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Investigating Preservice Science Teachers' Cognitive Structures on Environmental Issues

Zeynep Kıryak[1]*, Bahar Candaş[1], Haluk Özmen[1]

[1]Fatih Faculty of Education, Trabzon University, Turkey

*Corresponding Author zeynepkiryak@gmail.com

ABSTRACT Environmental knowledge and awareness of individuals affect their attitudes and behavior toward the environment. In this regard, it is essential to specify how environmental issues are interpreted in individuals' cognitive structures. This study aims to investigate preservice science teachers' cognitive structures on environmental issues. The study was conducted with 78 third-year preservice science teachers. The data were collected through a word association test that contains eight stimulus words about environmental problems and protecting the environment. *Global warming, greenhouse effect, radiation,* and *acid rain* were chosen for environmental problems; *recycling, waste disposal, sustainability,* and *solar energy* were selected for protecting the environment. Besides, preservice science teachers were asked to write a sentence for each stimulus word. Two concept networks were created based on the cut-off point method for the word association test, and content analysis was used for sentences. Besides, by comparing the data obtained from the concept networks and sentence analysis, an attempt was made to obtain more in-depth information. It is concluded that preservice science teachers focused on daily life rather than scientific facts about environmental issues. In this respect, new courses such as Green Chemistry may effectively eliminate alternative conceptions and raise awareness on environmental issues.

Keywords Environmental problems, Protecting the environment, Word association test, Preservice science teachers

1. INTRODUCTION

Since environmental awareness and knowledge levels of individuals affect their attitudes and behaviors towards environmental problems, environmental education in schools should develop students' sense of responsibility towards the environment (Abdullah, Halim & Shahali, 2011; Elliott, 1999; Huang & Yore, 2003). For this reason, it is essential to determine how the environment and environmental problems (EPs) are interpreted in individuals' cognitive structure. When education programs are examined, it is expected that environmental education, which occupies the most prominent place in science education and learning EPs (Brody, Chipman & Marion, 1988), will contribute to developing students' ability to create solutions to these problems. On the other hand, when looking at the previous studies, it is seen that students may create alternative concepts in their minds with superficial learning and gain scientific knowledge about environmental concepts. In such cases, environmental education is considered insufficiently effective (Çalık, 2009; Çalık & Eames, 2012). For effective environmental education, it is expected that the knowledge levels, environmental awareness, self-efficacy for teaching environmental education, and perceptions of EPs of teachers who are the implementers of the curriculum will be at a certain level. In this respect, it is believed that steps should be taken to increase the quality of teachers and teacher training programs to raise the quality of environmental education. For this reason, it is thought that determining preservice science teachers' (PSTs) knowledge levels and perceptions about the environment and EPs and structuring the training on these issues will be beneficial.

A variety of alternative evaluation and assessment techniques, such as concept maps, mind maps, structured grids, diagnostic trees and word association tests, are proposed to determine individuals' knowledge levels and perceptions. The word association test is often preferred in studies, since it allows the collection of data from a large number of individuals in a short time and allows the participants to discover how they construct the concepts in their minds as well as how they establish the relationships between these concepts (Ercan, Taşdere & Ercan, 2010;

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Kızılay, 2018; Özatlı & Bahar, 2010). The word association test will be provided mounting evidence in determining the opinions of PSTs about environmental problems and environmental protection. In this way, while the structures in their minds are revealed for each phenomenon, the relationships between them can also be revealed. Moreover, it is believed that when multiple problems and prevention ways are examined, more detailed and complex relationships can be revealed.

The Word Association Test (WAT) is one technique used to elicit the concepts in individuals' cognitive structures and inter-and intra-links among them and determine the significance levels of these concepts and links (Bahar, Johnstone & Sutcliffe 1999; Özatlı & Bahar, 2010). The number, order, type, and association levels of responses given to the stimulus words (SWs) in the WAT can be used to determine and evaluate the understanding of any subject or concept. A high number of responses to the SWs and links are regarded as evidence of better cognitive understanding (Ayas, 2005; Shavelson, 1974). However, how and in what context the links among the SWs and responses are established need to be revealed. Therefore, writing a sentence related to each SW after completing the WAT will provide effective results in evaluating the relationships at the cognitive level (Gunstone, 1980). When the studies on the WAT are examined, it is seen that most of the studies aimed to reveal students' cognitive structures and perceptions (Atabek-Yiğit, 2016; Bahar, Johnstone & Sutcliffe 1999; Canbazoğlu-Bilici, 2016; Derman & Ebenezer, 2018; Kıryak, Candaş, Özmen, Çalık & Zeybek, 2018; Kızılay, 2018; Köseoğlu & Bayır, 2011; Kurt & Ekici 2013; Nakiboğlu, 2017; Polat, 2013; Önel & Yüce, 2016; Şimşek, 2013; Tokcan, 2016; Yildirir & Demirkol, 2018) while some studies determined students' misconceptions (Bahar & Özatlı, 2003; Ercan, Taşdere & Ercan, 2010; Kiryak & Çalik, 2018) on various subjects and concepts.

When studies on environmental issues are examined, it is determined that there are various studies on eliciting individuals' perceptions (Doğan, 2017; Loughland, Reid & Petocz, 2002; Moseley, Desjean-Perrotta & Utley, 2010; Oztas, Kalipci & Bozkurt, 2011; Yavetz, Goldman & Pe'er, 2014), attitudes (Arık & Yılmaz, 2017; Özsoy, 2012), environmental literacy (Goldman, Yavetz & Pe'er, 2014; Stevenson, Carrier & Peterson, 2014), misconceptions (Arsal, 2010; Bozkurt & Cansüngü-Koray, 2002), behaviors (Fu & Liu, 2017), cognitive structures (Daskolia, Flogaitis & Papageorgiou, 2006; Kıryak & Özdilek, 2019) and thinking processes (Güven, 2017). When the data collection tools in these studies are examined, it is seen that questionnaires, scales, open-ended questions, interviews, and drawings are frequently used. In the literature, it is stated that students confuse the causes and consequences of EPs and think that the source and effects of some EPs are the same. Besides, while these studies are structured on one specific environmental problem such as global warming or the greenhouse effect, studies that aim to examine the links among various environmental problems and different concepts on protecting the environment and relationships between these concepts have not been found in the literature.

This study aims to determine PSTs' perceptions and alternative conceptions on environmental issues through a WAT, global warming, greenhouse effect, radiation, acid rain, recycling, waste disposal, sustainability, and *solar energy* SWs are selected. Different EPs and environmental protection practices are handled together to determine the PSTs' knowledge levels and perceptions about these concepts and determine their alternative conceptions on these issues. It aims to reveal the PSTs' alternative conceptions by selected SWs and reveal inter-and intra-links among the concepts in their cognitive structures through the concept networks to be formed due to the analysis.

2. METHOD

The descriptive survey method aims to reveal the dispositions, beliefs, feelings, and thoughts of a group on a specific subject or concept (Ekiz, 2013). In this study, the descriptive survey method is preferred to determine PSTs' perceptions of the relationship between EPs and protecting the environment (PE).

2.1 Participants

The study was conducted with 78 (54 female, 24 male, and 19-21 age) third-grade PSTs studying at a public university in Turkey. PSTs have been learning environmental issues within the scope of several courses since primary school. In undergraduate education and learning these subjects, they carry out studies on teaching, especially in applied courses such as Science Teaching. On the other hand, the Environmental Chemistry course, which is focused on environmental issues, is placed in the fourth-grade curriculum, and the PSTs who participated in this application have not taken this course yet. Therefore, the data obtained from this study did not measure the knowledge learned recently but revealed all the information they have acquired due to their education and life experiences. All participants voluntarily participated in the study.

2.2 Instruments

In this study, the WAT was used as the data collection tool to determine the PSTs' perceptions and the relationships among these on environmental issues. The SWs in the WAT was chosen through the studies in the relevant literature and the opinion of an expert in chemistry education. In this respect, concepts that address current environmental problems, namely *global warming, greenhouse effect, radiation,* and *acid rain*, and concepts related to PE, namely *recycling, waste disposal, sustainability,* and *solar energy,* were determined as SWs. Visually, each SW was written on

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Recycling .....

Sentence:

Figure 1 An example for WAT

a separate page ten times, one under the other. Also, at the bottom of each page, there was a space to write a sentence about the SW. An example for WAT is presented in Figure 1.

2.3 Data Collection

In the data collection process, the WAT was distributed to PSTs as eight small cards, each containing an SW, stapled to each other. The PSTs were asked to write the responses in their minds for each SW. After that, they were asked to write a sentence for the relevant SW. In this way, it was believed that the PSTs would give an idea of how they made sense of the SW in their minds. In this study, the PSTs were given 30 seconds for each SW and 15 seconds for writing a sentence. At the end of each 45 seconds, the PSTs were advised to pass on to the next SW.

2.4 Data Analysis

The responses given to the SWs were determined one by one and examined in detail by two researchers. A frequency table was created by determining how many kinds of responses there were and how many times they were repeated for each SW. In line with this table, two separate concept networks for the SWs, comprising *global warming, greenhouse effect, radiation* and *acid rain,* and *recycling, waste disposal, sustainability,* and *solar energy,* were developed using the cut-off point technique (Bahar, Johnstone & Sutcliffe, 1999). After determining the frequencies of the responses given to the SWs, a point five points below the maximum number of responses was defined as the first cut-off point. SWs with responses above this frequency constitutes the first part of the concept network. Other cut-off points were formed by moving down the list at certain intervals, in the form of five-number intervals. This technique was continued until all the SWs appeared in the networks (Bahar, Nartgün, Durmuş & Bıçak, 2006). It was determined whether a concept was structured correctly and meaningfully in mind by examining whether the responses to the WAT were related to the SWs. After two researchers examined these data separately, they were compared, and a joint decision was reached by taking the opinions of the third researcher in disagreements. Consistency between coders was calculated as 87%. After the concept networks were created by two researchers based on the final data obtained, the third researcher examined the inter and intra relationships between the concepts and response words.

Table 1 Frequencies of PSTs' responses to SWs related to environmental problems

SWs	Frequency
Radiation	153
Acid rain	145
Global warming	130
Greenhouse effect	99
Total	527

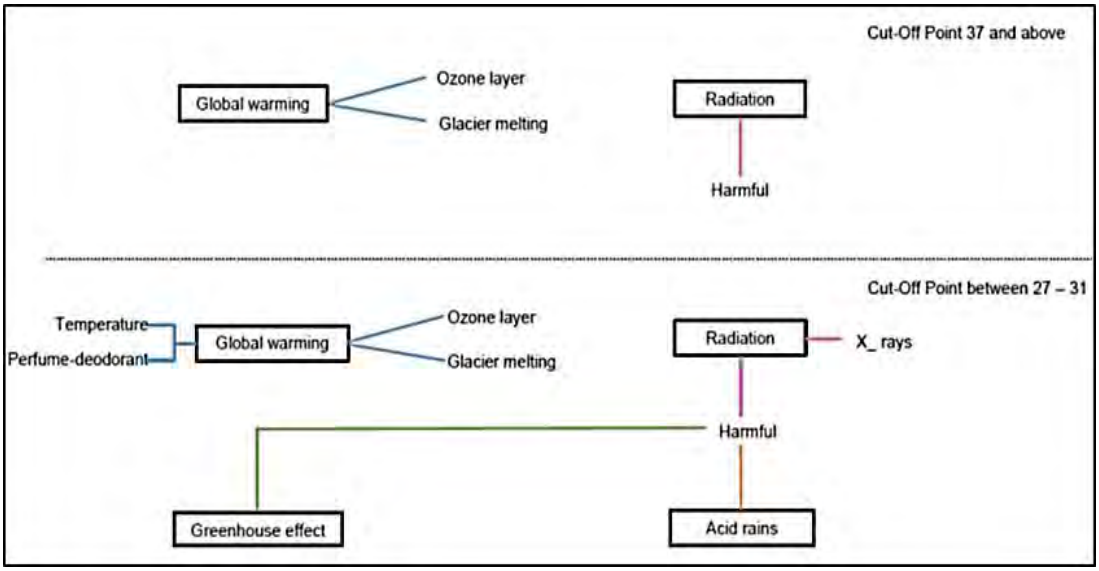

Figure 2 Concept network for EPs created for cut-off point 27 and above

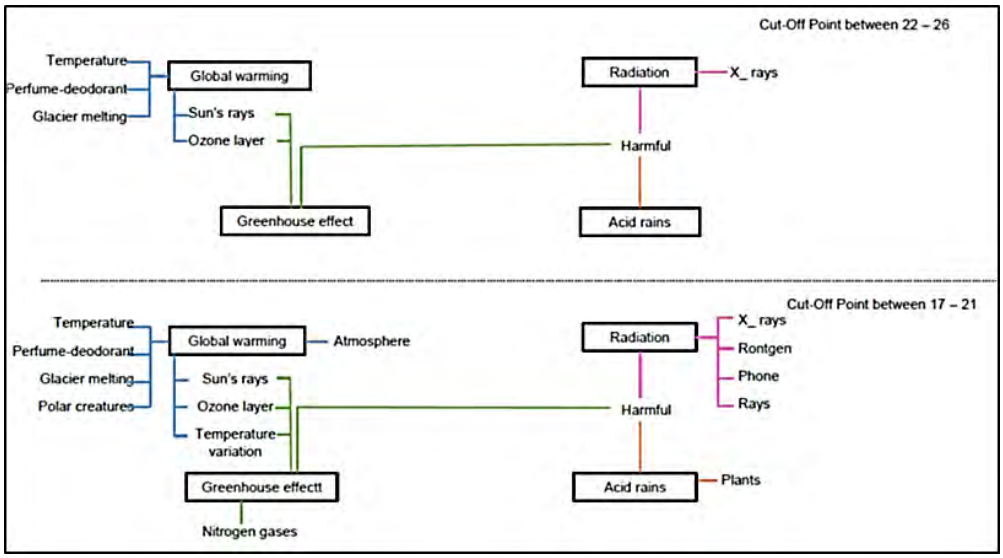

Figure 3 Concept network for EPs created for cut-off points 22-26 and 17-21

Their suitability was confirmed. The PSTs' sentences related to each SW were also grouped into categories created by content analysis to determine whether they were similarly meaningful and correct and whether they included alternative concepts. After two researchers did the sentence analysis separately, they were compared, and a joint decision was reached by taking the opinions of the third researcher in disagreement. Consistency between coders was calculated as 91%. In addition, by comparing the data

Table 2 PSTs' sentences related to SWs on Eps

Codes	GW	GE	R	AR	Examples
Harmful	15	5	28	30	- Global warming damages the earth. - The greenhouse effect is harmful to live beings. - Radiation damages the environment and living beings. - Acid rain damages the environment, nature, and living beings.
Negative effect	9	-	-	-	- Global warming hurts life.
Hazardous gases	-	-	-	9	- Gases such as CO2, CO, NH3, N2, HCl, and SO4 blend in the atmosphere, fall on the earth's surface and corrode materials.
Electronic devices	-	-	6	-	- Electronic devices emit radiation that is harmful to the environment.
Increasing the temperature	-	7	-	-	- The more the greenhouse effect rises, the more the temperature rises.
Glacier melting	6	-	-	-	- The rising temperature causes glacier melting.
Dangerous	-	6	-	1	- The greenhouse effect is dangerous.
Greenhouse cultivation	-	6	-	-	- Some plants are grown via the greenhouse cultivation method.
Others (frequencies of 5 and below)	20	10	22	8	- Global warming ruins the ecological balance. - The factors causing the greenhouse effect should be removed. - Genetic disorders and mutation arise because of radiation. - Acid rain decreases the growth of crops.
Alternative concepts	10	8	4	5	- Scientists report that cell phones transmit an excess amount of radiation. - Acid rain occurs because of global warming. - Aridity and settlement are low in places under the greenhouse effect. - The ozone layer is depleted via global warming.
Total	60	42	60	53	
Blank	18	36	16	25	

GW: Global Warming, **GE:** Greenhouse Effect, **R:** Radiation, **AR:** Acid Rain

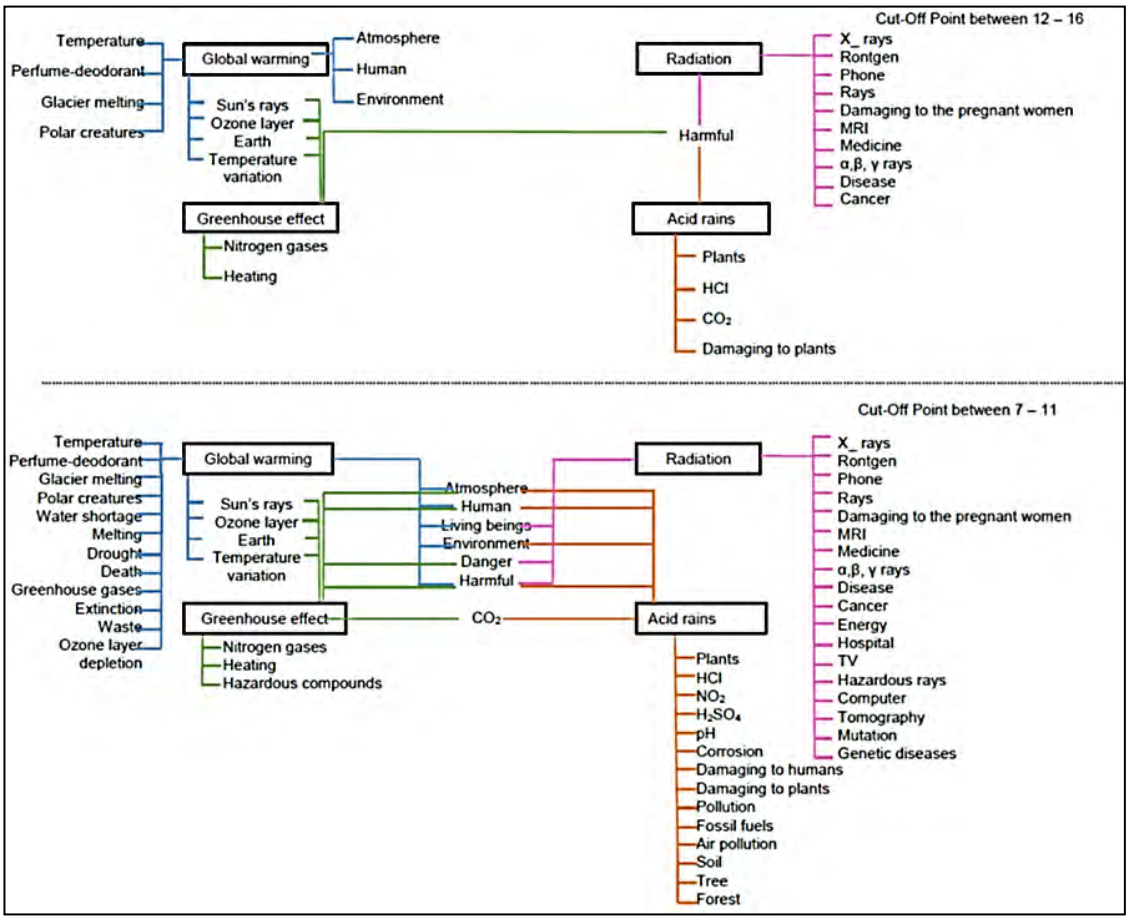

Figure 4 Concept network for EPs created for cut-off points 12-16 and 7-11

obtained from the concept networks and sentence analysis, an attempt was made to obtain more in-depth information.

3. RESULT AND DISCUSSION

3.1 Results for EPs

As shown in Table 1, in the EPs section of the WAT, the highest number of responses was found for the SWs *radiation* and *acid rain,* and the lowest frequency was for the *greenhouse effect*.

The concept network developed due to the analysis of the responses to the SWs *global warming, greenhouse effect, radiation,* and *acid rain* is given in Figure 2, Figure 3, and Figure 4.

As shown in Figure 2, for the cut-off point 37 and above, *global warming* was associated with two response words (RWs) and *radiation* with one word. In cut-off point 32-36, there were no new RWs, while it is seen that there were words associated with the four SWs in the cut-off point 27-31.

As seen in Figure 3, in cut-off point 22-26, new words associated with only *global warming* were revealed. When the cut-off point 17-21 was examined, it was found that the highest number of most related words was released for *global warming*. In addition, it is seen that there were common words associated with *global warming* and the *greenhouse effect* and that three new RWs were related to *radiation.*

In cut-off point 12-16, an increase in the number of associated RWs for *global warming, radiation,* and *acid rain* was determined. The cut-off point 7-11 contained the highest number of RWs associated with all SWs. It was also seen that the most relevant common words for two or more SWs appeared in this range. Table 2 shows the sentences written by the PSTs about Eps.

As seen in Table 2, the code with the highest frequency in the sentences written for *global warming, radiation,* and *acid rain* was revealed as "harmful." It was found that the code with the highest frequency for *greenhouse effect* was "increasing the temperature," while the number of codes associated with the four SWs was limited. The sentences formed were simple, and beginner-level sentences such as "Global warming damages the Earth" and "The more the greenhouse effect rises, the more the temperature rises." In addition, most of the PSTs were determined to avoid making sentences for the SWs. In contrast, some of them made sentences including alternative conceptions such as "Scientists report that cell phones transmit an excess amount of radiation," "Aridity and settlement are low in places under the greenhouse effect."

When concept networks and sentence analysis are examined, it is seen that the codes determined in the

sentence analysis, in general, did not correspond to a large extent with the RWs revealed in the concept network. As in Table 2, this analysis revealed that the most overlap was revealed for the "harmful" code. When frequency comparisons were made, it was determined that the frequencies in the concept network were relatively higher. For example, it was found that the code "rays emitting from electronic devices" which appeared for *radiation* in the concept network in the cut-off point 17-21 remained at six frequencies in the sentence analysis. In parallel with this situation, it is seen that the number of codes determined in the sentence analysis was significantly lower compared to the number of RWs given in Table 1 for each SW. For example, for *acid rain*, 145 different responses were revealed in the concept network, while sentences were formed for 53 codes, and five of these sentences included alternative conceptions. Similarly, while 130 RWs were included in the concept network for *global warming* (Table 1), it was found that 60 codes were revealed in the sentence analysis; 20 of these codes had frequencies of five and below, and 10 of them consisted of alternative conceptions.

3.2 Results for PE

As seen in Table 3, in protecting the environment section of the WAT, the maximum number of RWs was revealed for *waste disposal*. At the same time, the lowest frequency appeared for *solar energy*. On the other hand, the number of responses to PE was higher than that for EPs (Table 1 and Table 3).

The concept network developed as a result of the analysis of the responses to the SWs *recycling, waste disposal, sustainability,* and *solar energy* is given in Figure 5, Figure 6, and Figure 7

When the concept network in Figure 5 is analyzed, for the cut-off point 50 and above, *recycling* was associated with two RWs, and *sustainability* was related with one word. There were no new RWs associated with SWs down to the cut-off point 35-39, while one RW associated with *solar energy* was revealed in this range.

Table 3 Frequencies of responses to SWs related to PE

SWs	Frequencies
Waste disposal	175
Sustainability	156
Recycling	141
Solar energy	127
Total	599

As seen in Figure 6, new RWs were identified for each three SWs in the cut-off point 30-34. As well as an increase in the number of rows to which *recycling* and *solar energy* were associated in the cut-off point 25-29, responses related to *waste disposal* were revealed in this range. In addition, the intra-link between *waste disposal* and *recycling* was determined. In the cut-off point 20-24, three RWs were determined under *waste disposal* and *recycling*.

While the number of related words increased in the cut-off point 15-19, it was also observed that RWs such as savings, useful and sustained were associated with more than one SW. It was found that the number of RWs associated with all SWs increased for cut-off points 10-14 and 5-9 and that over twenty RWs were related with more than one SW. Table 4 shows the sentences written by the PSTs about ways of protecting the environment.

As seen in Table 4, in the sentences written by the PSTs, "clean environment," "reusing," "consciousness-raising," and "renewable energy source" codes have the highest frequency. Another noteworthy point is that, as in the EPs section, most PSTs avoided writing sentences. When the sentences written by the PSTs are examined, it is seen that they gave positive opinions such as "consciousness-raising," "clean environment," "important," "protecting nature," and "saving" for the four SWs. However, it was determined that the answers were generally composed of expressions that are frequently mentioned in daily life and the mass media, and especially, that the written sentences were at an elementary level, such as "It (solar energy) is a renewable energy source," and "Sustainability is important for the protection of the environment." In addition, it was

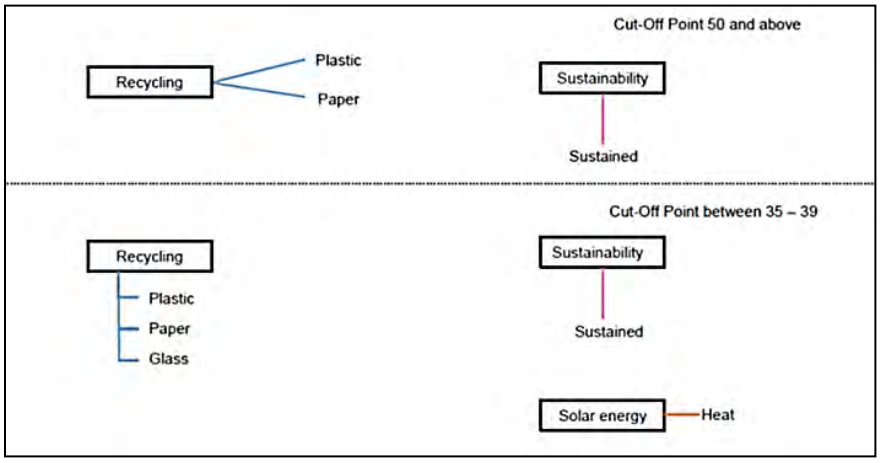

Figure 5 Concept network for PE created for cut-off point 35 and above

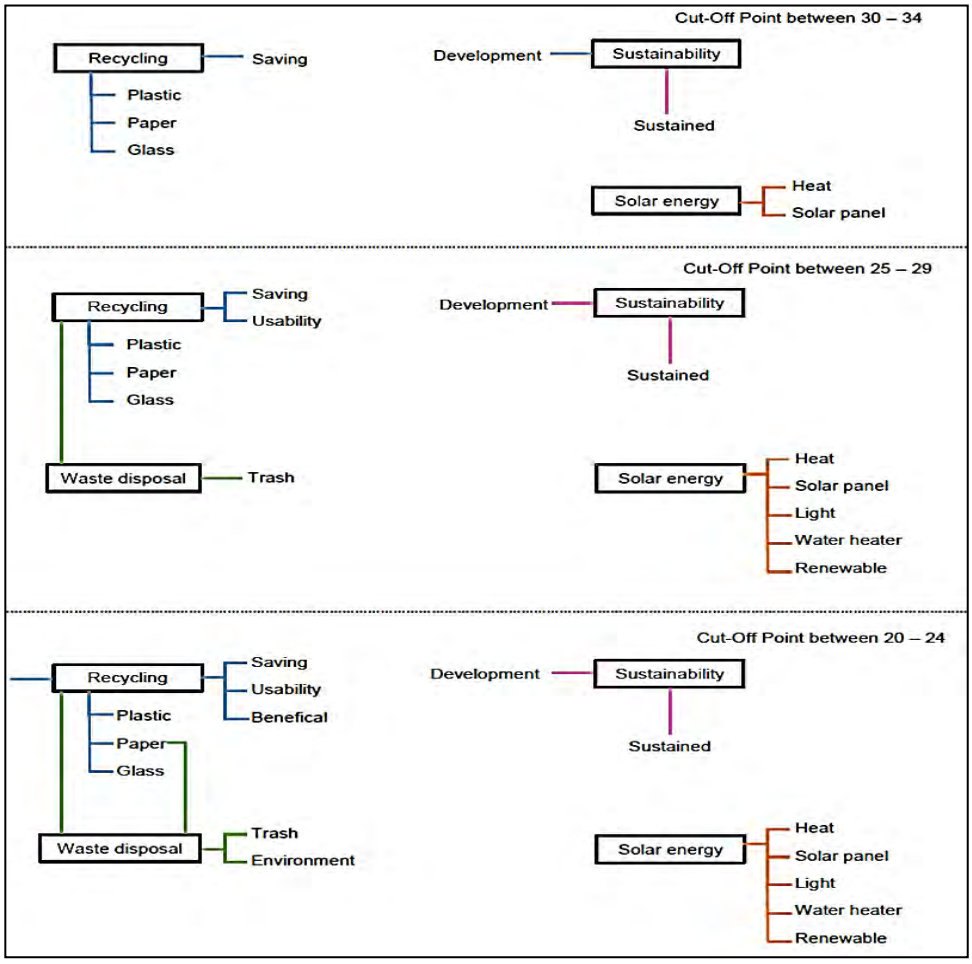

Figure 6 Concept network for PE created for cut-off points 30-34, 25-29, 20-24

determined that for the other SWs than *recycling*, sentences included alternative conceptions.

When concept networks and sentence analysis are examined together, it is seen that the codes obtained as a result of the sentence analysis did not generally coincide with the words detected in the concept network. While it was determined that there was no common overlap for each SW, it was found that three SWs were associated with "consciousness-raising" and "saving" codes. When the frequencies of the SWs were analyzed, it was found that the number of RWs appearing in the concept network was higher than the number of codes obtained from the analysis of the sentences. For example, the frequency of the "sustained" code for *sustainability* was found to remain at 10 in the sentence analysis, while it was at the cut-off point 50 and above in the concept network. However, when the data in Table 4 is taken into consideration, it is seen that there is a big difference between the number of words revealed for SWs and the number of codes obtained in the sentence analysis. For example, while 175 different words were identified in the concept network for *waste disposal*, it was found that 58 codes were revealed in the sentence analysis, nine of these codes included alternative conceptions, and 11 were codes with frequencies of four and below (Table 4).

3.3 Discussion on EPs

When the PSTs' responses to the SWs related to EPs were examined, it was found that the most RWs were revealed for *radiation* and the least for *greenhouse effect* (Table 1). For *radiation*, the high amount of incorrect information or information not proven to be accurate from media organs and everyday speech (Polat, 2012) may be why the large number of RWs to this SW. On the other hand, the low number of RWs to the *greenhouse effect* is thought to be because this concept does not allow for controversial inferences (e.g., *radiation*) and that the definitions from formal and informal environments are gathered around common views in the minds of the PSTs (Halloun & Hestenes, 1985; Hynd & Guzzetti, 1993).

When the relationships between SWs and RWs saw in the concept network in Figure 2 are examined, it is seen that the concepts of *global warming* and *radiation* emerged at the highest cut-off point and that the most familiar responses to these concepts contain common views that not only the PSTs but also all members of the society have encountered, heard and used. The fact that all SWs after this cut-off point were revealed in the range of 27-31, and

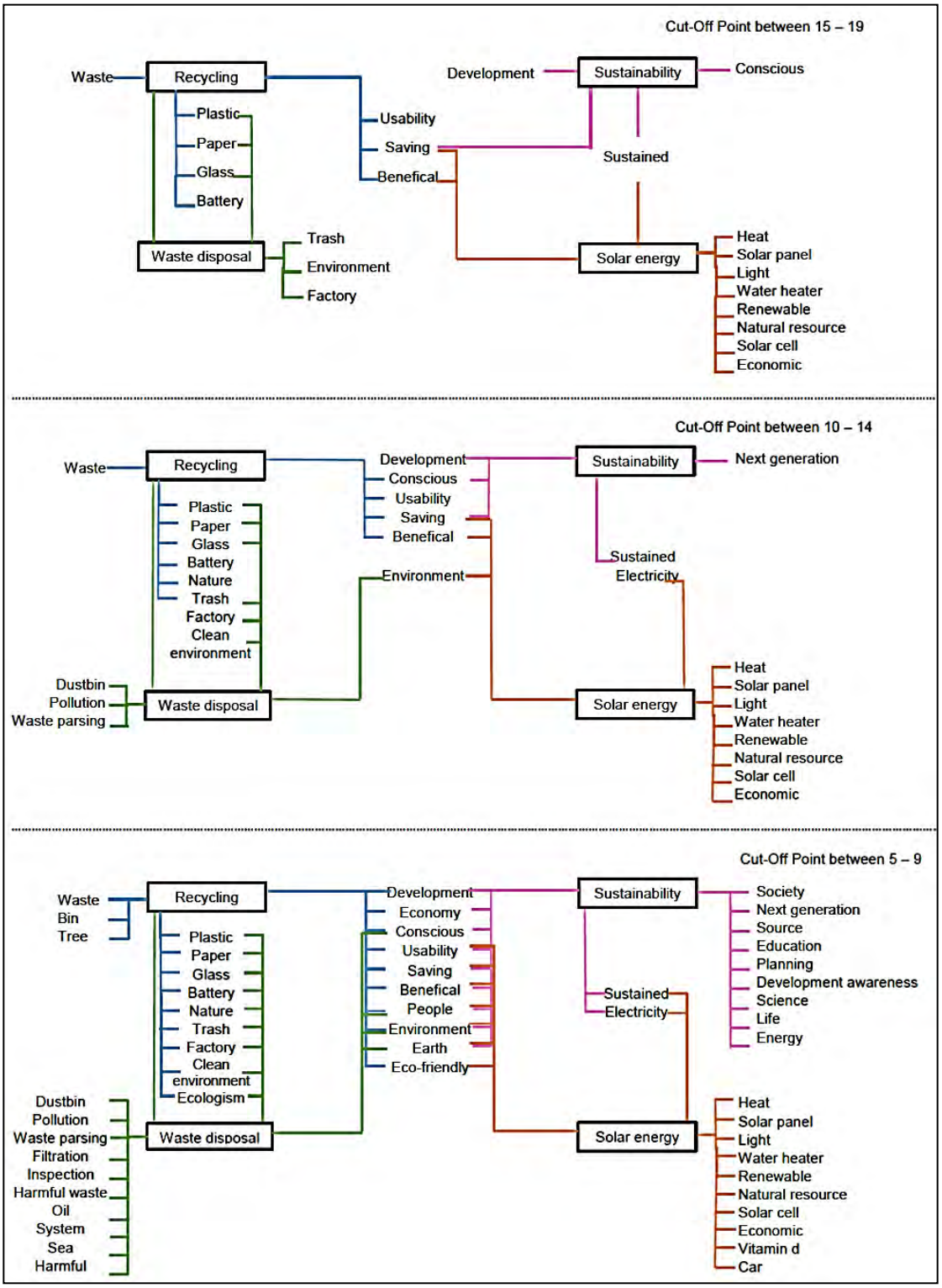

Figure 7 Concept network for PE created for cut-off points 15-19, 10-14, and 5-9

the limited number of RWs in this range, is thought-provoking for PSTs who are expected to have environmental knowledge and aware ness. Until cut-off point 7-11, the PSTs linked SWs with each other only in terms of being "harmful." When the PSTs' sentences are examined, it is seen that they are composed of superficial, simple structures and expressions without scientific knowledge (Demirbaş & Pektaş, 2009), and it is worrying that their desires and skills related to research, questioning, and reasoning, and their awareness about such serious EPs are extremely low. However, the most common RWs emerged for the *global warming* and *greenhouse effect* when evaluated in the light of the data obtained from the sentence analysis, which can be regarded as a result of the

Table 4 Sentences Related to SWs on PE

Codes	R	WD	S	SE	Examples
Clean environment	5	15	-	4	- Waste disposal helps prevent environmental pollution. - Environmental pollution is prevented via recycling.
Consciousness-raising	3	1	14	-	Students should gain-Sustainability consciousness. - We should stimulate people about recycling. - Development plan-consciousness should be created.
Re-using	11	-	-	-	- It allows us to re-use waste materials.
Recycling	-	11	-	-	- Waste disposal is related to recycling.
Renewable energy sources	-	-	-	10	- It is a renewable energy source.
Sustained	-	-	10	-	- It is sustained/continuous.
Recycle bin	9	-	-	-	- We should throw used materials into a recycle bin.
Important	9	3	6	2	- Recycling is important for humans, the environment, waste disposal, and the economy. - Sustainability is important for the protection of the environment.
Inspection	-	6	-	-	- Regular waste control should be carried out / checked.
Categorizing waste	5	2	-	-	- When disposing of waste, we must separate glass, oil, paper, and plastic.
Using sources	-	-	5	-	- Sustainability is about the effective use of resources.
Protecting nature	-	-	-	5	- It does not harm nature; it is useful.
Energy transformation	-	-	-	5	- Solar energy is transformed into different energies, and in this way, it provides advantages.
Saving	4	-	4	3	- We must use natural resources economically. - Materials should be recycled for saving. - It is an economical type of energy.
Others (frequencies of 4 and below)	8	11	10	14	- It contributes to the national economy. - Solar energy is an advanced technology used in many fields. - Waste disposal means saving the future.
Alternative concepts	-	9	5	3	- Factory waste should be checked. - Where sustainability is high, life is orderly. - Solar energy is a type of energy especially used in the Mediterranean Region. - Waste disposal means categorizing glass, plastic and paper separately.
Total	54	58	54	46	
Blank	25	29	29	35	

R: Recycling, **WD:** Waste Disposal, **S:** Sustainability, **SE:** Solar Energy

PSTs having alternative conceptions such as confusing these two concepts with each other and/or seeing each of them as causing or resulting from the other. Moreover, it was observed that the RWs and sentences related to EPs were mainly related to the causes of these problems and that a small number of them were related to the results. At the sa me time, none of the PSTs suggested a solution to prevent these problems. In addition, while the PSTs were able to give one-word answers to the concepts given in the WAT, the significant decrease in frequencies when they were asked to make sentences for these concepts may be due to their inadequate scientific language for thought expression (Table 3). That the PSTs were worried about presenting their knowledge in a meaningful and logical way. The low self-efficacy for transferring their thoughts to others can also be interpreted as reasons for this result.

Furthermore, it was determined that the PSTs had various alternative conceptions related to EPs (Figure 2, Table 2). It was seen that the PSTs associated the ozone layer with global warming and that they formed their answers with alternative conceptions such as ozone layer depletion causing global warming (Erdoğan & Cerrah-Özsevgeç, 2012). At the same time, it was found that there were PSTs who thought that ozone layer depletion would cause more sunlight to pass through and that the earth would get warmer. That may be because the PSTs misconstructed or misinterpreted the relationship between global warming and ozone depletion (Pekel, Kaya & Demir, 2007), or, in particular, that they often heard these two concepts together in the mass media (Boyes, Chuckran & Stanisstreet, 1993; Koulaidis & Christidou, 1999; Meadows & Wiesenmayer, 1999; Selvi & Yıldız, 2009;

Summers, Kruger, Childs & Mant, 2001). In addition, as shown in the concept network (Figure 2), it was determined that the PSTs had the opinion that using perfume and deodorant caused global warming (Seçgin, Yalvaç & Çetin, 2010). One of the expressions most associated with global warming is seen to be glacier melting. At the same time, none of the PSTs mentioned the consequences of global warmings, such as desertification and an increase in biological pests. This result can be regarded as an indication that the source of the information that the PSTs had was limited to the media and was only informed about the issues raised (Boyes & Stanisstreet, 1992).

Most of the PSTs used expressions containing alternative conceptions such as that the greenhouse effect causes negative consequences and is not necessary for life (Erdoğan & Cerrah-Özsevgeç, 2012; Selvi & Yıldız, 2009). At the same time, it is seen that the PSTs confused the causes and consequences of these concepts, in which they established erroneous relationships among global warming, the ozone layer, and the greenhouse effect. It was determined that a small number of PSTs associated the greenhouse effect with greenhouse cultivation and agriculture. This may be due to the lack of PSTs' knowledge on the greenhouse effect or the visualization in their minds of the greenhouse cultivation activities that they often encountered when they saw the SW (Bahar & Aydın, 2002).

In the answers given about *radiation*, it was seen that the PSTs focused on associations with the harmful effects of radiation, while they had common alternative conceptions for this concept. It was determined that they thought that the use of radiation in the medical field was necessary. Despite this, it should be avoided and not used, and that MRI emitted radiation and people should stay away from a radiation environment. Many PSTs confused radiation with radioactivity. While some of the PSTs stated that mobile phones emit radiation, some of them stated that they do not emit it. In the responses, it was seen that they discussed the radiation subject within the scope of a course they had taken in the previous year and stated that they obtained their knowledge from that course. At this point, it was seen that the PSTs' alternative conceptions about this concept stemmed from their everyday conversations and the knowledge they acquired through the media, and it is thought that the mistakes made about these relationships were effective in revealing such alternative conceptions (Bakaç & Kartal-Taşoğlu, 2016; Mavi, 2008).

It appeared that most of the RWs associated with the acid rain emerged as chemical compound formulas. Among these, as well as sulphuric and nitric acid compounds that cause acid rain, compounds not related to acid rain appeared in quite a large number. This may be because of the PSTs' inability to find expressions to write in the gaps given or because they thought mixing all compounds in the air caused acid rain. At this point, it can be stated that the PSTs behaved without thinking while writing responses. It can be assumed that the PSTs had incomplete and incorrect knowledge about acid rain and that although they had learned the subject within the scope of a course, they had taken in previous years, their knowledge was temporary, causing misinterpretation of the process and resulting in alternative conceptions (İncekara & Tuna, 2010; Demirbaş & Pektaş, 2009). Another striking point here is that there were opinions that acid rain significantly damaged plants. The PSTs' one-dimensional thinking about the subject and not thinking about other living things or the environment can be regarded as a result of not interpreting their knowledge and transferring it to different situations.

3.4 Discussion on PE

When the number of RWs related to PE was examined, it was seen that the concept of *waste disposal* had the highest frequency, while the *solar energy* concept had the lowest (Table 3). The conducting of various studies on solar energy in our country and the world in recent years may explain the PSTs' standard views towards this concept. On the other hand, since there is not much information about what *waste disposal* is and which practices related to this are applied in schools, daily life, or the media, it is thought that the PSTs gave their answers through evocations (Demirbaş & Pektaş, 2009; İncekara & Tuna, 2010; Kazak, 2014). When the responses in the concept network in Figure 3 were examined, it was seen that they associated this concept with recycling or that they focused on the waste term, which is included within the concept, and gave examples of various types of waste. Also, it was determined that the PSTs established an intra-link between only *recycling* and *waste disposal* in the concept network. This may be because they were ill-informed about *waste disposal* and that, therefore, they thought that this concept had the same meaning as recycling.

On the other hand, it is thought-provoking that although practices to support sustainability, such as recycling, waste disposal, and solar energy, were given together, they were not directly associated with the concept of sustainability. The fact that the PSTs did not think about the interactions related to PE may be why they could not establish the right relationships for how these ways affect or support each other (Seçgin, Yalvaç & Çetin, 2010). When all the SWs in the WAT are examined, it is thought that the PSTs had the most difficulty with this SW since the concept of waste disposal was only revealed at the fourth cut-off point. Likewise, it was seen that the PSTs explained the concept of sustainability with RWs, such as sustained and continuous, which the word evoked at the first stage. As a result of this association, the SW was revealed at the cut-off point 50 and above. The first reasonable response for this SW was expressed as "development" in the cut-off point 30-34. It can be concluded that the PSTs' knowledge levels and reasoning skills were insufficient. When looking at the concept network (Figure 3), it was determined that the most accurate responses and high-frequency SWs were

recycling and *solar energy*. This may be because tangible studies have been carried out in our country for many years regarding these two PE and that common sense on these issues is formed in society. The fact that even if individuals do not use recycle bins in their neighborhood, they see them constantly, that solar energy vehicles frequently appear in the media (Yılmaz, Morgil, Aktuğ & Göbekli 2002), and that projects in universities and various research institutions are carried out on this subject, may have supported the forming of common views on these concepts in their minds. Besides, it is thought that supporting the use of solar energy at home with state policy enables individuals to develop a positive attitude in this direction and increases their desire to research and learn about this issue.

When the PSTs were asked to make sentences with the SWs, it was determined that they were insufficient in PE subjects and EPs. For example, for the concept of sustainability, it was determined that only 10 PSTs wrote sentences for the sustained/continuous responses that appeared at the cut-off point 50 and above in the concept network, and these sentences are considered superficial knowledge. Also, it was determined that the PSTs tried to write sentences containing commonly encountered stereotyped expressions such as "making them reusable" and "renewable energy sources" such as recycling and solar energy. At this point, it can be said that the PSTs were inadequate in expressing themselves in a scientific sense.

When compared with EPs, it was determined that the PSTs formed a fewer number of sentences with alternative conceptions for PE (Table 5). While it was determined that none of the PSTs wrote any sentences with alternative conceptions about recycling, the highest number of sentences related to waste disposal indicates that they confused these two concepts. In addition, knowledge on *recycling* has been frequently acquired with the right policies for many years without information pollution. On the other hand, *waste disposal* has only recently come onto the agenda, and a lack of information on this subject may be the reason for this confusion.

Forming sentences containing alternative conceptions such as "solar energy is a type of energy used especially in the Mediterranean Region" can be expressed as the PSTs' low level of logical thinking and reasoning skills. It was seen from these explanations that the PSTs thought that this type of technology could be utilized only in a region with a high annual average temperature (Table 4). Similarly, from views such as "Life is orderly in places where sustainability is high", it was determined that PSTs perceived that sustainability, which is an event that will have a global impact, was an event that could occur for limited settlement areas only. From this point of view, it can be said that the PSTs' awareness of concepts that need to be considered and interpreted in a global dimension, such as the environment, was lower than expected and that they could not develop community-centered insights. In this context, it is thought that the adequacy of education and training activities applied in the training of PSTs, who will have one of the biggest roles in bringing societies forward, should be examined, and that steps should be taken for necessary interventions.

4. CONCLUSION

This study aimed to determine the PSTs' perceptions and alternative conceptions related to the determined concepts. In future studies, teaching practices aimed at eliminating their alternative conceptions can be designed, and the effectiveness of these practices can be investigated. This study was conducted with only third-year PSTs. As a result of the study, it was concluded that the PSTs had incomplete and incorrect knowledge about EPs and PE. In particular, it was determined that the concepts of *global warming, the ozone layer,* and the *greenhouse* effect were confused, and they had difficulty establishing causal links. When the responses given to the WAT and the written sentences are examined, it is seen that expressions frequently used in daily life were used mainly.

On the other hand, the PSTs expressed that they had taken courses including subjects based on some SWs. However, when looking at their responses, it is concluded that they preferred to respond in line with the knowledge they had gained in daily life instead of using scientific knowledge. In particular, the fact that the written sentences were superficial and simple supports this result.

One of the reasons for the alternative conceptions that the students had is that their teachers have incomplete and incorrect knowledge. For this reason, it is believed that the determination of the PSTs' alternative conceptions during their undergraduate education and organizing scientific activities such as practices, course contents, conferences, and panels to solve the existing deficiencies will produce beneficial and effective results. Although environmental education is intensively included in science courses with an interdisciplinary approach, it is also related to other fields. Therefore, it is essential to conduct similar studies with students from different grade levels and different disciplines.

Although the PSTs were partially aware of environmental protection in their answers, none of them gave in-depth answers on this issue. To prevent superficial responses, encouraging them to participate in activities in the teaching process and taking part actively in such socio-scientific situations will help eliminate such problems.

It is seen that the WAT used in this study enables the efficient data collection from large groups in a short time. Although the analysis process long and exhausting, it provides very effective results in revealing the links between the knowledge in the participants' minds and displaying them explicitly and clearly. For this reason, it is recommended to use the WAT for studies aimed at revealing the perceptions on a topic, alternative

conceptions, and relationships between the concepts on which the subject is constructed.

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