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Use of the Drawing-Writing Technique to Determine the Level of Knowledge of Pre-Service Teachers Regarding Renewable Energy Sources

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Abstract

The aim of this study was to determine the level of knowledge of pre-service science teachers in Turkey regarding the different types of renewable energy sources, the methods used for obtaining energy from these sources, and the areas of use for these energy sources. Within the context of the study, the drawing-writing technique was used in order to determine the level of knowledge of the pre-service teachers. A total of 106 pre-service science teachers were asked to make drawings related to the subject and purpose of the study; they were then asked to describe the drawing they made. Based on the study results, it was determined that while the majority of pre-service teachers could list solar, wind, and hydroelectric energy as sources of renewable energy, only a few mentioned geothermal, biomass, wave, and hydrogen energy as sources of renewable energy. In addition, some of the pre-service teachers mentioned nuclear energy as a source of renewable energy, which indicated that they possessed incorrect information regarding renewable energy sources.

Keywords: renewable energy, pre-service science teacher, sustainable energy, drawing-writing technique

1. Introduction

Energy is a critically important factor and input for all industries, as well as an indispensable component of daily life. It is known that the extensive use of fossil fuels to meet the majority of the world's energy demand contributes to global warming and environmental pollution such as acid rain. In the present-day world, environmental problems are also considered to be global problems. To ensure sustainable development, many countries are nowadays increasingly focusing on the protection of the environment and on finding solutions to current environmental problems. One of the most significant approaches that are implemented for resolving environmental problems is the promotion of the use of renewable energy sources instead of fossil fuels, since renewable energy sources are far less damaging to the environment than fossil fuels. The use of fossil fuels also causes many countries to be dependent on energy imports, requiring them to allocate considerable expenses for importing energy sources. In addition to this, many countries are concerned that due to the gradual depletion of fossil fuel reserves and the dramatic rise in the world population, they will be unable to satisfy their increasing energy demands in the future. Furthermore, as energy sources have an unequal distribution across the globe, with particular resources concentrated in particular regions, the desire to possess and control these sources, and the competition for energy sources between countries, is often a source of conflict. All these factors have led to an increased interest and emphasis on using renewable energy sources for satisfying energy demands.

Renewable energy sources are environment-friendly sources of energy that are naturally renewed; they can hence be used continually without the risk of depletion (Yıldız, Sipahioğlu & Yılmaz, 2000). In addition to the fact they represent continuous and sustainable sources of energy, renewable energy sources also have the advantage of being present and accessible in every region and country of the world (Yazıcı & Arıbaş, 2011). Renewable energy sources include solar energy, wind energy, hydroelectric (hydropower) energy, geothermal energy, biomass, wave energy, and hydrogen energy (Yıldız, Sipahioğlu & Yılmaz, 2000; Liarakou, Gavrilakis & Flouri, 2009; Daugherty & Carter, 2010).

Solar energy is produced as a result of complex nuclear fusion reactions taking place within the sun. Solar energy reaches the earth in the form of radiation (Reiss, 2005). Solar energy is used in lighting, heating, and cooling systems; in photovoltaic systems (Liarakou, Gavrilakis & Flouri, 2009); in the production of electrical energy; in homes and workplaces; in agricultural technologies; in various industries; in transportation vehicles; in communication devices; and in signalization and automation systems (Ateş, 2008).

Wind energy is produced through the conversion of kinetic energy associated with air movements (which are caused by differences in air pressure) into mechanical and electrical energy by wind turbines. Wind can also be converted into mechanical energy by using windmills, which are widely used across the world for pumping water, milling grain, and extracting oil (Biçici, 2008).

The production of hydroelectric energy from hydropower (Sevinç, 2009) involves the conversion of kinetic energy associated with water movement into electrical energy (Aksu, 2011).

Geothermal energy is obtained in the form of steam and water heated by magma in the earth's crust or young volcanoes and are released through cracks on the earth's surface. Depending on the temperature of the heated water or steam, geothermal energy can be used in two different ways. Low (20-70°C) and medium (70-150°C) temperature geothermal energy is used for heating, while higher temperature (above 150°C) geothermal energy is used for producing electricity (Biçici, 2008). Geothermal energy is used in heating of water, buildings and pools, in the production of electricity, in agriculture, and in thermal tourism (Biçici, 2008; Sevinç, 2009).

All living organisms of plant and animal origin are collectively called "biomass." Biomass can also be defined as solar energy stored in the form organic carbon. Energy produced from biomass is called "biomass energy" (Forsberg, 2000). It is possible to divide biomass energy into two groups as "conventional biomass energy" and "modern biomass energy." Conventional biomass energy refers to energy produced by fuel wood obtained from forests, and also by plant and animal wastes that are utilized as fuel. Modern biomass energy refers to energy produced by using waste from the forestry industry, plant waste from agriculture, urban waste, and industrial waste associated with agriculture (Boşça & Dilek, 2005). Forestry and agriculture waste, animal waste, and other sources of biomass are widely used in various industries (especially in the agricultural industry) for heating, lighting, and cooking purposes (Biçici, 2008).

Wave energy is produced by capturing the energy of waves, which are caused by winds resulting from the differential heating of the oceans, seas, and lands around the world. Wind speed and wave size determine the amount of energy that can be obtained (Gülsaç, 2009).

Hydrogen, which can be produced from primary energy sources and various raw materials, is a synthetic fuel that releases considerable quantities of heat when burning. Hydrogen energy can be used for heating and electricity production, and also as fuel in motor vehicles. Hydrogen itself can also be used as a raw material in the chemical industry (Biçici, 2008).

The drawing-writing technique used in the present study is an effective method that enables students to demonstrate their knowledge. This technique allows natural and objective data to be obtained regarding the thoughts, perspective, views, and attitudes of students on a particular subject (Pridmore & Bendelow, 1995; Levin & Bus, 2003; Garland, 2005).

Examples of previous studies performed by using the drawing-writing technique include Pridmore & Bendelow (1995) on children's opinions regarding health, Tapsell (1997) on children's opinions about rivers, Backett-Milburn & McKie (1999) on elementary students' opinions, concerns and attitudes regarding health, Piko & Bak (2006) on the perception of children between the ages of 8-11 regarding health and disease, Pluhar, Piko, Kovacs & Uzzoli (2009) on the knowledge of children between the ages of 9-11 regarding the effect of the environment on diseases and health, Kurt, Ekici, Aktaş & Aksu (2013) on the cognitive structure of pre-service biology teachers regarding the subject of photosynthesis, and Kurt (2013) on the cognitive structure of pre-service biology teachers regarding the subject of energy.

Through much of their youth, humans take part in learning processes that involve various educational and teaching activities. All conscious behaviors demonstrated by the students within the context of these learning processes are considered to be learning products or outputs. As environmental problems are mainly caused by humans' thoughtless and irresponsible behaviors and attitudes towards the environment, these problems need to be addressed through education. Education should be used as a mean for informing individuals about environmental problems and increasing their awareness about preventive measures (Aydoğdu & Gezer, 2007). For this reason, the main purpose of environmental education should be to raise responsible individuals who are sensitive towards environmental issues (Kawashima, 1998). As renewable energy sources are highly relevant to environmental issues, students should be informed about these energy sources during their education. In this context, science teachers play an important role in raising responsible individuals who are aware of environmental issues. The aim of this study was to determine the level of knowledge of pre-service science teachers in Turkey regarding the different types of renewable energy sources, the methods used to obtain energy from these sources, and the areas of use for these energy sources.

2. Method

The study was conducted with 106 fourth-year pre-service teachers receiving education at the Faculty of Education, Department of Elementary School Science Teaching of a university in the Black Sea Region of

Turkey. In this study, data collection was performed by using the drawing-writing technique and the general survey model, which is a survey approach employed in populations consisting of a large number of individuals. The general survey model involves the screening of a population as a whole or of a certain group or sample within the population in order to reach a general conclusion concerning the population in question (Karasar, 2011). In order to determine their level of knowledge regarding renewable energy sources, the pre-service teachers were asked the following questions: "What are the sources of renewable energy? What are the areas of use of these energy sources? Please explain by drawing." The study data were analyzed in terms of percentages (%) and frequencies (f). The names of the participating pre-service teachers were kept confidential and encoded as S_1,S_2,…S_n. Examples of the drawings made by the pre-service teachers are provided within the manuscript.

3. Findings

The frequency distribution of the categories/types of renewable energy sources described in the drawings and explanations provided by the pre-service teachers are shown in Table 1.

Table 1. The frequency distribution of the categories/types of renewable energy sources described in the drawings and explanations provided by the pre-service teachers

	The Number of the Drawing and Explanations Category (f)							
	1	2	3	4	5	6	7	Total
Drawing	24	20	39	19	4	-	-	106
Writing	29	21	28	9	5	-	-	83

As can be seen in Table 1, 39 of the pre-service teachers made drawings regarding three categories of renewable energy sources. During the writing activity, 29 of the pre-service teachers provided explanations about only one category of renewable energy source, while 28 of the pre-service teachers provided explanations about three categories of renewable energy sources. None of the pre-service teachers were able to make drawings or provide explanations on six or seven categories of renewable energy sources. This observation indicated that the pre-service teachers were not knowledgeable about all types of renewable energy sources that exist.

In total, eight different categories of energy sources were described in the drawings and written explanations provided by the participating pre-service teachers. Seven of these categories were solar, wind, hydroelectric, geothermal, biomass, wave, and hydrogen energy, which are all renewable sources of energy. On the other hand, one of the categories of energy described by the pre-service teachers was nuclear energy, which is not a renewable energy source. The frequency distributions for these categories of energy are shown in Table 2.

Table 2. The frequency and percentage distribution of the drawings and written explanations provided by the pre-service teachers regarding renewable energy sources

Categories	**Frequency (f)**	**Percent (%)**
Solar energy	95	89.6
Wind energy	83	78.3
Hydroelectric energy	50	47.2
Geothermal energy	26	24.5
Biomass energy	13	12.3
Wave energy	13	12.3
Hydrogen energy	3	2.8
Nuclear energy	5	4.7

The large majority of the pre-service teachers correctly identified solar, wind, and hydroelectric energy as renewable energy sources, while a smaller number of pre-service teachers were able to identify geothermal, biomass, hydrogen, and wave energy as renewable energy sources. In addition, 5 of the pre-service teachers described nuclear energy as a renewable energy source, which indicated that these pre-service teachers had limited knowledge regarding nuclear energy.

The frequency distribution of the pre-service teachers' drawings and explanations regarding solar energy is provided in Table 3.

Table 3. The frequency distribution of the pre-service teachers' drawings and explanations regarding solar energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Solar Energy	Sun	95	-
	Home	78	-
	Solar panel	85	-
	Otomobile	13	1
	Traffic lights	4	-
	Traffic warning sign	2	-
	Street lights	4	-
	Watch	1	1
	Telephone	1	1
	Calculator	1	1
	Battery	1	-
	Hot water at home	10	63
	Heating at home	1	12
	Home lights	7	2
	Electrical energy	-	15

The large majority of the pre-service teachers made drawings that illustrated the sun as the source of solar energy, and which described solar energy as being mainly used to provide warm water in homes with the aid of solar panels. Excerpts of the answers provided by the pre-service teachers regarding solar energy are provided below as examples:

"Solar panels convert solar energy into electrical energy" (S_3).

"By installing a system on the roof of a house that captures solar radiation, solar energy can be converted to electrical energy, or be used for heating water. This allows the production of both electricity and warm water in households" (S_{10}).

"Solar energy is used in the heating systems of houses and to produce warm water" (S_{37}).

"Solar energy is the most significant source of energy. It is necessary for life on earth. It finds use in many areas and devices, such as solar panels, solar cells, and solar cooking pots" (S_{55}).

"At night, solar energy stored during the day is converted into electrical energy to light street lamps" (S_{58}).

"The sun is a source of renewable energy. In households, solar energy systems are used to provide warm water" (S_{72}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding wind energy is provided in Table 4.

Table 4. The frequency distribution of the pre-service teachers' drawings and explanations regarding wind energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Wind Energy	Wind turbine	83	-
	Electrical energy	2	47
	Lighting	-	5
	Heating	-	2

The large majority of the pre-service teachers made drawings illustrating that wind turbines are used to capture wind energy, while 47 of the pre-service teachers described that wind energy is used in the production of electrical energy. Excerpts of the answers provided by the pre-service teachers regarding wind energy are provided below as examples:

"Wind energy is used to produce electricity for household" (S_6).

"The blowing of the wind causes wind turbines located on high slopes to rotate. The rotation of the wind turbine's rotor blades produces electrical energy. The electrical energy that is produced is then conveyed from electric power plants into electricity pylons. From electricity pylons, the electrical power will reach households, workplaces, etc…, thus providing the electricity we need in our daily lives" (S_{19}).

"When the wind is blowing, the wind turbine will rotate. The rotating turbine will thus convert wind into energy. It is possible to obtain more energy by increasing the number of wind turbines" (S_{30}).

"The wind is a renewable energy source. Wind turbines are used to produce electrical energy" (S_{72}).

"Energy is captured by the wind turbines, which is then distributed to houses, workplaces, and street lamps as electrical energy" (S_{91}).

"Wind turbines, which are used to capture energy from the wind, are generally located on high areas – in other words, on hills that receive strong winds" (S_{103}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding hydroelectric energy is provided in Table 5.

Table 5. The frequency distribution of the pre-service teachers' drawings and explanations regarding hydroelectric energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Hydroelectric energy	Dam	50	-
	Electrical energy	1	33
	Lighting	1	-
	It is geothermal energy	-	2

Among the pre-service teachers, 50 made drawings that illustrated that dams convert hydropower into energy, while 33 described that hydroelectric energy is used to produce electricity. In addition, 2 of the pre-service teachers described that hydroelectric energy is produced by geothermal energy, which indicated that they confused these two types of energy with one another. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Dams can be built on rivers with inclines and high flow speeds to produce electrical energy. Power lines can then be built from the dam to the cities in order to provide electricity" (S_{11}).

"Dams are systems that produce electrical energy by using hydropower associated with the flow of water, which is a renewable energy source" (S_{67}).

"Electrical energy produced by using waters flowing through the dam can be used in many areas" (S_{75}).

"Geothermal energy provides warm water" (S_{89}).

"The kinetic energy of rivers can be converted into electrical energy" (S_{96}).

"Electrical energy is produced by using the waters held by dams; this electrical energy can then be used in homes" (S_{103}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding geothermal energy is provided in Table 6.

Table 6. The frequency distribution of the pre-service teachers' drawings and explanations regarding geothermal energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Geothermal Energy	Underground water	6	3
	Sea	-	2
	Spa	9	8
	Electrical energy	-	2
	Heating at home	-	2
	Hot water	-	1

6 of the pre-service teachers made drawings that illustrated that geothermal energy is obtained from underground water. 3 of the pre-service teachers described that the source of geothermal energy is underground water, while 2 of the pre-service teachers described that the source of geothermal energy is sea water. This finding indicated that the pre-service teachers who described sea water as the source of geothermal energy had limited information concerning this type of energy. Some of the pre-service teachers made drawings that illustrated that geothermal energy is used in thermal springs (or spas) for thermal tourism. Some of the pre-service teachers also provided written explanations that described the use of this type of energy within the context of thermal tourism. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Geothermal energy is used to provide warm water to spas and sport facilities" (S_{37}).

"Geothermal energy is obtained from water, and is used to produce electricity" (S_{70}).

"Warm water that is found underground is a source of geothermal energy. In addition, warm water obtained from underground sources also has remedial effects for many diseases" (S_{75}).

"Geothermal energy is obtained from waters that are heated underground. Underground water is heated by magma, which has very high temperatures. The heated water is then used as a source of energy. Geothermal energy can be used in households and industries" (S_{103}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding biomass energy is provided in Table 7.

Table 7. The frequency distribution of the pre-service teachers' drawings and explanations regarding biomass energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Biomass Energy	Tree	1	-
	Animal wastes	1	2
	Trash	1	1
	Waste	1	-
	Plant and animal wastes	-	2
	Plant wastes	-	1
	Fertilizer	-	1

Only a few of the pre-service teachers made drawings or provided explanations that indicated that the source of biomass energy is plant and animal waste. This observation indicated that the pre-service teachers had inadequate knowledge regarding biomass energy. In addition, it was observed that the pre-service teachers did not mention in their responses the areas of use for biomass energy. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Biomass energy sources, which are obtained from animal wastes, can be used as fuel" (S_{37}).

"Biomass energy is produced from waste" (S_{68}).

"Biomass is energy obtained from animal and plant wastes" (S_{83}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding wave energy is provided in Table 8.

Table 8. The frequency distribution of the pre-service teachers' drawings and explanations regarding wave energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Wave Energy	Wave	13	1
	Oceans	1	-
	Electrical energy	-	3

13 of the pre-service teachers made drawings illustrating that wave energy is produced from sea waves, while 1 of the pre-service teachers described the relationship between the sea and wave energy in writing. Only 3 of the pre-service teachers mentioned that wave energy is used to produce electrical energy, which indicated that the pre-service teachers had inadequate knowledge regarding the areas of use of wave energy. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Energy is produced from the ebb and flow of waves" (S_{65}).

"Electricity is produced from the movement of the waves" (S_{81}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding hydrogen energy is provided in Table 9.

Table 9. The frequency distribution of the pre-service teachers' drawings and explanations regarding hydrogen energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Hydrogen energy	Hydrogen	-	3

Only a few of the pre-service teachers described that hydrogen is the source of hydrogen energy. This

observation indicated that the pre-service teachers had inadequate knowledge regarding the production and the areas of use of hydrogen energy. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Energy produced from hydrogen is an example of renewable energy" (S_{59}).

"Hydrogen energy is the most expensive type of renewable energy. The conversion of nuclear *energy into other forms of energy is both difficult and costly"* (S_{60}).

The frequency distribution of the pre-service teachers' drawings and explanations regarding nuclear energy is provided in Table 10.

Table 10. The frequency distribution of the pre-service teachers' drawings and explanations regarding hydrogen energy

Main Category	Sub-category	Drawing (f)	Writing (f)
Nuclear energy	Nuclear station	3	-
	İt is obtained by the results crashing atoms	-	1
	Nuclear energy is obtained from the elements uranium and plutonium	-	1

Some of the pre-service teachers described nuclear energy as a renewable energy source. This observation indicated that these pre-service teachers had inadequate knowledge regarding nuclear energy. Excerpts of the answers provided by the pre-service teachers are provided below as examples:

"Nuclear energy is obtained from the elements uranium and plutonium" (S_{83}).

"It is obtained through nuclear fission. It releases tremendous amounts of energy. The electrical energy it provides is used in industries, households, and factories" (S_{103}).

Several examples of the drawings and written explanations provided by the pre-service teachers concerning the types of renewable energy sources that exist, on how energy is obtained from these sources, and on the areas of use of these energy sources are provided in Figure 1 to Figure 4.

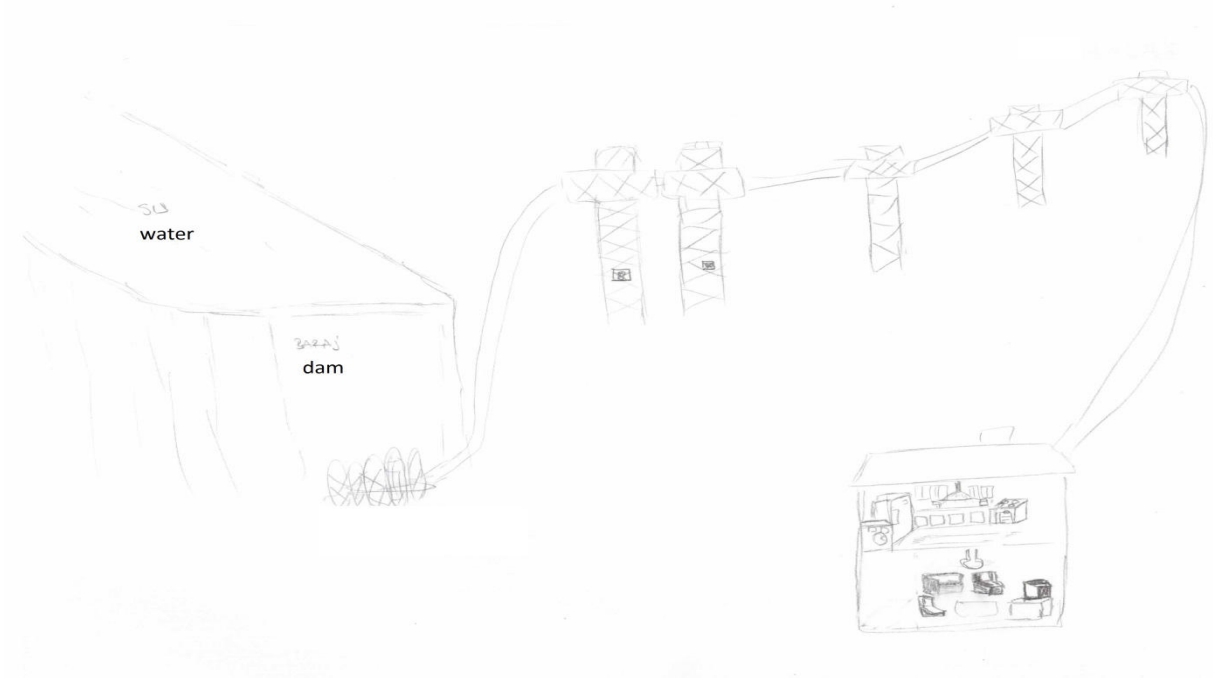

Figure 1. The drawing and written description provided by the pre-service teacher S_{16} regarding renewable energy sources

As can be seen in Figure 1, the pre-service teacher indicated in his drawing that the kinetic energy of water is converted into electrical energy by using dams, and that the obtained energy is then transmitted to households though the city's electrical grid.

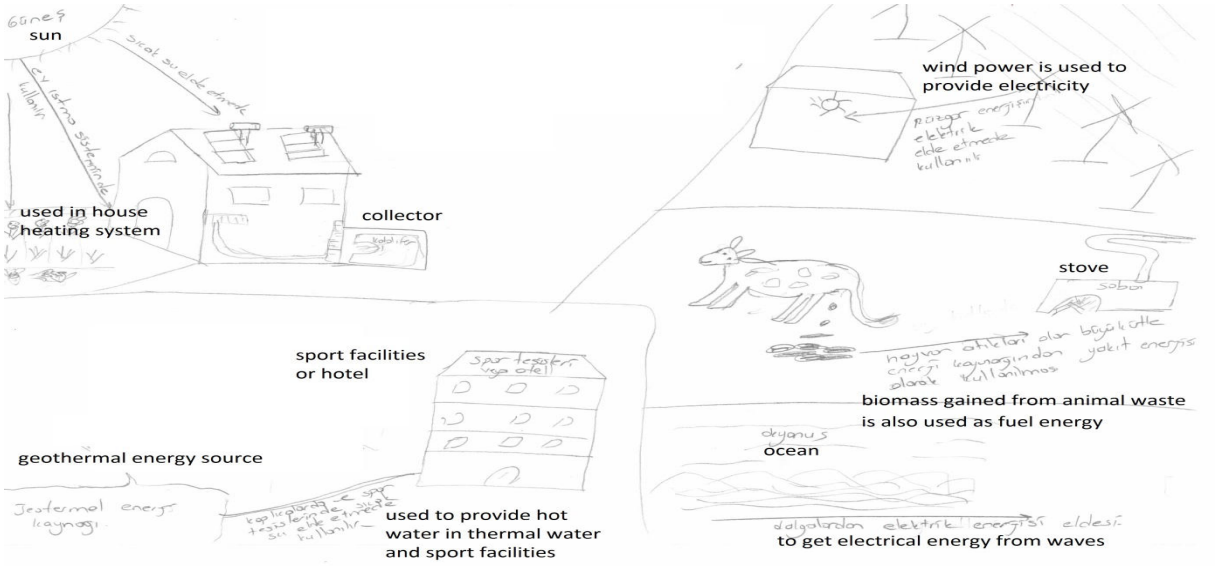

Figure 2. The drawing and written description provided by the pre-service teacher S_{37} regarding renewable energy sources.

The pre-service teacher illustrated in his drawing that solar energy is obtained/captured through solar panels and collectors, and explained that this energy is used in the heating systems of houses and to produce warm water. The pre-service teacher also explained that wind energy is converted into electrical energy by wind turbines, and made drawings illustrating that this energy is used for lighting purposes. The pre-service teacher also made drawings illustrating that geothermal energy is used in thermal springs (spas) within the context of thermal tourism. The pre-service teacher made drawings illustrating that biomass energy is obtained from animal wastes, and that it is used for heating purposes. The pre-service teacher's drawings also showed that oceans are the source of wave energy, and described that wave energy is, in turn, used to produce electrical energy.

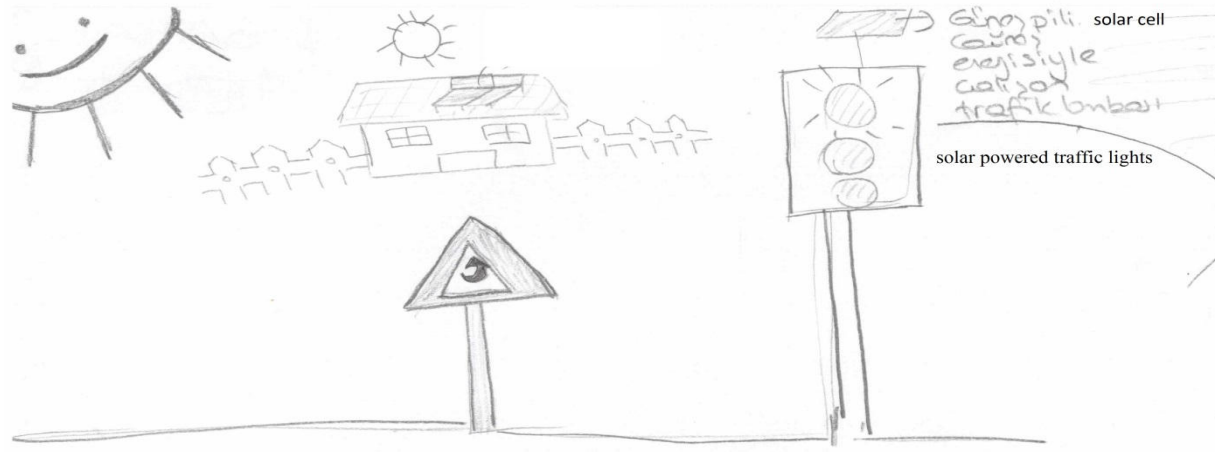

Figure 3. The drawing and written description provided by the pre-service teacher S_{47} regarding renewable energy sources

The pre-service teacher made drawings illustrating that solar energy is used at home with the aid of solar panels. In addition, the pre-service teacher explained through his drawings that solar energy is also used in traffic warning signs and in traffic lamps, by being stored in their solar cells.

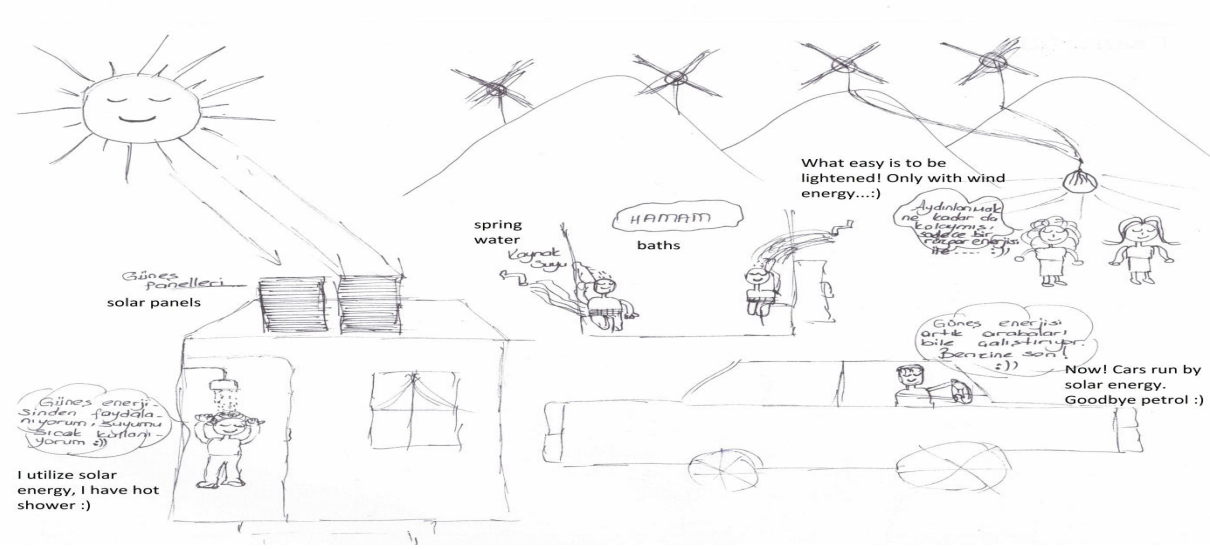

Figure 4. The drawing and written description provided by the pre-service teacher S_{56} regarding renewable energy sources

As shown in Figure 4, the pre-service teacher indicated in his drawings that solar panels convert solar energy into heat to provide warm water. In addition, the pre-service teacher also made a drawing showing that cars can function by using solar energy, and that petroleum-based fuels will no longer be necessary in the future. The pre-service teacher's drawing illustrated that wind turbines can convert wind energy into electrical energy, which can then be used for lighting. In addition, the pre-service teacher also showed in his drawings that warm water obtained from geothermal energy can be used in thermal baths.

4. Conclusions and Suggestions

The results of this study indicated that while there are seven categories of renewable energy sources (which include solar, wind, hydroelectric, geothermal, biomass, wave, and hydrogen energy), the large majority of the pre-service teachers could only draw and describe three categories of renewable energy sources, and none of the pre-service teachers could describe six or seven categories of energy sources. In addition, it was noted that some of the pre-service teachers described and illustrated nuclear energy as a type of renewable energy source, despite the fact that nuclear energy constitutes a non-renewable energy source. Although these pre-service teachers knew that uranium and plutonium are used to produce nuclear energy, they were unaware that the wastes of nuclear power plants are very hazardous. They hence erroneously described nuclear energy as a renewable energy source, illustrating that they were not very knowledgeable regarding nuclear energy.

The large majority of the pre-service teachers provided drawings and written explanations that described that solar energy is used to produce warm water for households with the aid of solar panels. It was observed that the majority of the pre-service teachers were unaware that solar energy is also used in traffic lights; in lighting systems (such as street and garden lamps); in calculators and watches; in solar ovens and solar pots; in solar cars; in heating and cooling systems; to provide electrical power to buildings; and to charge portable devices such as cell phones. In addition, it was observed that none of the pre-service teachers provided any drawings or explanations regarding the use of solar energy in agriculture to dry products and for maintaining greenhouses. They were thus unable to identify the relationship between solar energy and the vegetable and fruit products – both dried and fresh – that are produced by using this type of energy.

The majority of the pre-service teachers made drawings illustrating that wind turbines convert wind energy into electrical energy. This indicated that the pre-service teachers were fairly knowledgeable regarding this type of renewable energy. However, the pre-service teachers were only able to mention lighting and heating as the possible areas of use for electricity produced from wind energy. This indicated that the pre-service teachers were not aware of the fact that once wind energy is converted into electricity by wind turbines, the produced electrical energy can then be used in any area or system that requires electricity to function/operate.

The pre-service teachers made drawings related to hydroelectric energy by showing dams and indicating that they are used to produce electrical energy. However, they did not mention the areas of use of electricity produced by dams. Two of the pre-service teachers described that hydroelectric energy is produced by geothermal energy,

which indicated that they confused these two types of energy with one another. These pre-service teachers might have confused hydroelectric energy with geothermal energy due to the fact that both forms of energy are associated with water.

Some of the pre-service teachers described that geothermal energy is used in thermal springs within the context of thermal tourism. On the other hand, on a very limited number of pre-service teachers made drawings illustrating that geothermal energy is obtained from underground waters. Similarly, very few pre-service teachers mentioned that geothermal energy is used for producing electricity, to heat homes, and to heat water. This was probably due to the limited knowledge these pre-service teachers had regarding geothermal energy. In addition, it was observed that the pre-service teachers were not aware that geothermal energy is used for central heating and cooling; for fish farming at low temperatures; for the production of mineral drinking water; and for producing certain minerals. Two of the pre-service teachers described sea water as being the source of geothermal energy. This indicated that these pre-service teachers were unaware that underground waters are the actual source of geothermal energy.

Only a few of the pre-service teachers had any knowledge on the sources of biomass energy, while none of the pre-service teachers could list the areas of use for biomass energy. This indicated that the pre-service teachers had no knowledge regarding the fact that biomass energy is used in industry, in electricity production, in the production of biofuel, and also for heating. In their drawings and written explanations about wave energy, most of the pre-service teachers described that the sea is the source wave energy. However, very few of the pre-service teachers mentioned that wave energy is actually used to produce electricity. In addition, none of the pre-service teachers made drawings regarding hydrogen energy, and only a few were able to identify hydrogen as the source of hydrogen energy. This indicated that the pre-service teachers lacked adequate knowledge regarding hydrogen energy.

The fact that the pre-service teachers mainly mentioned and described solar, wind, hydroelectric, and geothermal energy sources is likely related to the more frequent and widespread use of these renewable energy sources in Turkey. On the other hand, it was observed that the pre-service teachers had inadequate knowledge regarding many aspects of renewable energy sources. To leave a more livable world for future generations, it is vitally important to raise conscious and responsible individuals who are aware of the importance of environmentally friendly renewable energy sources. In this context, and considering that raising consciousness and developing responsible individuals depends heavily on education, it is necessary to place greater emphasis on the subject of renewable energy in both pre-university school programs and undergraduate programs.

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