The effect of teaching in native and foreign language on students' conceptual understanding in science courses

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Abstract

The effectiveness of teaching academic courses such as mathematics and science in a foreign language has been investigated by several international studies in the literature. Even though the studies conducted have brought up contradictory results, most of them reveal that learning academic courses through a foreign language medium may pose conceptual, linguistic and psychological problems. Until now no research investigating the effect of foreign language on conceptual understanding has been conducted in Turkey. In this study, the effect of teaching in a foreign language on students' understanding the concept of Energy in a science course was investigated. Causal-comparative research design was used to determine the differences between students who took the science course in native and foreign language and the effect of language on conceptual understanding. The results indicated that students who were taught "Energy" in a foreign language, English, had more misconceptions than the students who were taught in their native language, Turkish.

Introduction

Social awareness of and efforts spent on foreign language teaching have been clearly increasing in Turkey for years. Along with this awareness and effort, language teaching has undergone many fluctuations and dramatic shifts over the years resulting in more emphasis on the need for all students to become competent language learners.

These fluctuations and shifts in foreign language teaching in Turkey have brought about striking changes which have created several problems as well. One of these problems is related to the selection of schools and their program content. In Turkey, after compulsory elementary school, students study hard to get into state or private secondary schools where they have one year preparatory stage and follow an immersion program. They have to take a central exam to be a student there. These schools use English as the medium for instruction for mathematics, sciences and other academic subjects. Other secondary schools which also accept students after this central exam teach academic courses in the native language, Turkish, and teach English as a course for four hours a week. The differences between these two systems, in the course of time, have raised issues such as students' attainments levels in courses like mathematics and science since these students have a central university exam in Turkish. Thus, foreign language teaching has vacillated between the two approaches in the Turkish educational system: teaching academic courses through foreign language and native language (Koksal, 2002; Koksal, 2003).

Never-ending discussions and criticism of the effectiveness of teaching in a foreign language and the methods to be followed call more attention to this problem in Turkey. It is especially salient at the present time because government policy seems to be in favour of abandoning foreign language as a medium for instruction in secondary schools. The main objections against the use of foreign language as the medium for instruction are students' misconceptions in academic subjects and their academic failure. However, studies across the country related to those discussions are inadequate and need further research, as stated by the Ministry of Education, and several universities and experts in Turkey (Baskan, 1978; Demircan, 1988; Ministry of Education; 1990, 1996).

Research done outside Turkey has looked into the effect of teaching academic subjects in foreign languages as well as bilingual education programs covering problems related to psychology, linguistics and exams. Having conducted several studies concerning the effect of foreign language, Cummins (1981a; 1989; 1992) highlights two levels of language proficiency: the Basic Interpersonal Communicative Skills (BICS) and the Cognitive Academic Language Proficiency (CALP). The former (BISC) represents the language of natural, informal conversation, whereas the latter (CALP) is the type of language proficiency needed to read textbooks, participate in dialogue and debate, and provide written tests. In other words, CALP requires both higher levels of language and cognitive processes in order to develop the language proficiency needed for success and achievement in school. Cummins (1982), Chamot (1981) and Shuy (1981) liken the relationship of language proficiency and academic achievement to an iceberg. While CALP, measuring higher levels of skills, is represented below the waterline, BICS, measuring lower levels of skills, is represented above the surface of the water. The studies by Krashen and Biber (1987), Rosenthal (1996) and Spurlin (1995) support the results by Cummins (1981a; 1982) and state that students who have not developed their CALP could be at a disadvantage in studying academic subjects and science in particular because this course requires an in-depth understanding of concepts acquired by reading textbooks, participating in dialogue and debate, and responding to questions in tests. Once again, stressing the difference between CALP and BICS, educational and linguistic theorists (Cummins, 1981a; Krashen, 1982 and Krashen, Long and Scarcella, 1979) explain that foreign language students may become quite proficient in the grammar, vocabulary and sentence structure of the English language, but may lack the necessary cognitive academic language proficiency to learn the subject matter in science courses.

A study by Johnstone and Selepeng (2001) backs up the claims by Cummins (1981b, 1982; Spurlin, 1995; Krashen, 1982). Johnstone and Selepeng (2001) state that students struggling to learn science in a second language lose at least 20 percent of their capacity to reason and understand in the process. This study has implications for countries which teach their students through the medium of a foreign language rather than in native language. Short and Spanos (1989) claim that basic proficiency is not adequate to perform the more demanding tasks required in academic courses since students do not have exposure to, or lack an understanding of the vocabulary and context-specific language.

The effects of bilingual education on academic subjects and its implications have also been investigated. Research on bilingual education programs and academic achievement has shown that bilingual program students made dramatic gains compared to the success of students schooled in second language only. The study by Collier showed that after 4-5 years of instruction, bilingual program students achieved dramatically whereas the English-only group dropped significantly below their grade level (1989, p. 522). Several studies have also shown that bilingualism may be positively associated with cognitive and academic performance (Duncan and De Avila, 1979; Kessler and Quinn, 1980; Bain and Yu, 1980; Swain and Lapkin, 1981).

Studies by Cassels and Johnstone (1983, 1985), Pollnick and Rutherford, (1993) reveal that learning academic courses through the medium of English poses problems for students whose mother tongue is not English. The explanations given for these problems are linguistic and psychological. Studies exploring the underlying psychological problems indicate that second language learners are frustrated by failure to see meaning in texts and start to have a tendency toward rote-learning. Therefore, not much is stored in memory since what is learned by rote is easily forgotten. Linguistic effects are a result of one's lack of knowledge of grammar, rules of syntax, as well as meanings of words used in different contexts. Poor knowledge of these rules puts second-language learners at a disadvantage, being less able to see meaning in texts, when compared with first language counterparts who have been exposed to inherent and informal methods of learning their language at an early stage (Howe, 1970; Johnstone and Selepeng, 2001).

The results of the study investigating the effect of language on performance of second language students in science examinations by Bird and Welford (1995) also showed the effect was significant. There were significant differences in performance of modified forms of the questions between British school pupils and pupils for whom English was the second language. The study gave a clear indication that the wording of questions in science examinations was a real influence on the performance of second language students.

The studies mentioned above are consistent with Vygotsky's perspective on development and learning. Vygotsky (1978) proposed that the role of language in the development of understanding can be explained in two ways: First, language accommodates a medium for learning. This means that learning can basically take place in a social context and social interaction is the essence of learning. Second, language is a tool which helps the child to construct a way of thinking. Vygotsky considers that students' understanding is formed and social experience is internalized through two-stage transformation: social level (interpsychological) and individual level (intrapsychological). Vygotsky strongly claims that concepts can not be acquired in conscious form without language and a child can not have a conscious understanding of concepts before they are explained in a related context using language (Vygostky, 1978).

In the light of these studies, in this study, the effect of a foreign language, English, as a medium for instruction, on conceptual understanding of "The Energy Unit" in a science course was investigated. The reason why it was chosen is because this unit is related to everyday experiences and also covers abstract concepts. As explained by Pfundt and Duit (2000), how to teach the topic of 'energy' is investigated in many studies because of its nature, containing abstract concepts.

The Ministry of Education and several universities have stated that no research related to the effect of foreign languages on conceptual understanding has yet been conducted in Turkey and the results of these types of studies are needed to inform and identify government policies and education targets. This study is of particular importance because several changes in schools following the immersion program are being planned in the Turkish educational system (Ministry of Education, 1990; 1996).

Purpose

The main objectives of the study are

i) to investigate the differences in conceptual understanding of "The Energy Unit" between students who study science in the native language and a foreign language;

ii) to compare the performance of students who study in the native language and in a foreign language on problems based on conceptual understanding;

iii) to generate suggestions for better conceptual understanding and the ways of teaching an energy unit taking into consideration the effect of language.

Research Questions

The research questions for the study are:-

i) Are there any quantitative differences between students who study science in the native language and a foreign language in terms of conceptual understanding of "The Energy Unit"?

ii) Are there any qualitative differences between students who study science in the native language and a foreign language in terms of conceptual understanding of "The Energy Unit"?

Method

Procedure

First, a research design and a timetable concerning the pilot study, interviews with the teachers, achievement and conceptual understanding tests were identified. Necessary permissions were obtained in order to carry out the research.

In this study, causal-comparative research design was used. Causal-comparative design determines the cause, or reason, for existing differences in the behaviour or status of groups. This design is retrospective; that is, it starts with an effect and seeks its possible causes (Gay and Airasian, 2000). Since this study was conducted to determine the differences between students who took the science course in native and foreign language and the effect of language on conceptual understanding, this approach was decided to be used.

The research was conducted at two types of schools - one following an immersion program, English, and the other teaching academic courses in the native language, Turkish- because they accept students based on their success identified by a nation-wide standardized central exam. Thus, the two schools both had students with a similar level of achievement based on this exam. In addition to this central exam, an achievement test was administered to students to identify groups of equal achieving students at each school. The test aimed to evaluate the general academic achievement and to identify any significant differences between the two schools. In this study, Ss_1 refers to the students who were taught in a foreign language, English and Ss_2 refers to the students who were taught in the native language, Turkish.

Two science teachers participated in this study. One of them taught "The Energy Unit" in the native language, Turkish, while the other taught in a foreign language, English. It was not possible for researchers to find a teacher who was able to teach at both schools because of the specialized foreign language and science training required to teach the science course in English in Turkey. Thus, researchers compared the method both teachers applied in the classroom, their experiences, the curriculum, and the materials they used in the classroom. Both teachers had over 7 years teaching experience, followed the same curriculum and syllabus, and used the same materials in the classroom. They both used traditional teaching methods, teacher-centred and mostly based on questions and presentations by the teachers.

In-class observations were made by the researchers to monitor the similarity of the teaching process.

Achievement Test

The first design of the achievement test consisted of 40-multiple choice questions about the topics taught in the 8th grade science courses. These questions were chosen from standardized tests and passed through a process of refinement and validation. To do this, the questions were revised based on the reactions on the three science teachers about face validity, clarity of language and suitability for the age level concerned. Researchers did not include questions about "The Energy Unit" in the achievement test since students had not yet learned this unit.

In order to optimize the reliability and validity of the original test, the test was first given to a pilot group of 60 grade 8 students. After necessary revisions stemming from the item analyses of the pilot study, in terms of item difficulty and item discriminatory indexes, a 25-question achievement test was formed. This refined version of the test had Coefficient Alpha (or KR-20) of 0.87 and average item difficulty index of 0.65.

Before the "Energy Unit" was taught, the finalized achievement test was administered simultaneously to five 8^{th} grade classes at the English medium school and five 8^{th} grade classes where academic courses were taught in Turkish. Five classes were chosen from each school to ensure that the five classes at each school had the same science teacher. ANOVA (Analysis of Variance) was used for statistical analysis of the achievement test. The results indicated that there were significant differences among the groups in both schools [F=9,616; (p=,000<.05)] (see Table I). In order to identify which groups were equal to each other, LSD (Least Significant Difference) test was applied. Statistically, three groups from Ss_1 and three groups from Ss_2 were found to be equal. Table II shows that the means of the second (20.1579), the fourth (20.0588) and the fifth (20.8571) groups from Ss_1 are close to the sixth (20.3824), seventh (20.0000) and the tenth (20.5946) groups from Ss_2.

Table I. Comparison of 8th Grade Students Based on the Classes at Both Schools In Terms of Achievement

Source of Variance	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1007,073	9	111,897	9,616	,000
Within Groups	4107,902	353	11,637		
Total	5114,975	362			

Table II. The Results of LSD Significance Test of 8th Grade Students Based on the Classes at Both Schools.

School Type	Class	Number of Stu. (N)	Mean	Mean Difference									
				1	2	3	4	5	6	7	8	9	10
Ss1	1	38	16,5789										

	2	38	20,1579	3,579*									
	3	39	17,8718	1,293	-2,286*								
	4	34	20,0588	3,480*	-99	2,187*							
	5	35	20,8571	4,278*	699	2,985*	798						
	6	34	20,3824	3,803*	224	2,511*	-323	-475					
	7	36	20,0000	3,421*	-158	2,128*	-59	-857	-382				
Ss2	8	36	16,9444	365	-3,213*	-927	-3,114*	-3,913*	-3,438*	-3,056*			
	9	36	16,7778	199	-3,380*	-1,094	-3,281*	-4,079*	-3,605*	-3,222*	-167		
	10	37	20,5946	4,016*	437	2,723*	536	-263	212	595	3,650*	3,817*	

*The mean difference is significant at the .05 level.

After 3 equal groups at each school were identified statistically, a conceptual understanding test was given to the students after "the Energy Unit" was taught to both groups in the second term by two science teachers.

Participants

After the achievement test had been analysed, total 214 students coming from those 3 classes at each school participated in the study. 107 of the students were from the immersion programme secondary school. 63 were male and 44 were female students. The remaining 107 students were from the native language secondary school 58 were male and 49 were female students.

Instrument

The conceptual understanding test: During the process of structuring the instrument, concepts in the energy unit were first identified and a concept map was formed (see Figure 1). Meanwhile, literature about energy was reviewed to prepare the questions covering those concepts. It was decided to include six questions in the instrument, two of which were adopted from the studies of Brook and Driver (1984) and the rest of the questions were designed by the researchers. Additionally, experts' opinions were taken into consideration and the questions were translated from English into Turkish by a linguist.

The conceptual understanding test was tested on two focus groups, one from the school taught in Turkish and one from the school taught in English for piloting purposes. After interviews with experts in the field and students about the comprehensibility and clarity of the questions, the questions were revised and only four questions (see Appendix) were included in the test. Figure 1 shows the connection of the questions in the conceptual understanding test to the related concepts.

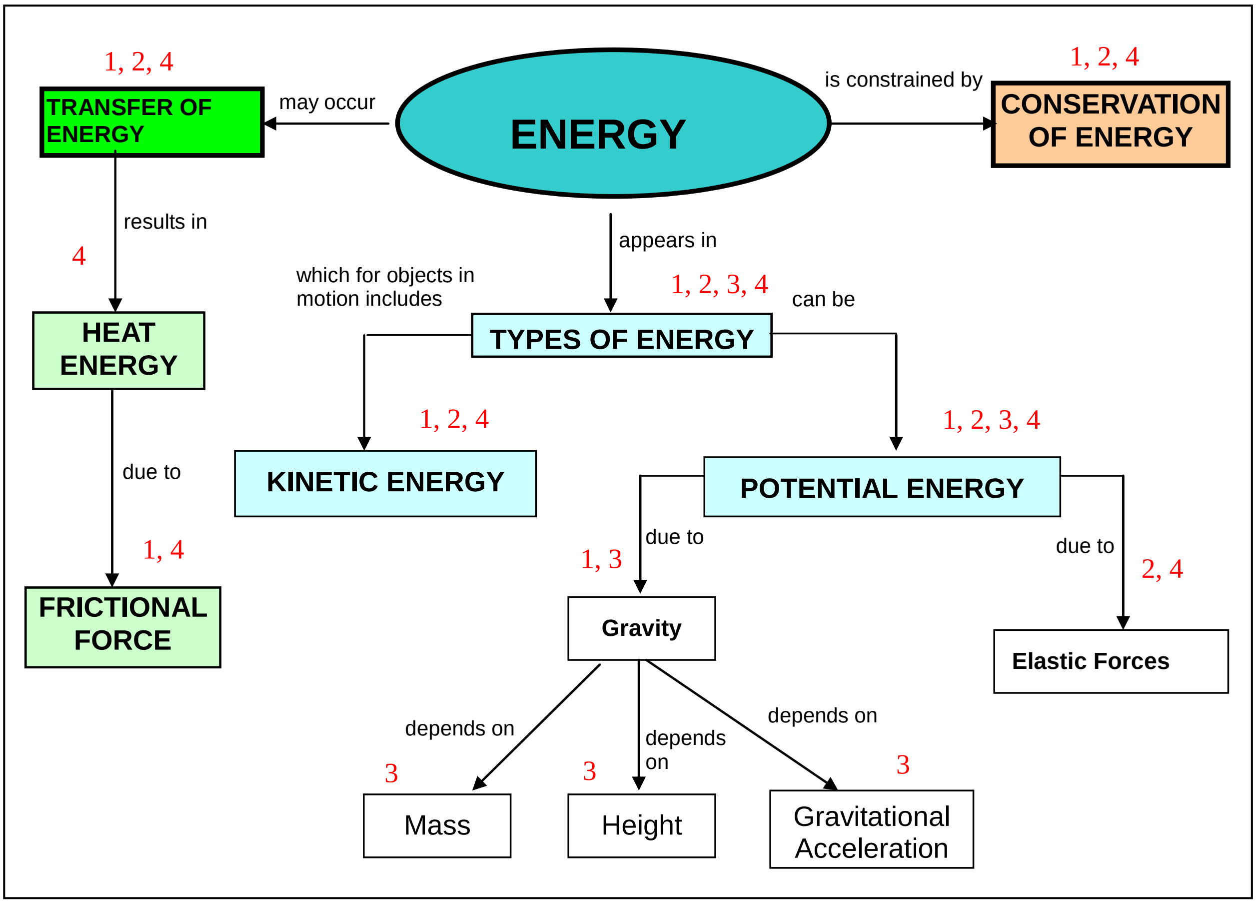

Figure 1. Concept map for energy unit and the distribution of test questions.

Questions were asked in the native language, Turkish. The reason for this was to reveal any difference between the two groups of students taught in Turkish and English and to identify whether students had assimilated "the Energy Unit" conceptually. If the aim were to evaluate how much they could understand in English, this would be measured with a reading comprehension paragraph. Taking those reasons into consideration, researchers decided to give the instrument in Turkish.

Data Analysis

The student responses obtained from the conceptual understanding test were coded in different categories using the same categorization process as that employed by Driver and Erickson (1983). First, the nomothetic approach was used to identify a set of scientifically acceptable response categories together with the correct response to each question developed by the researchers and experts in the field. Then, the students' answers to the open-ended questions were categorized according to scientifically acceptable or unacceptable ideas. Coding continued ideographically (Kocakulah, 1999). The response categories in the scientifically unacceptable group were later developed. Under this category, different ideas were classified into mutually exclusive sets according to the ideas related or unrelated to energy. The total percentages of students in each response category were recorded. The coding system used in the analysis of four questions is illustrated in Table III, which shows the two main categories - "scientifically acceptable arguments" and "scientifically unacceptable arguments" with their sub-categories.

Table III. Coding System Used for Students' Responses to Conceptual Understanding Test

TYPE OF RESPONSE
A. Scientifically Acceptable Arguments
1. Full Argument
2. Part of Argument
B. Scientifically Unacceptable Arguments
1. Response Related to Energy
2. Response Related to Other Inappropriate Ideas
C. Uncodeable response
D. No Response

Findings

Findings of the conceptual understanding test are presented quantitatively and qualitatively. In quantitative findings, responses given to four-open ended questions by the two groups of students were analysed in percentages. In qualitative analysis, responses to open-ended questions were interpreted conceptually.

Quantitative Findings

The findings are presented and discussed separately question by question.

Table IV. Distribution of Students' Responses in Conceptual Understanding Test.

Scientifically Acceptable Arguments	**Skier Question**			**Clockwork mouse Question**			**Porter Question**			**Compressed Spring Question**		
	Ss1	Ss2	Df*	Ss1	Ss2	Df	Ss1	Ss2	Df	Ss1	Ss2	Df
Full Argument	2.80	11.21	8.41	9.34	10.28	0.94	4.67	16.82	12.15	9.34	22.43	13.09
Part of Argument	3.74	14.02	10.28	32.71	47.67	14.96	13.08	13.08	0.00	12.15	30.84	18.69
Scientifically Unacceptable Arguments			18.69			15.90			12.15			31.78
Response Related to Energy	26.17	14.95	11.22	41.13	29.90	11.23	63.55	53.27	10.28	40.20	35.51	4.69
Response Related to Other Inappropriate Ideas	61.68	54.21	7.47	9.34	6.54	2.80	16.83	14.96	1.87	25.23	5.61	19.62
Uncodeable Responses	4.67	4.67	0.00	6.54	3.74	2.80	1.87	1.87	0.00	10.28	5.61	4.67
No Response	0.94	0.94	0.00	0.94	1.87	0.93	0.00	0.00	0.00	2.80	0.00	2.80

**Df: shows the difference between Ss1 and Ss2*

Analysis of the Skier question:

Skier question (see Appendix) was to evaluate comprehensibility level of concepts concerning "transfer of energy", "kinetic and potential energy" (see Figure 1). The results showed a difference of 18.69% in favour of Ss2. This shows that those who studied the science course in the native language were capable of giving more scientifically acceptable explanations than those who studied in the foreign language (see Table IV).

Analysis of the Clockwork mouse question:

Clockwork mouse question (see Appendix) is related to the concepts of "transfer of energy" and "potential energy of a spring" and aims to evaluate students' ability to synthesize. As Table IV clearly shows that the difference between the percentages of the students at both schools who gave full arguments has decreased to 0.94%. On the other hand, the difference between the two groups regarding the scientifically unacceptable responses concerning "the concept of energy" has been found to be 11.23%, which shows that more Ss1 lack the ability to use coherent conceptual explanations related to energy than Ss2. The results also indicated that 9.34% of Ss1 and 6.54% of Ss2 gave scientifically wrong responses. A difference of 2.80% can be interpreted as showing that Ss1 have more misconceptions and difficulties in explaining the question than Ss2 do.

Analysis of the Porter question:

Students were asked to give an explanation of the concept of "potential energy" based on mass, height and gravitational acceleration. The analysis of the Porter question (see Appendix) shows that 16.82% of Ss2 answered this question correctly as opposed to only 4.67% of Ss1. There has been no difference found between the two schools concerning scientifically acceptable and partly correct responses. The striking point, in view of the results, is the difference between the percentages of the two groups of students who gave scientifically unacceptable responses. While the percentage of Ss2 who used the concept of energy but scientifically wrong is 53.27%, the percentage of Ss1 is 63.55%. A difference of 10.28% indicates that Ss1 had more misconceptions concerning "energy" than Ss2 had. Furthermore, it is seen that the number of Ss1 giving wrong explanations unrelated to energy is more than the number of Ss2 (1.87%).

Analysis of the Compressed spring question:

Compressed spring question (see Appendix) aims to evaluate comprehensibility of "kinetic energy", "potential energy of a string", "heat energy" and "frictional force" by the two groups of students. It is striking that more Ss2 gave completely correct and partially correct responses than Ss1 did (31.78%). In addition, it should be noted that percentage of scientifically unacceptable responses given by Ss1 is also higher than the percentage given by Ss2 (24.31%).

Quantitative findings show that students at the English medium school gave more scientifically unacceptable arguments than students at the native language school. The following section covers qualitative findings in detail related to students' responses at both schools.

Qualitative Findings

This section examines samples of misconceptions. First, responses were categorized for each question in the conceptual understanding test. Analysis revealed that Ss1 used quite different concepts related to the questions. This situation yielded the fact that more response categories were given by Ss1 than were given by Ss2, which might demonstrate that Ss1 had more misconceptions than Ss2 did. Second, each category was examined in detail and common misconceptions were identified. This process was particularly important for the researchers to bring up the matter of difficulties in learning since those misconceptions were used in all responses by many students. Table V shows some of the striking misconceptions given to the questions by students.

Table V. Common Misconceptions Identified in Students' Responses

Common Misconceptions	Ss1(%)	Ss2(%)
An object can't continue moving if there is no friction force	30.84	28.03
It is necessary to give an object power in order to set it in motion	36.45	19.63
When compressed, a spring has kinetic energy	28.03	14.95
An object has to stop in order to have potential energy	42.06	30.84

Only the objects at a certain height from ground have potential energy	44.86	40.19
Motionless objects do not have energy	37.38	28.03
Gravity reduces the energy which an object has. If there is gravity, there is energy loss	12.15	11.21
Objects always have potential energy	23.36	19.63
Potential energy which an object has before starting moving is more than its kinetic energy it has at the final stage of motion	17.76	14.95

Table V briefly indicates that Ss1 have more misconceptions than Ss2. Particularly the difference between two groups increases in response categories in which there are misconceptions that can be attributed to the effect of language. To illustrate, the rate of Ss1 (36.45%) stating that "it is necessary to give an object power in order to set it in motion" is more than the rate of Ss2 (19.63%). It is interesting to note that students used the concept of "power" instead of "energy" The following excerpt proves how the concept of "energy" becomes identical with the concept of "power".

> "When Ayse winds up her clockwork mouse, she gives **power** to it. While the clockwork mouse is moving, its energy is reduced with friction; it has no **power** when it stops" **(from student 106)**

It is also interesting to note that students often used "force", "acceleration", "velocity" instead of the concept of "energy". For example, some Ss1 (20.56%) used expressions such as "Energy=Force x Distance" and "energy equals to work". As indicated in Table V, 28.03% of Ss1 and 14.95% of Ss2 confused "potential energy" with "kinetic energy" and explained the question related to the compressed spring as follows:

> "spring has kinetic energy when it is compressed" **(from student 22)**

Table V indicates that students have many misconceptions about "potential energy". The idea that an object has to stop in order to have potential energy was accepted by 42.06% of Ss1 and 30.84% of Ss2. Students at English medium instruction school (44.86%) and students at native language instruction school (40.19%) thought that only the objects at a certain height from ground have potential energy. Moreover, 23.36% of Ss_1 and 19.63% of Ss_2 explained that objects always have potential energy. Compared to Ss_2, more Ss_1 (37.38%) stated that motionless objects do not have energy. In the case of clockwork mouse question, students reasoned that the clockwork mouse's energy would depend on its movement, in the sense that the clockwork mouse would only have energy when moving, or would have the most energy when moving.

The reasons why students have many misconceptions related to potential energy, transfer of energy, conservation of energy, and frictional force are explained with samples as below:

Responses Including Unacceptable Ideas about Potential Energy

Students should know the concept of "potential energy" in order to explain the situations given for the questions of 1, 2 and 4. However, it is seen that both groups of students had difficulty in explaining the concept of "potential energy". Ss_1 attributed different meanings to "the concept of potential" due to its meanings in foreign language. The concept "potential" was explained by many students as an energy already existing in the structures of objects. This misconception might have stemmed from the dictionaries that students used. When defined in dictionaries, the word "potential" is explained as "power; force, potential as existing in possibility; not at present active or developed, but able to become so".

Samples of answers by Ss_1 about potential energy are outlined below. For instance, 20 students responded the question by using a similar explanation;

> "Skier has potential energy as long as he does not move" **(an example from student 72)**

while 19 students referred to potential energy such as:

> "A clockwork mouse has potential energy when it is not moving. Potential energy is transferred into kinetic energy when it moves. That is, it consumes more energy and it has only potential energy when it stops." **(an example from student 93)**

As indicated in Table V and in students' responses, Ss1 do not have scientifically acceptable ideas about when and how potential energy is used.

Responses Indicating the Lack of Understanding about the Transfer of Energy

The students were asked to explain *"how one form of energy is transferred into different form?"* which related to questions 1, 2 and 4. Ss1 gave variety of explanations concerning those questions compared to the Ss2. Particularly the concepts they used in their responses indicated diversity. It was seen that Ss1 often used "release of energy", "degradation of energy" and 'the waste of energy" instead of using 'transfer of energy". The following explanation given by student 91 is an example of the lack of understanding about 'transfer of energy":

> "A clockwork mouse has state energy while motionless. After it stops moving, and while it is motionless, it still has state energy. When Ayse winds up the mouse, it has got potential energy. When the potential energy is consumed, the potential energy of mouse is ready to turn into kinetic energy. When the mouse starts moving, kinetic energy is released and it has the highest energy in this state"

Another student who could not explain the transformation of energy from one form into different form gave the following explanation;

> "Before Ayse winds up the clockwork mouse it has no energy. While winding up the clockwork mouse, some of Ayse's energy passes through the clockwork mouse" **(an example from student 48)**

In this example, the student thinks that the transfer of energy is the transmitting of energy from one form (Ayse) to another (the clockwork mouse) without any change. In fact, the answer should have indicated that Ayse's energy is transferred to the clockwork mouse as potential energy.

Situations in Which Conservation of Energy is Considered as Conservation of Velocities

While answering the Skier question, students were expected to consider that total energy is conserved during transformation and that the energy is changed into a different form.

Responses concerning conservation of energy reveal that both groups had difficulty in explaining "the transfer of kinetic energy and potential energy". In frictionless systems, however, Ss1, attributed the source of kinetic energy (which objects have due to motion) only to the concept of velocity (which objects inherently have). Ss1 students thought that the kinetic energy of those objects was already formed at the moment of movement due to their intrinsic velocities they already had instead of thinking that the objects had potential energy. They explained conservation of energy as conservation of velocity. The following example is given to indicate how 20 students in the Ss1 group used the term "velocity" instead of 'kinetic energy".

> "Murat will lose velocity while skiing down from hill A and climbing up hill B. He will start climbing up at hill C with the help of gained velocity while skiing down at hill B. But, his speed will be zero before he comes to summit C due to gravity and he will start skiing back. He will ski reversely, with gained velocity at hill C, but he will be unable to reach the summit of hill B since his velocity again comes to zero."
> **(an example from student 12)**

This explanation proves that the student ignored the concepts of "potential energy and kinetics energy" and conservation of energy was explained through the speed change of the object in motion. It is certainly possible to explain the change of kinetic energy which an object has by considering the change of its speed. However, it is interesting to note that the student did not mention the word "energy". Briefly, it was stated that what changed during movement was not energy, but speed and that conservation of energy was conservation of speed.

Situations in Which Frictional Force is not Understood

It was found that students gave scientifically unacceptable answers using the concept of frictional force for the first and fourth questions even though those questions were not directly related to frictional force. When the responses are examined, Ss2 think that there will not be an action impeding the motion in situations in which there is an absence of frictional force. This is a scientifically acceptable explanation even though it does not take part in the full argument part of the student responses. On the other hand, Ss1, attributing an opposite meaning to the frictional force, stated that frictional force was a kind of force that maintains motion and motion can not be maintained without the existence of this force.

The following examples are among the typical answers which are given by 16 Ss1 students;

> "When there is no friction, the skier does not move, because there must be a frictional force between the ski and snow in order to push the ski". **(an example from student 108)**

> "The skier has to stop after a while due to lack of friction, because speed increases only in case of frictional effect" **(an example from student 84)**

or

> "If there was a friction between ski and snow, the skier could climb over the hill" **(an example from student 81)**

As seen in the extracts, although Ss2 fully comprehended the concept of "frictional force" , Ss1 have understood the opposite of what is actually true. This may be given as a concrete example which shows the effect of a foreign language on conceptual understanding.

Discussion

The analysis of responses to conceptual understanding test questions, each of which involved the use of ideas about types of energy, energy conservation and transfer, illustrated the difficulties experienced by students in using such ideas. The discussion which follows focuses on two main issues: the proportions of students using accepted ideas about energy and the types of ideas, other than the scientifically accepted ideas, commonly used by students.

The quantitative and qualitative findings indicate that students who studied "the Energy Unit" in the native language were capable of giving more scientifically acceptable explanations than those who studied in a foreign language. In other words, Ss1 used quite different concepts related to the questions and came up with more response categories, proving that they had more misconceptions. The results of this study are consistent with the results of several studies which suggest that students who have not developed their cognitive academic language proficiency could be at a disadvantage in studying academic subjects and science in particular since this course requires reading textbooks to gain a deep understanding of concepts, participating in dialogue and debate, and responding to questions in tests (Cummins, 1981b, 1982; Krashen, 1982; Krashen and Biber, 1987; Rosenthal 1996; Spurlin; 1995).

As results suggest more Ss1 lack the ability to use coherent conceptual explanations related to energy than Ss2 do, although both groups of students had difficulty in explaining the questions. Results show that more Ss1 used the concept of "force" instead of "energy" and confused "potential energy" with "kinetic energy". Explanations regarding questions 1, 2, and 4 revealed that Ss1 had misconception about "transfer of energy" instead, they used "release of energy" , "degradation of energy" and "waste of energy". On the other hand, more Ss2 gave completely correct and partially correct responses when considering "kinetic energy", "potential energy of a string", "heat energy" and "frictional force" as compared to Ss1 .These results back up the claims by Johnstone and Selepeng (2001) that students who learn science in a second language lose at least 20 percent of their capacity to reason and understand the process. Claiming that basic proficiency is not adequate to perform the more demanding tasks required in academic courses, Short and Spanos (1989) suggest that students might lack conceptual understanding.

The reason why Ss1 students gave more scientifically unacceptable answers than did Ss2 can be explained by BICS and CALP (Cummins 1981a; 1982). Ss1 may have the language of natural, informal conversation, but lack language proficiency needed to read textbooks and to give scientific explanations in written tests. The fact that students are quite proficient in the grammar, vocabulary and sentence structure of the English language does not mean that they have the necessary cognitive academic language proficiency to learn the subject matter (Cummins, 1981a; Krashen, 1982).

Studies by Cassels and Johnstone (1983, 1985), Pollnick and Rutherford, (1993) reveal that learning in academic courses through the medium of English poses problems for students whose mother tongue is not English. One of these problems is rote-learning. Students who study main courses in a foreign language have difficulty connecting new and old information meaningfully. They can not store much in long term memory and lose information. Linguistic effects are also a result of one's lack of knowledge of grammar, rules of syntax as well as meanings of words used in different contexts. In this study, for example, responses to questions highlighted the idea that for many students the notions of energy and of power are strongly associated. More than one in three students focussed on the concept of power to set an object in motion, and some used the word "power" in a similar way to that in which a scientists might use "kinetic energy".

Results and Implications

The results of the study indicate that there is a considerable difference between the two groups of students: those who studied the science course in the native language (Ss_2) and those who studied in a foreign language (Ss_1). Findings showed that Ss_2 gave more scientifically acceptable answers to the questions than did Ss_1. Besides, Ss_1 had more difficulties in explaining the reasons for their answers; presumably because of the scientific language they used in their written explanations.

Abundance of scientifically unacceptable responses by Ss_1 identifies a close relationship between the language and conceptual understanding in the science course. In other words, foreign language used in the science course becomes a barrier for students. Science is a discipline in which experiential and concrete examples should be presented as an in-class process in order to improve the level of students' conceptual understanding. Thus, if students are exposed to everyday concepts by using their native language, it will be easier for them to understand scientific concepts in a classroom setting. This will take the load off the students and will give more time to present experimental examples to comprehend scientific ideas more efficiently. From the teachers' point of view, it will also be easier to diagnose scientific misconceptions by asking students to give everyday examples for the topic taught. Briefly, misconceptions in "The Energy Unit" may be overcome by encouraging students to talk about them. The more students express their own ideas about those concepts, the more they will be aware about the limitations and problems in their understanding the concepts. Therefore, the scientific language which mediates the meanings of the concepts is important and the native language should be preferred for such purposes.

The ideas which students bring into the science classroom may originate from their early experiences with the physical world. These ideas may include, for example, the knowledge that motionless objects do not have energy or that objects cannot continue moving if there is no frictional force. It may be that such intuitive ideas can be developed towards more formal scientific ideas throughout teaching about energy. The role of the teacher may be considered to be that of helping students to modify their intuitive ideas to relate them to the formal scientific ideas. This can be done by encouraging students to talk about their own intuitive ideas either in small groups or as a whole class. This may serve two purposes: firstly when students talk through their own ideas, they may use the ideas in familiar situations and thus consolidating the relationship between science theory and the experiences with which they are familiar, students' confidence in theory can be increased by using ideas to make sense of a wider range of tasks. Such tasks may involve language activities, such as explaining an industrial process or writing an imaginative piece of prose. Secondly, and perhaps more important in the case of energy, students may become aware that different people think differently, and this could provide a useful foundation upon which to introduce the scientific ideas about energy.

As stated by Vygotsky (1978), language accommodates a medium for learning and is a tool to construct a way of thinking. Learning takes place in a social context through language and students need to internalize knowledge in a related context using language. If students are not competent in that language, they may come up with misconceptions in understanding. Thus, the results of this study are consistent with several studies (Cummins, 1989; 1992; Rosenthal, 1996; Spurlin, 1995) conducted in the field in terms of the effect of teaching in a foreign language on conceptual understanding in science courses. Teaching the main courses such as mathematics and science through a foreign language may lead to misconceptions in understanding.

Consequently, students should be well informed about the different uses of words in different contexts, so that they can better understand the concept of "energy". However, this process requires time for students to investigate and discuss the related ideas in a language in which they can express themselves without any difficulty. No matter how good they are at foreign language in terms of grammar and vocabulary, language competence in a foreign language may be a handicap while expressing their own ideas for students. As the findings of the study indicate, ideas for the construction of energy conservation need to be restructured carefully and analogically. This process could be done through the native language by discussing forms of energy in relation to physical systems, investigating more novel phenomena which are related to the topic and contextualizing the concept of energy.

New regulations about teaching the academic courses in native language will help students' conceptual understanding. For further studies, it is suggested to conduct research at English medium universities in different departments such as engineering and business administration, with a wide range of samples and to come up with different ideas.

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Appendix - Conceptual Understanding Test

INSTRUCTIONS TO CANDIDATES

This instrument is not a test. It is prepared to find out your ideas about energy concepts. It is essential that you write down what you actually think about the question without considering whether your response is correct or not. Therefore, it would be very grateful if you could write the answer, which might be organised and stated the relevant ideas, to open-ended questions in the spaces provided in this instrument.

You can start to answer from any question you would like and use the blanks on this question paper for rough work. If you need more space please turn over the page and use the empty space at back.

Name of the School	Sex	
	Male☐	Female☐

Question 1: Skier

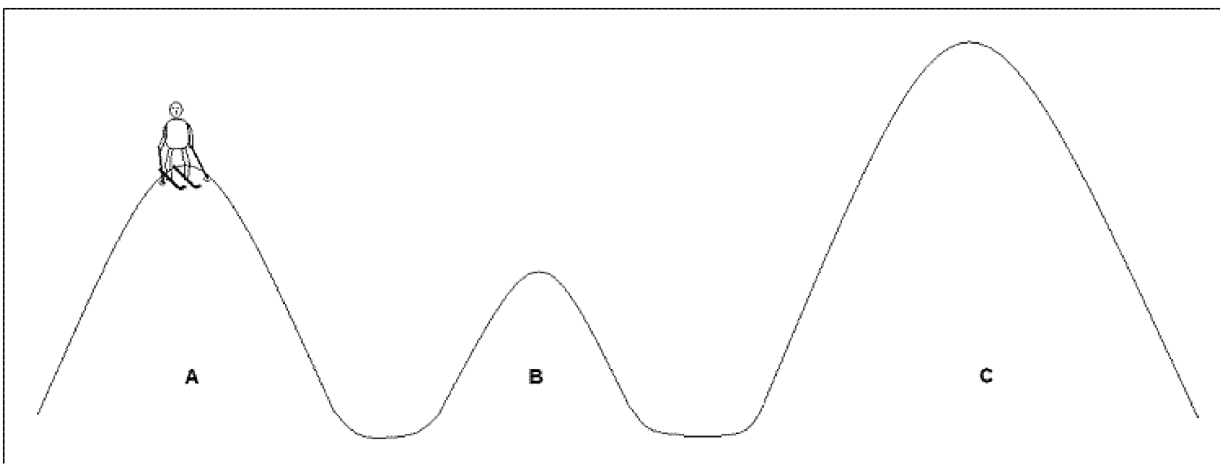
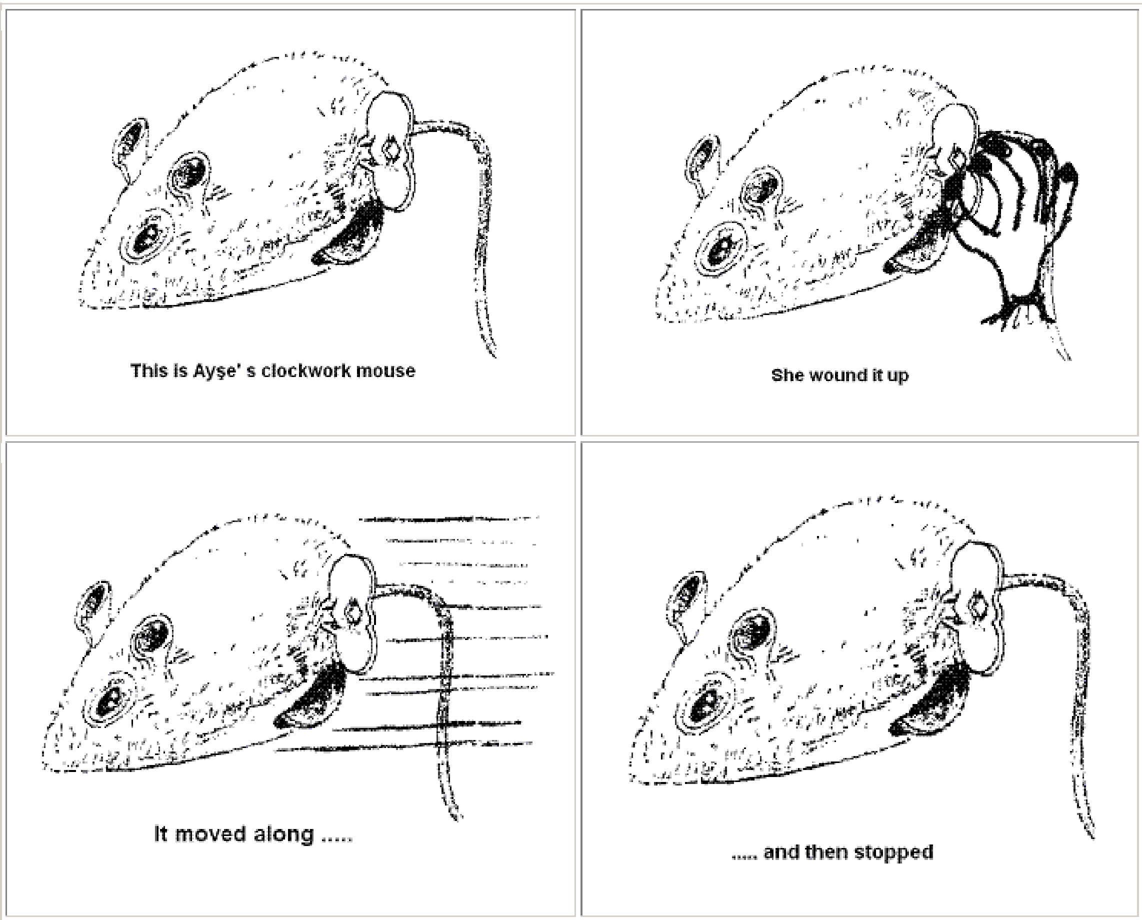


Figure above shows three hills which have different heights and are covered with snow. Murat, who is enrolled the skiing race, wants to make practice and starts skiing down the hill A without using his hands. If we ignore the friction between the ski and the snow, put an X on the picture to show how far Murat will go before he stopped.

Please give the reasons for your answer.

Question 2: Clockwork mouse



a) When did Ayse's clockwork mouse have the most energy? Tick in the box next to the one you choose.

☐ A) Before it was wound up
☐ B) When it had just been wound up
☐ C) When it was moving
☐ D) When it had stopped
☐ E) Same all the time

b) Give the reason for choosing the one you did.

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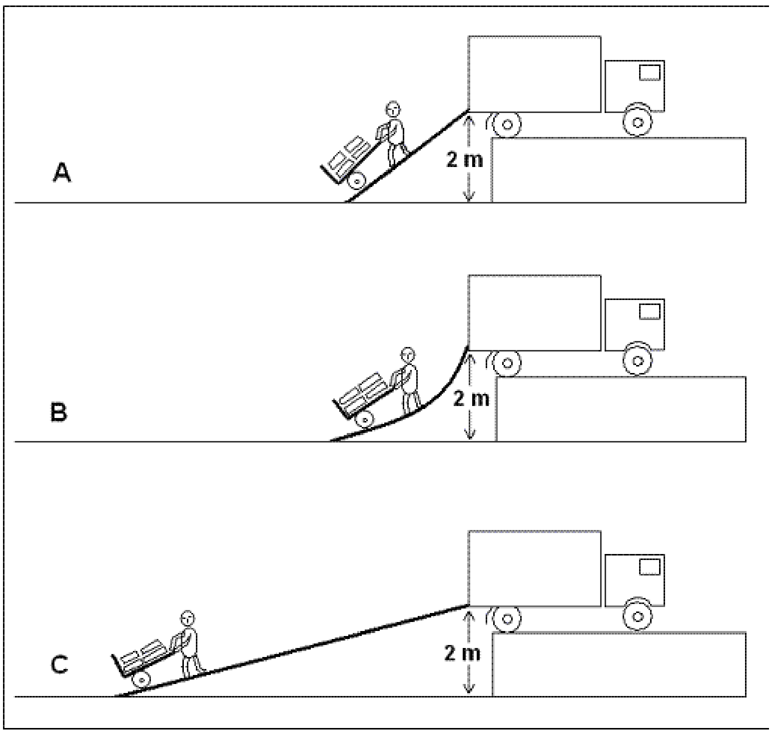
Question 3: Porter



The pictures above show the choices of a porter lifting the boxes of grapes using a wheelbarrow to load them up the lorry. The statements below are about the amount of energy he uses in each case.

a) Put a tick in the box beside the one statement you agree with.

☐ A) The energy he uses to lift the boxes with the wheelbarrow on route A is least
☐ B) The energy he uses to lift the boxes with the wheelbarrow on route B is least
☐ C) The energy he uses to lift the boxes with the wheelbarrow on route C is least
☐ D) The energy he uses to lift the boxes with the wheelbarrow is the same whichever route is chosen.

b) Give the reason for your choice of answer.

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Question 4: Compressed spring

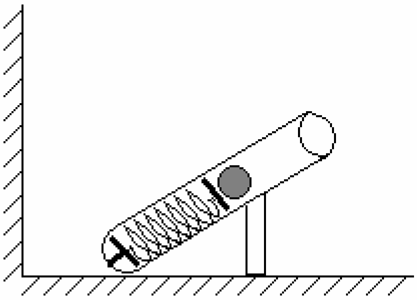
Figure 1

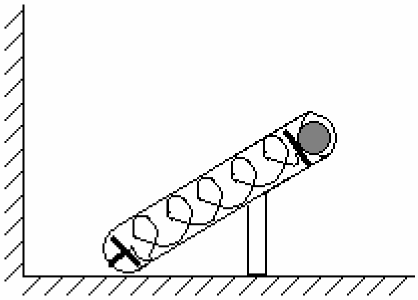
Figure 2

Figures above depict two situations on a set-up of throwing a ball. Figure 1 shows a compressed spring with a ball in front of the spring. Figure 2 shows a released spring repelling the ball which uses the gained energy. As the ball moves along the cylindrical tube, which is made of transparent glass, some heat is also produced.

Mehmet, who makes an experiment with this set-up, thoughts that the compressed spring has more energy than the repelled ball.

What is right?____

Why?____

____

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____

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THANKS FOR YOUR CO-OPERATION