group t=2.628, p=.014, control group t=0.780, p=.443).

3. Third sub-problem: Does the use of alternative teaching models with the guidance of the FAR Guide lead to a significant relationship between a student's understanding of the role of models in science and academic achievement, in terms of how students comprehend the topic of energy?

Finally, multi-regression analysis was conducted to determine whether use of alternative teaching models with the FAR Guide could lead to a stronger relationship comprehension of the role of models in science and academic achievement, for increasing student comprehension with regard to the topic of energy. Findings are provided in Table 7.

Table 7. Results of regression analysis relating to the prediction of experimental group's success in terms of comprehending energy

Variable	β (Standardized coefficients)	(Standardized coefficients) Beta	t	p	Binary r	Partly r
Fixed	4,666		1.850	0.079		
Abstractness of the models	0.092	0.166	0.889	0.385	0.440	0.195
Content of the models	0.151	0.259	1.436	0.166	0.529	0.306
Structure of the models	0.373	0.532	2.450	0.024	0.558	0.480
Changeability of the models	0.144	0.279	1.326	0.200	0.153	0.284
Accuracy of the models	-0.168	-0.353	-1.465	0.158	0.044	-0.311
R=0.731	R^2=0.534	F=4,588	p=0.006			

Variables including abstractness, content, structure, changeability and accuracy of the models, collectively have a high level and significant relationship with achievement scores relating to the topic of energy (R=0.731, R^2=0.534, p<.01). All these variables together explain approximately 53 % of the total variance in the achievement scores relating to the topic of energy. According to the standardized regression coefficient (beta), the relative order of the importance of predictor variables in achievement is the structure of the models, accuracy of the models, changeability of the models, content of the models and abstractness of the variables. An examination of t-test results relating to the significance of regression coefficients shows that just the variable of structure of the models is an important predictor on the achievement. Accuracy of the models, changeability of the models, and content of the models and abstractness of the models do not have as significant an impact.

IV. RESULTS AND SUGGESTIONS

The interview results and the results of the achievement test, given in order to determine the impact of the use of alternative teaching models with the assistance of the FAR Guide on students' comprehension of the topic of energy, indicate that students were able to supply more meaningful and detailed answers after the administration, compared to before the administration. According to the findings obtained from the achievement test and interview results, teaching via alternative teaching models had a significant impact on how well students understood energy. In the experimental class, students' scores increased substantially after being in a learning environment supported by use of alternative teaching models with the FAR Guide. Introducing abstract concepts like energy by portraying them as events or pictures renders them more easily understandable for students.

Including the models within the science subjects is important for the students in both understanding and forming a mental image, and correlating it with daily life (Treagust et al., 2002). These subjects should be taught using more than one teaching method. Through the use of alternative teaching models, students were given the means and ability to construct the abstract concepts mentally.

The results of this research, conducted in order to determine the effects of alternative teaching models activities based on 9^{th} grade students' achievements of the energy concepts and students' understanding of the role of scientific models are as follows:

Students' understanding of energy concepts; prior to the beginning of the research, it was found that there was no significant difference between the experimental and control groups students' achievements of the energy concepts and students' understanding of the role of scientific models. Therefore, the levels of both groups were assumed to be the same at the beginning. The experimental group students have higher levels of achievement than the control group students. The experimental group students' achievements are positively affected by the experiment-based/alternative teaching models activities. In addition, at the conclusion of the interviews with experimental group students before and after the administration, the level of comprehension for students increased; these results are supported by the achievement test. No significant change is also observed in the level of achievement of control group students towards energy.

Students' understanding of the role of scientific models; There was an increase in students' understanding of the role of scientific models at the end of the lessons conducted using alternative teaching models presented to the students other than the accepted models. The experimental group students have a more positive understanding of the role of scientific models than the control group students. The experimental group students' understanding of the role of scientific models is positively affected by the alternative teaching model activities. No significant change is also observed in the control group students' understanding of the role of scientific models.

The relationship between students' academic achievement and their understanding about the role of scientific models; there is a significant relationship between the achievements of experimental group students and structure of the model. There is no significant relationship between achievements of experimental group students and accuracy of the models, changeability of the models, content of the models and abstractness of the models. If the model structure is easily comprehensible, students may understand it more easily, increasing their achievement level. At this point, it can be said that structure of the models impacts achievements of students with regard to the topic of energy. The structure of teaching-based models should be at a level that the students can comprehend and it should not be overly complex, as this is a significant factor in achieving success.

These results show that experiment-based activities and the use of alternative teaching models with the guidance of the FAR Guide can effective in raising the 9th grade students' level of understanding of energy concepts.

The use of alternative teaching models with the guidance of the FAR Guide provides methods of examining how students comprehend and mentally visualize scientific concepts. In previous studies, results have indicated that students did not understand the purpose, nature or objective of the models (Justi and Gilbert, 2002; Treagust et al., 2002). Most secondary students believe that there is a 1:1 correspondence between the models they use and the actual target. While students recognize the existence of these differences, they do not consistently search for reasons to explain the apparent differences. Because of this, it is helpful for students to have epistemologically guided lessons on how to construct and interpret analogical models. Constructivist learning theories suggest that students will need extended experience in model-based thinking and learning in a consensual environment if they are to become effective relational thinkers (Harrison and Treagust, 2000). When students participate in the thinking process of the emergence of scientific models, they better understand how scientists produce scientific models and how they use them. It is not enough to simply present models or to say they create their own models. Scientific models are complicated presentations. Therefore, students must use cognitive processes that include understanding and creating analogies, and if they know them, they can learn them in the best way (Sibley, 2009). For example, Sins, Savelsbergh, Joolingen and Van Hout-Wolters (2009) conducted a study and had concluded that, for the modelling tasks given to the students, their epistemological understanding should be taken into consideration. Generally teachers use models and modelling during lectures, without asking the students to engage or participate in model-making. As a result, students do not necessarily grasp modelling during the lectures. In this context, it is important to ensure that students actively participate and engage in creating their own models; only by this active participation can students grasp abstract concepts like energy. This has an added benefit of stimulating student creativity and their imagination, and easing the learning process for abstract concepts. In addition, the teachers also can determine how much students understand by examining the models created by the students.

In the light of these findings, the following suggestions are put forward;

Teachers can use of alternative teaching models with the guidance of the FAR Guide alternative teaching model in teaching of energy. These models can help the students to configure such an abstract concept as ‘energy’ in their minds. An uncontrollable variable (the effect of luck, take special tutoring, etc.) that may influence students' achievement is the limitations of this study.

Similar research studies can be conducted for different physics and science topics in secondary school.

A future study should include a section where students form their own models. In order to conduct such a study, students must understand what modelling is, and how it is executed. So, in future studies, teachers may first demonstrate modelling in class, to be followed by students creating their own models in subsequent lessons.

This study can be done on a wider sampling, and with more than one experimental and control classes and schools.

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