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CORRELATION BETWEEN ENERGY METAPHOR AND EMPATHY TENDENCY

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Abstract. *Creating a metaphor for the concept of energy can contribute to the determination of the mental structuring of the concept of energy. Pre-service teachers' metaphors about the concept of energy were classified according to traditional and scientific fields. The metaphors produced by the mathematics and science teacher candidates for the concept of energy consisted of structural and abstract concepts, approximately 60% of them were the continuity of life and 40% were science categories. While pre-service mathematics teachers mainly produce metaphors for biology, pre-service science teachers produce metaphors mainly for physics. Empathic tendency scores and levels of pre-service teachers were determined. Pre-service teachers have a high level of empathic disposition and predominantly see the other person's problem and emotion as their own. There was no quantitatively significant difference between traditional metaphor types and empathic tendencies. It is understood that the pre-service teachers have high empathic tendencies, and mostly in the you stage, the concepts related to the continuity of life are primarily used in developing metaphors related to the concept of energy, and they tend to produce structural metaphors. Metaphor and empathy will contribute to the determination of mental models and the establishment of a connection between the fields of science.*

Keywords: *energy metaphor creation, empathic disposition and relationship identification*

Introduction

The cognitive learning theory regards learning as a cognitive process and focuses on mental operations (encoding, storing, and retrieving information) to make sense of the occurrences in the environment. In parallel with the cognitive learning approach, the dominant view of the concept of the metaphor (the metaphor is the art of speaking, embellishing speech, and eloquence) has gradually begun to change. In addition to the art of eloquence, the view that the metaphor is the product of a mental process and that the focus of the metaphor is not a language but a mental mechanism has gained prominence. Lakoff (1993) emphasized that the metaphor is not only the art of eloquence but also reflective of the way of thinking.

While authors, poets, and artists were interested in metaphors and empathy in classical times, today, different fields of science have shown interest in the concepts. Artists reflect the mental models they developed based on their empathic perceptions of their works. Artworks are a product of the artist's emotional, cognitive, and empathic state. Authors and artists have tried to put themselves in the shoes of what they are trying to depict, believing that empathetic understanding is the key to good writing and practical art (Smith, 2012). The person looking at a work of art internalizes the artist's thoughts and feelings through empathy. As how internalization is made varies by person, a work of art evokes different feelings and thoughts in everyone. Metaphors and empathy are a way of reflecting on one's mental models of the world. Metaphors and empathy are similar concepts, and in situations of creating the metaphor and empathy, relationships and similarity patterns are used (Swan & Riley, 2012).

Individuals utilize different features and connections when creating metaphors, which makes metaphors unique to the individual. Empathy, on the other hand, is about how the other person is perceived and internalizing his behavior cognitively or emotionally. Empathy is understanding the other person's feelings, perspectives, or situations and experiencing the other person's emotional state (Swan & Riley, 2012). When a person uses the metaphor and practices empathy, they acknowledge another person's mental models, knowledge, and experiences through mental processes. The metaphor is a way of reflecting perceptions, concepts, and thoughts through mental

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processes. Morgan (1998) defined metaphors as a way of thinking and seeing in perceiving the world. Empathy, on the other hand, is trying to understand the thoughts and feelings of another person and seeing the world from their point of view. Empathy is the ability to make inferences by decoding another person's thoughts, feelings, and behaviors (Swan & Riley, 2012). Metaphors and empathy are mental processes at the end of which the external projection of internalized situations is presented. The metaphor is a way of reflecting perceptions, concepts, and thoughts through mental processes, while empathy is acknowledging the feelings and thoughts of another person. In creating metaphors, mental models are developed based on existing information while empathy is the practice of perceiving the feelings and thoughts of another person and acknowledging them through unique mental models.

The Metaphor

Mental models (scientific models) are defined as a set of meaningful metaphors, and one way of projecting mental models is by using metaphors. Lakoff and Johnson (1980) stated that metaphorical concepts are the essence of scientific thinking and that without them, little can be understood beyond our direct physical experience. Mental models help us understand the surrounding phenomena around us by making meaningful connections with and extending our prior knowledge. Thinking metaphorically enables a new phenomenon to be understood by relating it to previous experiences (mental models). Conceptual metaphors represent the relationship mental models and are created by connections such as relationships and analogies. Additionally, metaphors serve as the interface between mental models and are an element of the mental mapping mechanism, which shapes thinking (Beasley & Waugh, 1996).

It is difficult to directly observe and measure an abstract concept. The concept of energy is appropriately defined within the confines of science, but these definitions do not apply to all fields. For example, students think that the definition of energy in biology is different from that in physics. Lakoff and Johnson's (1980, 1999) conceptual metaphor theory presents an ideal method through which to teach this topic (Amin, 2009; Dreyfus et al., 2014; Lancor, 2014; Scherr et al., 2012). Conceptual metaphor theory plays an important role in understanding abstract concepts, being a cognitive theory arguing for the largely metaphorical nature of the way we understand the world and that most conceptual structures are built based on metaphors that help us make sense of the world through the familiar (Lakoff & Johnson, 1980, 1999). A new experience or concept is constructed by establishing relations between mental models, and metaphors are used in understanding a concept or field based on other concepts or experiences. Metaphorical language is essential for expressing and understanding abstract ideas, and conceptual metaphor theory provides a way for researchers to gain insight into how students understand abstract concepts such as energy (Lancor, 2015). With the metaphor, a new concept, phenomenon, or object is instinctively associated with the important features of the concepts, phenomena, and objects that exist in our minds, making the new concepts, phenomena, and objects understandable. This helps to interact with and make sense of the environment.

When we conceptualize an experience or an idea, we make sense of the experience or idea by picking its most important parts and comparing them with what already exists in the mind. This mental process creates metaphors by pairing phenomena, objects, and concepts otherwise difficult to understand with other concepts that have common characteristics, thus facilitating learning and recall by making them understandable. Metaphorization is explaining a concept or phenomenon by drawing an analogy with another concept and phenomenon (Oxford et al., 1998). The metaphor enables complex and abstract aspects of reality to be understood in more concrete, familiar, and easily imaginable terms (Refaie, 2001; Semino, 2008). Metaphors also contribute to eloquence, are effective in persuading and influencing others, and facilitate strengthening communication and building intimacy between the speaker and the listener (Semino, 2008).

Empathy

The Turkish Language Association (2018) defined empathy as the ability of an individual to put themselves in the shoes of another individual in terms of emotion and thought. Empathy is a human trait, a psychological mechanism, that enables individuals to establish and maintain social relationships and to take an evaluative stance toward the vantage point of aesthetics and epistemology. It is also a behavior that enables individuals to make logical inferences from moral and social mistakes by empathizing and reasoning with and drawing lessons from them. Earlier, empathy was addressed from the vantage point of aesthetics and epistemology. Aesthetic empathy refers to individuals' spontaneous projection of feelings and thoughts while observing objects, whereas epistemological

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empathy has been used by artists and poets as a means to achieve their goals (Gulseren, 2001).

Today, empathy is defined as putting oneself in the other person's shoes, seeing the similarities and differences in the other person's ideas, and respecting and tolerating differences. Respecting others' opinions is important for establishing healthy communication and relationships. Denis (1999) stated that those who are good at building positive relationships generally empathize with people more easily. Empathy is taking the place of the other person and possessing and internalizing the same emotions and ideas as them. Baron-Cohen (2003) defined empathy as the urge to identify the thoughts and emotions of another person and respond to them with an appropriate emotion. Reacting by understanding the other person facilitates healthy social relations and achieving common goals.

The literature distinguishes between two types of empathy, namely cognitive and emotional (Brems, 1989; Hoffman, 1977; Rogers, 1980; Shantz, 1975; Strayer, 1987), and the type of empathy practiced changes by a situation (Gladstein, 1983). Cognitive empathy is the ability to accurately perceive or imagine what another person is thinking and feeling by ascribing mental states to them. This mental process is sometimes referred to as the theory of mind or perspective (Davis, 1983; Hogan, 1969). Emotional empathy is the emotional response of individuals who put themselves in another's place. It refers to sharing emotional responses, for example, feeling distressed in response to the other person's pain or feeling happy in response to their joy. Hoffman (2008) defined emotional empathy as the ability to identify with the emotions of others and to understand what the other individual is feeling. Emotional and cognitive empathy are equally important in communicating with others, perceiving what they are thinking and feeling, relating to them emotionally, and allowing them to share their thoughts. There is a consensus in the literature that these two elements are inseparable (Feshbach, 1975; Greenberg et al., 1993; Greenson, 1960; Katz, 1963; Schafer, 1959; Strayer, 1987).

Metaphors, Empathy and Teaching Energy

In everyday life, mental models are unwittingly used to understand the environment and describe phenomena. Metaphors and empathy are abstract concepts involving mental modeling. Mental models (scientific models) include analogies or metaphors (Aubusson et al., 2006) and are often constructed through analogical reasoning (Collins & Gentner, 1987). Often mental models are verbalized through metaphoric and empathetic responses. These responses serve to activate, elaborate, or modify mental models as in understanding something (Hestenes, 2006). Therefore, understanding the language used to communicate the mental model provides insight into this model (Lancor, 2015). In teaching, with the help of metaphors and empathy, students' mental models of the subjects can be identified, in light of which the course content can be restructured and processes suitable for these mental models can be developed.

Metaphors constantly change due to the physical and cultural interaction with the environment, which enables the development of mental models and paves the way to establishing new connections with different fields. Metaphors can be used as learning outcomes that aim to identify students' mental models and thoughts on the subject. Since metaphors and empathy are projections of mental models, they can be used to restructure the curriculum and teaching methods used and determine learning outcomes. In addition, examples of empathetic utterances can be used in the in-class interactions between students and teachers.

Students can use metaphors as a tool to describe and understand their environment and practice empathy to build healthy communication and relationships. While creating a metaphor, it is possible to expand an existing model or create a new one by establishing relationships, similarities, and commonalities between mental models. They stated that there is a relationship between mental models and metaphors (Duit, 1991; Hestenes, 2006), and empathy is the basis for how we understand someone else's mind and how we reflect our own mental states or create a mental model (Fonagy et al, 1991). Empathy is basically metaphorical (Swan & Riley, 2012), empathy and metaphor are formed as a result of models using mental information, emotions, thoughts and experiences. Metaphors function as a pathway to empathy (Smith, 2012). Familiar terms are used when generating metaphors and practicing empathy. Individuals likely empathize with victims similar to themselves (family members), which is called "familiarity bias" (Hoffman, 2000).

Empathy and metaphors can be utilized in the interactions between students and teachers in the classroom environment. The teacher can empathize with what the students are thinking and feeling with the help of emotional and cognitive expressions such as worry, feedback, understanding, and reaction. This use of empathy makes it easier for the teacher to meet the students' needs. Additionally, teaching-learning models can be adjusted in light of the information about the mental processes and structures students utilize to create metaphors and practice empathy.

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To eliminate the complexity of the concept of energy and establish stronger scientific relationships between the fields, a common definition of the concept of energy is required. In crafting this definition, the relationships between mental models related to the concept of energy can be determined with the help of metaphors. Empathetic tendencies can also help determine the relationships between models and define metaphors. Future metaphor studies can investigate mental models related to the concept of energy within the context of preliminary scientific information. It is necessary to identify students' preliminary information regarding how and why a phenomenon takes place and reorganize the teaching-learning models for the science class in a way to address students' misconceptions (Dekkers & Thijs, 1998; Osborne & Wittrock, 1983). Students' preliminary knowledge about the concept of energy can be identified through metaphors. As metaphors serve as an interface between different pieces of information in the mental structuring of scientific knowledge, they can be used in forming mental maps related to the concept of energy. These maps can be used to correctly define the concept of energy as well as to eliminate confusion related to the properties of energy and energy as it is taught during class time. Mental models that facilitate the comprehension of the concept of energy can be used to produce a definition of energy that is common across different disciplines.

Problem Situation

Since metaphor and empathy are abstract concepts, their definitions vary from person to person and according to scientific fields. Definitions are made using similar characteristics of different concepts, phenomena, relationships, events, etc. Since similar characteristics vary from person to person, it is difficult to create a common definition for abstract concepts. People in scientific fields express the same concept as a metaphor using mental processes according to different definitions or specific characteristics. Therefore, metaphor sheds light on how the mental structure is formed. In addition, the use of metaphor will contribute to a common definition of abstract concepts among scientific fields. In this context, the concept of energy is expressed with different metaphors in different fields of science. These expressions will enable the establishment of connections between scientific fields, the elimination of deficiencies and errors, and the establishment of correct and effective relationships between fields. It is important to establish a correlation between concepts in the mental structuring of abstract concepts. Determining the correlation between energy metaphor and empathic tendency is important in terms of mental structuring. Learning is realized by establishing connections between mental structures. Knowing the connections between concepts will enable learning to take place more effectively.

In this study, qualitative and quantitative relationships between the classification of energy metaphor according to traditional and scientific fields and the empathic tendency status and empathic tendency levels were examined. It was investigated whether there was a quantitative correlation between empathic tendency scores and traditional metaphor classes. A qualitative correlation between empathic tendency levels and the fields of science (categories) in which the energy metaphor is included was tried to be determined. The correlation between energy metaphor and empathy was determined with the following questions.

1- What are the traditional classes and categories of the metaphors produced by pre-service mathematics and science teachers for the concept of energy?
2- What are the empathic tendencies and empathic steps of pre-service mathematics and science teachers?
3- Is there a significant difference between empathic tendency scores according to the traditional Energy Metaphor type?

Research Methodology

In the study, a semi-structured form and an empathic disposition scale were used to determine metaphors for the concept of energy. Mathematics (40) and science (71) pre-service teachers took part in the study. The concept of energy is very common in the fields of physics, chemistry and biology in science. Therefore, pre-service science teachers were included more in the study.

The metaphors formed by the pre-service teachers for the concept of energy were categorized according to traditional and scientific fields. The empathic tendencies and empathic tendency steps of the pre-service teachers were determined. The correlation between the traditional metaphor classes and empathic tendency scores and the science fields (categories) in which the energy metaphor is included and the empathic tendency steps were determined.

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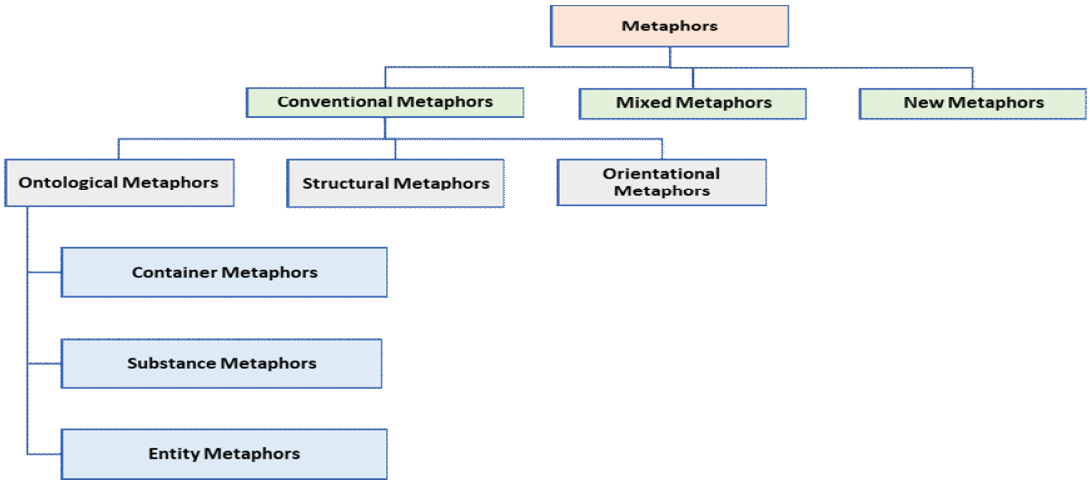
The importance of the study is that concrete and abstract concepts are used as metaphors to define abstract concepts. The metaphors produced for the concept of energy contribute to the determination and definition of the mental structuring of the concept of energy. The fields of science use the concepts, events and objects in their own fields of science to define the concept of energy. This means that each field of science produces metaphors for the concept of energy according to its own mental structuring. It is to define the concept of energy according to the fields of science. By using the energy metaphor, a common definition of energy between the fields of science is provided and the connections between the fields of science are strengthened. It will also contribute to the definition of a common energy concept that can be used by science fields to determine learning situations. In addition, determining the connection between the abstract concept of empathic tendency and energy metaphor will contribute to the more comprehensive mental structuring and definition of the concept of energy.

In the study process, candidates were given metaphors and examples of metaphors including the feature that connects the metaphor to the subject. While producing metaphors, it was emphasized that the metaphor alone would not make sense and that the feature linking the metaphor to the subject should be specified. A semi-structured form was created for the concept of energy and the pre-service teachers were asked to express their mental reflections about the concept of "energy" with another name using the form. The metaphors created for the concept of energy were obtained through content analysis. If the metaphor created for the concept of energy did not have energy-binding properties, it was considered invalid. The valid metaphors determined by the researchers were classified according to the traditional metaphors and science fields in Figure 1. The empathic tendency scale (Table 1) was used to determine the empathic tendency scores and empathic training stages of the teacher candidates. It was determined whether there was a quantitative correlation between traditional metaphor classes and empathic tendency scores. The fields of science (categories) in which the metaphors were created were compared with the empathic disposition levels.

In this study, metaphors related to the concept of energy were classified according to the traditional metaphor classification in the "Dictionary of Linguistic Terms" (SIL, 2018). The International Summer Institute of Linguistics (SIL, 2018) made a classification based on the work of Lakoff and Johnson (1980), Beekman and Callow (1974) and Mish (1991). This classification is given in Figure 1:

Figure 1
Classification of Metaphors. SIL. (2018)



Conventional metaphors: A conventional metaphor is commonly used in the colloquial language of a culture to give structure to part of the conceptual system of that culture. There are three different kinds of conventional metaphors: ontological, orientational, and structural. A structural metaphor is a conventional metaphor, whereby a concept is understood and expressed vis-à-vis another structured, sharply defined concept. Orientational metaphors involve orientations, such as space, place, inside, and outside, and are concerned with systematic relationships between emotions and motor-perceptual experiences. An ontological metaphor is a metaphor where an abstrac-

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tion, such as an activity, emotion, or idea, is represented by something concrete, such as an object, substance, container, or person. There are three kinds of ontological metaphors: container, entity, and substance. Container metaphors are ontological metaphors in which some concepts are represented as having an inside and outside and capable of holding something else. Material metaphors are ontological metaphors in which an abstraction, such as an event, activity, emotion, or idea, is represented as material. Entity metaphors are ontological metaphors in which an abstraction is represented as a concrete physical object (SIL, 2018).

Mixed metaphors: Mixed metaphors are used to express the same concept, used in the same utterance, especially in the same sentence. In other words, it involves expressing a concept in a sentence using different metaphors. Mixed metaphors often, but not always, lead to a clash of concepts.

New metaphors: New metaphors are not part of a culture's conceptual system as reflected in its language. This is defined as allegory (SIL, 2018). Allegories are metaphors extendable as stories, especially used to make sense of and express aspects of fictional characters, actions, and concepts related to human existence (Kurt, 2019).

The empathetic tendencies of pre-service teachers were measured using the empathic tendency scale developed by Dökmen (1988) in Table 1. The scale is Likert type and consists of 20 question statements about empathic tendency. The lowest score that can be obtained from the scale is 20 and the highest score is 100. The highest score for each item is 5 and the lowest score is 1.

Table 1
The Empathic Tendency Scale (Dökmen, 2018)

	Empathic tendency questions	Strongly Disagree (1)	I agree very little (2)	Sometimes I agree (3)	Usually I agree (4)	Completely I agree (5)
1	I have many friends.	( )	( )	( )	( )	( )
2	Sometimes I get teary-eyed while watching a movie.	( )	( )	( )	( )	( )
3	I often feel lonely.	( )	( )	( )	( )	( )
4	Those who talk to me about their problems feel relieved after our conversation.	( )	( )	( )	( )	( )
5	The problems of others concern me as much as my problems.	( )	( )	( )	( )	( )
6	I have difficulty communicating my feelings to others.	( )	( )	( )	( )	( )
7	I find it strange when people cry while watching a movie	( )	( )	( )	( )	( )
8	Sometimes, when I'm arguing with someone, my attention is more focused on my answer than on what the other person is saying.	( )	( )	( )	( )	( )
9	I am a very popular person in my social circle.	( )	( )	( )	( )	( )
10	I feel relieved when movies have a happy ending.	( )	( )	( )	( )	( )
11	I have difficulty communicating my thoughts to others.	( )	( )	( )	( )	( )
12	Most people are selfish.	( )	( )	( )	( )	( )
13	I'm an angry person.	( )	( )	( )	( )	( )
14	I usually trust people.	( )	( )	( )	( )	( )
15	People don't completely understand me.	( )	( )	( )	( )	( )
16	I'm a sociable person.	( )	( )	( )	( )	( )
17	It makes me feel better to open up to someone close to me about my problems.	( )	( )	( )	( )	( )
18	I am generally satisfied with my life.	( )	( )	( )	( )	( )
19	My close ones often tell me about their problems.	( )	( )	( )	( )	( )
20	I'm usually in a good mood.	( )	( )	( )	( )	( )

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A high total score indicates a high level of empathetic tendency; a low score indicates a low empathetic tendency. Using the medians of each empathic tendency statement in the scale, the ranking of the empathetic tendency levels was determined. Mean empathic tendency scores vary between 1 and 5. According to the mean empathic scores, the empathic disposition behaviors of the pre-service mathematics and science teachers were ranked. According to this ranking, empathic disposition classes were determined.

The metaphors about the concept of energy created by pre-service mathematics and science teachers were traditionally classified and categories were formed. Empathic tendency scores and average empathic scores of the candidates were calculated. Mann Witney-U test was used in the comparison of the traditional classifications of the metaphors formed by the candidates and their empathic tendency scores, since normality and homogeneity of variance were not ensured.

Data Collection

In the semi-structured form, sample metaphors were presented, and the pre-service teachers were asked to examine them. The pre-service teachers were asked to write a metaphor for and a property of the concept of energy in the blanks in the form. In the form, the first blank is for the source of the metaphor, and the second blank is for the property associated with the concept. Below is the template used by the pre-service teachers.

Energy is ..... (source of the metaphor)..... *Because*.....(the property that links the metaphor to the concept).....

The metaphors produced in accordance with the template were classified traditionally in Figure 1 and Table 2 and Table 3 of pre-service mathematics and science teachers were created. In addition, the fields of science in which the energy metaphors took place are shown in Figure 2 and Figure 3.

The empathic disposition levels of the pre-service teachers were measured using the 20-item "empathetic disposition scale" (Table 1) developed by Dökmen (1988). Each question was answered on a Likert scale from 1 to 5, the lowest and the highest scores that can be obtained from an item, respectively. The 3rd, 6th, 7th, 8th, 11th, 12th, 13th, and 15th items were reverse scored. Based on the scores obtained from the scale, the pre-service teachers' empathetic tendency scale scores and the mean scores of the items were determined.

Data Analysis

The metaphors for the concept of energy and the features linking the metaphor to the source subject were obtained using a semi-structured form. The energy metaphor was created by passing the data through the following stages (Saban, 2009).

1- Coding and sorting: The data obtained through the semi-structured form were coded and sorted, and the metaphors developed by the participant teachers for the concept of energy and the associated property that links the metaphor to the subject were determined.
2- Sorting and presenting valid metaphors in a table: The metaphors the pre-service teachers developed were classified under the respective types of conventional metaphors and tables were created accordingly.
3- Categorization: The valid metaphors were categorized by their characteristics.
4- Validity and reliability: Appropriate sample metaphors, instructions on what the metaphors should entail, the purpose of the study, and information about the concept of metaphors were laid out in a semi-structured form. The metaphors produced by the pre-service teachers about the concept of energy were examined by the researchers to check whether the metaphors and the associated properties were consistent, and the inconsistent ones were removed.
5- Analysis of qualitative data: After the stages listed above, Table 2 and Table 3 were created, which contain the metaphors, the number of each metaphor, and the classification of the metaphors under types of conventional metaphors. In addition, the distribution of energy metaphors in Table 2 and Table 3 according to science fields (categories) are given in Figure 1 and Figure 2.

The data on empathic tendency consisted of the mean item scores and total scores of the pre-service teachers on the empathic tendency scale (Table 1). The mean and total scores of each item were found separately for 20 question items. Means were found for each question in Table 1 and are presented in Table 4 and Table 5. The sum of the mean scores constituted the empathic tendency scores of pre-service mathematics and science teachers.

The empathic disposition score corresponding to the traditional classification of the energy metaphor created

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by each pre-service teacher was determined (Table 6 and Table 8). The averages of the empathic tendency scores of the candidates who produced a common energy metaphor were taken. The traditional ontology metaphor 1 was represented by the structural metaphor 2 and the correlation between metaphor and empathic disposition was determined using the Mann-Whitney U test. The test results are listed in Table 7 and Table 9.

The findings are presented under three sub-sections: the categorization of the metaphors and their classification under different types of conventional metaphors, pre-service teachers' empathetic tendency levels, and the correlation between different types of metaphors and levels of empathetic tendency.

Research Results

The classification of the pre-service teachers' metaphors for the concept of energy under different types of conventional metaphors and the categorization of the metaphors were made separately for mathematics and science pre-service teachers. Findings on the classification of the pre-service teachers' metaphors for the concept of energy under different types of conventional metaphors and the categorization of the metaphors. Results related to the metaphors created for the concept of energy are presented separately for pre-service mathematics and science teachers. The metaphors developed and their classification under two traditional metaphor types are given in Table 2 and Table 3. Categories are created according to the metaphors in Table 2 and Table 3.

The findings related to the empathic disposition levels of the participating pre-service mathematics and pre-service science teachers are given in Table 4 and Table 5. In the tables, empathic disposition scale items, mean scores for each item, and total scores are given. Total scores were obtained by summing the average score of each question item.

Findings on the correlation between the classification of pre-service teachers' metaphors about the concept of energy under traditional metaphor types and pre-service teachers' empathic tendency levels. Table 6 and Table 8 were created based on the data in Table 2 and Table 3, in which the participant pre-service teachers' metaphors about the concept of energy were classified under different traditional metaphor types. Using these tables, the correlation between the metaphors classified as traditional and empathic tendency scores was determined using the SPSS software program. Since empathic tendency scores did not show normal distribution, Mann-Whitney U test was used, and the test results are given in Table 7 and Table 9.

Traditional Classification of Energy Metaphors Produced by Pre-Service Mathematics Teachers.

The pre-service mathematics teachers produced 40 metaphors for the concept of energy. The main concepts used by these pre-service teachers in creating metaphors were vitality and life (Table 2). These metaphors are classified as structural (n = 27) and ontological (n = 13) (entity) metaphors.

Table 2
Traditional Classification of Energy Metaphors Generated by Pre-service Mathematics Teachers

Metaphor for energy	*N*	Kind of conventional metaphor	Metaphor for energy	*N*	Kind of conventional metaphor
Vitality	7	Structural	Motivation	1	Structural
Life	4	Structural	A book	1	Ontological (Entity)
Food	2	Ontological (Entity)	Entrepreneurship	1	Structural
Water	2	Ontological (Entity)	A need	1	Structural
Movement	2	Structural	Power	1	Structural
A mischievous child	2	Ontological (Entity)	A radiator	1	Ontological (Entity)
Happiness	2	Structural	Breathing	1	Structural
A cake	1	Ontological (Entity)	Nutrition	1	Ontological (Entity)
A child	1	Ontological (Entity)	Playing a game	1	Structural
An emotion	1	Structural	Walking	1	Structural

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Metaphor for energy	N	Kind of conventional metaphor	Metaphor for energy	N	Kind of conventional metaphor
A friend	1	Structural	A daily activity	1	Structural
Joy	1	Structural	A state of mind	1	Structural
The sun	1	Ontological (Entity)	A tree	1	Ontological (Entity)
				Total = 40	

5 Below is the categorization of the metaphors presented in Table 1,

Energy as the perpetuity of life: The metaphors under this category are life (n=4), food (*n* = 2), water (*n* = 2), happiness (*n* = 2), cake (*n* = 1), child (*n* = 1), emotion (*n* = 1), friend (*n* = 1), joy (*n* = 1), motivation (*n* = 1), book (*n* = 1), entrepreneurship (*n* = 1), need (*n* = 1), breathing (*n* = 1), food (*n* = 1), playing a game (*n* = 1), daily activity (*n* = 1), and state of mind (*n* = 1). A total of 24 metaphors fell under this category, and in their metaphors, the said pre-service teachers used the concept of life the most.

Energy as an aspect of the science of biology: Eight metaphors fell under this category, including vitality (*n* = 7) and tree (*n* = 1).

Energy as an aspect of the science of physics: Six metaphors fell under this category, including movement (*n* = 2), a mischievous child (*n* = 2), power (*n* = 1), and walking (*n* = 1).

Energy as an energy source: Two metaphors fell under this category, namely, sun (*n* = 1) and radiator (*n* = 1).

Figure 2
Distribution of Energy Metaphors Produced by Mathematics Teacher Candidates by Science Fields (categories).

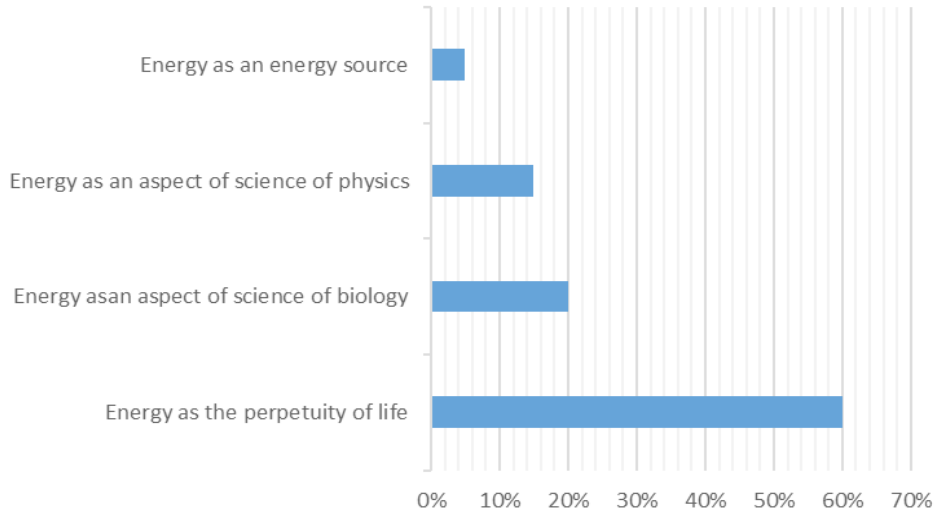

Figure 2 shows the distribution of the metaphors produced by pre-service mathematics teachers for the concept of energy according to their fields of science.

Traditional Classification of Energy Metaphors Generated by Pre-service Science Teachers

The pre-service science teachers produced 71 metaphors for the concept of energy. The main concepts used by these pre-service teachers in creating metaphors were water, existence, money, mobility, food, and friends in generating metaphors for the concept of energy (Table 3). These metaphors are classified as structural (*n* = 40) and ontological (*n* = 31) (entity) metaphors.

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Table 3
Traditional Classification of Energy Metaphors Formed by Pre-service Science Teachers

Metaphor for energy	*N*	Kind of conventional metaphor	Metaphor for energy	*N*	Kind of conventional metaphor
Water	6	Ontological (Entity)	An emotion	1	Structural
Existence	6	Structural	Reunion	1	Structural
Money	6	Ontological (Entity)	A telephone	1	Ontological (Entity)
Movement	5	Structural	Dessert	1	Ontological (Entity)
Food	4	Ontological (Entity)	Open-air	1	Structural
A friend	3	Structural	Joy	1	Structural
Vitality	2	Structural	Walking	1	Structural
Standing	2	Structural	A need	1	Structural
Happiness	2	Structural	Power	1	Structural
Work	2	Structural	Effort	1	Structural
Light	2	Ontological (Entity)	Motivation	1	Structural
Doing work	2	Structural	An atom	1	Ontological (Entity)
Nutrition	1	Ontological (Entity)	A wave	1	Ontological (Entity)
Life	1	Structural	The Universe	1	Structural
Electricity	1	Ontological (Entity)	Indestructible	1	Structural
Fuel	1	Ontological (Entity)	Infinite	1	Structural
A factory	1	Ontological (Entity)	Diddling	1	Structural
A machine	1	Ontological (Entity)	Human	1	Ontological (Entity)
The sun	1	Ontological (Entity)	Moving	1	Structural
A battery	1	Ontological (Entity)	Transformation	1	Structural
Matter	1	Ontological (Entity)			
					Total = 71

Below is a categorization of the metaphors presented in Table 2.

Energy as the perpetuity of life: The metaphors under this category are water (*n* = 6), existence (*n* = 6), money (*n* = 6), food (*n* = 4), friend (*n* = 3), happiness (*n* = 2), work (*n* = 2), nutrition (*n* = 1), life (*n* = 1), factory (*n* = 1), machine (*n* = 1), emotion (*n* = 1), reunion (*n* = 1), telephone (*n* = 1), dessert (*n* = 1), open-air (*n* = 1), joy (*n* = 1), need (*n* = 1), effort (*n* = 1), and motivation (*n* = 1). A total of 42 metaphors fell under this category, and in their metaphors, the said pre-service teachers used the concepts of water, existence, and money the most.

Energy as an aspect of the science of physics: A total of 16 metaphors fell under this category, including movement (*n* = 5), standing (*n* = 2), doing work (*n* = 2), walking (*n* = 1), power (*n* = 1), the universe (*n* = 1), indestructible (*n* = 1), infinite (*n* = 1), diddling (*n* = 1), and moving (*n* = 1).

Energy as an energy source: A total of 16 metaphors fell under this category, including light (*n* = 2), electricity (*n* = 1), fuel (n = 1), sun (*n* = 1), battery (*n* = 1), and wave (*n* = 1).

Energy as an aspect of the science of biology: Three metaphors fell under this category, including vitality (*n* = 2) and human (*n* = 1).

Energy as an aspect of the science of chemistry and physics: Three metaphors fell under this category, namely matter (*n* = 1), atom (*n* = 1), and transformation (*n* = 1).

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Figure 3
Distribution of Energy Metaphors Produced by Pre-service Science Teachers According to Science Fields (category)

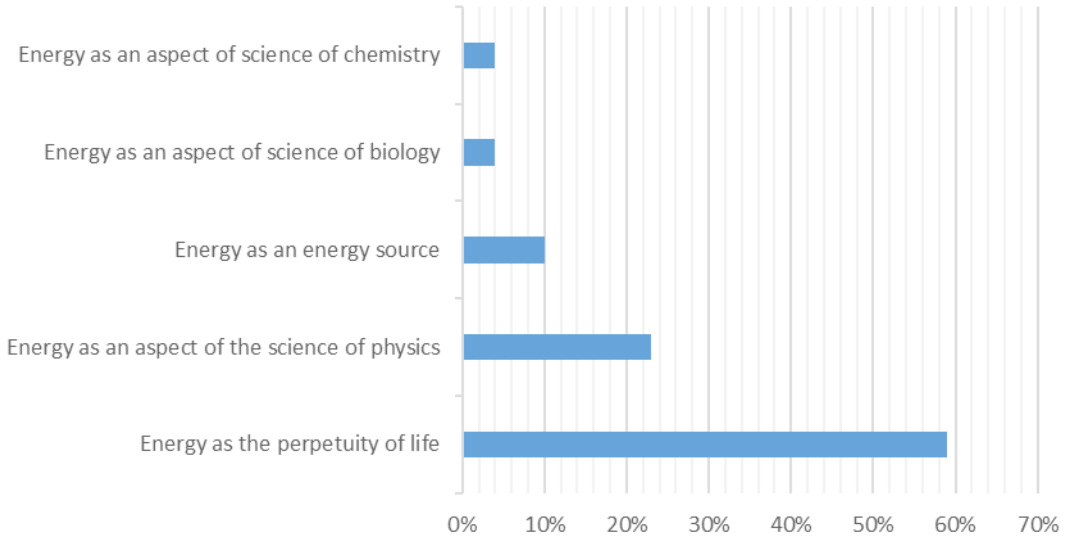

Figure 3 shows the distribution of the metaphors produced by pre-service science teachers for the concept of energy according to their fields of science.

The categorical distributions of energy metaphors created by pre-service mathematics and science teachers are similar. Unlike science teachers, mathematics teachers predominantly produced metaphors in the category of chemistry and physics. While 41% of the metaphors produced by science teachers were related to science (Figure 3), this rate was 40% for mathematics teachers (Figure 2). Pre-service mathematics and science teachers produced the most metaphors in the category of the perpetuity of life (60% and 59%, respectively).

Empathic Tendency Levels of Pre-service Mathematics Teachers

The responses of the pre-service mathematics teachers to the statements in the empathetic tendency scale were ranked from the one with the highest mean score to the one with the lowest. The closer the mean score to 5 the higher the level of empathetic tendency.

As seen in Table 4, the total of the mean scores pre-service mathematics teachers obtained from the items of the empathic tendency scale was found to be 69.57. The participant pre-service mathematics teachers were found to exhibit a high level of empathetic tendency. The items whose mean scores are between 3.72 and 4.17 showcase a high level of empathetic tendency. These items are related to helping others and solving others' problems, which are, according to the stages of empathy proposed by Dökmen (1988), associated with the you stage. Individuals who respond at this stage show behaviors such as supporting others, addressing problems, repetition, and understanding deep feelings.

The items whose mean scores are between 3.15 and 3.70 showcase an above-moderate level of empathetic tendency (Table 4). Items that point to an above-moderate level of empathetic tendency are associated with the I stage of Dökmen's (1988) stages of empathetic tendency, meaning that individuals practice empathy with a self-centric approach. Individuals who respond at this stage make empathetic remarks such as "I feel" and "I think".

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Table 4
The Mean Scores of The Items of Empathic Tendencies of Pre-service Mathematics Teachers

Empathic tendency questions	Empathetic tendency statements (n = 40)	Average empathetic disposition scores
7	I find it strange when people cry while watching a movie	4.17
10	I feel relieved when movies have a happy ending.	3.91
5	The problems of others concern me as much as my problems.	3.9
4	Those who talk to me about their problems feel relieved after our conversation.	3.85
19	My close ones often tell me about their problems.	3.72
6	I have difficulty communicating my feelings to others.	3.7
3	I often feel lonely.	3.7
17	It makes me feel better to open up to someone close to me about my problems.	3.67
9	I am a very popular person in my social circle.	3.65
20	I'm usually in a good mood.	3.62
18	I am generally satisfied with my life.	3.42
8	Sometimes, when I'm arguing with someone, my attention is more focused on my answer than on what the other person is saying.	3.3
11	I have difficulty communicating my thoughts to others.	3.3
13	I'm an angry person.	3.25
16	I'm a sociable person.	3.22
2	Sometimes I get teary-eyed while watching a movie.	3.2
15	People don't completely understand me.	3.17
12	Most people are selfish.	3.05
1	I have many friends.	2.95
14	I usually trust people.	2.82
	Total	**69.57**

The items whose mean scores are between 2.82 and 3.05 showcase a moderate level of empathetic tendency (Table 4), which is associated with making friends, trusting, and selfishness. This level is associated with the they stage proposed by Dökmen (1988). Individuals who respond at this stage are concerned with what society (they) think or feel about an individual's problems. The most prevalent stage at which pre-service mathematics teachers respond is the you stage, followed by the I stage and the they stage.

Empathic Tendency Levels of Pre-service Science Pre-Service Teachers

The responses of the pre-service science teachers to the statements in the empathetic tendency scale were ranked from the one with the highest mean score to the one with the lowest.

As seen in Table 5, the total mean score pre-service science teachers obtained for the items of the empathic tendency scale was found to be 68.86. The participant pre-service science teachers were found to exhibit a high level of empathetic tendency. The items whose mean scores are between 3.91 and 4.02 showcase a high level of empathetic tendency. These items are related to helping and supporting others and solving others' problems, which are, according to the stages of empathy proposed by Dökmen (1988), associated with the you stage.

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Table 5
The Mean Scores of The Items of Empathic Tendencies of Pre-service Science Teachers

Empathic tendency questions	Empathetic tendency statements (n = 71)	Average empathetic disposition scores
5	The problems of others concern me as much as my problems.	4.02
4	Those who talk to me about their problems feel relieved after our conversation.	4.01
10	I feel relieved when movies have a happy ending.	3.97
7	I find it strange when people cry while watching a movie.	3.91
3	I often feel lonely.	3.85
9	I am a very popular person in my social circle.	3.85
19	My close ones often tell me about their problems.	3.83
6	I have difficulty communicating my feelings to others.	3.73
20	I'm usually in a good mood.	3.7
16	I'm a sociable person.	3.61
18	I am generally satisfied with my life.	3.4
2	Sometimes I get teary-eyed while watching a movie.	3.35
1	I have many friends.	3.25
11	I have difficulty communicating my thoughts to others.	3.22
17	It makes me feel better to open up to someone close to me about my problems.	3.19
13	I'm an angry person.	3.12
15	People don't completely understand me.	3.05
8	Sometimes, when I'm arguing with someone, my attention is more focused on my answer than on what the other person is saying.	2,78
12	Most people are selfish.	2.64
14	I usually trust people.	2,38
	Total	**68.86**

The items whose mean scores are between 3.12 and 3.85 showcase an above-moderate level of empathetic tendency. Items that point to an above-moderate level of empathetic tendency are associated with the I stage of Dökmen's (1988) stages of empathetic tendency, meaning that individuals practice empathy with a self-centric approach. The items whose mean scores are between 2.38 and 3.05 showcase a moderate level of empathetic tendency, which is associated with a lack of understanding of the other person, distrust, and selfishness This level is related to the tens level suggested by Dökmen (1988). The most common stage to which pre-service science teachers responded was the you stage, followed by the I stage and the they stage.

Relationship Between Traditional Energy Metaphors Constructed by Pre-service Mathematics Teachers and Their Empathic Tendencies

Table 6 shows the mean scores of the traditional energy metaphors and empathic tendencies of pre-service mathematics teachers. Ontological metaphors were coded as 1 and structural metaphors as 2. Since the mean scores of empathic tendencies did not show normal distribution, the correlation between metaphor and empathic tendency was found using Mann-Whitney *U* test.

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Table 6
Mathematics Teachers' Mean Empathic Tendency Scale Scores and the Types of Conventional Metaphors They Produced

Energy metaphor	*N*	Empathic tendency score	Kind of conventional metaphor	Energy metaphor	*N*	Empathic tendency score	Kind of conventional metaphor
Vitality	7	73.28	Structural	Motivation	1	46	Structural
Life	4	78	Structural	A book	1	80	Ontological(Entity)
Food	2	62	Ontological(Entity)	Entrepreneurship	1	46	Structural
Water	2	69	Ontological(Entity)	A need	1	78	Structural
Movement	2	69	Structural	Power	1	56	Structural
A mischievous child	2	73.5	Ontological(Entity)	A radiator	1	75	Ontological(Entity)
Happiness	2	61	Structural	Breathing	1	62	Structural
A cake	1	78	Ontological(Entity)	Nutrition	1	75	Ontological(Entity)
A child	1	63	Ontological(Entity)	Playing a game	1	80	Structural
An emotion	1	75	Structural	Walking	1	56	Structural
A friend	1	73	Structural	A daily activity	1	78	Structural
Joy	1	83	Structural	A state of mind	1	62	Structural
The sun	1	75	Ontological(Entity)	A tree	1	68	Ontological(Entity)

The results of the Mann-Whitney *U* test to compare the empathic tendency scores according to the traditional energy metaphor types created by the pre-service mathematics teachers are shown in Table 7. In this table, no statistically significant relationship was found between the scores of the empathic tendency scale according to the traditional metaphor types according to the Mann-Whitney *U* test results ($U = 174$; $p > .965$).

Table 7
Comparison of Pre-service Mathematics Teachers' Empathic Tendency Scores According to The Traditional Metaphor Types

Traditional metaphor types	*N*	*MR*	*SR*	*U*	*p*
Ontological (entity)	13	20.86	265	174	.965
Structural	27	20.56	555		

Not: Mean Ranks: *MR* and Sun of Ranks: *SR*

Relationship between Traditional Energy Metaphors Constructed by Pre-service Science Teachers and Their Empathic Tendencies

Table 8 shows the mean scores of pre-service science teachers' traditional energy metaphors and empathic tendencies. Ontological metaphors were coded as one and structural metaphors as 2. Since the mean empathic disposition scores were not normally distributed, the comparison of empathic tendency scores according to traditional metaphor types, according to Mann-Whitney *U* test.

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Table 8
Science Teachers' Mean Empathic Tendency Scale Scores and The Types of Conventional Metaphors They Produced

Energy metaphor	N	Empathic tendency score	Kind of conventional metaphor	Energy metaphor	N	Empathic tendency score	Kind of conventional metaphor
Water	6	65.5	Ontological(Entity)	An emotion	1	68	Structural
Existence	6	68.83	Structural	Reunion	1	67	Structural
Money	6	69.03	Ontological(Entity)	A telephone	1	63	Ontological(Entity)
Movement	5	71.8	Structural	Dessert	1	59	Ontological(Entity)
Food	4	62	Ontological(Entity)	Open-air	1	75	Structural
A friend	3	62.66	Structural	Joy	1	80	Structural
Vitality	2	73	Structural	Walking	1	74	Structural
Standing	2	76.5	Structural	A need	1	78	Structural
Happiness	2	65.5	Structural	Power	1	80	Structural
Work	2	68.5	Structural	Effort	1	68	Structural
Light	2	69	Ontological (Entity)	Motivation	1	65	Structural
Doing work	2	69.5	Structural	An atom	1	63	Ontological(Entity)
Nutrition	1	68	Ontological(Entity)	A wave	1	74	Ontological(Entity)
Life	1	59	Structural	The Universe	1	82	Structural
Electricity	1	83	Ontological(Entity)	Indestructible	1	47	Structural
Fuel	1	78	Ontological(Entity)	Infinite	1	79	Structural
A factory	1	80	Ontological(Entity)	Diddling	1	80	Structural
A machine	1	78	Ontological(Entity)	Human	1	78	Ontological(Entity)
The sun	1	77	Ontological(Entity)	Moving	1	76	Structural
A battery	1	56	Ontological(Entity)	Transformation	1	61	Structural
Matter	1	58	Ontological(Entity)				

Table 9 shows the results of the Mann-Whitney *U* test, which was conducted to compare the scores of empathic tendencies according to traditional energy metaphors created by pre-service science teachers. According to this table, when the scores of the empathic disposition scale were compared with the traditional metaphor types produced by the pre-service teachers, there was no statistically significant difference on the empathic disposition scale score of the metaphor generation type ($U = 527.5$; $p > .282$).

Table 9
Comparison of Pre-service Science Teachers' Empathic Tendency Scores According to the Traditional Metaphor Types

Traditional metaphor types	N	MR	SR	U	p
Ontological (entity)	31	33.02	1023.50	527.50	.282
Structural	40	38.31	1532.50		

Note: Mean Ranks: *MR* and Sun of Ranks: *SR*

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Discussion

Mathematics and science teachers produced metaphors for the concept of energy by using abstract and concrete concepts. The metaphors produced were in the structural and ontological (entity) metaphor class in the traditional classification. The metaphors produced mostly consisted of structural and abstract concepts. Concrete objects and concepts were used as ontological metaphors.

Traditional Classification and Categorization of the Metaphors Produced by Pre-service Teachers for the Concept of Energy

The metaphors produced by pre-service mathematics teachers for the concept of energy were distributed as 27 structural and 13 ontological (being) metaphors according to the traditional metaphor classification. Pre-service science teachers distributed 40 structural and 31 ontological metaphors. While producing metaphors for abstract concepts, pre-service mathematics and science teachers mainly used structural metaphors. Pre-service mathematics teachers produced more structural metaphors than pre-service science teachers did.

Pre-service mathematics teachers predominantly expressed the abstract concept of energy using abstract concepts. These concepts, such as *vitality, life, and happiness*, are used in daily life. Lakoff and Johnson (2003) stated that structural metaphors have an important place in describing daily events. While pre-service mathematics teachers produced metaphors for the concept of energy, they used concepts such as interaction, *entrepreneurship, friend, need, play, playfulness,* and mood. Inam (2008) stated that structural metaphors are frequently used in daily life and communication. Pre-service mathematics teachers produced 13 ontological (being) metaphors by abstracting the abstract concept of energy. These metaphors are oriented toward daily needs and comprise concepts such as food, water, cake, and book. Ontological metaphors consist of concepts used to concretize abstract concepts (Akın, 2015).

The metaphors produced by pre-service mathematics teachers for the concept of energy were categorized as 60% *continuity of life*, 20% *biological science*, 15% *physical science*, and 5% *energy source* (graph 1). Pre-service teachers produced metaphors about the sustainability of life rather than lessons. Of the metaphors produced, 40% were related to lessons.

While producing metaphors for the concept of energy, pre-service science teachers predominantly used the structural metaphor (n=40). Structural metaphors *are* composed of abstract concepts oriented toward daily life, such as life, movement, friends, vitality, happiness, and living. Because energy is an abstract concept and there are differences between scientific and everyday energy perceptions, metaphors related to everyday concepts were predominantly produced. This emphasizes that students use terms related to the world they live in when trying to explain events or situations in science (Yürümezoğlu et al., 2009). Pre-service science teachers produced 31 ontological (being) metaphors by abstracting the abstract concept of energy. These metaphors generally consisted of concrete concepts related to daily needs, such as *water, money, food, food, sun, telephone, and dessert*. Candidates produced a low number of metaphors for science, such as *doing business, electricity, fuel, battery, matter, humans, atoms, and wave*s. Pre-service teachers used abstract concepts when expressing the abstract concept of energy. This is because the complex and abstract aspects of metaphors can be understood in more concrete, familiar, and easily imagined terms (Lancor, 2015; Refaie, 2001; Semino, 2008). According to conceptual theory, since conceptual systems are metaphorical, abstract concepts can be understood using concrete metaphors (Lakoff & Johnson, 2003). The human conceptual system is metaphorical, and it has been stated that abstract concepts can be understood through concrete concept metaphors (Lakoff & Johnson, 1980, 2003).

The metaphors produced by pre-service science teachers for the concept of energy were 59% *continuity of life*, 23% *physical science*, 10% *energy source*, 4% *biological science* and 4% *chemistry*. The metaphors created by the candidates for science courses constitute 41% of the total metaphors. The number of metaphorical expressions related to the concept of energy in the field of science was low. In a study, it was stated that students had a limited conceptual understanding of energy related to science lessons (Opitz et al., 2019). In general, the metaphors produced consisted of concrete and abstract phenomena necessary for human life.

Empathic Tendencies of Pre-service Mathematics and Science Teachers

The empathy tendency score of pre-service mathematics teachers was 69.57 and 68.86 for pre-service science teachers. According to the scores of the candidates, their empathetic tendencies can be said to be at a high level.

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Although the ranking of the expressions of empathic tendency of pre-service mathematics and pre-service science teachers according to the mean score is different, the same empathic tendency expressions are in the first place. The expressions of empathic disposition of pre-service mathematics and pre-service science teachers with the highest mean were expressions such as *supporting the other person, addressing their problems, and understanding their feelings*. The pre-service teachers experienced the emotions, thoughts, and perspectives of the other person from their point of view. Empathy is about one being permeated by the other's self as though one were taking part in the other's emotional state and experiencing the other's perspective and life (Zahavi & Overgaard, 2012). The pre-service teachers felt the other person's problem and emotion as their own and showed an empathetic tendency in this direction. These tendencies correspond to ***the you stage*** according to Dökmeni's (1998) classification of empathetic tendencies.

The expressions of empathic disposition that had the second-ranked mean for pre-service mathematics and science teachers were the expressions of empathetic disposition that included their feelings and thoughts. Candidates preferred empathetic expressions that emphasized their feelings and thoughts rather than those of the other person. Expressions of own feelings and thoughts correspond to *the I* step in the classification of empathetic tendencies. Pre-service mathematics and science teachers preferred empathetic disposition expressions such as what society thinks and feels in the face of their problems. These were empathetic expressions such as *selfishness, distrust, and lack of understanding*. These statements correspond to *the tens level* in the classification of empathic tendencies.

The Correlation between Traditional Classes of Metaphors Related to the Concept of Energy and Empathic tendencies

The correlation between the traditional metaphors created by pre-service mathematics and science teachers and their empathic tendency scores was found using Mann-Witney U test. It was determined that there was no statistically significant difference between the empathic tendencies of pre-service mathematics and science teachers and traditional metaphor classes. The empathetic dispositions of pre-service mathematics and pre-service science teachers were found to have the highest mean at the sen step and high empathetic disposition in the study. In the traditional metaphor classification of the pre-service teachers, structural metaphors were the most common. In addition, more than half of the total energy metaphors produced were in the category of continuity of life. If an inference is made from these, it can be that the candidates have a high level of empathetic tendencies, that the class of empathetic tendencies is the sen level, and that they mainly produced structural metaphors and categorically produced concrete and abstract metaphors for the continuity of life.

Conclusions and Implications

Abstract concepts such as energy and empathic disposition are difficult to define. The correct definition of abstract concepts contributes to increasing learning effectiveness and connections between disciplines. In order to define abstract concepts, common features of other concepts are used, and this is done through mental processes. Mental processes vary from person to person. It is important to use abstract concepts such as metaphor and empathic tendency to meet this change at a common point, which will contribute to determining mental structuring. In this study, the results of the 3 questions regarding the concepts of energy metaphor and empathic tendency are given in the following paragraphs.

Mathematics and science teachers produced metaphors for the concept of energy by using abstract and concrete concepts. The metaphors produced were classified as structural and ontological (being) metaphors in the traditional classification. The metaphors produced by the pre-service teachers are structural and consist of abstract concepts. Concrete objects and concepts were used as ontological metaphors.

Approximately 60% of the metaphors produced by pre-service mathematics and science teachers for the concept of energy were in the category of continuity of life. Approximately 40% of the metaphors produced were in the science categories. Biology is the prominent field focused on by pre-service mathematics teachers, while physics is the prominent field for pre-service science teachers. In generating metaphors for courses, pre-service mathematics teachers produced metaphors for biology science, while pre-service science teachers produced metaphors for physics science.

Pre-service mathematics and pre-service science teachers have an above-average (high-level) empathic disposi-

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tion and have the sen level as the empathic disposition level. Pre-service teachers feel the other person's problems and emotions as their own. Pre-service teachers look at events and situations from the other person's point of view.

No quantitatively significant difference was found between traditional metaphor types and empathic tendencies. It can be inferred from this that while the pre-service teachers' empathic tendencies were high and the "you" level was prominent while producing metaphors for the concept of energy, they produced structural metaphors from the concepts related to the sustainability of life the most.

Recommendations

Metaphors and empathy are abstract concepts and reflections of mental models. A contribution can be made to the determination of mental structuring by determining the models in empathy and metaphor formation. Metaphors can be used as learning outcomes in determining mental models and thoughts about the subject in education and training processes. As empathy and metaphors are reflections of mental models, they can be used in restructuring the educational process and learning outcomes. In addition, expressions of an empathetic disposition can be used in teacher-student interactions during the lesson. The concept of energy is used in different fields of science. Using metaphors to establish connections between branches of science, the connections between branches of science can be extended.

Declaration of Interest

The authors declare no competing interest.

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