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CONTRIBUTIONS OF EPISTEMOLOGICAL BELIEFS ON ENERGY LITERACY IN LOWER-SECONDARY SCHOOL STUDENTS IN TURKEY

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Abstract. *Energy literacy has become a critical issue in recent years. The purpose of this study was to examine the contributions of epistemological beliefs to energy literacy in lower-secondary school students in Turkey. Data were collected via self-report questionnaires from 656 lower-secondary school students in the Aegean Region of Turkey. To address the research questions, Pearson correlation and multiple regression were implemented. Descriptive results revealed that students had a low energy literacy mean score in the knowledge dimension whereas they had moderate mean scores in the behavioral and affective dimensions. Multiple regression results yielded statistically significant contributions of epistemological beliefs to energy literacy. Analysis revealed that the reasoning dimension positively predicted the energy literacy in the knowledge dimension whereas the authority and accuracy dimension did negatively. The results of this study suggest that advancing students' epistemological beliefs can be a way to increase students' energy literacy levels.*

Keywords: *energy literacy, epistemological beliefs, lower-secondary school, regression analysis*

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Introduction

In recent years, energy has become a hot research topic in all disciplines from social science to engineering. One reason for this is that the development of industry, globalization and the rapidly growing world population have led to the need for more energy (Shao et al., 2022; Zhang et al., 2023). Today, the majority of energy production still relies on non-renewable energy resources, which will deplete in the near future. Additionally, excessive usage of fossil fuels (gas, petroleum etc.) is the main source of greenhouse gases, which leads to global warming (van den Broek, 2019). This has led to the need to produce new approaches and ideas on the effective use of energy and energy resources. Therefore, many countries put great efforts into developing energy policies for the efficient use of energy and energy saving (Erdal et al., 2008). In order to overcome energy issues, it is important to raise awareness in society about the use of energy resources and their effects (Karagöz & Bakırcı, 2009; Karatepe et al., 2012). Furthermore, raising awareness in society of energy may help in providing human resources for energy-related fields as people have their attention drawn to energy-related careers. For this reason, it is very important to educate and raise awareness in society of issues such as energy, energy resources, and energy consumption.

In order to sustain energy, society must be energy literate (Karpudewan et al., 2016). The concept of energy literacy has emerged to solve the energy crisis, to change the attitudes, beliefs and behaviors of people about energy and to raise public awareness (DeWaters & Powers, 2013). It covers individuals' habits of making appropriate choices about energy and using energy carefully. This includes emotional and behavioral characteristics as well as having extensive content knowledge on energy (DeWaters & Powers, 2011). Fah et al. (2012) defined energy literacy as paying attention to the efficient use of energy resources, having knowledge about the consumption and production of energy, and recognizing the social, global, and environmental effects of energy use. Based on these definitions, we define that energy literate people are those who know how energy is obtained, for what purpose and how much of it is used, who are able to evaluate the accuracy of knowledge about energy, are sensitive about developing alternative sources to fossil

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fuels and energy saving. They should also feel responsible for the future and can make decisions to use energy consciously (Martins et al., 2020).

Energy literacy is rooted in the theory of planned behavior change (Ajzen et al., 2018). Energy literacy includes knowledge (cognitive), sensitivity and attitude (affective) and behaviors (Kandpal & Garg, 1999). The cognitive dimension includes knowledge of the basic scientific principles, concepts, theories in energy and energy transfers, and the role of energy in the ecosystem (Martins et al., 2020). The attitude dimension is about the understanding of the progressions of the production and use of energy and the consequential environmental impacts, the common energy supply and shut down situations, as well as the influence of energy issues on human life (DeWaters & Powers, 2013). The behavior dimension assesses the awareness of the impact of day-to-day actions, the production and use of energy and the commitment to effective actions in saving energy (Martins et al., 2020). As a multi-dimensional concept, energy literacy does not only cover the knowledge about the concept of energy but also provides people with a positive attitude towards energy saving enabling them to exhibit correct energy-related behaviors throughout his/her daily life (DeWaters & Powers, 2011).

As an interdisciplinary concept, energy is included in the primary and secondary school science curriculum, and directly or indirectly related to many concepts in this course (Yürümezoğlu et al., 2009). Previous studies have examined the energy literacy of diverse groups from lower-secondary schools to adults in different counties (DeWaters & Powers, 2006; Güven & Sülün, 2017; Lee et al., 2015; Merritt et al., 2019; van den Broek, 2019). However, students from different levels (elementary to university) find energy a difficult and abstract concept to be understood (Erdemir & İngeç, 2023; Rizaki & Kokkotas, 2013). The results of the previous studies reported that individuals' energy literacy is not at a satisfactory level. Studies underscored that although individuals reported having positive attitude and behavior, their knowledge on energy and energy-related issues was limited. For instance, Güven and Sülün (2017) examined Turkish pre-service teachers' awareness of renewable energy and reported that most of them (72%) viewed petroleum products as renewable energy resources. In addition, the majority of the pre-service teachers in their study (78%) had limited knowledge of biomass energy. In another study, DeWaters and Powers (2011) studied 3708 upper-secondary school students' energy literacy in New York State and found that the students had low cognitive scores but did have high emotional energy literacy scores. Soğukpınar and Yenice (2022) examined Turkish lower-secondary school students' (seventh and eighth grades) energy literacy and found that students had high mean scores in affective and behavioral dimensions ($M = 3.43$ and 3.58, respectively) but a low mean score ($M = 0.35$) in the cognitive dimension. Evidence from these studies has shown that there is a need to examine factors related to energy literacy, especially in the cognitive dimension.

The low level of energy literacy, especially in the cognitive dimension, may be related to students' epistemological beliefs. Epistemological beliefs are about the beliefs of how knowledge is constructed, produced, and validated. It reflects one's philosophical perspective on the characteristics of scientific knowledge and how it is shared (Conley et al., 2004). Epistemological beliefs focus on the nature of scientific knowledge, including the source of such knowledge, its truth value, scientifically appropriate warrants, and so forth (Sandoval, 2005). According to Hofer and Pintrich (1997), epistemological beliefs are defined as what individuals believe about what counts as knowledge, how individuals come to know, and how knowledge is evaluated and constructed. Individuals' views on the nature of knowledge and knowing are associated with their meaning, learning strategies, ability to comprehend information, decision-making and evaluation of information sources (DeWaters & Powers, 2006).

Deng et al. (2011) argued that possessing advanced epistemological beliefs was related to comprehending the scientific process, making informed choices regarding socio-scientific matters, recognizing science's significance in modern culture, being more cognizant of scientific community norms, and acquiring a deeper understanding of scientific content. Studies addressing students' learning have reported that epistemological beliefs are so powerful that they directly and indirectly influence students' learning in many ways (Schommer-Aikins et al., 2005). Epistemological beliefs were related to motivation, academic achievement, and self-regulated learning (Ata & Alpaslan, 2019; Wang et al., 2022). Guo et al. (2022), for example, examined the association of epistemological beliefs with aspiration in science, motivation, and achievement from PISA 2015 data of 72 countries from 514,119 students. They found that epistemological beliefs were positively associated with intrinsic value, utility value and self-efficacy. In another study, Greene et al. (2018) reviewed 132 non-experimental studies to examine the relationship between epistemological beliefs and academic achievement. They found that epistemological beliefs were statistically related to academic achievement ($r = .16$, $p < .05$). Their study showed that those people with a more sophisticated view were more likely to have a higher academic achievement score. Additionally, Özbay and Köksal (2021) examined the role of epistemological beliefs on intellectual risk-taking and science achievement among Turkish lower-secondary school students. They found that epistemological beliefs were directly and indirectly,

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throughout intellectual risk-taking, related to scientific achievement. Evidence from these studies has shown that epistemological beliefs are directly and indirectly associated with science learning.

Today, energy is a critical issue in the world because of energy shortages and the increased usage of fossil resources, which are related to greenhouse gas emission that has led to climate change. This makes energy literacy even more important because it relates to people's awareness and behaviors on energy and enables them to act responsibly on energy issues (Lee et al., 2015). In the literature, studies have reported that the concept of energy is a difficult and abstract concept to understand, and students have low scores in the cognitive dimension of energy literacy. Additionally, in the 21st century, students are expected to participate productively in scientific and technological discourse, to evaluate and generate scientific explanations and evidence, thus indicating the importance of epistemological beliefs (Duschl et al., 2007). Technological and scientific discourse includes energy-related discourse, such as the issues of nuclear energy, carbon emission and renewable energy. From this perspective, it can be said that epistemological beliefs are very critical on energy literacy and its social implications.

The purpose of this study was to examine the contributions of epistemological beliefs on energy literacy. Theories and previous studies have underscored that epistemological beliefs influence students' comprehension of knowledge, their learning and decision-making. Understanding the role of epistemological beliefs on energy literacy is very important to fostering energy-literate individuals. Therefore, this study sheds light on how students can be better energy literate. In this study, the following research questions (RQ) were to be addressed:

RQ1: Is there a significant relationship between energy literacy and scientific epistemological beliefs?

RQ2: What proportion of variance in energy literacy can be accounted for by scientific epistemological beliefs?

Research Methodology

General Background

This research used the correlational research method with quantitative approaches. The correlational research method was suitable for determining the relationship between two or more variables without manipulating any variable (Fraenkel et al., 2012). Because the purpose of this research was to examine the relationship between energy literacy and scientific epistemological beliefs, The Energy Literacy Scale and the Scientific Epistemological Beliefs Scale were used to collect data. Data were collected in Spring 2021. Statistical techniques, including Pearson correlation and multiple regression, were implemented to address the RQs.

Sample and Context

All lower-secondary schools in Turkey must follow the science curriculum prepared by The Ministry of Turkish National Education. In the science curricula, energy-related topics are covered in the Fall semester of the seventh (force and energy unit) and the Spring semester of the eighth grade (energy recycling and environmental science unit) curricula. Because the eighth-grade students take the High School Entrance Examination (LGS) at the end of the semester, they usually are absent to study on the LGS. Moreover, during the COVID-19 pandemic (from Spring 2020 until Fall 2021), science teaching was done in distance learning settings. Therefore, all spring semester science units in science curricula, including energy recycling and environmental science, were removed from the LGS. Additionally, previous research reported that seventh and eighth-grade students' energy literacy did not statistically significantly differ (Soğukpınar & Yenice, 2022). For these reasons, in the study, the seventh-grade students were included as they were taught the energy concept in the force and energy topic. The population of this study was lower-secondary school students in Turkey. Since it was difficult to reach out to all regions in Turkey, Mugla Province was selected as the accessible population to save time and money. The ethical permission of the data collection was granted by Muğla Sıtkı Koçman University and the Muğla Directorate of National Education. Data were collected in Spring 2021. A parent consent form was distributed to the volunteer students who would participate in the study. Then, energy literacy and scientific epistemological scales were administered to those students whose parents had granted permission. For regression analysis with five independent variables (a power of .80 and alpha of .05), Green (1991) recommended at least 645 participants for small effect size, 91 for medium effect size and 42 for large effect size. Because the previous studies reported a small effect size for the relation of epistemological beliefs with achievement (Greene et al., 2018) and self-regulation (Alpaslan et al., 2017), it was decided to reach out at least 650 participants in the data collection. A total of 656 seventh-grade lower-secondary school students volunteered to participate in the study. The demographic characteristics of the sample are given in Table 1. As seen

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in Table 1, great attention was given to the inclusion of both urban and rural schools as well as obtaining female and male students in order to obtain a diverse sample in terms of gender and school location.

Table 1
Demographic Characteristics of the Participants

Categories	Sub-categories	*N*	%
Gender	Female	350	53.4
	Male	306	46.6
School location	Urban	387	59.0
	Rural	269	41.0

Data Collection Tools

In the study, the Energy Literacy Scale and Scientific Epistemological Beliefs Scale were used to collect data because both scales have been validated in the Turkish context and are suitable for lower-secondary school aged students.

Energy Literacy Scale

In order to determine the energy literacy of lower-secondary school students, DeWaters et al. (2013) developed the Energy Literacy Scale, adapted into Turkish by Güven et al. (2019). The scale comprised 57 items in three dimensions such as knowledge, affective, and behavioral. The knowledge dimension was in the form of a multiple-choice test (a total of 30 questions). Affective and behavioral dimensions were in the form of a 5-point Likert scale (1: Strongly disagree, 5: Strongly agree) and consisted of 17 and 10 items, respectively. DeWaters et al. (2013) reported the internal consistency values of Cronbach alphas ranged from .75 to .83. In this study, the internal consistency values of Cronbach alphas were computed to be .76 for affective dimension, .82 for behavioral dimension and .72 for the knowledge dimension.

Scientific Epistemological Beliefs Scale

The Scientific Epistemological Beliefs Scale was developed by Elder (1999) to measure primary school students' scientific epistemological beliefs. It was adapted into Turkish by Acat et al. (2010). As a 5-point Likert scale, the scale consisted of 25 items in five dimensions: process of knowledge production, authority and accuracy, reasoning, resource of knowledge, and variance of knowledge. The authority and accuracy dimension is that scientific knowledge is certain and takes place outside of the individual (nine items). The process of knowledge production is the belief about the role of experimentation or experience on scientific knowledge construction (six items). Resource of knowledge is about the beliefs on the accuracy of inquiries made from sources of knowledge other than from the individuals themselves (four items). Reasoning is about the role of curiosity and advancing the knowledge in the nature of knowledge (three items). The variance of knowledge is about the beliefs regarding the tentative nature of scientific knowledge (three items). Acat et al. (2010) found Cronbach alphas ranged between .57 and .86. In this study, Cronbach alphas were .89 for authority and accuracy, .81 for process of knowledge production, .79 for the resource of knowledge, .68 for reasoning and .75 for variance of knowledge.

Data Analysis

In the study, several statistical techniques were used. First, the normality of data was analyzed, and any outliers identified. Using a ±2.5 SD cutoff value, 46 students were removed from the dataset (46 out of 702) and the data from the remaining 656 students were analyzed. Kurtosis and skewness values were between -2 and +2 and thus, data were accepted as being normally distributed. We converted the knowledge test in the energy literacy scale for the affective and behavioral dimensions into the 5-point scale to find a total score of energy literacy. To address the RQ1, the Pearson product moment correlation coefficient was used to determine the relationship between the two scale sub-dimensions. Moreover, it was utilized because a statistically significant Pearson correlation was a

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pre-requisite to establish a linear regression model. Then, for the RQ2, multiple linear regression analysis was used to determine what proportion of variance in energy literacy could be accounted for by epistemological beliefs. Multiple linear regression analysis is a statistical technique to examine the explained variance of the dependent variable by more than one independent variable.

Research Results

The descriptive statistics of the variables and Pearson correlation coefficients are given in Table 2. The mean score in the total score of energy literacy was 3.24 (standard deviation of 0.40). The students in the sample were assessed as having moderate energy literacy. In the knowledge dimension, their mean score was very low (1.68 out of 5.00), indicating that the students involved in the study did not have adequate knowledge of energy. The highest mean score was in the behavioral dimension (M = 4.11) whereas their affective mean score was at the moderate level (M = 3.61).

Table 2
Descriptive Statistics and Pearson Correlation Coefficients among Variables

	Variables	*M*	*SD*	1	2	3	4	5	6	7	8	9
1	Total score of Energy literacy	3.24	0.40	-								
2	Knowledge	1.68	0.69	.59 **	-							
3	Behavioral	4.11	0.70	.79 **	.24**	-						
4	Affective	3.61	0.53	.60 **	.02	.44 **	-					
5	Authority and accuracy	2.92	1.01	.05	-.34 **	.19 **	.32 **	-				
6	Process of knowledge production	3.98	0.73	.49 **	.21 **	.43 **	.42 **	.22 **	-			
7	Resource of knowledge	3.14	1.02	.16 **	-.18 **	.22 **	.33 **	.78 **	.36 **	-		
8	Reasoning	4.04	0.79	.51 **	.32 **	.40 **	.39 **	.05	.67 **	.18 **	-	
9	Variance of knowledge	3.94	0.85	.39 **	.24 **	.31 **	.28 **	.01	.59 **	.11 **	.57 **	-

*Note: * p < .05; ** p < .01*

Pearson correlation coefficients showed that scientific epistemological beliefs were statistically correlated with the total score of energy literacy with the exception of the authority and accuracy dimension. The highest coefficient was between reasoning and energy literacy ($r = .51$, $p < .01$), indicating there was a large correlation between advancing information and scientific curiosity and the total energy literacy score. Additionally, the coefficient between the process of knowledge production and energy literacy score was close to the boundary for having a large effect ($r = .49$, $p < .01$). This showed that the more sophisticated beliefs on the role of experimentation in scientific knowledge were related to a higher energy literacy score. The results also showed that the variance of knowledge was correlated to the energy literacy score ($r = .39$, $p < .01$). For the relationship between epistemological beliefs and the dimensions of energy literacy, it was seen that all correlations were statistically significant with some being positive and others being negative. The knowledge dimension of energy literacy was negatively correlated to authority and accuracy ($r = -.34$, $p < .01$) and resource of knowledge ($r = -.18$, $p < .01$). However, it was positively correlated to the process of knowledge construction ($r = .21$, $p < .01$), reasoning ($r = .32$, $p < .01$) and variance of knowledge ($r = .24$, $p < .01$). The behavioral dimension was positively correlated with all epistemological belief dimensions, with the coefficients (*r*) ranging from .19 to .43. Lastly, the affective dimension of energy literacy was significantly positively correlated to all dimensions of epistemological beliefs, with *R-values* ranging from .28 to .42.

Multiple regression analysis tests were run to determine what proportion of variance in energy literacy could be explained by epistemological beliefs. Since the linear correlation was one of the prerequisite assumptions for multiple regression, non-significant correlations were not included in multiple regression as a predictor. The results of multiple regression are given in Table 3. The results of multiple linear regression showed that the dimensions of

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epistemological beliefs significantly predicted the total energy literacy score (F (4, 651) = 70.36, p <.01). Additionally, it was found that epistemological beliefs could explain 30.2 % of the variance in energy literacy. Reasoning and process of knowledge production were strong predictors of energy literacy (β = .31 and β = .22, respectively).

Table 3
Multiple Regression Results for the Total Score of Energy Literacy

Dependent: the total score of energy literacy	*B*	*SE*	*β*	*t*	*p*	95% CIs
Predictors						
(Constant)	1.95	0.08				[1.79, 2.11]
Process of knowledge production	0.12	0.03	.22	4.52	.00	[0.07, 0.17]
Resource of knowledge	0.01	0.01	.02	0.59	.55	[-0.01, 0.04]
Reasoning	0.16	0.02	.31	6.77	.00	[0.11, 0.20]
Variance of knowledge	0.04	0.02	.08	1.83	.07	[0.00, 0.08]
R^2 and Adj. R^2	.30 and .30					
F (df)	70.4 (4, 651), p < .01					

Note: The authority and accuracy dimension was removed from the model because it did not have a significant linear correlation with the dependent variable.

For each dimension of energy literacy, a multiple regression was run to better understand the role of epistemological beliefs in energy literacy (See Table 4). For the knowledge dimension, the multiple regression results showed that epistemological beliefs were significant predictors of energy literacy (F (5, 650) = 40.93, p < .01). Epistemological beliefs accounted for 23.9% of the variance in the knowledge dimension. Authority and accuracy was the strongest predictor of knowledge of energy literacy, but its sign was negative (β = -.44, p < .01). In addition, reasoning significantly contributed to the knowledge dimension (β = .25, p < .01), whereas the other three dimensions of epistemological beliefs were not. Epistemological beliefs significantly explained 26.4% of the variance of the affective dimension (R^2 = .246, F (5, 650) = 46.71, p < .01). Reasoning was the largest predictor of the affective dimension (β = .24, p < .01). Authority and accuracy and process of knowledge production were the other significant predictors of the affective dimension (β = .22, p < .01 and β = .17, p < .01, respectively). The other dimensions of epistemological beliefs were not significant predictors. Similarly, authority and accuracy, the process of knowledge production and reasoning were significant predictors of the behavioral dimension while the other two dimensions were not.

Table 4
Multiple Regression Results for each Energy Literacy Dimension

	Knowledge			Affective			Behavioral		
Predictors	*B*	*β*	*t*	*B*	*β*	*t*	*B*	*β*	*t*
(Constant)	1.04			1.97			2.076		
Authority and accuracy	-0.30	-.44	-7.95*	0.11	.22	4.12*	0.09	.13	2.30*
Process of knowledge production	0.08	.08	1.55	0.12	.17	3.40*	0.22	.23	4.37*
Resource of knowledge	0.06	.09	1.58	0.03	.06	1.03	0.01	.01	0.04
Reasoning	0.21	.25	5.03*	0.16	.24	4.91*	0.18	.20	4.18*
Variance of knowledge	0.04	.05	1.16	0.02	.04	0.80	0.05	.06	1.22
R2 and Adj. R2	.24 and .23			.26 and .26			.22 and .21		
F (df)	40.9 (5, 650), p < .01			46.7 (5, 650), p < .01			36.6 (5, 650), p < .01		

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Discussion

The need for energy is increasing daily. In order to advance our knowledge of energy and to find solutions, it is first necessary to foster energy literate individuals in society and engage them in scientific discourse on energy related issues. Here, the importance of energy literacy and epistemological beliefs emerges. However, studies have reported that students' energy literacy, especially in the knowledge dimension, was not at a satisfactory level. To overcome this issue and endeavor to increase energy literacy, it is critical to examine the factors influencing energy literacy. Therefore, in this study, the contributions of epistemological beliefs on energy literacy were examined.

One of the main purposes of education in schools is to produce scientifically literate individuals, who understand what counts as science, are able to think scientifically and are aware of the benefits of science (Holbrook & Rannikmae, 2009). These purposes address the fostering of individuals who have sophisticated epistemological beliefs. In order for students to transform information into desired behavior, they need to be aware of why they are learning information. Epistemological beliefs are known as individuals' personal beliefs about how to know and learn, and thus, students' scientific epistemological beliefs should be known in order to prepare learning processes in which they can transform knowledge into behavior (Constantinou & Papadouris, 2012).

The descriptive statistics showed that for the students questioned, the total energy literacy was at a moderate level. Previous studies in Turkey and other countries have reported that students at different levels generally have positive attitudes towards energy but limited knowledge and misconceptions about energy (DeWaters & Powers, 2011; Erdemir & İngec, 2023; Genç & Akilli, 2019). For the dimension of energy literacy, their mean score was at a high level for the behavioral dimension whereas it was at a low level in the knowledge dimension. Consistent with the results of this study, Soğukpınar and Yenice (2022) found that Turkish lower-secondary school students had high mean scores in the affective and behavioral dimensions; however, they had a low mean score in the cognitive dimension. Moreover, they reported that the mean value of the correct answer in the cognitive dimension was 10.5 out of 30.0, showing a nearly similar percentage with this study. That means that Turkish lower-secondary school students tend to have a low mean score (around 35%) in the cognitive dimension. Additionally, Töman and Çimer (2012) determined that primary school students have incomplete and incorrect information on energy and energy conversion. Similarly, DeWaters and Powers (2011) reported that lower-secondary students had the lowest score in the cognitive dimension but the highest in the affective dimension. However, the mean percentage of students' correct answers on the cognitive dimension in their study was 40.17%, indicating a higher percentage of correct answers in the cognitive dimension knowledge than Turkish students did in this study (33.6%). The high score in the behavioral dimension indicates that students accept the existence of energy problems and the need for energy conservation and are willing to apply behaviors related to energy conservation in their daily lives. However, the low mean score in the knowledge dimension shows that the source for the energy-related behaviors might not be their knowledge in energy. The reason may be that in the current lower-secondary school curricula energy concepts are taught during the science curriculum of the seventh and eighth grade. However, energy-related behaviors including how to save energy start to be taught at primary schools. Therefore, students obtained a high score in the behavior or affective dimensions but not in the knowledge dimension. It seems that the reason for their behavior or positive attitudes can arise from what they have been told; without knowing the logic or knowledge behind their behavior. Thus, energy concepts should be taught at an earlier age than at lower-secondary school in order for students to have an adequate knowledge of energy.

Pearson correlation coefficients showed that the dimensions of epistemological beliefs were statistically correlated to all the dimensions comprising the total score of energy literacy with the exception of the correlation between authority and accuracy and the total score of energy. The positive correlation coefficients obtained indicate that the more sophisticated epistemological beliefs students have, the more energy literate they are. A higher score in reasoning means that students are more likely to believe that scientific knowledge comes from curiosity and wondering why things happen. Consistent with this finding, Bahçivan (2014) assessed that believing in the important role of experimenting in developing scientific knowledge resulted in students being more self-efficacious in science learning. Thus, it is not surprising that students who have that belief would like to have a higher energy literacy score because they would have knowledge, logic, and the science behind the way to save energy. Similarly, students who have sophisticated ideas on the process of knowledge production tend to accept the empirical nature of scientific knowledge (e.g. scientists do experiments to test their ideas). This is plausible because having this idea is related to meaningful learning. Consistent with the results of this study, Özbay and Köksal (2021) found that students who accepted authorities as the only source of knowledge tent were more likely to take intellectual risks and be less archivers. Moreover, this is because students are more likely to believe that test-

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able ideas are more convincing when they can observe or test their ideas in daily life. Consistent with the findings of this study, in a recent meta-analysis, Greene et al. (2018) found that among epistemological belief dimensions, development and justification of knowledge were stronger predictors of academic achievement.

An interesting finding of this study was that having an authority and accuracy in science knowledge was negatively correlated to the knowledge dimension but was positively correlated with the affective and behavioral dimension. In addition, it was not significantly correlated with the total score of energy literacy. A plausible explanation for the non-significant correlation is because the negative and positive correlations neutralized each other for the total score of energy literacy (the total score of energy literacy was the sum of all dimensions). The authority and accuracy dimension refers to the idea that scientific knowledge is certain and that there is one right answer in science. It seems that most believe in the idea that scientific knowledge is not tentative and causes a lower knowledge score in energy literacy. These results support findings of previous studies done in Turkish contexts, reporting the more sophisticated epistemological beliefs lower-secondary school students have, the higher achievement score they have in science. For instance, Özbay and Köksal (2021) reported that having a belief in the tentative nature of scientific knowledge was associated with a higher score in achievement test. Moreover, Alpaslan et al. (2016) argued that believing that knowledge is certain is related to memorization, which leads students to adapt a surface learning approach. Additionally, students who have a belief of authority in scientific knowledge either externally (such as teachers or scientists) or internally (self-constructed) tend to obey the rules and do what they have been told (Alpaslan et al., 2017). For this reason, it seems plausible that authority and accuracy of epistemological beliefs were positively correlated to the behavioral and affective dimensions of energy literacy.

The previous studies in energy literacy reported that energy literacy is influenced by gender, the environmental attitude, the school type and curricula, parents, and socio-economic status (Ballantyne et al., 1998; Dijkstra & Goedhart, 2012; Sovacool & Blyth, 2015). Results of multiple linear regression showed that epistemological beliefs explained a proportion of 30.2% variance in the total score of energy literacy, 23.9% in the knowledge dimension of energy literacy, 22.0% in the behavioral dimension of energy literacy and 26.4% in the affective dimension of energy literacy. These results can be considered as good and significant because they underscore the importance of epistemological beliefs in energy literacy. Epistemological beliefs refer to beliefs on the nature of knowledge and knowing, which are associated with how they approach knowledge, select appropriate strategies and goals and can affect their attitudes and behavior. In addition, previous studies have reported that students' epistemological beliefs are influenced by their gender, socio-economic status, parents' educational level, knowledge level, school curricula and school experience (Alpaslan et al., 2017; Kurt, 2009). For this reason, although this study provides evidence of the direct role of epistemological beliefs on energy literacy, indirect or reciprocal roles of epistemological beliefs on energy literacy should also be investigated.

Conclusion and Implications

The results of this study have provided evidence that epistemological beliefs play an important role in their conceptual, behavioral, and affective understanding of energy concepts. Based on the results of the study, it can be concluded that fostering students' epistemological beliefs is not only important for scientific literacy but also critical for them to become energy literate individuals. In other words, believing in the idea that scientific knowledge comes from reasoning and curiosity leads students to have a better literacy score in energy. Additionally, holding a sophisticated belief in the production of scientific knowledge results in the students being aware of the importance of energy saving. Similarly, based on the results of this study, it can be concluded that students who accept the authority and accuracy in scientific knowledge tend to pay attention to the efficient use of energy but have less knowledge regarding the energy concept.

The results of this study suggest that teachers should employ innovative instructional approaches to advance their students' epistemological beliefs in order for students to comprehend the energy concepts. The studies on fostering epistemological beliefs suggest that hands-on and mind-on activities, including inquiry-based instruction, project/problem-based instruction, and argumentation-based instructions, have the potential to advance students' ideas on knowledge and knowing. Therefore, rather than traditional approaches, employing these sorts of instructions in energy education would be more effective in teaching the concept of energy.

Limitations of the study

This study has some limitations. First, the sample of this study included seventh-grade students at lower-

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secondary schools that had received little emphasis on energy concept in the Turkish science curriculum. Upper-secondary school curricula in Turkey give much more emphasis on energy. Therefore, examining the relations of epistemological beliefs and energy literacy of upper-secondary school students would be beneficial to understanding the role of epistemological beliefs on energy literacy. Secondly, there are other factors affecting energy literacy and epistemological beliefs, including motivation, attitude, learning strategies and demographic variables. There is a need for future studies that include these variables to explain the variance of energy literacy. Lastly, to measure the knowledge dimension of energy literacy, we used a multiple choice investigation, which has some potential limitations such as bias, cheating etc. The use of two-tier diagnostic tests is suggested to better detect their understanding of the concepts to be measured. Therefore, there is a need to develop two-tier diagnostic tests to better measure their conceptual understanding of energy.

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Ethics Committee Approval

The study was approved by Mugla Sitki Kocman University Ethics Boards of Research in Social Science on 27 June 2021 (No: 319).

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