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A thematic review of 'energy' teaching studies: focuses, needs, methods, general knowledge claims and implications

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Abstract

A review and synthesis of the studies of teaching the 'energy' concept are worthy for science education researchers, teachers, curriculum developers, and policy makers. Since teachers may have a busy schedule, they may lack of tracking related studies. Therefore, this thematic review will highlight them on the studies' perspectives-focuses, needs, methods, general knowledge claims and implications- of 'energy' teaching studies. Finally, this paper intends to evaluate the 'energy' teaching studies to notice where we are. Using a thematic matrix, each study was described. General trends were also apparent. Further, the similarities and differences were obvious since the unique features of each study were clear. Briefly, an interpretive account of the 'energy' teaching studies was followed. In light of the general knowledge claims, it can be deduced that most of the studies has pointed out that their used alternative approaches are more effective in student's conceptual learning or made a significant contribution to student's learning experience/motivation/skills. However, the only two studies also pointed out some disadvantages of their used approaches. Most of the studies under investigation recommended audience to carry out their used alternative approaches in their teaching-learning processes.

*Keywords***:** Energy teaching; Thematic review; Science education; Physics education

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1. Introduction

Since constructivism stresses that learning can only appear when the student is able to relate new information provided by a teacher to their existing knowledge [1], students generate new knowledge through their experiences, mental structures, abilities and beliefs. Thereby, they construct their conceptions which are in a harmony with their prior knowledge [2-5]. However, if student's pre-existing knowledge is different from consensually accepted scientific idea [6-9], it influences his/her meaningful learning and engenders to uncompleted learning. That is, unless the teachers or science educators know the depth and tenacity of the student's pre-existing knowledge, they cannot help students to improve the scientific understanding [10]. Because of importance of the student's pre-existing knowledge, two popular research trends have emerged: (a) students' alternative conceptions [11] and (b) conceptual change [12].

Since energy is an interdisciplinary concept, i.e. science, chemistry, physics, biology, economic, policy [13-15], there have been enormous studies of students' alternative conceptions and of effectiveness of alternative interventions [16-25]. Since most of the scientists even describes this concept as *'Energy is the capacity of a physical system to perform work'* [15, 26] or '*capacity for doing work'* [27] or '*capacity to produce change*' [28], a consensually accepted scientific definition has not still been produced [29]. Despite this disadvantage, several perspectives associated with the concept 'energy' have been investigated: *energy and its description* [30-33], *energy conversion* [34-36], and *teaching and/or learning energy* [17, 20, 22, 37, 38].

Some of the aforementioned studies recommend some new theoretical alternative approaches for teaching 'energy' concept even though the question 'how to teach energy' has still been a problematic issue [39]. At least, to get teachers to become aware of these proposals, a thematic review should be undertaken by means of a matrix with *focuses, needs, research methodologies (sample, data collection and data analysis), general knowledge claims and implications for teaching and learning*.

The current study intends to evaluate the 'energy' teaching studies to notice where we are. To this end, the authors ask the following questions:

1. What are the *focuses* of the 'energy' teaching studies?
2. What are the *needs* of the 'energy' teaching studies?
3. What are the *methodologies -sample, data collection and data analysis- of* the 'energy' teaching studies?
4. What are the general *knowledge claims of* the 'energy' teaching studies?
5. What kinds of *implications* for teaching and learning have been suggested in the 'energy' teaching studies?

1. 1. Significance

A review and synthesis of the 'energy' teaching studies are worthy for science education researchers, teachers, curriculum developers, and policy makers. Since teachers may have a busy schedule, they may lack of tracking related studies. Therefore, this thematic review will highlight them on the studies' perspectives-focuses, needs, methods, general knowledge claims and implications- of the 'energy' teaching studies. Further, they will be able to easily translate the methodologies and approaches used for research into classroom practice. Summarizing general knowledge claims and implications will inform science education. Teachers will be able to capture the question 'how to teach the energy concept' and may improve alternative ways for science curriculum since the questions 'when should the energy concept be taught?' and 'which grade is best for teaching the 'energy' concept?' have still been problematic. Also, researchers will become conscious the status of the 'energy' teaching studies and may concentrate on unexplored areas for further research.

1. 2. Limitation of the study

After reviewing the related databases such as ERIC; Springer, EBSCOHOST etc., the authors defined 132 energy papers whose perspectives are *energy teaching, students misconceptions of 'energy' and related concepts, energy learning, energy's conceptual framework*. Therefore, this paper is restricted with the only energy teaching studies.

2. Methodology

Based on the research questions for evaluating the 'energy' teaching studies, the authors adapted the subsequent matrix used by Calik, Ayas and Ebenezer [40] and by Unal, Calik, Ayas and Coll [41]: *focuses, needs, research methodologies (sample, data collection and data analysis), general knowledge claims* and *implications for teaching and learning*. Using this thematic matrix, each study was described. General trends were also apparent. Further, the similarities and differences were obvious since the unique features of each study were clear. Briefly, an interpretive account of the 'energy' teaching studies was followed. Now the authors present each study in regard to thematic matrix.

2. 1. Focuses

As seen from Table 1, alternative approaches have been dominant for the ‘energy’ teaching studies. Since the concept and its definition are problematic issue, the science educators have been attempting to find the alternative ways to teach the concept effectively. Taking into account students’ pre-existing knowledge, Trumper [42-44] organized a constructivist based introductory course for teaching the ‘energy’ concept. Likewise, Aydın and Balım [45] devised an interdisciplinary constructivism based instruction on interrelated concepts, i.e. work, power, energy, its conservation and its transformation, and compared this approach with traditional one.

An excerption for the instructional strategies is indicated as follows:

> First, pupils have to be aware of their own anthropocentric framework. Next, they have to create a new and more generalized framework, based on the analysis of comparative events (analogies) [42].

There are three project- based studies which are outcomes of CLIPS [17] and LIPS [46, 47]. Brook and Wells [17] introduced an energy circus that encourages students to construct the ideas of *energy conservation, transfer, degradation and dissipation*. Kirkwood and Carr [46] used several techniques such as *brainstorming, small group discussion, posters of students’ ideas and open ended class debates* to enhance students’ conceptions of *forms of energy, its changes and its source*. Kirkwood and Carr [47] repeated their earlier experiences as an action research by means of brainstorming session and group works to develop posters.

Table 1. Frequencies of focuses of the 'energy' teaching studies

Focus	Strategy	Concept	f	Studies
Alternative approach	Constructivism based instruction	A process of conceptual change from anthropocentric framework to the scientific view.	1	43, 44
		Teaching the energy concept by taking into account the 'anthropocentric, product and cause' frameworks.	1	42
		Work, power, energy, energy conservation and transformation	1	45
		Energy conservation and transformation	1	17
		Forms of energy, energy changes and source of energy.	2	46, 47
	Instruction accompanied with different graphical representation, i.e. diagrams, energy bars and so on	Energy conservation, types of energy, energy changes.	3	20, 48, 50
		Work-energy process	2	49, 51
	An integrated instruction	Integration of physical, chemical and biological events related with energy	1	13
Appropriate grade	Which grade is best for teaching the 'energy' concept	Energy concept	1	52
Teaching energy's nature or its types	An intervention approach	Mechanical energy	1	53
	Defining 'energy' concept qualitatively	Nature of energy	1	54

(i) A brainstorming session about forms of energy. Students were asked what forms of energy they knew about and all their ideas were displayed in the classroom, with no selection or value judgments made about them.

(ii) Group work to develop posters on energy changes and sources of energy. Students' ideas about energy changes in some defined situations were developed by groups into posters [47).

Fry et al. [48] tried to fill a gap in professional stance and used an abstract picture language. Rather than depicting the 'energy' concept as *something what makes things happen*, they used abstract diagrams to help students to comprehend any change by taking differences, i.e. concentration, temperature, pressure, into consideration. A sample diagram illustrating the conventions for 'just happens' and 'doesn't just happen' is presented in Fig. 1.

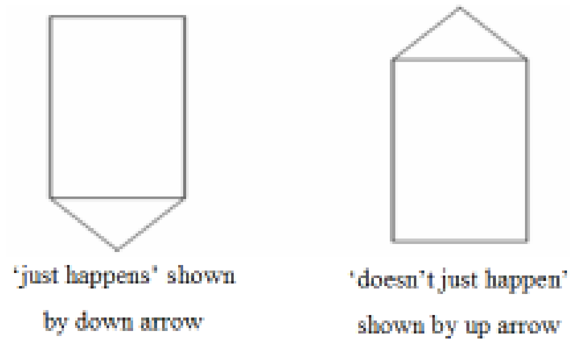
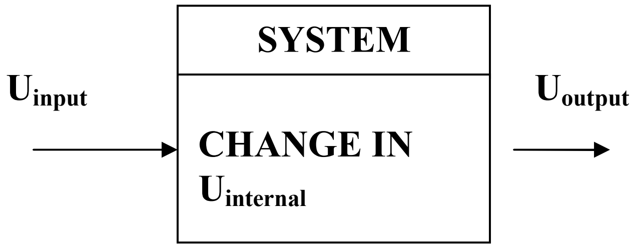


Fig. 1. A sample diagram used by Fry et al.

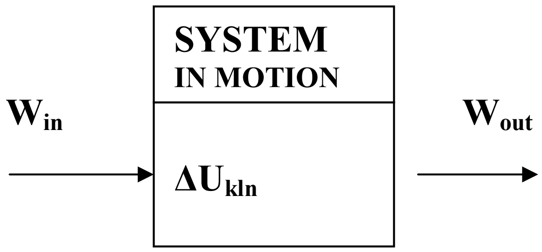
Heuvelen and Zou [49] improved an instruction accompanied with verbal, pictorial, bar chart and mathematical representations for teaching work-energy process whilst Horner, Jeng and Lindell [50] intended to compare three different treatments -no physical representation, energy bar charts and energy bars- with one another for the concepts *'energy conservation, types of energy, energy changes'*. In context of the same concepts, Huis and Berg [20] proposed a very systematic approach with five sections. This approach is displayed in the following:

(1) The choice of the system and determination of its boundaries.

(2) Applying the first law of thermodynamics by stating the difference between input and output energies equals a change in the total internal energy of the system, $\sum U_{in} - \sum U_{out} = \Delta U_i$, visualized as in figure;



(3) Writing the formula includes the work-kinetic energy theorem as $\sum W_{in} - \sum W_{out} = \Delta U_k$, visualized as in figure;



Here, students learned the work concept through work-kinetic energy theorem.

(4) Identification of input, output and internal energy. Heat, work, radiation energy, electrical energy can be seen examples of internal and output energy for a closed system and particle energy can be seen an example of open systems.

(5) Students are directed using the system approach to different situations (p. 147).

Mutimucuio [51] devised a three-step representation strategy of the concept 'work-energy process' and investigated its effect on student achievements. A quotation is showed below:

> A process, given in words, is first translated into a drawing, called visual representation. Next, an idealized diagram representing a system at each state of interest is drawn, in what we call scientific representation. Finally, the process is translated into a mathematical representation in which identified principles are systematically applied in equation form to each interaction identified in the scientific representation [51, p.1].

Gurdal, Bayram and Sahin [13] developed an integrated instruction by combining various disciplines, i.e. physics, chemistry, biology and explored its effect on student's long-term memory and meaningful learning. The only one study, Trumper [52] focused on the question 'which grade is best for teaching the 'energy' concept'. Further, Tsagliotis [53] designed "Model of Educational Reconstruction" within a practically context for mechanical energy. An excerption is seen as follows:

> Dropping balls on wet sand (Fig. 2), of various weights and from different heights, study the craters they create in the sand and make inferences about dynamic energy and its relation to weight and height [53].

Papadouris and Constantinou [54] described the 'energy' concept qualitatively on the basis of its nature and recommended a three-step learning: *(i) differentiate between observations, theories and models, (ii) appreciate the role of each in science and (iii) recognize how they are connected* (p. 2).

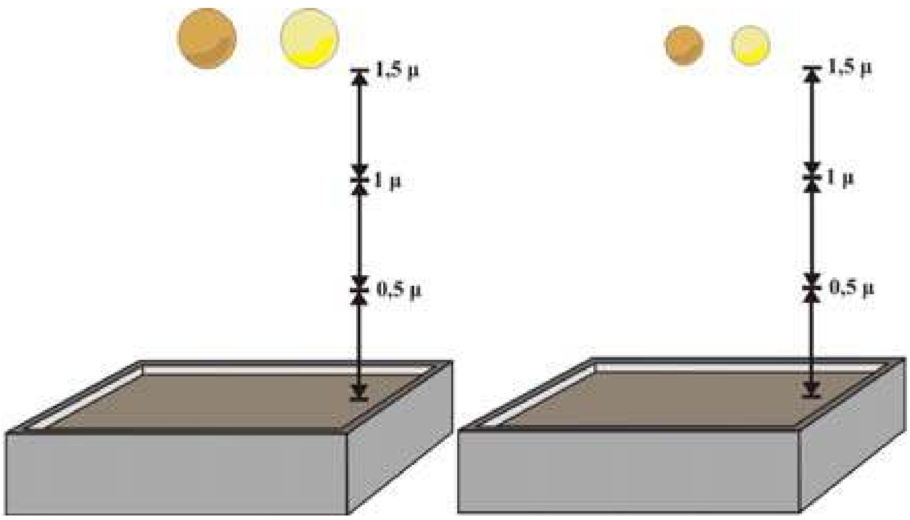


Fig. 2. Dropping balls on wet sand.

2. 2. Needs

The 'energy' teaching studies described here are presented in Table 2 based on their specific need.

Table 2. Frequencies of needs of studies of teaching the 'energy' concept

Need	Studies
A need to understand the abstractness of the 'energy' concept	17, 46, 47, 53
A need to improve alternative strategies incorporating in alternative conceptions	42-45
A need to suggest a systematic approach for teaching the 'energy' concept since students' conceptions of the 'energy' concept are too swamp-like for an adequate reconstruction.	20
A need to have a more professional stance requirement since little change has existed in textbooks	48
The notion that students should acquire the 'energy' concept qualitatively	54
A need to investigate effectiveness of some teaching methods	13, 50
A need to discuss the question 'which grade is best for teaching the 'energy' concept'	52
A need to develop simplified representations for solving work-energy problems.	49, 51

Since outcome of the energy transfer can be perceived at macroscopic level, a need to understand the abstractness of the 'energy' concept is obvious [17, 46, 47, 53]. That is, students find difficult to link their macroscopic experiences (real world) with theoretical knowledge at microscopic level (scientific world). Of course, this issue may lead to alternative conceptions. Since alternative conceptions are mainly obstacles for further learning [55-58], alternative strategies incorporating in students' alternative conceptions should have been improved. That is, the four studies have concentrated on this need [42-45]. Since a consensually accepted definition of the 'energy' concept has not been available, there is a need for its teaching to suggest a systematic approach which helps students to reconstruct the concept adequately [20]. Because of the fact that the textbooks essentially neglect students' prior knowledge, the related literature indicates that they are not good at facilitating conceptual understanding [59, 60]; therefore, there is a need to devise a more professional requirement for them. If algorithms or quantitative inferences or formulas are exploited, students tend to memorize them rather than grasping conceptual understanding [61, 62]. Thereby, teaching the energy concept qualitatively may provide more effective results for achieving conceptual understanding in science learning and teaching [54]. Exploring students' learning difficulties and facilities of the energy concept may enable both teachers and science educators to hold insights of students' conceptions so that a more effective strategy may be developed in teaching the energy concept [48]. Since the energy concept is interrelated with different disciplines, students may encounter the concept as a pre-existing knowledge before his/her schooling process. Thus, even if the energy concept is not taught formally in lower grades, they perceive it informally in their daily life. To work out this dilemma, the question 'which grade is best for teaching the 'energy' concept' should be handled well [52].

Since students find the concepts 'work' and 'energy' difficult to comprehend, it is not astonishing that they are unable to solve the related problems. Therein, there is a need to simplify work-energy problems. Heuvelen and Zou [49] and Mutimucuio [51] concentrated on this issue.

2. 3. Methods of studies

As seen from Table 3, there are four research methodology used by the energy teaching studies: experimental research design (n=10), action research (n=2), classroom research (n=2) and case study research design (n=1). Further, the only one study [17] did not mention their research methodology explicitly. Why the experimental research design is very common may stem from framework of the study. That is, since they concentrate on the effects of their used interventions or conceptual change, the experimental research design is the best methodology for investigating the effectiveness of their studies [12]. Action research is in a harmony with a Turkish idiom '*if everybody clears up his or her home front, there is no need to use a street sweeper'!* In other words, action research encourages the teacher to determine and work out the problems that they encountered in their teaching processes [63]. Then, they share their gained experiences and results with their colleagues and experts. In the energy teaching studies, Kirkwood and Carr [46] conducted their action research study with three science teachers whilst Tsagliotis [53] focused on his Grade 6 students. The only two studies, Huis and Berg [20] and Tsagliotis [53], preferred classroom research design that explores systematically how our teaching influences student learning within the purpose of improving instruction [64]. The classroom research design is not only context-dependent but also interactive, multiple-focused, interrelated, and formative [64]. The classroom research design gets students to relay their opinions and ideas to the class as a whole, thereby, it produces a student-centered classroom instead of a teacher-centered one [64]. Trumper [43] exploited a case study research design to explore students' conceptions in depth rather than following a rigid protocol to examine limited number of variables. Moreover, the only one study, Brook and Wells [17], did not clarify their research methodology clearly.

As can be seen from Table 3, the samples of the energy teaching studies ranged from primary school students to primary/science teachers. Some of them tended to make a comparison amongst grades [17, 42-44, 52]. Such a research not only gets the teachers/researchers to capture how their students' conceptions evolve but also to answer the question 'Which grade is best for teaching energy'?

2. 4. Data collection

To achieve the purpose of triangulating data, multiple methods are generally used [65, 66]. Hence, this process increases both the study's validity and reliability. When we look at Table 4, about half of them tended to use multiple methods. Now data collection methods the studies used will be outlined as follows.

2. 4. 1. Interviews

As seen from Table 4, nine studies exploited interviews to collect data. That is, Brook and Wells [17] and Mutimucuio [51] used interviews to measure how their teaching approaches influenced students' conceptual learning. Huis and Berg [20] used interviews to evaluate the students' capability of using the systems approach. For this, they presented some situations to students such as '*a toy car propelled by a compressed spring, a moving car, the electrical socket'* (p. 149). Similarly, Trumper [42-44] conducted group interviews to elicit students' pre-existing knowledge by means of some pictures, as seen in Fig. 3 [42].

Table 3. The methods of teaching studies

Studies in the chronological sequence	Experimental	Action Research	Classroom Research	Case Study	Unclear	Sample	Sample's selection: Purposely	Randomly	Unspecified	Volunteered
Kirkwood and Carr [46]		X				Three science teachers			X	
Brook and Wells [17]					X	Students amongst 11 and 15 year olds, teachers			X	
Kirkwood and Carr [47]		X				14 and 15 year old students and their teacher	X			
Trumper [43]	X					Grade 9-11 students			X	
Trumper [42]				X		Grade 9-11 students			X	
Trumper [44]	X					Grade 9-11 students			X	
Trumper [52]	X					Grade 5-9 students			X	
Huis and Berg [20]			X			15-16 year old students			X	
Gürdal et al. [13]	X					Grade 4-5 students		X		
Heuvelen and Zou [49]	X					Undergraduate students	X			
Mutimucuio [51]	X					Freshman undergraduate students			X	
Fry, et al [48]	X					Grade 8 students			X	
Aydın and Balım [45]	X					Grade 7 students	X			
Tsagliotis [53]			X			Grade 6 students			X	
Papadouris and Constantinou [54]	X					Students amongst 11 - 14 year olds				X
Horner et al. [50]	X					Freshman and sophomore undergraduate students			X	

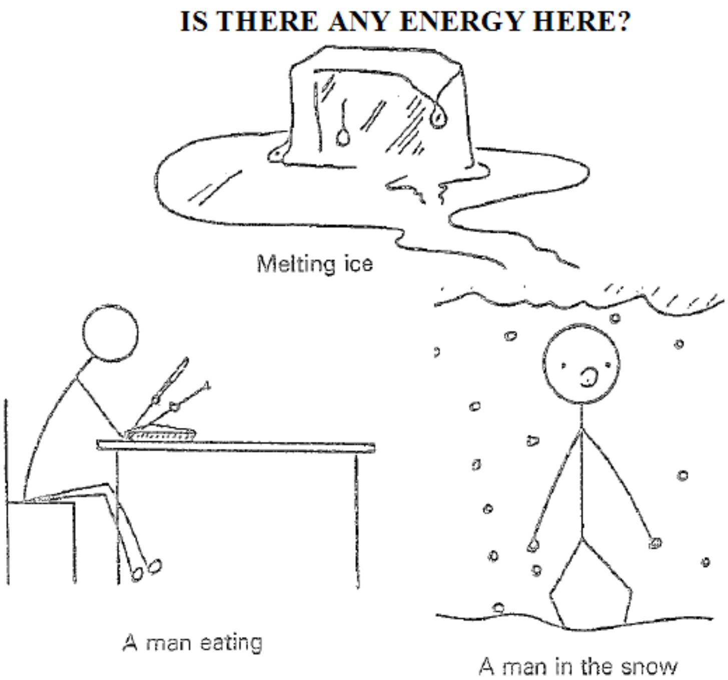


Fig. 3. A sample figure used by Trumper.

Tsagliotis [53] conducted *Interview- About-Instances* with a-10 everyday activity interview cards such as man pushing a heavy box.

To identify what interviewees thought about energy teaching and its learning, Kirkwood and Carr [46] implemented the interview method to capture insights of the participants. Likewise, Fry et al. [48] examined students' perspectives of the effects of their used approach on students' scientific skills. In their interview sessions, such questions as '*why was it good to do some drawings instead of writing*' or '*do you find the diagrams easier to use than the textbook ... than the written information*' were asked. An excerption of students' responses to the question is in the following: '*Yes. ...because some people don't understand English so well, like…they like the pictures better? ...it gives them more of an idea*'.

In interview about instances (named clinical interview by [67, 68] or individual interviews, students are confronted with an intellectual empathetic environment where a natural conservation/interaction takes place between the researcher and interviewee. To create follow-up questions, the interviewer listens to the interviewee carefully. Because of the free flow of ideas student's talk is rich and diverse, the interviewer spends enormous amount of time to transcribe the audiotapes verbatim [40]. Moreover, in group interviews, since students discuss the concepts under investigation, they become conscious of other students' ideas so they are freely able to collectively and individually generate solutions and group decisions for the presented event [56, 69]. However, one or two of the interviewees may outweigh in their group and cover others' ideas.

2. 4. 2. Paper pencil surveys

As seen from Table 4, seven studies used paper-pencil surveys to investigate the extent to which the goals of their studies were achieved. The only one study, Horner et al. [50] preferred exploiting open ended questions and multiple-choice ones together to compare different methods with each other. A sample question used by Papadouris and Constantinou [54] is illustrated in Fig.4.

Multiple-choice questions are very common to measure student's recall of the concept. That is, multiple choice questions emphasize *what students recalled* instead of understanding. But open-ended questions stress *what students comprehended*. Also, the open-ended questions are highly in a harmony with tenets of constructivism. As a matter of fact, Aydın and Balım [45] preferred administering multiple-choice questions despite the fact that their study was based on constructivism.

Table 4. The data collection methods for each study

Studies in the chronological sequence	DATA COLLECTION METHODS						
	I	PPS		FW	O	H	W
		QEQ	MCQ				
Kirkwood and Carr [46]	X				X		
Brook and Wells [17]	X				X		
Kirkwood and Carr [47]					X		
Trumper [43]	X			X			
Trumper [42]	X						
Trumper [44]	X						
Trumper [52]			X	X			
Huis and Berg [20]	X		X			X	X
Gürdal et al. [13]			X				
Heuvelen and Zou [49]		X					
Mutimucuio [51]	X					X	
Fry, et al [48]	X				X		
Aydın and Balım [45]			X				
Tsagliotis [53]	X						
Papadouris and Constantinou [54]		X					
Horner et al. [50]		X	X	X			

Note: W: Worksheet (n=1); H: Homework (n=2), O: Observation (n=4), I: Interviews (n=9); FW: Free writing (n=3); PPS: Paper and pencil surveys [OEQ: Open ended questions (n=4), MCQ: Multiple choice questions (n=5)]

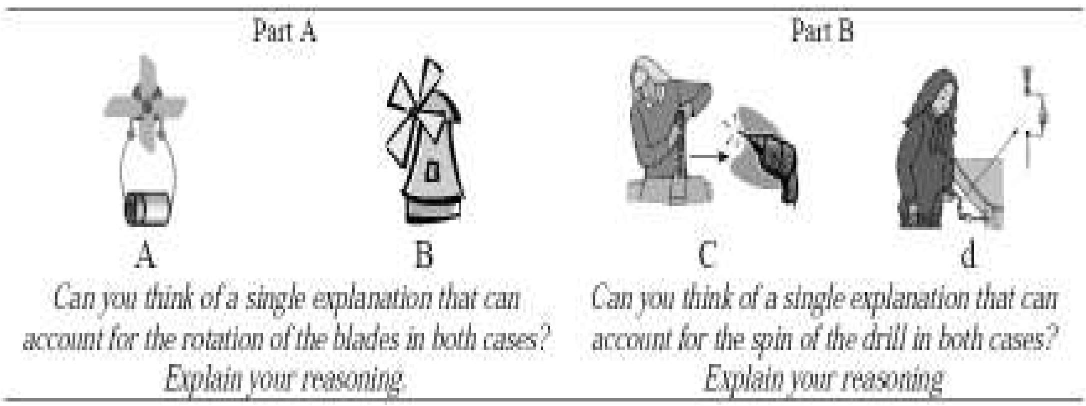


Fig. 4. Task for the model of energy as a cause of changes.

Heuvelen and Zou [49] went over students' attitudes toward the energy bar chards and the multiple representations of work-energy processes by means of open-ended questions. For this, they asked three principal questions such as "*Did using the energy bar charts help you learn energy concepts and solve work-energy problems? Explain why they were useful or not useful.*" (p.191).

2. 4. 3. *Free writing*

As can be seen from Table 4, three studies used free writing to collect data. For example, Trumper [42, 52] initially asked students to write the first three relationships of the *energy* concept and then to explain them. Horner et al. [50] also investigated the students' free response to the common exam questions. Producing prior categories before free writing like the interview excerpts is not common. In other words, categories are inductively derived from students' responses [40]. However, Trumper [42, 52] labeled students' responses in regard to criteria used by Duit [70]: *things, processes, phenomena, physical concepts, words*. Furthermore, Horner et al. [50] did not imply how they analyzed students' free writings. They initially concentrated on their responses to open-ended questions and multiple-choice questions.

2. 4. 4. Observation

To determine what happens in classroom or what problems are available, four studies exploited *observation* method to accumulate data. For example, Kirkwood and Carr [46, 47] attempted to identify what problems existed in teaching and learning the 'energy' concept.

"*The LISP teaching approach, i.e. using students' ideas and incorporating them into the lesson structures, has been valuable for me. I am now much more aware of the need to approach any modification of student ideas by being much more aware of where they are at when a topic begins. Some other valuable teaching approaches have also been made manifest, for example the use of posters to display the students' ideas has been a valuable learning exercise for them. Students appear to be very interested in seeing their own and other work displayed have attempted, and will further attempt, to use this approach [using students' ideas] in future topics next year [46]*"

Brook and Wells [17] used informal observations and observed each lesson of two classes in depth in order to monitor the effectiveness of their used approach. Such a procedure not only enabled them to portray their used procedure and task time but also to become aware of a number of issues that became apparent. As a matter of fact, Fry et al. [48] addressed what observation has advantage: *to probe how teachers incorporate, and how students use, the materials, with a focus on how energy ideas are communicated and learnt in the classroom (p.39).*

2. 4. 5. Homework and Worksheet

Huis and Berg [20] exploited both homework and worksheet, but these are unspecified in their study. That is, how they used them is unclear. Also, Mutimucuio [51] used *homework* within six different problems. These problems not only required students to calculate unknown variables but also to respond qualitative questions such as "*a block moving up an incline, a boy sliding down a slide and a stone being thrown upward* [51, p.1].

3. General knowledge claims

As seen from Table 5, most of the studies has paid more attention to effectiveness of alternative approaches. In fact, it is not surprising because all alternative attempts are better than traditional approach [12]. However, two studies, Huis and Berg [20] and Papadouris and Constantinou [54], also pointed out some disadvantages of their used approaches. Trumper [52] tried to answer the question 'which grade is best for teaching 'energy' concept': *(1) No significant difference among students' associations with the word energy was found in grades 7-9 (2) No significant difference among students' choice of pictures and students' alternative frameworks about energy was found in grades 6-9 (3) The buildings blocks in the teaching of the energy concept, the 'cause' and 'product' frameworks, are held by students from 5th grade onwards. These frameworks appear in more than half of the occasions in which students, from 6th grade on, describe the pictures they have chosen (4) Fifth-grade students seemed to have a remarkable tendency to anthropocentrism when relating to the energy concept* (p.146). Similarly, Kirkwood and Carr [46] identified seven fundamental reasons why learning/teaching the 'energy' concept is tough: *(1) energy in current science curricula (2) children's ideas about energy (3) science educators' understanding of the energy concept (4) current teaching and learning about the energy concept (5) alternative approaches in teaching and learning about the energy concept (6) professional development and (7) resource material* (p.17-21).

Table 5. An outline of general knowledge claims of the energy teaching studies

General Knowledge Claim	Study
There are seven major issues in teaching and learning the 'energy' concept	46
Alternative approach is more effective in enhancing student's conceptual learning or made a significant contribution to student's learning experience/motivation/skills	13, 17, 20, 42-51, 53, 54
What students learned is used for building a model	17
The teacher found the strategy [LIPS] useful to modify students' ideas and to incorporate them in his teaching-learning process	47
There are four major inferences for 'cause' and 'product' frameworks	52
The system approach also possesses some limitations in its own applicability, i.e. students find it difficult in identifying input, output and internal energies	20
Although some of the students could capture the mechanisms of energy transfer and its transformation in a detailed systematic analysis of the systems, majority of them tended to constrain themselves to only describing a small portion of the energy chains	54

4. Implications for practice and teaching

Although students expect a precise definition of the 'energy' concept, a consensually accepted definition has not been yielded. For this reason, some authors view this as a slippery concept [71-73]. Since this concept plays a significant role in personal, social and environmental issues [29, 73, 74], understanding the concept is certainly essential for its teaching processes. As a matter of fact, even if students are formally introduced with this concept at upper grades, they may bring some pre-existing knowledge related to the energy concept [17, 42-47, 52, 75]. Thus, they may inhibit student's scientific (conceptual) learning of the energy concept [42]. Therefore, there is highly a need to decide the question 'when should the concept be taught' [44, 52].

Trumper [43, 52] recommended that this strategy be firstly implemented in grade 5 and onwards as early as possible. Trumper [44] emphasized that a new curriculum for teaching the energy concept in senior high schools should be revised by taking into consideration in the following issues:

i. The teaching should take into account and rely on the pupils' more pervasive alternative frameworks: the anthropocentric framework, the 'energy as causing some process to occur' and the 'energy as a product of some processes' frameworks.
ii. The energy concept and the conservation of energy principle should be taught in the Mechanics course in senior high school as a continuation of what the pupils learned in Grade 9, with the corresponding enrichment and deepening of all the concepts.
iii. The definition of energy as the capacity or ability to do work should be completely abandoned (p. 9).

Meanwhile, most of the studies under investigation pointed out that their used approaches are more appropriate for the 'energy' teaching and recommended audience to carry out them in their teaching-learning processes [13, 20, 45, 54]. Furthermore, Heuvelen and Zou [49] suggested that the degree to which the energy bar charts and the multiple representation strategy help the students to understand the work-energy processes qualitatively should be investigated. Further, some studies recommended that further study comparing their used teaching approaches with the others is supposed to be implemented [49-51].

References

[1] Taber KS. Alternative conceptions in chemistry: Prevention, diagnosis and cure? The Royal Society of Chemistry, London, 2002.

[2] Karamustafaoglu S, Costu B, Ayas A. Efficiencies of periodical table material developing with simple tools [*In Turkish*: Basit araç-gereçlerle periyodik cetvel öğretiminin etkililiği]. J Turkish Sci Educ 2005;2:19-31.

[3] Nakhleh MB. Why some students don't learn chemistry? J Chem Educ 1992;69:191–196.

[4] Osborne RJ, Freyberg P. Learning in science: the Implications of children's science. Oxford, Heinemann Education, 1996.

[5] Osborne RJ, Wittrock MC. Learning science: a generative process. Sci Educ 1983;67:489–508.

[6] Bodner GM. Why good teaching fails and hard-working students do not always succeed? Spectrum 1990;28:27–32.

[7] Ozsevgec T. Determining effectiveness of student guiding material based on the 5E model in "Force and Motion" unit [*In Turkish*: Kuvvet ve Hareket Ünitesine Yönelik 5E Modeline Göre Geliştirilen Öğrenci Rehber Materyalinin Etkililiğinin Değerlendirilmesi]. J Turkish Sci Educ 2006;3:36-48.

[8] Cerrah Ozsevgec L. What do Turkish students at different ages know about their ınternal body parts both visually and verbally? J Turkish Sci Educ 2007;4:31-44.

[9] Unal S, Calik M, Ayas A, Coll RK. A review of chemical bonding studies: Needs, aims, methods of exploring students' conceptions, general knowledge claims, and students' alternative conceptions. Res Sci Technol Educ 2006;24:141-172.

[10] Carey, S. Cognitive science and science education. Am Psychologist 1986;41:1123–1130.

[11] Wandersee JH, Mintzes JJ, Novak JD. Research on alternative conceptions in science. In:Handbook of Research on Science Teaching and Learning, ed. D. Gabel, New York: Simon & Schuster Macmillan, 177-210, 1994.

[12] Calik M, Unal S, Costu B, Karatas, FO. Trends in Turkish science education. Essays in Educ 2009;23-46.

[13] Gurdal A, Bayram H, Sahin F. Ilkogretim okullarinda enerji konusunun entegrasyonu ile ogretilmesi. III. Ulusal Fen Bilimleri Egitimi Sempozyumu, Trabzon, pp 204-208, 1998 (in Turkish).

[14] Hirca N, Calik M, Akdeniz F. Investigating grade 8 students' conceptions of 'energy' and related concepts. J Turkish Sci Educ 2008;5:76-89.

[15] Taber K. Energy-by many other names. School Sci Rev 1989;70:57-62.

[16] Beynon J. Some myths surrounding energy. Physics Educ 1990;25:314–316.

[17] Brook AJ, Wells P. Conserving the circus? An alternative approach to teaching and learning about energy. Physics Educ 1988;23:80-85.

[18] Carr M, Kirkwood V. Teaching and learning about energy in New Zealand secondary school junior science classrooms. Physics Educ 1988;23:86-91.

[19] Dumanoglu F. Teaching of energy concept and energy education at secondary education, Unpublished Master Thesis. Univ. of Karadeniz Technical, Trabzon, 1997 (in Turkish).

[20] Huis CV, Berg EV. Teaching energy: A system approach. Physics Educ 1993;28:146-153.

[21] Kesidou S, Duit R. Students' conceptions of basic ideas of the second law of thermodynamics. J Res Sci Teach 1993;29:85-106.
[22] Kurnaz MA. Analysis of learning situations of the energy concept at university year 1 level, Unpublished Master Thesis. Univ. of Karadeniz Technical, Trabzon, 2007 (in Turkish).
[23] Man MF. Student's use of formal and informal knowledge about energy and the human body. Ph.D. Dissertation Curtin Univ. of Technology, 2003.
[24] Solomon J. Teaching the conservation of energy. Physics Educ 1985;20:165-170.
[25] Trumper RA longitudinal study of physics students' conceptions on energy in pre-service training for high school teachers. J Sci Educ Technol 1998;7:311-318.
[26] Hirca N. The determination of misconceptions related energy concept in the eight-level students and comparing the differences between schools. Unpublished Master Thesis. Univ. of Kafkas, Kars, 2004 (in Turkish).
[27] Warren JW. The nature of energy. European J Sci Educ 1982;4:295-297.
[28] Chisholm D. Some energetic thoughts. Physics Educ 1992:27:215-220.
[29] Domenech JL, Gil-perez D, Gras-marti A, Guisasola J, Torregrosa JM, Salinas J, Trumper R, Valdes P, Vilches A. Teaching of energy issues: A debate proposal for a global reorientation. Sci Educ 2007;16:43-64.
[30] Diakidoy IAN, Kendeou P, Ioannides C. Reading about energy: The effects of text structure in science learning and conceptual change. Contemp Educ Psychol 2003;28:335-356.
[31] Driver R, Squires A, Rushworth P, Wood-Robinson V. Making sense of secondary science: Research into children's ideas (2nd Ed.), Routledge, London, 1994.
[32] Duit R. Should energy be illustrated as something quasi-material? Int J Sci Educ 1987;9:139-145.
[33] Kruger C, Palacio D, Summers M. Surveys of English primary school teachers' conceptions of force, energy and materials. Sci Educ 1992;76:339-351
[34] Ebenezer JV, Fraser MD. First year chemical engineering students' conception of energy in solution processes: Phenomenographic categories for common knowledge construction. Sci Educ 2001;85:509-535.
[35] Gayford CG. Some aspects of the problems of teaching about energy in school biology. Europ J Sci Educ 1986;8:443-450.
[36] Liu X, Ebenezer J, Fraser DM. Structural characteristics of university engineering students' conceptions of energy. J Res Sci Teach 2002;39:423-441.
[37] Duit R. Learning the energy concept in school-empirical results from the Philippines and West Germany. Physics Educ 1984;19:59–66.
[38] Trumper R, Gorsky P. Learning about energy: the influence of alternative frameworks, cognitive levels, and closed-mindedness. J Res Sci Teach 1993;30:637-648.
[39] Pinto R, Couso D, Gutierrez R. Using research on teachers' transformations of innovations to inform teacher education. The case of energy degradation. Sci Educ 2004;89:38-55.
[40] Calik M, Ayas A, Ebenezer JV. A review of solution chemistry studies: insights into students' conceptions. J Sci Educ Technol 2005;14:29-50.
[41] Unal S, Calik M, Ayas A, Coll RK. A review of chemical bounding studies: needs, aims, methods of exploring students' conceptions, general knowledge claims and students' alternative conceptions. Res Sci Technol Educ 2006;24:141-172.

[42] Trumper R. Being constructive: An alternative approach to the teaching of the energy concept, part one. Int J Sci Educ 1990;12:343-354.
[43] Trumper R. Energy and a constructivist way of teaching. Physics Educ 1990;25:208-212.
[44] Trumper R. Being constructive: An alternative approach to the teaching of the energy concept, part two. Int J Sci Educ 1991;13:1-10.
[45] Aydın G, Günay Balım A. Yapilandirmaci yaklasima gore modellendirilmis disiplinler arasi uygulama: Enerji konularinin ogretimi. Ankara Universitesi Egitim Bilimleri Fakultesi Dergisi 2005;38:145-166 (in Turkish).
[46] Kirkwood V, Carr M. Final report: Learning in Science Project (Energy), Centre for Science and Mathematics Education Research, University of Waikato, Hamilton, 1988.
[47] Kirkwood V, Carr M. A valuable teaching approach: some insights from LISP (Energy), Physics Educ 1989;24:332-334.
[48] Fry M, Dimeo L, Wilson C, Sadler J, Fawns R. A new approach to teaching “energy and change”: using an abstract picture language to teach thermodynamic thinking in junior science classes. Aust Sci Teach J 2003;49:36-43.
[49] Heuvelen AV, Zou X. Multiple representations of work-energy processes. Am J Phys 2001;69:184-194.
[50] Horner ML, Jeng M, Lindell R. Comparison of teaching methods for energy conservation, Physics Education Research Conference, AIP Conf. Proceedings 883 (161), 2006.
[51] Mutimucuio I. Multiple representations of energy processes in mechanical energy systems. Research and quality of science education, ESERA Conference, Netherlands, 2003. http://www1.phys.uu.nl/esera2003/programme/pdf%5C164S.pdf.
[52] Trumper R. Children’s energy concept: a cross-age study. Int J Sci Educ 1993;15:139-148.
[53] Tsagliotis N. Hands-on science activities for the teaching and learning of mechanical energy with 6th grade primary school children in Greece. Hands-on Science: Science in a changing Education, University of Crete campus at Rethymno, Greece, July 13-16, 2005.
[54] Papadouris N, Constantinou CP. Design, development and validation of a teaching proposal for energy: results from a pilot implementation, GIREP, Amsterdam, 2006.
[55] Coll R, Treagust D. Learners’ use of analogy and alternative conceptions for chemical bonding: A cross-age study. Aust Sci Teach Jl 2001;48:24-32.
[56] Calik M, Ayas A. A comparison of level of understanding of grade 8 students and science student teachers related to selected chemistry concepts. J Res Sci Teach 2005;42: 638-667.
[57] Nakhleh MB. Why some pre-service teacher trainees don’t learn chemistry. J Chem Educ 1992;69:191-196.
[58] Taylor N, Coll R. The use of analogy in the teaching of solubility to preservice primary teachers. Aust Sci Teach J 1997;43:58-64.
[59] Kim, S. & Van Dusen, L.M. The role of prior knowledge and elaboration in text comprehension and memory: A comparison of self-generated and text provided elaboration. Am J Psychol 1998;111:353-378.
[60] Spilich GJ, Vesonder GT, Chiesi HL, Voss JF. Text processing of domain-related information for individuals with high and low domain knowledge. J Verbal Learn Verbal Behavior 1979;18:275-290.
[61] Nakhleh MB, Mitchell RC. Concept learning versus problem solving, J Chem Educ 1993;70:190–192.

[62] Nurrenbern SC, Pickering M. Concept learning versus problem solving: is there a difference? J Chem Educ 1987;64:508–510.
[63] Cepni S. Arastirma ve proje calismalarina giris, Uc Yol Kultur Merkezi, Trabzon, 2005 (in Turkish).
[64] Kochis B. Classroom research: An introduction. 2008; Retrieved September 21, 2008. Available from http://www.evergreen.edu/washcenter/resources/acl/c1.html
[65] Guba EG, Lincoln YS. Fourth generation evaluation. Newbury Park, California: Sage, 1989.
[66] Harrison AG, Treagust DF. Learning about atoms, molecules, and chemical bonds: A case study of multiple-model use in grade 11 chemistry. Sci Educ 2000;84:352-381.
[67] Osborne RJ, Cosgrove MM. Children's conceptions of the changes of state of water. J Res Sci Teach 1983;20:825-838.
[68] Posner JG, Gertzog WA. The clinical interview and the measurement of conceptual change. Sci Educ 1982;66:195-209.
[69] Miller H, Hunn GD. Using group discussions to improve social problem-solving and learning. Education (Chula Vista, CA) 2001;121:470–475.
[70] Duit R. Students' notions about the energy concept-before and after physics instruction. In W. Jung, H. Pfundt and C. Rhöneck (eds), Proceedings of the International Workshop 'Problems Concerning Students' Representations of Physics and Chemistry Knowledge', Ludwigsburg, 1981, pp 268-319.
[71] Kruger C. Some primary teachers' ideas about energy. Physics Education 1990;25:86-91.
[72] Kucuk M, Cepni S, Gökdere M. Turkish primary school students' alternative conceptions about work, power and energy. J Phys Teach Educ 2005;3:22-28.
[73] Sefton I. Understanding energy. Proceedings of 11th Biennial Science Teachers' Workshop, 2004, the University of Sydney.
[74] Martinas K. Energy in Physics and in Economy. Interdicip Descrip Complex Sys 2005;3:44-58.
[75] Trumper R. Applying conceptual conflict strategies in the learning of the energy concept. Res Sci Technol Educ 1997;15:5-18.