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Pre-service Teachers' Comprehension of Renewable Energy Sources

Öğretmen Adaylarının Yenilenebilir Enerji Kaynakları ile İlgili Anlayışları

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Abstract: This study aims to identify pre-service science teachers' comprehension of renewable energy sources. The study was conducted with a qualitative research method. 33 pre-service science teachers were included in the study group. A purposeful sampling method was used in choosing the participants in the study. The study data were collected through 15-20-minute semi-structured interviews. The interview form containing questions prepared by the researchers on why to prefer renewable energy sources, whether or not the use of renewable energy sources was necessary, and how to promote the use of those sources was used in the interviews. All the interviews were voice recorded by taking the consent of the participants. The data obtained from the interviews were transcribed and then put into a computer by the other researcher and analyzed by content analysis. During the analysis, themes were created after the codes and categories were determined. After that, the data were divided into themes. The findings were considered in three themes and the results obtained were evaluated generally. Although it was considered a result that the pre-service science teachers stated their views in three different themes, the fact that the low rates of the views stated can be interpreted as that their comprehension of renewable energy sources is inadequate.

Keywords: Energy, environmental protection, renewable energy, renewable energy sources, pre-service teachers

Öz: Bu çalışmada fen bilgisi öğretmen adaylarının yenilenebilir enerji kaynakları ile ilgili anlamalarını belirlemek amaçlanmıştır. Çalışmada nitel araştırma yöntemi kullanılmıştır. Çalışmaya 33 fen bilgisi öğretmen adayı katılmıştır. Çalışmada katılımcıların belirlenmesinde amaçlı örnekleme yöntemi kullanılmıştır. Çalışmada veriler 15-20 dakikalık yarı yapılandırılmış görüşmeler ile elde edilmiştir. Araştırmacılar tarafından hazırlanmış olan ve yenilenebilir enerji kaynaklarının neden tercih edilebileceği, yenilenebilir enerji kaynaklarının kullanımının gerekli olup olmadığı ve yenilenebilir enerji kaynaklarının kullanımının nasıl artırılabileceği ile ilgili soruların yer aldığı görüşme formu kullanılmıştır. Tüm görüşmeler öğretmen adaylarından izin alınarak ses kayıt cihazıyla kaydedilmiştir. Görüşme verileri diğer araştırmacı tarafından transkript edilerek bilgisayar ortamına aktarılmıştır. Elde edilen veriler içerik analiziyle analiz edilmiştir. Analiz sonucu konu ile ilgili kodlar ve kategoriler belirlendikten sonra temalar oluşturulmuştur. Öğretmen adaylarının yenilenebilir enerji kaynakları ile ilgili anlamalarının incelendiği çalışmada elde edilen veriler 3 farklı tema altında toplanmış ve sonuçlar genel olarak değerlendirilmiştir. Elde edilen bulgular doğrultusunda öğretmen adaylarının konu ile ilgili 3 farklı tema altında oldukça faklı görüş bildirseler de bu fikirleri bildiren fen bilgisi öğretmen adayı yüzdesinin düşük olması anlama düzeylerinin yeterli olmadığı şeklinde yorumlanabilir.

Anahtar Kelimeler: Çevre koruma, enerji, öğretmen adayları, yenilenebilir enerji, yenilenebilir enerji kaynakları

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Introduction

Energy is of vital importance in all countries for the quality of life and economic development. However, some countries do not even have fossil energy sources to meet their energy needs. Therefore, the competition and conflicts about sharing fossil energy sources between countries are one of the most important problems in today's world. From this perspective, energy is the starting point for both the problems and the opportunities (Keho, 2016). Besides, the rapidly increasing energy consumption of developed and developing countries is neither physically nor socially sustainable. For this reason, having abundant and affordable energy, which will keep the probable environmental and ecological harms in production and consumption to the minimum, will support improvement in life quality and economic growth in developing countries (Açıkgöz, 2011). At this point, Renewable Energy Sources (RES) are thought to play critical roles in reducing dependence on traditional fossil sources of energy and the negative effects of those sources on the environment (Lise & Bayramoğlu-Lise, 2020). However, the use of renewable energy sources will have positive effects on reducing CO_2 emissions (Kırıkkaleli & Adebayo, 2021; Zhang et al., 2023), economy (Candra et al., 2023; Zhe et al., 2021), energy security by reducing dependence on fossil fuels (Trifonov et al., 2021), environmental quality (Khan et al., 2021), and reducing income inequality (Topçu & Tuğçu, 2020).

Several countries aim to develop technologies of renewable energy and to deploy them on a large scale to meet their energy needs and to capture the opportunities for sustainable energy (Kandpal & Broman, 2014). This is because solving such global problems as greenhouse gases, climate change, and air and water pollution will be easier with an increase in the use of renewable energy sources (RES). Therefore, international environmental agreements and policies directed towards the worldwide use of such sources of energy emphasize the need for countries to revise their energy models (Ocetkiewicz et al., 2017). Moreover, Ocetkiewicz et al. (2017) argue that the changes in the energy consumption model and energy policies can only be actualized through a holistic approach that considers several factors such as education, society, the environment, politics, and the economy.

Global and local trends indicate that a large portion of energy needs can be met by RES (Jurasz et al., 2020). RES has more advantages than fossil fuels in energy production and in protecting the environment. However, it should also be explained and introduced to the public, as in the case of any

new technology. Many developed and developing countries also consider formal and informal education important in raising awareness of renewable energy (Açıkgöz, 2011). Akinwale (2022) suggests that students who have completed a course on renewable energy are likely to possess greater knowledge in this field than those who have not undertaken such a course. Education can raise awareness of the environment and energy, and it can contribute to the development of positive attitudes toward renewable energy (Liarakou et al., 2009; Yüksel, 2020). As Assali et al. (2019) express, an increase in students' awareness is possible only through education. Today, it is widely accepted in the world that education in renewable energy is needed (Kandpal & Broman, 2014). The concepts of renewable energy should be included in university and school curricula to raise all students' levels of awareness and knowledge regardless of their academic expertise (Assali et al., 2019). In addition, research, development, and publicity activities should be held to raise the labor force needed to attain the desired level of growth in renewable energy technologies (Bhattacharya, 2001

One of the important reasons for the failure of RES technologies to become widespread is the unavailability of a structured framework for energy education in general and renewable energy education in particular (Açikgöz, 2011). Education can make a significant contribution to countries in terms of energy consumption and renewable energy (Kaplan Mintz et al., 2021). Thus, several countries around the world have been trying to implement academic programs related to renewable energy technologies (Kandpal & Broman, 2014). Those countries are making various modifications to their curricula so that the concepts and activities related to the environment and energy are included in their curricula at different levels (Açikgöz, 2011). On the other hand, university-level courses or programs on energy education aim to raise learners' understanding and awareness of issues such as renewable energy sources and technologies, the transformation of traditional energy sources into RES, and the energy crisis (Alawin et al., 2016). Countries should make efforts to advance environmental conservation and incorporate renewable energy education in order to foster the acquisition of affective, cognitive, and behavioral learning outcomes as well as practical and social skills in individuals (Kaplan Mintz et al., 2021). Enhancing energy education plays a critical role in fostering awareness of the importance of energy conservation, the use of sustainable energy sources, and the establishment of a low-carbon economy (Akinwale, 2022).

On the other hand, the most important factor in adopting new technologies, in general, is societies' resistance to innovations (Abdmouleh et al., 2018). Moreover, the limitations in countries' investments in renewable energy are mostly due to low awareness in societies, political missteps, and the characteristics of the market (Assali et al., 2019). Those technologies are not widely adopted by end-users because there is no awareness of some renewable energy technologies (Açikgöz, 2011). Since the spread of renewable energy applications is dependent on the acceptance of society, studies conducted are generally concerned with determining the social acceptance of society (Karasmanaki & Tsantopoulos, 2019). Determining society's attitudes toward environmental choices, for instance, will enable decision-makers to develop appropriate strategies (Abdmouleh et al., 2018). According to Assali et al. (2019), high awareness of renewable energy indicates positive attitudes toward these technologies. The researchers state that determining the attitudes of university students or students in schools and their awareness will make such technology widespread, support the development of the sector, and increase social acceptance.

The Significance and Purpose of the Study

The use of renewable energy sources is not at the desired level despite various studies concerning RES technologies in many countries (Açikgöz, 2011). One of the biggest obstacles in the development of the energy market and widespread use of those technologies is the unavailability of qualified human resources with the necessary knowledge and skills (Alawin et al., 2016; Lucas et al., 2018; Negro et al., 2012). Experts in renewable energy are expected to have certain capabilities such as environmental awareness in addition to sector-based skills (Malamatenios, 2016). Education equips both individuals and communities with the essential knowledge and skills required to effectively address future energy demands (Solarz et al., 2022). Providing renewable energy courses to social science students as well as engineering and science students will help build knowledge and awareness of energy conservation and renewable energy among future energy users and leaders (Akinwale, 2022). Additionally, training individuals in energy productivity and renewable energy will support sustainable development (Alawin et al., 2016). Particularly, teachers will play a role in educating individuals about renewable energy since they can explain the importance of renewable energy sources to society in the best way (Çelikler, 2013). Therefore, pre-service teachers, who are going to be teachers in the future, should be well-equipped and well-trained in issues such as environmental consciousness and environmental ethics. The subject of renewable energy sources should be included in the curricula for training pre-service teachers, which will contribute to an increase in awareness of renewable energy and such technologies, and they should be allowed to receive more comprehensive knowledge in this respect (Güven & Sülün, 2017).

It is important to understand what people think about renewable energy and environmental problems, which are extremely important all over the world. Success in political practices is dependent on understanding the perceptions, attitudes, and knowledge of society about these issues (Qu et al., 2011). In this way, the focus of attention will be determined in the education system and in the studies to be conducted to raise awareness (Özil et al., 2008). There is not much knowledge about university students' attitudes toward RES, either (Karasmanaki & Tsantopoulos, 2019). A review of the literature demonstrated that most of the studies concerning sources of renewable energy collected the data through surveys and used study groups of primary and secondary school students (Altuntaş & Turan, 2018; Çelikler & Aksan, 2016; Keramitsoglou, 2016; Zyadin et al., 2012), university students (Alawin et al., 2016; Assali et al., 2019; Karatepe et al., 2012), pre-service teachers (Çelikler, 2013; Güven & Sülün, 2017) and teachers (Liarakou et al., 2009; Ocetkiewicz et al., 2017; Zyadin et al., 2014). This study stands out from others due to its unique focus on pre-service science teachers as the study group. Given that this group will have a significant impact on educating and informing future generations about renewable energy sources, it is crucial that they possess a thorough understanding of this important topic. Therefore, the utilization of pre-service science teachers in this study is of great significance in terms of promoting awareness and comprehension of renewable energy. Setting out from this point, it is thought that revealing pre-service science teachers'

comprehension will provide both educators and policymakers with significant data. It is also predicted that the results obtained in this study can highlight how many places the subject of renewable energy sources and technologies should occupy in the teacher training programs in higher education. Considering the fact that the pre-service science teachers who constituted the study group were the people who would raise the experts, politicians, scientists, and engineers of the future; it is extremely important to obtain their views. The pre-service science teachers' knowledge, attitudes, and awareness are expected to influence the energy consumption choices of the future, the development of the energy market, and the productivity of energy. However, the number of studies that were conducted through semi-structured interviews and which identified pre-service science teachers' comprehension of renewable energy sources was limited. By conducting semi-structured interviews, the researchers were able to obtain more detailed information by delving deeper into pre-service science teachers' comprehension of renewable energy sources. Therefore, this paper aims to identify pre-service teachers' comprehension of renewable energy sources. This study aimed to answer the following research questions:

1. What is pre-service science teachers' comprehension of the reasons for preferring renewable energy resources?
2. What is the pre-service science teachers' comprehension of the need for using of the renewable energy resources?
3. What are the pre-service science teachers' recommendations for increasing the use of renewable energy resources?

Method

This study uses a qualitative research method. Qualitative studies make efforts to put forward a complex picture of the subject or problem considered, and thus researchers create patterns, categories, and themes by transforming their data into more and more abstract units of knowledge (Creswell, 2009).

The Study Group

A total of 33 pre-service science teachers (PST) attended the study. All participants were selected from pre-service science teachers who took courses such as Environmental Protection, Environmental Education, Chemical Wastes, and Environmental Pollution and they (26 females and 7 males) were in the 21-23 age range. Given that the study group needed to possess qualifications relevant to the problem, the criterion sampling method, a purposive sampling, was chosen as the preferred method (Patton, 1990). Information-rich cases are selected in a purposeful sampling method according to the purpose of a study, and thus an opportunity to do in-depth research is obtained (Fraenkel et., 2012). Besides, Karamanaski and Tsantopoulos (2019) stress that studies revealing the RES and RES application awareness of university students who are registered in graduate programs that are directly related to the environment are lacking. Therefore, pre-service teachers who had knowledge about renewable energy sources (RES) were selected as the sample of this study. Since pre-service teachers who had taken courses related to environmental education were especially preferred, it was thought that these pre-service teachers had relatively more knowledge about RES compared to other students.

Data Collection Tool

The research data were collected through 15-20-minute semi-structured interviews. All the interviews were voice recorded by taking the consent of the participants. The interviews were conducted outside the classroom by one of the researchers. The interview form containing questions prepared by the researchers on why to prefer RES, whether or not the use of RES was necessary, and how to promote the use of those sources was used in the interviews. The interview form comprises a set of four questions, out of which three are open-ended and one is focused on gathering recommendations from pre-service teachers regarding the process. In addition, probe questions have been devised to accompany the first three questions. The interview form, which can be found in the supplementary section, was developed through a thorough review of relevant literature to ensure that the questions are informed by the research in the field (Açikgöz, 2011; Bozdoğan & Yigit, 2014; Dönmez Usta et al., 2016; Güven & Sülün, 2017; Karakaya Cirit, 2017). Two lecturers were consulted for expert opinion in relation to the content validity of the interview form. A different group of pre-service science teachers' views were received to find the intelligibility of the questions on the form. As a result, the final shape was given to the interview form.

Data Analysis

The data obtained from semi-structured interviews were transcribed and then put into a computer by the other researcher. The data were then put to content analysis. Content analysis is a method that can be used in both quantitative and qualitative research (White & Marsh, 2006). Content analysis, which is frequently used in analyzing and interpreting text data, offers advantages such as being adaptable to flexible research designs and being able to analyze various types of qualitative data (Kyngäs, 2020). In addition, content analysis provides benefits to researchers compared to other qualitative data analysis methods, as it can be used to convert qualitative data into quantitative data (Duriau et al., 2007). This methodology tool can help researchers by making the categorization process that assists in exploring themes and summarizing raw verbal data easier (Mayring, 2002). Therefore, in this study, it can be stated that descriptive content analysis is preferred for these reasons. The data obtained within the scope of this study were analyzed with the summarizing content analysis method described by Mayring (2002). The aim here is to reduce the data set through data reduction. Inductive categorization is preferred and the data are coded by reading the data line by line. As a result of summarizing content analysis, categories and themes for the data set are obtained and a general framework for the data is obtained.

Validity and Reliability Studies

When the study was conducted according to the qualitative research method, importance was given to the dimensions of transferability, confirmability, credibility, and reliability in ensuring the validity and reliability of the study (Yıldırım & Şimsek, 2013). To prevent conflicts of interest, pre-service teachers were selected without any academic relationships with the researchers, and pre-service teachers from other departments within the faculty were only included based on their voluntary participation and adherence to these selection criteria. Prior to conducting the interviews, the pre-service

teachers were presented with a voluntary participation form and asked to provide their signature as an indication of their voluntariness to participate. The interviews were conducted with all pre-service teachers, especially by the same researcher. The data collection process took about two weeks. Sample quotations were included to increase the reliability of the study by quoting directly from the interviews with participants without revealing their identities.

In the study, semi-structured interviews were held outside the classroom by one of the researchers. All the interviews were audio recorded by taking the consent of the participants while conducting them to ensure the credibility of the study. Audio recordings were transcribed by the other researcher. The researchers tried to present the events and facts without distorting their reality. In this process, pre-service teachers were not directed or influenced during the interview. Thus, as stated by Miles and Huberman (1994), the events and phenomena were tried not to be separated from their contexts and the opinions of the pre-service teachers were tried to be conveyed as they were. On the other hand, expert opinion has been taken. While reporting the data obtained from the audio recordings, they were examined by two field experts, and necessary corrections were made in line with their opinions. In addition, after the interviews, the audio recordings were played to the pre-service teachers, and the data obtained were approved. During the interviews, the statements of the pre-service teachers were repeated by the researcher to ensure participant confirmation.

In the stage of ensuring transferability, the theoretical knowledge of the study is presented in the introduction part, and the course of the study, the study group, the data collection tool, and the data analysis are presented in detail in the method section. The findings were reported impartially, and the findings were associated with the references in the literature in the conclusion and discussion sections.

The findings obtained in ensuring internal reliability were presented to the reader by transferring them without comment. Also, the similarities and differences in coding made by the two researchers were compared to raise internal validity, and interrater reliability was calculated as 92%. Having at least 70% reliability is considered adequate in qualitative studies (Miles & Huberman, 1994).

Findings

The findings obtained through content analysis are shown in Table 1, Table 2, and Table 3. Thus, Table 1 shows the categories and codes for the theme of reasons for preferring RES, Table 2 shows the categories and codes for the theme of the need for using RES and Table 3 shows the categories and codes for the theme of recommendations for increasing the use of RES. Some examples of the answers given by the pre-service science teachers related to the reasons for preferring RES are presented below;

Category of negative aspects of fossil fuels; PST1: It can be preferred to meet our energy needs as fossil fuels start to run out.

Category of the properties of RES; PST7: Renewable energy sources should be used because they are constantly renewing themselves.

Category of benefits of RES; PST8: Since it is a domestic resource, it can be preferred because it reduces foreign dependency in energy.

Table 1. Analysis results for the theme of reasons for preferring RES

Themes	Categories	Codes	f	%
Reasons for preferring RES	Negative aspects of fossil fuels	Fossil fuels are about to be depleted	15	45.45
		Fossil fuels destroy the environment	8	24.24
		It takes too long time for fossil fuels to form	2	6.06
	The properties of RES	Resources which are renewed through continuous motion	28	84.85
		Environment-friendly	13	39.39
		Clean energy	11	33.33
		They exist in natural processes	9	27.27
		They are not fossil-based	6	18.18
		Dependable resource	5	15.15
		Native resource	4	12.12
	Benefits of RES	Relieving from external dependence in energy	22	66.67
		Causing less harm to the environment	18	54.55
		Providing employment opportunities in the area	16	48.48
		Being economical apart from set up costs	15	45.45
		Very little or no release of greenhouse gases	10	30.30
		Meeting increased need for energy	10	30.30
		Reducing the use of fossil fuels	4	12.12
		Contributing to social and economic development	4	12.12
		Low running costs	4	12.12
		Ensuring sustainable development	3	9.09
		Respectful to current and next generations' rights	3	9.09
		Ensuring to leave clean environment to next generations	2	6.06

It is apparent from Table 1 that pre-service teachers' comprehension of the reasons for preferring RES is divided into three categories. The views that fossil fuels are about to be depleted stated by 45.45% of the pre-service teachers, that fossil fuels destroyed the environment stated by 24.24% of them and that the formation of fossil fuels took a long time stated by 6.06 % were included in the category of negative aspects of fossil fuels. On the other hand, the category of the properties of RES included such participants' views as renewal through continuous motion (84.85%), being environmental-friendly (39.39%), being clean energy (33.33%), existing in natural processes (27.27%), not being fossil-based (18.18%), being dependable (15.15%) and being native (12.12%). In the category of the benefits of RES, the views stated were as in the following: relieving from external dependence in energy (66.67%), causing less harm to the environment (54.55%), providing opportunities for employment in the area (48.48%), being economical apart from set up costs (45.45%), having very little or no release of greenhouse gases (30.3%), meeting the increased need for energy (30.3%), reducing the use of fossil fuels (12.12%), contributing to social and economic development (12.12%), having low running costs (12.12%), ensuring sustainable development (9.09%), espect for current and next generations rights (9.09%) and ensuring to leave clean environment to next generations (6.06%). Some examples of the answers given by the pre-service science teachers related to the need for using RES are presented below;

Category of necessity on the basis of fossil fuels; PST10: It is a necessary type of energy for the world, as serious damage is done to the environment during energy production from fossil sources.

Category of necessity on the basis of the properties of RES; PST15: Renewable energy sources are important because they are inexhaustible and environmentally friendly.

Category of necessity on the basis of the benefits of RES; PST22: Renewable energy sources provide an advantage in terms of both the environment and economy, as the damage to the environment is very low.

According to Table 2, the pre-service teachers' comprehension of the need for using RES is divided into three categories. Thus, the views in the category of necessity on the basis of fossil fuels held by the participants were as the following: Fossil fuels were harmful to the environment (54.55%), fossil fuels were about to be depleted (51.52%) and there were import expenses on fossil fuels (30.3%). The participants' views in the category of the necessity on the basis of the properties of RES were stated as sources renewed through continuous motion (60.61%), clean (18.18%), dependable (6.06%) and native source (3.03%). In the final category- the category of necessity on the basis of the benefits- the pre-service teachers thought that those sources reduced harm to the environment (69.7%), that they met the increased need for energy (36.33%), that they reduced external dependence in energy (36.36%), that they provided opportunities for employment (33.33%), that they were profitable in the long-term (24.24%), that they ensured sustainable development (15.15%), that they were not influenced by fluctuations in the market (12.12%), that they increased national capital (9.09%), that they reduced the use of fossil fuels (6.06%) and that they were respectful to present day generation's and next generations' rights (3.03%). Some examples of the answers given by the pre-service science teachers related to recommendations for increasing the use of RES are presented below;

Category of educational recommendations; PST 9: The public can be made known through advertisements, short films, and animations.

Category of individual recommendations; PST3: The use of fossil fuels, which harm the environment above a certain amount, can be reduced.

Category of economic recommendations; PST12: More investments should be made in renewable energy resources and credit and financial support should be provided to relevant institutions and organizations in this regard.

Category of political recommendations; PST30: Countries should include the concept of renewable energy when making political decisions.

Table 2. Content analysis results for the theme of need for using RES

Themes	Categories	Codes	f	%
The need for using RES	Necessity on the basis of fossil fuels	Fossil fuels' harm to the environment	18	54.55
		Almost depletion of fossil fuels	17	51.52
		Import expenses on fossil fuels	10	30.30
	Necessity on the basis of the properties of RES	Sources renewed through continuous motion	20	60.61
		Clean energy	6	18.18
		Dependable	2	6.06
		Native source	1	3.03
	Necessity on the basis of the benefits of RES	Reducing the harm to the environment	23	69.70
		Meeting increased need for energy	12	36.36
		Reducing external dependence in energy	12	36.36
		Providing opportunities for employment	11	33.33
		Profitable in the long-term	8	24.24
		Ensuring sustainable development	5	15.15
		Not being influenced by market fluctuations	4	12.12
		Increasing national capital	3	9.09
		Reducing the use of fossil fuels	2	6.06
		Respectful to current and next generations' rights	1	3.03

Table 3. Content analysis results for the theme of recommendations for increasing the use of RES

Themes	Categories	Codes	f	%
Recommendation for increasing the use of RES	Educational recommendations	Informing the public	28	84.85
		Educating the public through adverts/films/animations	10	30.30
		Introducing courses related to the environment in school programmes	6	18.18
		Training technical staff	4	12.12
		Opening relevant departments in universities	2	6.06
	Individual recommendations	Reducing the use of fossil fuels	8	24.24
		Installing solar panels in houses	5	15.15
		Using appliances which are charged with solar energy	2	6.06
		Using electrical cars	2	6.06
	Economic recommendations	Providing government promotion	17	51.52
		Reducing set up costs	8	24.24
		Reserving a state budget	6	18.18
		Providing incentive for generating the necessary technology	5	15.15
		Supporting entrepreneurs/companies	4	12.12
		Increasing investment in renewable energy	3	9.09
	Political recommendations	Including in environmental policies	9	27.27
		Determining suitable regions	7	21.21
		Making international decisions/implementing them	5	15.15
		Preparing the necessary infrastructure	3	9.09
		Supporting the work of non-governmental organisations	2	6.06
		Activities to be held by the ministry of environment	2	6.06

It is apparent from Table 3 that the pre-service teachers' recommendations for increasing the use of RES are considered in four categories. Accordingly, the participants recommended to inform the public by 84.85%, to educate the public through adverts, films and animations by 30.3%, to add courses related to the environment in school programmes by 18.18%, to train technical staff by 12.12% and to open relevant departments in universities by 6.06% in the category of educational recommendations. They recommended reducing the use of fossil fuels by 24.24%, installing solar panels in houses by 15.15%, using appliances, which are charged with solar energy by 6.06%, and using electrical cars by 6.06% in the category of individual recommendations. They made such recommendations as providing government promotion by 51.52%, reducing set up costs by 24.24%, reserving a state budget by 18.18%, providing incentive for generating the necessary technology by 15.15%, supporting entrepreneurs and companies by 12.12% and increasing investment in renewable energy by 9.09% in the category of economic recommendations. And finally, in the category of political recommendations, they recommended including in environmental policies by 27.27%, determining suitable regions by 21.21%, making international decisions and implementing them by 15.15%, to prepare the necessary infrastructure by 9.09%, to support the work of non-governmental organisations by 6.06% and they also recommended that the ministry of environment should hold activities by 6.06%.

Conclusion and Discussion

The present study sought to investigate the comprehension of renewable energy sources among pre-service science teachers. A sample of thirty-three participants was recruited, and an interview form was utilized to elicit their views on the reasons for preferring RES, the importance of their utilization, and ways to increase their use. The collected data were subjected to qualitative content analysis, and relevant codes and categories were identified and organized into distinct themes. The findings of the study were presented under three main themes, and each theme was examined separately to draw meaningful conclusions about the participants' understanding of renewable energy sources.

The Reasons for Preferring RES

Accordingly, most of the pre-service teachers made the statements that;

Fossil fuels were about to be depleted,

Renewable energy sources were continuously renewed through motion,

Those sources relieved countries from external dependence on energy,

Those sources did little harm to the environment,

Such sources provided opportunities for employment in the area,

They were economical apart from set up costs as the reasons for preferring to use RES.

Considering the reasons, it can be said that pre-service science teachers have positive views towards such sources of energy. When the statements that the pre-service science teachers listed as the reasons prefering RES are examined, it is seen that they stated that the characteristics of RES resources and the benefits they provide are important as well as considering the negative effects of fossil fuels. There are similar studies in the literature. Qu et al., (2011) found in a study conducted with the participation of university students that students had positive thoughts on the use of renewable energy. Another study conducted by Özil et al., (2008) found that Canadian, Romanian and Turkish university students made the statements on affecting the environment in positive ways, having less dependence on imported fuels and being good for economy as the top three benefits of renewable energy. Besides, most of the Canadian university students said that countries should support renewable energy while fewer

numbers of Turkish and Romanian students made such a statement.

The Need for Using RES

The pre-service teachers in general held the views in relation to the necessity for using RES that;

Fossil fuels were harmful to the environment,
Fossil fuels were about to be depleted,
RES were continuously renewed through motion,
Those sources reduced harm to the environment.

When the statements of the pre-service science teachers about the need of using RES are examined, it is seen that they consider this requirement in terms of fossil fuel use on the one hand and the characteristics and benefits of RES resources on the other.

Recommendation for Increasing the Use of RES

As to increasing the use of RES, the majority of pre-service teachers recommended that;

The public should be informed,
Government promotion should be provided for using such sources.

When the recommendation for increasing the use of RES by the pre-service science teachers is examined, it is seen that they especially refer to the recommendation related to education. It was determined that this was followed by the economic and political recommendations, and the recommendations in the individual dimension were relatively lower than the other recommendations. The recommendation for raising public consciousness for the widespread of RES was in parallel to the ones in the studies available in the literature (Assali et al., 2019; Karasmanaki & Tsantopoulos, 2019; Qu et al., 2011). Review of literature shows that there is no such awareness in the society. Qu et al., (2011) report that approximately 90% of Canadian students argued that their country should inform the society more of renewable energy and that the rate was surprisingly lower in the case of Turkish students.

Although it was considered a result that the pre-service science teachers stated their views on three different themes, the fact that the low rates of the views stated can be interpreted as that their comprehension of the RES is inadequate. A review of relevant literature also demonstrates that the results obtained in this study are in parallel to the ones reported in the literature. In their study, Assali et al. (2019) made attempts at determining university students' levels of comprehension about renewable energy. The results indicated that their awareness of and knowledge about renewable energy was limited. The researchers pointed out that factors such as the educational system and curriculum might be effective in the result. Revák et al. (2019) analysed the knowledge of students related to renewable energy resources and concluded that they have poor and less stable knowledge related to RES. In parallel with this result, in our study, it is seen that educational recommendations are in the first place among the recommendations made by the pre-service science teachers, especially for the increase in the use of RES. Zyadin et al. (2014), on the other hand, found that teachers had limited comprehension of renewable energy and that they had neutral perceptions about the use of such energy sources. This study, however, found that teachers had positive attitudes towards developing renewable energy. Alawin et al. (2016), in another study, reported that the final year engineering students at universities generally had low level of knowledge about technologies of renewable energy. Zyadin et al. (2012) found that students were inadequate even in discrimination between renewable and non-renewable energy sources.

In conclusion, the pre-service science teachers were found to have a certain level of comprehension about renewable energy even though it was inadequate. Yet, what is important is that pre-service teachers should have more knowledge and more awareness than the rest of the society so that renewable energy could become widespread and gain social acceptance. The reason for it is that pre-service teachers are the most important factors that will affect, develop and modify the energy market and consumption preference of the future. Therefore, they should be well equipped in renewable energy and trained accordingly. The spread and development of renewable energy sources is not dependent only on economic and technical factors but is also on social acceptance (Komendantova et al., 2014). The acceptance of RES is a social process and the process can be developed by raising social awareness and by changing the lifestyle of the society (Rezaei & Ghofranfarid, 2018). Education plays significant roles in raising awareness since the increase in the use of renewable energy is dependent on social awareness (Qu, et al., 2011). According to Ewim et al. (2023) the government must take swift action to address fossil fuels and energy needs by promoting the deployment of RES in schools. Also, Çoker et al. (2010) recommended that more learning outcomes related to RES must be added to the primary and secondary education curricula with environmental issues. In this respect, the recommendations that relevant departments should be opened at universities and that compulsory and elective courses in renewable energy should be included in teacher training programmes at universities- which were also stated by some of the pre-service teachers in this study- should be taken into consideration. In addition to that, pre-service teachers should be made to take part in projects or activities related to the environment in general and to sources of energy in specific, and thus they should be made to develop awareness of and positive attitudes towards the issues.

Author Contributions

All authors equally took part in all processes of the article. All authors read and approved the final version of the study.

Ethical Declaration

The purposes and procedure of the current study were granted approval from the ethical committee of the Hacettepe University (Ethics Committee's Decision Date: 11.10.2022, Ethics Committee Approval Issue Numbers: E-76942594-600-00002426609).

Conflict of Interest

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

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Ek: Görüşme Formu
Araştırma Problemi: Öğretmen adaylarının yenilenebilir enerji kaynakları ile ilgili anlayışları nasıldır?

Tarih:__/__/____ Saat(Başlangıç/Bitiş):_____/_____

Bu çalışma "Öğretmen Adaylarının Yenilenebilir Enerji Kaynakları ile İlgili Anlayışları" başlığı altında öğretmen adaylarının yenilenebilir enerji kaynakları ile ilgili anlayışlarını belirlemek amacıyla yürütülecektir. Bu araştırma için, Etik Komisyonu'ndan izin alınmıştır. Başlamadan önce herhangi bir sorun veya belirtmek istediğin herhangi bir görüşün yoksa sorularıma başlamak istiyorum.

Sorular
1. Yenilenebilir enerji kaynaklarını tercih eder misin?
    a. Evet, ise yenilenebilir enerji kaynaklarının tercih etme nedenlerin nelerdir?
    b. Tercih etmeme nedenlerin ne olabilir?
2. Yenilenebilir enerji kaynaklarının kullanımı gerekli midir?
    a. Evet, ise neden gereklidir?
    b. Neden gerekli değildir?
3. Yenilenebilir enerji kaynaklarının kullanımı nasıl artırılabilir?
    a. Sen ne yapabilirsin?
    b. Ülke olarak ne yapılabilir?
    c. Kimler bu konuda katkı sağlayabilir?
    d. Hangi kurumlar katkı sağlayabilir?
4. Önerilerin nelerdir?