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**Preservice Teachers' Knowledge Levels,  
Risk Perceptions and Intentions to Use  
Renewable Energy: A Structural  
Equation Model**

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## Preservice Teachers' Knowledge Levels, Risk Perceptions and Intentions to Use Renewable Energy: A Structural Equation Model

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### Abstract

In today's world, energy consumption constitutes a topic on countries' main agendas. In parallel with the military, technological and scientific developments associated with the increasing population, countries are generating policies that highlight energy sources that play a part in global competition. As with many innovations, factors such as the public's knowledge levels regarding the innovations, social acceptance, attitudes, intentions and risk perceptions are seen to be directly related to the use of renewable energy. For this reason, the aim of this study was to test the relationships among the knowledge levels, risk perceptions and intentions of preservice teachers regarding renewable energy sources using structural equation model analysis. 642 preservice teachers studying in 3rd and 4th grades, and selected by convenience sampling, participated in the study. According to the results of the structural equation model analysis, the knowledge levels of the preservice teachers related to renewable energy sources negatively predicted their risk perceptions regarding renewable energy sources. Furthermore, while individuals' risk perceptions negatively predicted some of the theory of planned behavior components related to renewable energy sources, the theory of planned behavior components related to attitude, subjective norms and perceived behavioral control positively predicted the intention to use renewable energy sources. These analyses related to the structural equation model findings are discussed in detail.

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### Introduction

In today's world, energy consumption constitutes a topic on countries' main agendas. In parallel with the military, technological and scientific developments associated with the increasing population, countries are generating policies that highlight energy sources that play a part in global competition. These policies are mainly those that emphasize clean and renewable energy use (Açıkgöz, 2011; Bang, Ellinger, Hadjimarcou, & Traichal, 2000; Karagöl & Kavaz, 2017; Leiserowitz, 2008). However, despite these policies, the superiority of fossil fuels in supplying a large part of the world's energy demands continues. For example, according to the BP Energy Outlook 2035 report, in 2015, %32.8 of the world primary energy consumption met by oil, %29 by coal, and % 24.2 by natural gas (Karagöl & Kavaz, 2017). While fossil fuels continue to supply the energy needs of a growing population, their impact on the environment and their share in global warming have reached serious proportions. Similarly, when IEA (International Energy Agency) data in 2012 was considered, it was stated that around 31.7 million tons of carbon dioxide emissions were released worldwide and that fossil fuels having high carbon emissions played an important role in this (Çoban & Şahbaz Kılınc, 2015).

In this context, countries have organized meetings and signed protocols for controlling the use of fossil fuels and for trying to reduce the effects of greenhouse gases on a global scale. For example, with the meetings held in Rio de Janeiro and Kyoto, certain regulations and requirements related to emissions into the atmosphere and environmental pollution were introduced (Çoban & Şahbaz Kılınc, 2015; Leiserowitz, 2008). The aim of countries is to meet the growing need for energy on the one hand, while increasing the potential of clean and Renewable Energy Sources (RES or RE Sources) on the other (Açıkgöz, 2011). Many countries determine policies that target the meeting of future energy needs through the use of renewable energy sources. Turkey, for example, is one of these countries. The target is for one third of the country's energy needs to be supplied through renewable energy sources by 2023 (Karagöl & Kavaz, 2017; Ministry of Energy and Natural Resources 2014). Although countries and governments have determined investments and policies related to RE sources, the use of these energy resources is related to the public's adoption of RE sources. As with many innovations, factors such as the public's knowledge levels regarding the innovations, social acceptance, attitudes, intentions

and risk perceptions are seen to be directly related to the use of renewable energy (Devine-Wright, 2007; Güven & Sülün, 2017; Halder, Pietarinen, Havu-Nuutinen, Pöllänen, & Pelkonen, 2016).

The public's acceptance of RE sources and their intention to use them result in RE sources being adopted and spread to large populations. In this context, while on the one hand, investment and policies are being determined, on the other hand, revealing and examining the factors that affect public use will give clues to policymakers. For example, when examining the studies related to RE sources, it is seen that factors such as the attitudes (Kaldellis, Kapsali & Katsanou, 2012; Upreti & van der Horst, 2004; Zyadin, Puhakka, Ahponen, Cronberg, & Pelkonen, 2012), awareness and ideas (Altuntaş & Turan, 2018; Kılınç, Stanisstreet & Boyes, 2009), knowledge levels (Güven & Sülün, 2017) and beliefs (Bang et al., 2000; Halder et al., 2016) of individuals affect the use of RE sources. It can be said that all these factors are examined together and that there is no widely accepted psychological model (L'Orange Seigo, Dohle & Siegrist, 2016). However, in this context, it is also true that the Theory of Planned Behavior (TPB) is often adopted by researchers in determining acceptance for environmentally friendly behaviors such as RE sources (Halder et al., 2016).

TPB investigates intentions affecting the behavior of individuals with factors such as attitude (AT), perceived behavioral control (PBC) and subjective norms (Ajzen, 1991). Moreover, the TPB allows for other variables, which can be considered as related to the components it contains, to be tested together with these (Kilinc, Ertmer, Bahcivan, Demirbag, Sonmez, & Ozel, 2016). On the other hand, when individuals encounter innovations, one of the most important factors other than the TPB components that affect the adoption and use of these innovations is risk perceptions (L'Orange Seigo, Dohle & Siegrist, 2016; Visschers, Keller, & Siegrist, 2011; Whitmarsh, 2009). The public's perceptions of risk, particularly in matters they perceive as dangerous such as nuclear power plants and genetically modified organism directly affect social acceptance (Kılınç, Boyes & Stanisstreet, 2013). When risk perceptions are felt, the public may decide with lack of knowledge and limited reasoning. (Kılınç et al., 2013; Upreti & van der Horst, 2004). In this sense, countries and policymakers should demand at least that public awareness is raised regarding risk perceptions that hinder the fair evaluation of evidence and decision-making mechanisms such as logical reasoning (Frewer, 2004; Upreti & van der Horst, 2004). Therefore, in this study, an attempt will be made to model the knowledge, risk perceptions and intentions which, as outlined above, affect the use of RE sources by considering them together. In the study, preservice teachers were selected as the sample group, since preservice teachers, when they themselves undergo training related to the use of RE sources and then begin their careers, play an important role in raising public awareness of RE sources. Therefore, from the perspective of the teachers who assume a leading role in the public's use of RE sources, it is important that the factors regarding the use of RE sources are clarified. For this purpose, the knowledge levels, risk perceptions and intentions of preservice teachers regarding RE sources will be examined with the Structural Equation Model (SEM) model.

## **Theoretical Framework**

### *Knowledge Levels*

Changes in energy policies by countries and their efforts to start looking for new types of energy have led individuals to turn towards formal and informal energy training aimed at increasing their awareness and knowledge of eco-friendly, renewable energy types. In this context, there are studies in the related literature that examine individuals' knowledge levels about RE sources, as well as their attitudes, awareness and risk perceptions regarding RE sources (Altuntaş & Turan, 2018; Güven & Sülün, 2017; L'orange et al., 2014; Upreti & van der Horst, 2004; Wolsink, 2007). Examining the studies conducted, for example, Upreti and Van der Horst (2004) stated in their research that individuals do not know about bioenergy power plants, which are one of the types of RE, and that because of this, they have high levels of risk and anxiety. Moreover, the public's lack of knowledge and misunderstandings regarding bioenergy production, which is one of the RE sources, how it is carried out and its potential impacts on the environment give rise to risk perceptions and cause these to spread in society. In his study, Wolsink (2007) examined the effect of individuals' knowledge levels about RE on the use of RE sources and the changes in their attitudes and behaviors when they were familiarized with this type of energy. In the latest research conducted after wind turbines were established and local people were informed about the subject, it was concluded that individuals' knowledge levels increased and that there were positive changes in their behaviors. In their research, in which the mixed-method design was used, Altuntaş and Turan (2018) investigated the awareness of high school students about RES. As a result of the study, it was determined that the high school students had high awareness levels about RES, that there was a significant relationship between knowledge levels and attitudes, and that students with high levels of knowledge stated that they did not see a risk in the use of RES, that they had a positive attitude towards them, and that they would

prefer them in the future. In their studies, Güven and Sülün (2017) examined the knowledge and awareness levels of preservice teachers regarding RE sources. They utilized knowledge test and awareness scale for RE sources in the data collection process. As a result of the analyses, it was concluded that there was a significant relationship between RE sources knowledge levels and awareness of the preservice teachers and that their knowledge levels were a predictor of their awareness. In their study, in which they investigated the knowledge and perceptions of Finnish high school students regarding RES, Halder et al. (2016) found that the great majority of the students had low levels of knowledge about RE sources and that students living in the city center had more positive perceptions about RE sources than did students living in rural areas. They suggested that students' knowledge about RE sources could be increased through cooperation with policy makers and training programs.

### *Risk perceptions*

One of the most popular concepts in the decision-making mechanism of individuals over the last half century is risk. According to researchers, risk is addressed in two dimensions, namely direct exposure to risk, that is the risk itself, and perception of risk in the individual (Sjöberg, Moen & Rundmao, 2004). In this research, since individuals are not directly at risk from renewable energy, their risk perceptions are discussed in the study. According to risk theorists, risk perceptions are defined as the possibility of there being unwanted events such as accidents (Howard, 2011; Rohrmann & Renn, 2000). Risk perceptions include subjective evaluations of individuals regarding the possibility of there being a specific situation, such as the occurrence of an accident. Besides an evaluation of its probability, perception of the risk also includes its negative consequences (Sjöberg et al., 2004). Furthermore, risk perceptions are related to a specific attitude formed by individuals towards a specific object (a potential hazard) and are intertwined with other psychological factors (Frewer, Lassen, Kettlitz, Scholderer, Beekman, & Berdal, 2004).

Examining risk theory, two dominant theories are revealed in studies related to risk, namely cultural theory and the psychometric paradigm. While the psychometric paradigm is based on psychology and decision-making science, cultural theory has been developed by sociologists and anthropologists (Sjöberg et al., 2004). While cultural theory is limited in terms of empirical studies, the psychometric paradigm is effective in quantifying and measuring factors related to risk with appropriate survey instruments (Sjöberg et al., 2004; Slovic, 1992). In this study, when discussing the perceptions of risk, the psychological paradigm is focused on. The psychometric paradigm assumes that there is no risk perception that is independent from our minds and culture, and includes subjective evaluations. The psychometric paradigm includes risk-related factors such as dread, voluntary risk, catastrophic potential, control, severity of consequences, etc. In many studies, these factors are gathered by researchers under the headings of "dread" and the "unknown" (Kılınc et al., 2016; Slovic, Fischhoff, & Lichtenstein, 1982). "Dread" is characterized by a lack of control over the risk, the potential for catastrophic or fatal consequences, and the degree to which distribution of the risk is inequitable. The unknown is characterized by the newness of the hazard, the degree to which its dangers are unobservable, and the delay mechanism of the harm (Sohn, Yang & Kang, 2001, p.555).

Examining the studies on risk perceptions and RE, it is observed that risk perceptions are closely related to attitudes, use behavior and knowledge. For example, in their study, Eltham et al. (2008) examined the attitudes and views of individuals living in coastal regions of Scotland before and after the establishment of wind turbines (a period of 14 years), with regard to energy safety and negative effects. Following the interviews conducted, it was concluded that the residents of the region stated that wind farms were clean, sustainable and environmentally friendly, and even that they had begun to support them after their installation. Moreover, it was determined that their attitudes had changed positively, while their risk perceptions of negative and harmful aspects decreased after installation and use. Again, in other studies (e.g., Upreti & van der Horst, 2004), it was stated the manipulative portrayal of environmental and social risks related to RE sources by the local media had led to a negative attitude towards public and that this negative attitude and risk had been spread by communication among people. Pongiglione (2011) argued that knowledge of the subject, risk perception and individual interests are three important components in individuals' environment-friendly decision-making processes. Previous studies evaluated each of these components independently and therefore were unable to fully ensure that the environment-friendly decision-making process was carried out. For example, Pongiglione (2011) reported that individuals' possession of knowledge about global warming is not directly reflected in behaviors aimed at reducing global warming, that is, it does not lead to effective behavior change. For this reason, Pongiglione (2011) stated that factors such as knowledge, risk perception and self-interest should be evaluated together in environmentally-friendly decision-making processes, and that only in this way can they bring about behavior change by activating deep psychological mechanisms.

*The Theory of Planned Behavior*

The Theory of Planned Behavior (TPB) is one of the most important theories that have pioneered the understanding of human behavior. The TPB is based on “the Theory of Reasoned Action” (Ajzen, 1991; Halder et al., 2016). Theory of Reasoned Action postulates that individuals’ own wills and desires guide behavior. However, in his later research, Ajzen (1991) stated that external factors and barriers affect an individual’s behavior and that the individual predicts his behavior in his perception of and belief in his control over these external structures (Perceived Behavioral Control), and so he put forward the TPB.

The TPB attempts to explain the factors that guide behavior by centering on individual and social judgements such as belief and attitude (Ajzen, 1991; Halder et al., 2016). In this context, the TPB is established on the trio of attitude (AT), which include individuals’ positive and negative judgements regarding behavior, Subjective Norms (SN), which include the effect of other people’s discourses and attitudes on behavior, and Perceived Behavioral Control (PBC), which includes individuals’ perceptions of their control over the external factors that make their behaviors easier or more difficult. TPB assumes that these factors together form the basis of behavioral intention (I) (Ajzen, 1991). The TPB is a widely accepted and studied theory covering a very wide range from marketing to consumer behavior, from the use of educational technologies to inability to explain health-related behaviors. In recent years, the TPB has also been used to explain the intentions of individuals towards environmentally friendly behaviors (Halder et al., 2016). For example, with the TPB, attempts have been made to explain university students’ willingness and behaviors regarding the use of recycling (Chan & Bishop, 2013) and their purchasing of organic foods (Yazdanpanah & Forouzani, 2015) or adults’ willingness to use individual vehicles and to reduce their use (Abrahamse, Steg, Gifford & Vlek, 2009) and their choice of public transport types when commuting (Donald, Cooper & Conchie, 2014) and more particularly, individuals’ energy conservation behaviors (Wang, Zhang, Yin & Zhang, 2011), their willingness/intention to reduce carbon use (Lin, Wu, Liu, & Lee, 2012), or their intentions related to afforestation efforts and underlying parameters (Karppinen, 2005).

The TPB also functions as an important theoretical framework in determining the intentions for use of RE sources. For example, in Halder et al.’s (2016) study, the tendencies of 9th and 10th grade high school students (n=532) in Finland and India to use bioenergy were investigated. With the structural model they established, they examined the power of the TPB to predict bioenergy use. As a result of the analyses, it was concluded that the attitude component was statistically the strongest and most meaningful predictor of bioenergy use, that the second strongest predictor was the SN component and that the PBC component, however, had a negligible or insignificant effect on the intention dimension. In general, it is emphasized that the model was accepted and that when the model was examined, it predicted the high school students’ intentions to use bioenergy.

In their scanning study, Alam and Rashid (2012) examined perceptions regarding the use of RE sources in Malaysia (N=200) by means of the scale they developed. In the analyses of the data obtained, they utilized exploratory factor analysis and multiple regression analysis. As a result of the factor analysis, items were grouped into five dimensions, namely relative advantage, perceived behavioral control, ease of use, awareness and benefit-cost trade-off. As a result of the multiple regression analysis to test the five dimensions, relative advantage and perceived behavioral control positively mediated attitude towards renewable energy, while attitude positively mediated intention to use renewable energy. However, ease of use, benefit-cost trade-off and awareness positively but directly influenced intention to use renewable energy.

*Proposed Model*

When the literature summarized above is considered, no study related to RE sources has been encountered in which knowledge level, risk perceptions and intentions in the context of the TPB are modelled together. However, when the literature outlined above is examined, it is considered that knowledge, risk perceptions and intentions regarding RE sources may be interrelated. As suggested by Pongiglione (2011) it is aimed to test the structural relationships proposed in Figure 1 by taking into consideration his suggestion that factors such as knowledge and risk perception are examined together with intention when examining environmentally friendly behaviors. Examining Figure 1, paths between knowledge, risk perceptions and the TPB with regard to RE sources are proposed. On the paths suggested, the broken arrowed lines show negative relationships, while the continuous arrowed lines show positive relationships. When these relationships are examined, first of all, the hypothesis that an increase in the knowledge levels of the preservice teachers regarding RE sources “may be a positive predictor of intention to use RE sources” is proposed, in accordance with the literature (Altuntaş & Turan, 2018; Bang et al., 2000).

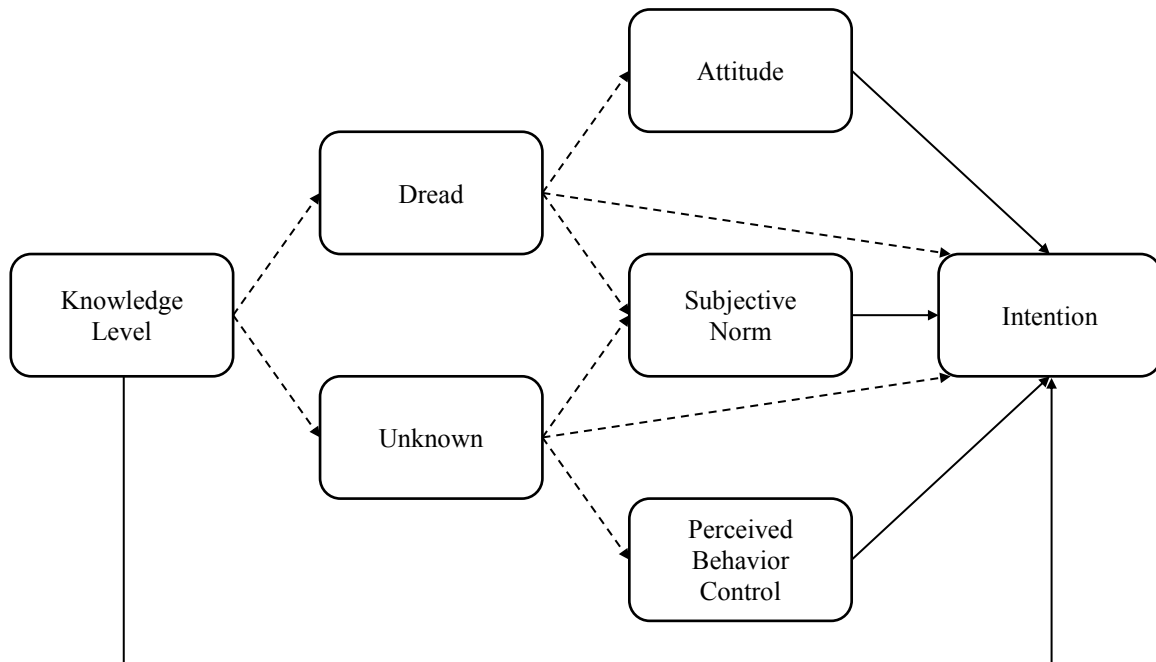


Figure1. Proposed model

On the other hand, considering knowledge levels and risk perceptions regarding RES, it is assumed that risk perceptions (some clues exist) may decrease as knowledge levels increase (Painuly, 2001; Upreti & van der Horst, 2004). Considering another relationship, the one between risk perceptions and the TPB, it is hypothesized that the preservice teachers' risk perceptions regarding RE sources may have a negative effect on the TPB components (AT, SN, PBC and I). Considering the dread and unknown risk factors related to RE sources, it can be expected that the dread factor, which accompanies concerns about the damage that renewable energy sources can cause to nature and living things, and the unknown factor, which includes the possible unknown damage from the risks in the future, will be negative predictors of the intention to use RE sources and of the other factors related to intention (AT, SN and PBC). Indeed, studies exist which show that risk perceptions about the use of RE sources negatively affect factors such as attitudes towards and intention to use RE sources (L'Orange et al., 2014; Wolsink, 2007). With these expectations in mind, answers to the following research question have been sought in the proposed model:

- 1) What are the relationships among preservice science teachers' knowledge levels, risk perceptions and intentions with regard to RE sources?

### *Significance of the Study*

When the literature is examined, it is seen that especially the variables chosen for this study are generally considered independently. In this study, the first significance of the study is to examine all three variables together and test the relationship between SEM analysis. Secondly, the results of the studies showing how TPB, which is frequently discussed in environmental studies, are diffused with other variables will contribute to the literature. In this sense, considering the risk perceptions and knowledge level together with the TPB reveals the second significance of the study. Finally, the selection of prospective teachers in this study shows another importance of the study, because it is important to clarify the perspectives of future teachers, who play a leading role in the acceptance of the public's use of RE resources.

## **Methods**

### **Participants**

In this study, the relationship between the variables presented in Figure 1 was investigated by SEM analysis. Therefore, the correlational research design was applied in the study (Fraenkel & Wallen 2009). A total of 642

preservice teachers from six different universities, selected by convenience sampling participated in the study. The preservice teachers were selected from preservice teachers attending to the 3rd and 4th grades of the science teaching and classroom teaching departments. Prior to this selection, the researchers examined the courses given and the departments in the faculty of education with regard to RE sources. The reason for the selection of preservice teachers from these grade levels and departments was because courses such as environmental science that include content knowledge related to renewable energy sources are included with priority in the curricula of the science teaching and classroom teaching departments and because these courses are completed by the preservice teachers at these grade levels.

## **Development and Implementation of Measurement Tools**

### *Development of Risk Perception Scale and Intention Scale*

It was aimed to develop scales containing preservice teachers' risk perceptions and intentions with regard to renewable energy sources. For this purpose, firstly, an interview form consisting of open-ended questions was prepared by taking inspiration from studies in the literature (e.g. Ajzen, 1991; Kılınc et al., 2009; Sjöberg et al., 2004). In the interview form, together with questions applying to the TPB and its components, such as Are you planning to use renewable energy sources? (I), Who will support the use of renewable energy sources? (SN), and What can be facilitated by using renewable energy sources, and what will you need? (PBC), questions applying to risk perceptions based on the psychometric paradigm were used, such as Does using renewable energy sources pose a risk to you? Can you explain your answer? (Dread), Can the risks that will be created using RE sources be brought under control? (Control), and Can the use of renewable energy sources cause any damage that we cannot observe today? (Unobserved Effect). The interview form consisted of 22 questions. Secondly, by means of the interview form prepared, focus group interviews were conducted with 16 preservice science teachers and preservice classroom teachers selected from the third and fourth grades. The focus groups were selected separately according to department and grade level and 4 focus groups were thus formed. Each group consisted of 4 preservice teachers, as follows: 4 classroom preservice teachers in third grade (2 low, 2 high), 4 science preservice teachers in third grade (2 low, 2 high), 4 classroom preservice teachers in fourth grade (2 low, 2 high), and 4 science preservice teachers in fourth grade (2 low, 2 high). To provide maximum diversity, the students in each focus group were evaluated according to their final grades in the environmental science course which included content related to renewable energy sources from the previous semester, and were separated into low and high achievement according to a certain pass mark set by the university automation system. Semi-structured interviews conducted with each focus group lasted approximately 45 minutes and were recorded with a voice recorder. With the aid of the transcripts of the data obtained from the interviews, the process of writing the items was begun and the item pool was created. The items created were examined by two academicians who are experts in the field, and the draft versions of the scales were created by making the necessary semantic and linguistic revisions and content control. The risk perception scale for RE sources consisted of 22 items, while the intention scale for use of RE sources consisted of 37 items. The scales were designed as 5-point Likert-type scales.

### *Risk Perception Scale*

Exploratory Factor Analysis (EFA) was applied to the risk perception scale developed as outlined above. Following maximum likelihood and Varimax rotation, factor loads below 0.40 were eliminated. As a result of the first analysis, 5 items with factor loads below 0.40 were removed and a two-dimensional structure was obtained. When the remaining 17 items were analyzed in themselves, it was seen that the two items were collected under a common dimension, these items were also removed. When the two-dimensional factor structure in the remaining 15 items was examined, it was seen that the factors were separated under the headings of "dread" and "unknown", as in previous studies. However, since two items which should, theoretically, have been collected under the title dread, were instead collected under the title unknown, these items were also removed and the analysis was finalized based on the remaining 13 items. Following the analysis, the KMO measure of sampling adequacy was 0.94 and Bartlett's test of sphericity was significant, with chi-square (4552,  $n=642$ ),  $p < 0.0001$ . Several verifications (eigenvalue $>1$ , scree plots and communalities value  $> 0.5$ ) were considered during the exploratory factor analysis, which produced a 2-factor solution. The factor loadings were between 0.82 and 0.46. Also, the Cronbach Alpha reliabilities were calculated as 0.85 and 0.90 for the dread and unknown dimensions, respectively. This explains 56% of the total variance.

### *Intention Scale for Renewable Energy*

To ensure validity of the intention scale for RE sources, EFA was performed using maximum (n=642) likelihood analysis with direct oblimin rotation. It was observed that the factors were distributed according to the Theory of Planned Behavior (TPB). Factors were divided into the PBC, SN, I and AT dimensions. However, it was seen that there were some problems in the attitude and intention dimensions. Firstly, considering the problem related to the attitude dimension, the analysis revealed that the items were collected in a fifth dimension outside the TPB components. When the items in this scale were examined, it was seen that although the items could be named in the attitude sub-dimension, they had shifted to a different dimension. Interestingly, when these items were examined in detail, it was seen that they consisted of negative attitude items. Although these items were recoded prior to analysis, the fact that they were placed in a separate dimension posed a problem. In order to solve this problem, first-order analysis was performed with AMOS software, and since a high degree of correlation was observed between items in the two dimensions, these were combined into a single dimension. After an item which reduced the estimated factor load had been removed from these combined items, the attitude dimension was finalized. As for the problem with the intention dimension, it was determined that some items of the intention dimension contained self-efficacy items. The analysis was finalized by removing these 3 items. Following the analysis, the KMO measure of sampling adequacy was 0.89 and Bartlett's test of sphericity was significant, with chi-square (4883, n=642),  $p < 0.0001$ . Several verifications (eigenvalue  $> 1$ , scree plots and communality value  $> 0.5$ ) were considered during the exploratory factor analysis, which produced a 5-factor solution. The factor loadings were between 0.84 and 0.41. Also, the Cronbach Alpha reliabilities were calculated as 0.66 for SN, 0.86 for PBC, 0.86 for I, and 0.75 for A, respectively. This explains 47% of the total variance.

### *Knowledge Level Test*

The knowledge test for RE sources was previously developed by Güven and Sülün (2017). The knowledge test used has a 3-point Likert-type ("correct", "wrong", and "don't know") structure consisting of 12 items. A reliability coefficient of KR20 = 0.84 was obtained by the researchers. Item difficulties for each item ranged from 0.39 to 0.65, and discrimination indices ranged from 0.32 to 0.58. In this study, while using the test, correct answers were awarded a score of 1 point, while wrong and "don't know" answers were given a score of 0. The test was subjected to structural equation modelling and evaluated on the basis of total score, and the total reliability coefficient of the test was determined as Cronbach's alpha = 0.72.

### *Procedure and Analysis*

The scale, which consists of the developed risk perceptions and intention scales and knowledge level test, was applied to 642 preservice teachers studying in the science teaching and classroom teaching departments of six different state universities. The reason for applying the scale to preservice teachers in these departments was because the curricula of these departments include content related to RE. Before the implementation, brief information about the purpose of the study was given to the participants and it was stated that since personal data would not be shared in any way, they should not specify their identity on the questionnaire. The data, collected using SPSS 25 software, were checked for missing values after the application. The explanatory factor analysis (EFA) of the developed risk perception and intention scales and the reliability analysis of the knowledge test were performed using SPSS 25 software. After the necessary analyses were performed and the scales were verified, Structural Equation Model (SEM) analysis was performed with the aid of AMOS software.

## **Results**

### **Descriptive Results**

The descriptive analysis shows that the mean scores of the preservice teachers related to renewable energy sources is 9.40. Considering that the maximum score that could be obtained from the knowledge test was 12 points, it can be said that according to their mean scores, the preservice science teachers had high levels of knowledge about RE sources. According to the results of the analysis, it can be said that the prospective teachers' risk perceptions with regard to RE sources were not very high. When the Table1 is examined, it is seen that the items related to risk perceptions are below the mean value.



Table 1. Descriptive and factor analysis results for risk perception

Dread	Mean	SD	Fac.
To what extent can renewable energy sources harm the lives of plants?	2.05	1.03	0.82
To what extent can renewable energy sources harm the lives of animals?	2.13	1.04	0.87
To what extent can renewable energy sources harm the lives of humans?	1.98	1.05	0.85
To what extent can renewable energy sources harm the lives of future generations?	2.09	1.12	0.78
To what extent do you worry about using renewable energy sources for the first time?	2.40	1.15	0.46
To what extent does using renewable energy sources mean disrupting the natural world?	2.14	1.06	0.56
Unknown			
To what extent may renewable energy sources contain risks which are invisible now, but which are potential risks in the future?	2.60	1.07	0.53
How worrying is the fact that renewable energy sources are new?	2.39	1.10	0.47
To what extent can the risks of renewable energy sources have a knock-on effect on other living things?	2.44	1.06	0.54
To what extent can scientists manipulate the risks of renewable energy sources for commercial purposes?	2.96	1.17	0.48
To what extent can a harmful effect of renewable energy sources created in one region impact other regions?	2.76	1.12	0.69
To what extent will the risks created by renewable energy sources increase in time?	2.63	1.03	0.76
To what extent can renewable energy sources cause unknown negative results today?	2.55	0.97	0.62

Table 2. Descriptive and factor analysis results for TPB dimensions

Attitude	Mean	SD	Fac.
Renewable energy sources provide an inexhaustible energy supply.	3.67	0.96	0.59
Using renewable energy sources reduces dependence on foreign resources.	4.03	0.90	0.62
The use of renewable energy sources can provide sustainable development.	3.84	0.87	0.71
Using renewable energy sources is environmentally friendly.	3.90	0.99	0.63
Renewable energy sources can increase global warming.	3.47	1.06	0.69
The technological infrastructure of renewable energy sources may disrupt nature.	3.12	1.01	0.67
Renewable energy sources can cause climate change.	3.23	1.06	0.71
Renewable energy sources may not replace fossil fuels for the consumer.	3.10	1.00	0.44
The use of renewable energy sources creates aesthetic pollution.	3.52	1.05	0.59
Renewable energy sources may not be able to meet the supply-demand balance.	3.03	0.98	0.43
Perceived Behavioral Control			
If the tools and equipment used for working with renewable energy sources ensure ease of use, I will choose them.	3.92	0.93	0.70
If renewable energy sources are safe, I will use them.	4.08	0.90	0.75
If the necessary infrastructure is provided to suit regional and climatic conditions, I will use renewable energy sources.	3.95	0.93	0.71
I will use renewable energy sources if they can meet our basic needs as much as fossil fuels.	3.79	0.95	0.61
If the use of renewable energy sources is tested in a region and the results are seen, I will use them.	3.83	0.90	0.66
If renewable energy sources ensure energy continuity, I will use them.	3.89	0.89	0.73
If technical support is provided for problems related to renewable energy sources, I will use them.	3.89	0.84	0.68
It is necessary to have sufficient knowledge in order to use renewable energy sources.	3.95	0.97	0.48
Subjective Norms			
If politicians and government officials approve my use of renewable energy sources, I can use them.	3.31	1.07	0.65
If the use of renewable energy sources is supported by the media, I can use them.	3.29	1.02	0.76
Intention			
I plan to use renewable energy sources in the future.	3.69	0.90	0.83
I am considering obtaining the necessary energy from renewable energy sources.	3.58	0.94	0.84
I am willing to use renewable energy sources.	3.83	0.95	0.80

However, when the mean values of the items under the dread heading and the items under the unknown heading are compared, it can be stated that with regard to RE sources, the unknown dimension was a more important parameter for creating risk than the dread dimension for the preservice teachers. For example, under the heading

of unknown, the preservice teachers agreed more strongly with the risks that “scientists may manipulate the risks of renewable energy sources for commercial purposes” and “a harmful effect created in one region may also impact other regions” than they agreed with other items. On the other hand, under the unknown title, the preservice teachers showed less agreement with the items related to the risks of newness of renewable energy sources. When the items under the dread heading are examined, however, the preservice teachers showed a high level of agreement with the point regarding using RE sources for the first time, while they showed low agreement with the point stating that renewable energy sources harm people’s lives. Considering each of the sub-dimensions of the TPB including the factors related to intention (Table 2), it can be said that attitude towards RE use, SN, PBC and intention have high mean values. For example, when the AT sub-dimension is examined, it can be stated that a large percentage of the preservice teachers considered renewable energy sources to be an important factor in reducing dependence on foreign sources. Again, while the preservice teachers accepted RE sources as environmentally friendly, they had a less positive attitude towards RE sources replacing fossil fuels for the consumer and towards RE sources meeting the supply-demand balance. When examining the SN of the preservice teachers, both items appear to have similar mean agreement values. The preservice teachers stated that with the approval of politicians and government officials and with the support of the media for the use of RE sources, then they could use RE sources. Examining another factor, that of PBC, the preservice teachers indicated that they gave more importance to safety, infrastructure and knowledge levels as facilitators for using RE sources and that they planned to use them after they were controlled. Although the PBC item for the ability of RE sources to meet basic needs as much as fossil fuels has a high mean score when considering the scale in general, it can be said to be a weaker facilitator in comparison with the other items in this dimension.

*SEM Results*

Structural equation modelling analysis was conducted to investigate the relationships among preservice teachers’ knowledge levels, risk perceptions and intention of using renewable energy. The statistical model has an acceptable fit index ( $\chi^2/df=2.82$ , CFI=0.90, TLI=0.89 and RMSEA=0.037). The structural relationships are displayed in Figure 2.

AT: Attitude, SN: Subjective Norms, INTENT: Intention

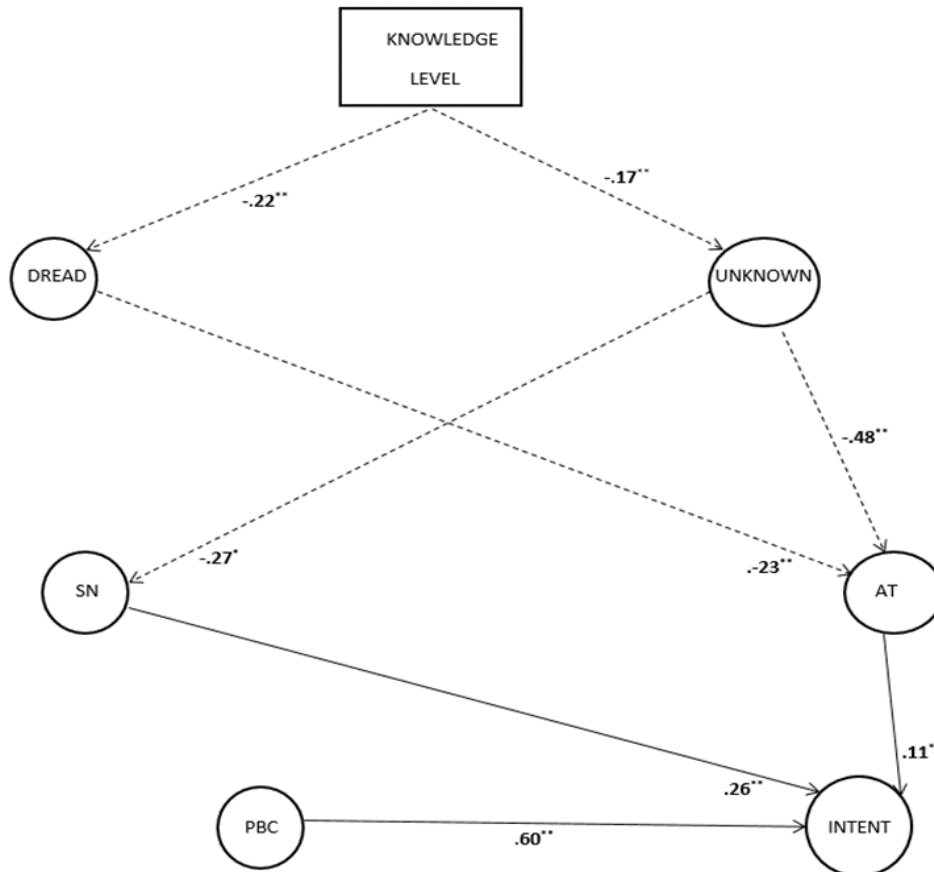


Figure 2. The statistical model (\*p<0.05, \*\*p<0.001)

The continuous arrowed lines display positive prediction whereas the broken arrowed lines are used to show negative prediction. According to the results of the SEM analysis, the preservice teachers' levels of knowledge about RE sources significantly predicted their risk perceptions, while there was no significant relationship with intention to use RE sources. As shown in Figure 2, the preservice teachers' levels of knowledge about RE sources were negative predictors of the "dread" and "unknown" factors that cause risk perceptions. Moreover, one of the most important results is that the risk perceptions of individuals negatively predicted almost all of the TPB components (excluding the PBC) that predict the intention to use RE sources.

When risk perceptions and subjective norms are examined together, risk perceptions are seen to predict subjective norms negatively. In other words, the less individuals know about the risks of renewable energy sources and the more their uncertainty increases, the less they pay attention to subjective norms that include other people's discourses and evaluations of the social environment. On the other hand, when positive relationships are examined, it is seen that all the TPB components have a positive effect on intention, in accordance with the theoretical framework. Individuals' attitudes towards renewable energy sources, subjective evaluations involving the influence of other people and the environment (subjective norms) and perceptions of control related to factors outside individuals' own worlds (perceived control) positively affect the intention to use renewable energy sources.

## Discussion and Conclusions

In this research, it was aimed to test the relationships among the knowledge levels, risk perceptions and intentions of preservice teachers regarding use of RE sources by using SEM analysis. For this purpose, an intention scale and risk perception scale related to RE sources were developed. As a result of the analysis, the factor structures of the risk perception and intention scales regarding use of RE sources were seen to be compatible with the theoretical framework in terms of validity and reliability. Of the two scales developed, the risk perception scale was divided into dimensions with the headings "dread" and "unknown" in accordance with the psychometric paradigm, which is a theoretical framework used in risk perception studies (Kılınc et al., 2016; Sjöberg, et al., 2004). Examining the intention scale, it was seen that it consisted of reliable factors including the TPB components of AT, PBC and SN, as well as intention, in line with the TPB framework. When the factors divided into sub-dimensions in accordance with the theoretical framework and with other studies (e.g. Halder et al., 2016; Karppinen, 2005) were subjected to SEM analysis, the structure in Figure 2 appeared. When this structure and the required values (RMSEA, etc.) are examined, it can be said to be a fit model. When beginning to discuss these results, it is considered that especially the relationship of the risk perceptions dimension with the knowledge level and TPB components may be regarded as interesting and of a type that will contribute to the literature.

The existing studies related to the use of RE in the literature consist of studies that are true to the framework of the TPB and reveal positive results of the TPB components, a finding which is also seen in this study (Alam & Rashit, 2012; Halder et al., 2016). In this context, testing the relationship between the TPB and risk perceptions can be considered important, as there are some studies (Kılınc et al., 2009; Wolsink, 2007), even though they do not directly include the term risk perceptions, which suggest that risk perceptions regarding RE sources may be a negative predictor of intention. For example, in their study, Kılınc et al. (2009; p.1089) mentioned that "there were some concerns about safety; although half of the students thought that renewable power installations were safer than other types of power generators, over half thought that renewable power generators could in some way harm plants, animals or humans that lived nearby". At this point, it is important to note that this study is not only important in raising the voice of such studies, but also in establishing this relationship and analyzing it with the SEM. When the findings shown in Figure 2 are discussed from this perspective, it is observed that the preservice teachers' knowledge levels regarding RE negatively predicted the "dread" and "unknown" factors that cause risk perceptions. Firstly, when the descriptive results are examined, it can be said that the knowledge levels of the preservice teachers' related to RE sources were high. Courses included in the curriculum such as environmental education, earth sciences, socio-scientific issues, and advertisements in the media such as public service announcements may have been effective in achieving these high levels of knowledge about RE sources in the preservice teachers. The fact that as the knowledge levels of the preservice teachers increased, their risk perceptions decreased may be because their fears decreased and because their fear of the unknown, which causes uncertainty, also decreased. Clues may also be found in the literature to the fact that as knowledge levels related to renewable energy sources increase, individuals' perceptions of risk towards that subject or object decrease (Upreti & van der Horst, 2004; Painuly, 2001).

Moreover, another point that should be discussed is that individuals' risk perceptions negatively predicted almost all the TPB components (except for PBC) with regard to the use of RE sources. This result is consistent with the hypothesis in the proposed model. Of these results, firstly, when the relationship between risk perceptions and attitude is examined, it is seen that although individuals believed that there would be positive results of RE sources and they had a positive attitude towards using RE sources, their high levels of risk perceptions related to RE sources affected their attitudes negatively. Indeed, both of the risk sources which create these risk perceptions and which are separated under the headings of dread and unknown in other risk studies, also negatively predicted attitude in this study (as seen in Figure 2). Similarly, in some research findings (e.g., Graham, Stephenson, & Smith, 2009; Wolsink, 2007), it is stated that concerns that can be considered as risk perceptions of RE sources (noise, impacts on wildlife, plants, ecosystems and water quality) are responsible for negative attitudes in individuals towards RE sources. In our study, it was observed that the preservice teachers had similar risk perceptions under the dread and unknown headings and that these had a negative effect on attitude. According to Frewer et al. (2004) risk itself is also regarded as a negative attitude towards a specific object, and risk is closely related to other factors such as attitude. Therefore, the risk perceptions of the preservice teachers towards RE sources may have had a negative effect on their attitude. Considering the descriptive results related to risk (Table 1), this situation may contribute to discussion on the subject. For example, the preservice teachers experienced uncertainty about how scientists could manipulate the risks of RE sources and about how a disaster occurring in one region could also affect other regions. In particular, the preservice teachers may have encountered some examples in lessons such as nature of science and history of science related to unscientific use of some of the activities carried out by scientists. Again, in recent years, it is increasingly stated that science is becoming commercialized (Irzik, 2013). This situation may have led to a high perception of risk among the preservice teachers. Regarding another risk factor, that of a harmful effect formed in one region also impacting other regions, the preservice teachers may have been directed towards this factor by remembering the events at Chernobyl, which was a nuclear disaster that closely affected Turkey and the effects of which are still seen today in the form of health problems (Kılınç et al., 2013). Again, under the dread dimension related to risk perceptions, using RE sources for the first time and the fact that their use is not yet considerably widespread may have constituted the risk borne out of fear. In risk studies, first time use is one of the most important factors (Demirbağ & Kılınç, 2018; Kılınç et al., 2016). Therefore, all risks perceived in this way may play a leading role in forming negative relationships with attitude and other factors.

Regarding risk perceptions and subjective norms, although individuals are encouraged to use renewable energy sources by their social environment, the more individuals perceive risks in renewable energy, the less important this incentive becomes. In other words, the less individuals know about the risks of renewable energy sources and the more their uncertainty increases, the less attention they give to subjective norms that include the discourses of others and evaluations of the social environment. However important the social environment is, since it is individuals themselves who perceive the risks, the impact of the environment may be of secondary importance. Especially in studies such as self-efficacy theory studies, in which individuals' own experiences are compared with the discourses of other people, and belief system studies, people's self-assessment is more effective than the verbal persuasion of others (Bandura, 1997; Rokeach, 1968).

On the other hand, when positive relationships are examined, it is seen that all of the TPB components affected intention, in accordance with the theoretical framework. The descriptive results can help to enlighten us on this point. As RE sources provide an inexhaustible energy supply, as dependence on foreign resources is reduced, as sustainable development is ensured, and as global warming decreases, individuals will evaluate RE sources more positively and their intention to use them with a positive attitude will increase. Indeed, many studies have shown that eco-friendly attitudes are positively associated with social acceptability and intentions (Alam & Rashid, 2012; Bang et al., 2000; Halder et al., 2016; Lin et al., 2012).

When PBC is examined, it is clear that the preservice teachers gave more importance to safety, infrastructure and knowledge levels regarding RE sources and that they intended to use them after they were controlled. Individuals may have believed that these external factors would be provided by policy makers and authorities, and that they themselves could carry out these factors following their control. A number of studies (e.g., Alam & Rashid, 2012; Halder et al., 2016) have reached similar conclusions to ours, with positive findings revealing that PBC directed towards RE sources was a positive predictor of intention. Examining the relationship between SN and intention, which is another positive relationship, the preservice teachers stated that they intended to use RE sources when these received support from policy makers and the media. Similarly, in studies conducted on the subject, the effect of SN on individuals' intentions towards environmentally friendly behavior was found to be positive (Kano, 2013; Karppinen, 2005).

## Implications

Firstly, considering the findings obtained, the implications of the study can be interpreted as follows. As seen in our study, the risk perceptions of the preservice teachers negatively predicted the TPB components. Therefore, researchers should assist users and stakeholders on the subject of risk mitigation and risk reduction related to RE sources. As stated in the literature, social acceptance regarding the use of RE sources should be realized and popularized (Upreti & van der Horst, 2004; Wolsink, 2007). In this context, in the matter of risk perception, which is one of the most important obstacles to logical decision-making and the use of sources of evidence (Kılınç et al., 2013), it may be necessary to raise public awareness and to develop public understanding of science. For this purpose, the opinions of experts (stakeholders such as engineers, risk psychologists, etc.) related to RE sources can be consulted. In addition, especially in risk assessment of the subject of RE sources, preservice teachers who are effective agents in the diffusion of innovations, it may be necessary to create educational environments in which individuals are taught to evaluate risk impartially. The impact created by such educational environments can be tested with studies related to risk. Since an increase in knowledge level negatively predicts risk, as can be seen in the findings of the study, and since this finding is encountered in a number of studies, it may be necessary to increase the knowledge levels of preservice teachers related to RE sources. Secondly, in the study, individuals stated that they would use RE sources when they possessed positive attitudes towards them. In this context, individuals can be further supported with regard to the positive aspects of RE sources. In particular, preservice teachers can be made aware of the factors that constitute attitude and which are studied in a decomposed way (perceived usefulness, perceived ease of use, compatibility) in the TPB, and the factors related to this type of attitude can be discussed in studies. With regard to SN, great responsibilities and duties fall on decision and policy makers and on the media, since the preservice teachers stated that they would be able to use RE sources provided that they were supported by politicians, government officials and the media. For this reason, support for the use of RE sources by the authorities can be given in the written and visual media through campaigns, advertising and discussion programs that explain why RE sources are needed in Turkey and in the world. For, unfair evaluation of evidence related to the risks of RE sources in the media may lead to dissemination of risks and distrust among the public and may weaken their acceptance of RE sources (Upreti & van der Horst, 2004). Finally, when the findings related to another variable, PBC, are examined, authorities and decision-makers should be responsible for providing security, meeting energy needs, conforming to climate conditions, providing energy reliability, and providing incentives like technical support and infrastructure related to RE sources. In particular, these factors can give important clues for social acceptance both to those who provide technical design and production of RE sources (engineers, etc.) and to policy-makers.

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