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THE EFFECT OF MULTIDIMENSIONAL ENERGY EDUCATION ON RENEWABLE ENERGY AWARENESS

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ABSTRACT

This research aims to reveal the effect of energy education, in which different teaching methods and techniques are used, on renewable energy awareness. The multidimensional energy education given within the scope of the study includes the theoretical and practical dimensions of the education, open field trips for renewable energy, and workshops. The study group consists of Vocational and Technical Anatolian high school students who will be among the decision makers of the future. In this study, qualitative and quantitative research methods were used together. One-group experimental design was used in the quantitative dimension and structured interviews were used in the qualitative dimension. Related samples t-test was used for quantitative data and content analysis was performed for qualitative data. The obtained findings show the success of multidimensional energy education in increasing energy awareness. Interview results reveal that students' statements about the environmental impacts of non-renewable energy sources increased after the education. The results of this study can help design and deliver effective energy education programs to raise awareness of renewable and non-renewable technologies and their impact on the environment.

Key Words: Awareness, energy education, renewable energy, vocational high school students

ÇOK BOYUTLU ENERJİ EĞİTİMİNİN YENİLENEBİLİR ENERJİ FARKINDALIĞINA ETKİSİ

ÖZET

Bu araştırma, farklı öğretim yöntem ve tekniklerinin kullanıldığı enerji eğitiminin yenilenebilir enerji farkındalığına etkisini ortaya çıkarmayı amaçlamaktadır. Çalışma kapsamında verilen çok boyutlu enerji eğitimi, eğitimin teorik ve pratik boyutlarını, yenilenebilir enerjiye yönelik saha gezilerini ve çalıştayları içermektedir. Çalışma grubu, geleceğin karar vericileri arasında olacak Mesleki ve Teknik Anadolu Lisesi öğrencilerinden oluşmaktadır. Bu çalışmada, nitel ve nicel araştırma yöntemleri bir arada kullanılmıştır. Nicel boyutta tek gruplu deneysel tasarım, nitel boyutta ise yapılandırılmış görüşmeler kullanılmıştır. Nicel veriler için ilgili örnekler t-testi, nitel veriler için ise içerik analizi yapılmıştır. Elde edilen bulgular çok boyutlu enerji eğitiminin enerji farkındalığını artırmadaki başarısını göstermektedir. Nitel bulgular, öğrencilerin yenilenemeyen enerji kaynaklarının çevresel etkilerine ilişkin ifadelerinin eğitim sonrasında arttığını ortaya koymaktadır. Bu çalışmanın sonuçları, yenilenebilir ve yenilenemeyen teknolojiler ve bunların çevre üzerindeki etkileri konusunda farkındalığı artırmak için etkili enerji eğitimi programlarının tasarlanmasına ve sunulmasına yardımcı olabilir.

Anahtar Kelimeler: Farkındalık, enerji eğitimi, yenilenebilir enerji, meslek lisesi öğrencileri

1. INTRODUCTION

Demographic change, population growth and rapid industrial growth have increased energy demand. Increasing energy demand has brought various environmental problems, especially climatic changes, to the agenda. Alternative energy sources have gained importance in order to minimize the environmental damage that has reached serious dimensions.

The fact that fossil resources will be depleted in a predictable time period has accelerated the trend towards renewable energy sources throughout the world. At the same time, it is predicted that radical changes in energy systems will increase the orientation towards renewable energy in the near future (Jorgenson, Stephens, & White, 2019). Renewable energy sources have more advantages over fossil fuels in terms of environment. Renewable energy sources (RES) (i.e. solar, wind, biomass, geothermal, hydroelectric) are now widely accepted as an effective response to the global climate change problem (Sargunanathan, Elango, & Mohideen, 2016; Rahman, Farrok, & Haque, 2022).

The widespread use of renewable energy can be achieved through increased public confidence, regulatory reforms, and technological progress in these resources (Sherman, 2003). Liu, Wang and Mol (2013) reported that the increase in the use of renewable energy depends on the acceptance of the individual. The individual's acceptance of renewable energy sources is possible by raising their awareness of this issue. Energy awareness can be defined as individuals' awareness of sustainable energy behaviors and is considered an important sub-dimension of environmental awareness (Seidel, 2017). Studies show that students' awareness and knowledge about renewable energy should be improved (Alawin, et al., 2016; Güven & Sülün, 2017; Assali, Khatib & Najjar, 2019). Three basic methods of raising energy awareness are: Education, incentives and visibility (Hassan, Hirst, Siemieniuch & Zobaa, 2009). Education, which is in the first place, increases awareness of renewable energy sources and ensures the widespread use of these resources (Li, Li, Öztürk & Ullah, 2022). It can also give ideas to individuals who want to become professional in this field. Individuals with professional experience in this field are required for rapid growth in renewable energy (Jennings, 2009).

Renewable energy education is expected to contribute to improving the quality of life and sustainable development (Ocetkiewicz, Tomaszewska, & Mróz, 2017). Content and teaching method are very important in education given for a sustainable future. In the last 50 years, the subject of climate change in the environmental education curriculum has been insufficient to develop students' knowledge and skills about energy systems and the forced transition from

fossil fuels (Saul & Perkins, 2022). According to DeWaters and Powers (2011), energy literacy that integrates broad information content, attitude formation and behavioral characteristics will not only enable citizens to save energy, but also help them to make appropriate energy-related decisions.

There is a common consensus that renewable energy education should be included in schools, universities and other academic institutions at different levels (Skamp, et al. 2019). However, how effective the renewable energy education will be is closely related to the way the education is given (Buldur, Bursal, Yücel & Erik, 2018). In the literature, besides out-of-school learning environments on environmental issues (Braun & Dierkes, 2017; Mullenbach, Andrejewski, & Mowen, 2019), the positive educational outcomes of technology-supported teaching are emphasized (Johnson, Horton, Mulcahy & Foth, 2017; Fraternali & Gonzalez, 2019).

This study investigates the effect of multidimensional energy education on the awareness of vocational high school students about renewable energy sources. This study is important in terms of contributing to the orientation of vocational high school students, who can be the decision makers and producers of the future, to renewable energy sources. The education of vocational high school students can be a key to ensuring the energy awareness of future generations. Within the scope of the study, answers to the following questions were sought.

- What is the effect of multidimensional energy education on cognitive and affective awareness of renewable energy sources?
- How does multidimensional energy education affect their awareness of the effects of energy resources on nature?

2. METHOD

2.1. Model of Research

In this study, qualitative and quantitative research methods were used together. While awareness about renewable energy sources will be revealed with quantitative results, quantitative findings will be supported with qualitative results. The quantitative step of the research is a single-group experimental study. The qualitative step was designed with a case study. In this step, interviews were conducted before and after the experimental application.

2.2. Study Group

The study group consists of 32 vocational high school students. 50% of the participants were female (f=16) and 50% were male (f=16). Participants were selected from vocational high schools located in the Thrace part of Turkey. 70% of the participants are studying in the field of electrical and electronic technologies/renewable energy technologies, and 30% are studying in the field of health.

2.3. Data Collection Tools

As a data collection tool, the Renewable Energy Resources Awareness Scale developed by Çakırlar-Altuntaş and Turan (2018) was used at the quantitative level. While 9 items of the scale are for affective awareness, 14 items are for cognitive awareness. While cognitive awareness is defined as being motivated towards the relevant subject and focusing on that subject (Gelen, 2004); affective awareness is the ability to identify, understand and distinguish emotions (Smith, Killgore & Lane, 2018). Affective awareness can be associated with pre-learning, learning process and post-learning (Duman & Yakar, 2017). Cronbach-α value was reported as 0.90 for the emotional dimension, 0.95 for the cognitive dimension, and a total value of 0.95.

The items of the renewable energy resources awareness scale used in the study were examined by two field experts. The structured form was composed of questions that would support the scale. The structured form used in the interviews includes the following questions:

- How do energy resources affect nature?
- Do they affect flora and fauna?
- Will they have an impact on climate change?

2.4. Data Collection Process

Before multidimensional energy education, the Renewable Energy Resources Awareness Scale and a structured interview form were applied to the participants.

Multi-dimensional energy education is a part of the TUBITAK-4004 supported nature and environment education project. It includes theoretical and practical aspects of education, technology-supported applications, interdisciplinary workshops and out-of-school learning environments. Some of the education was held in Kırklareli and some in Tekirdağ.

Within the scope of this education, open field trips were organized for the ecological importance of the Kırklareli Longoz Forest. In this way, it was ensured that the participants got to know the

ecosystem in the places they live. The importance of the sun and wind in the ecosystem was emphasized. Then, theoretical information about renewable and non-renewable energy sources is given. The operation of the wind turbine with virtual reality (VR) glasses, one of the wearable technologies, has been examined. In the workshop studies, circuits working with wind turbine and solar panels were made and tested in the open field. Wind power measurements were made in the open area. In the workshops, the effect of energy on the environment was explained using new approaches in education. On the last day, a trip was organized to areas with wind power plant (WPP) and solar power plant (SPP). Thus, energy production from renewable energy sources and their environmental effects were examined on-site. Multidimensional energy education program is given in Table 1.

Table 1. Multidimensional Energy Education Program

Education program	Educational aim	Method/Techniques
Renewable and Non-Renewable Energy Sources	To be able to explain renewable and non-renewable energy sources.	Computational thinking
Effect of Energy on the Environment	To be able to comprehend the negative effects of non-renewable energy sources on the environment and that renewable energy sources are environmentally friendly	Station technique
Effect of SPP and WPP on Flora and Fauna	To be able to comprehend the effects of SPPs and WPPs on flora and fauna	Problem solving
From Wind Energy to Electric Energy	To be able to explain how the power plants are established and the turbine models used in the process of electricity generation from wind energy.	Open and closed-ended experimentation, Computational thinking, Virtual reality
From Solar Energy to Electric Energy	To be able to explain how solar energy systems use solar energy	Open and closed-ended experiment, Computational thinking
SPP Trip	To be able to reason about the environmental effects of solar power plants	Open field excursion
WPP Trip	To be able to reason about the effects of wind power plants on the environment	Open field excursion

At the end of the Education, the Renewable Energy Resources Awareness Scale and a structured form were applied. 6 weeks after the education, the Renewable Energy Resources Awareness Scale was applied again and the permanence was examined.

2.5. Data Analysis

For the analysis of quantitative data, first of all, the normal distribution was examined. The skewness and kurtosis coefficients range from -1 to +1. Tabachnick and Fidell (2013) reported that skewness and kurtosis coefficients can be used to decide on normality in small samples. In the analysis of the normally distributed data set, the related samples t-test was used to test the

significance of the difference between the measurements. In addition, descriptive statistics of the data set were calculated. IBM SPSS Statistics 21 was used in data analysis.

Content analysis was used in the analysis of qualitative data. The obtained data was read by the two researchers. Codes were created from similar meaningful words obtained by reading under the themes of renewable and non-renewable energy sources and then, codings have been done. Concordance between codings was calculated by Miles and Huberman's (1994) reliability formula "consensus/(consensus+dispute) x100". The reliability calculated for the coding of the qualitative data set is 95.7% for the pre-interview and 96.3% for the post-interview. According to Miles and Huberman (1994), this ratio should be at least 80%.

3. RESULTS

3.1. Quantitative Findings

The descriptive statistics for the mean scores obtained with the awareness scale for renewable energy sources are given below.

Table 2. Descriptive Statistics on Renewable Energy Resources Awareness Scale

Test	Dimension	n	$\bar{X}$	S
Pretest	Cognitive Awareness	32	43.69	2.80
	Affective Awareness	32	38.62	5.49
	Total	32	82.31	6.66
Posttest	Cognitive Awareness	32	45.56	3.75
	Affective Awareness	32	40.16	4.42
	Total	32	85.72	5.98
Formative Test	Cognitive Awareness	32	46.12	4.84
	Affective Awareness	32	40.25	4.69
	Total	32	86.37	7.43

n: Size of the study group X: Mean S: Standard deviation

As seen in Table 2, both affective and cognitive awareness scores increased in pretest ($\bar{X}$=82.31), posttest ($\bar{X}$=85.72) and formative tests ($\bar{X}$=86.37). The statistical significance of these score increases was checked with the related samples t-test.

Table 3. Related Samples T-Test Results

Test	Dimension	N	t	p
Pretest-Posttest	Cognitive Awareness	32 32	-3.23	.003*
	Affective Awareness	32	-5.59	.006*
Posttest-Formative test	Cognitive Awareness	32	-.658	.515
	Affective Awareness	32	-.186	.854
Pretest- Formative test	Cognitive Awareness	32	-3.06	.004*
	Affective Awareness	32	-2.19	.036*

*p<0.05

When the t-test results given in the Table 3 are examined, it is seen that multidimensional energy education increases affective and cognitive awareness about renewable energy sources (td (31) = -5.59, tb (31)=--3.23, p<0.05).

While there was an increase in affective and cognitive awareness scores in the posttest and formative test, this increase was not statistically significant (p>0.05). However, it is seen that there is a significant difference between the affective and cognitive awareness levels of the students before the education and the cognitive and affective awareness scores obtained as a result of the formative tests (td (31) =-2.19; tb (31) =-3.06; p<0.05).

3.2. Qualitative Data Analysis

The content analysis of the structured interviews with the participants before and after the multi-dimensional energy education is given in Table 4.

Table 4. Content Analysis Results of Pre- and Post-Interviews

Theme	Code	Pre-interview		Post-interview	
		f	%	f	%
Renewable Energy Sources	Positive effects on the flora	6	13	4	7.4
	Harmless to the ecosystem	6	13		
	Positive effects on the fauna	5	10.9	3	5.5
	Harmful to ecosystem	4	8.7	-	-
	The harm to the ecosystem is acceptable	-	-	9	16.7
	Sum	21	45.6	16	29.6
Non-Renewable Energy Resources	Causes global climate change	8	17.4	15	27.8
	Harmful to ecosystem	7	15.2	10	18.5
	Negative effects on the flora	5	10.9	7	13
	Negative effects on the fauna	5	10.9	6	11.1
	Sum	25	54.4	38	70.4
Total		46	100	54	100

While the positive aspects of renewable energy sources (45.6%) and negative aspects of non-renewable energy sources (54.4%) were close in the pre- interview, the negative aspects of non-renewable energy sources came to the fore after the multi- dimensional energy education. In addition, it is noteworthy that the awareness of the participants about the possible harms of renewable energy sources for the ecosystem has increased and they found this acceptable (16.7%).

Below are some participant (P) statements from the preliminary interview.

P6: "*The energy sources we use are generally damaging to our nature. These resources have an effect on flora and fauna. In particular, it harms health, reproduction, nutrients and the ecosystem."*

P12: "*Renewable energy sources are beneficial and harmless to nature. Non-renewable energy sources cause great harm to nature. There is no great harm to flora and fauna in renewable energy sources. These damages are being remedied day by day or projects are being carried out to eliminate them. Non-renewable energy is a major threat to flora and fauna*."

Below are some participant (P) statements from the last interview.

P21: "*Fossil resources cause serious damage such as global warming, climate change and depletion of nature. Renewable energy sources are low cost and environmentally friendly*."

P13: "*Without the sun, plants would not be able to photosynthesize, we would not be able to heat, trees would not be able to grow."*

Ö22: "*If we use alternative energy sources, it will not have an effect on climate change. It affects animals to some extent, but if we use non-renewable energy sources, we cause global warming, endangerment of animals, and death of plant species."*

4. DISCUSSION AND CONCLUSION

This study was carried out with the aim of revealing the effect of multidimensional energy education on students' cognitive and affective awareness. The multidimensional energy education provided provided the opportunity for vocational high school students to observe the natural resources in their immediate surroundings. This education highlighted the need for renewable energy sources to prevent ecosystem damage caused by energy use in the region where students live.

The results of the study show that there is a statistically significant increase in the cognitive awareness of renewable energy sources after multidimensional energy education. This finding is important for the orientation towards the use of renewable energy sources. There are studies in the literature reporting that cognitive awareness has a linear relationship with motivation (Boulware-Gooden, Carreker, Thornhill & Joshi, 2007; Çubukcu, 2008). A significant effect of multidimensional energy education on the increase of affective awareness about renewable energy sources was determined. Duman and Yakar (2017) stated that affective awareness is important for solving daily life problems and learning motivation of individuals and defined it as a concept with a procedural nature. This statement supports the increase in affective awareness scores in the formative test. The score increases in the three tests (pre-, post-, formative test) applied can be interpreted as the success of multidimensional energy education in raising awareness. Buldur Bursal, Erik and Yucel (2020), it was reported that energy trainings given in the open area increased awareness about renewable energy sources.

In the interview after the multidimensional energy education, it is seen that the expressions about the environmental effects of non-renewable energy sources have increased. Individuals' awareness of the effects of non-renewable energy sources on the ecosystem in their immediate surroundings can accelerate the reduction of the use of non-renewable energy sources and the orientation to renewable energy sources in energy needs. If people start to think about the impact of energy use on the environment, people's awareness of energy increases (Hassan, et al., 2009). Studies report that awareness of environmental issues is parallel to concern for the environment (Chen, Cheng, Song & Wu, 2016; Xie, Fang & Liu, 2017).

Ensuring sustainable energy development based on the use of renewable energy can reduce environmental problems based on fossil fuel use for energy. Increasing awareness of renewable energy can lead to a positive attitude towards this technology. Zakaria, Basri, Kamarudin and Majid (2019) emphasize the importance of raising awareness of the public on the issue for the widespread use of renewable energy. Most importantly, the relationship between the use of renewable energy sources and ecosystem sustainability should be understood by individuals (Broman & Kandpal, 2010). Because increased awareness improves pro-environmental behavior. Yue, Long and Chen (2013) found a positive relationship between energy awareness and behavior.

Based on all the results, it is important to raise awareness of future decision makers about the energy resources in their immediate surroundings in order to prevent increasing environmental problems and to lead to sustainable energy. In order to increase the awareness of today's youth,

who are gradually moving away from the natural environment and growing intertwined with technology, on renewable energy technologies, it can be recommended to use teaching methods and techniques for their interests and needs together.

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