PES
www.ijpes.com
International Journal of Psychology and Educational Studies

Investigation of Prospective Science Teachers' Understandings on Ergastic Substances with the Semantic Mappings*

Yusuf ZORLU[1], Fulya ZORLU[2]

[1] *Kütahya Dumlupınar University, Faculty of Education, Kütahya, Turkey*

[2] *Zonguldak Bülent Ecevit University, Ereğli Faculty of Education, Zonguldak, Turkey*

ARTICLE INFO

Article History:
Received 01.06.2020
Received in revised form 29.11.2020
Accepted 23.12.2020
Available online 27.01.2021

ABSTRACT

The aim of this study was investigated of prospective science teachers' understandings on ergastic substances with the semantic mappings. This study was phenomenological research method. 38 prospective science teachers in the science teaching department of a public university participated in the research. The prospective science teachers were asked to prepare the semantic mappings about Ergastic Substances. In this study, student products are 36 semantic mappings prepared by the prospective science teachers. The semantic mappings were analyzed content analysis method. According to the findings obtained from the research, it can be said that in the semantic mapping, the prospective science teachers used most of concepts related to Ergastic Substances in the experiments. Additionally, it can be said that conducting experiments and preparing the semantic mappings have important contributions to the teaching, researching and associating of concepts. In order to eliminate the difficulties, intervals applications at different times will contribute to the literature instead of one-off applications. According to the results of 36 semantic mapping prepared by the prospective science teachers, a semantic mapping containing 6 groups and 140 concepts was formed.

Keywords:
Conceptual investigation, ergastic substances, science education, semantic mappings

1. Introduction

Ergastic Substances are the general name given to lifeless substances, which are formed as a result of physiological activities in plant cells as residuum or substitute products (Algan & Toker, 2004). Ergastic substances are products of metabolism (Idu & Onyibe, 2011) and represent waste products, which are solid and secondary (Simon & Nayyagam, 2018). Ergastic substances are present in the fruit wall, cortex, and vascular parenchyma of the stem and of the petiole but in the root, except in the cortex near the origin of secondary roots, they are practically absent (Scott, 1941).

Ergastic Substances consist of coloring agents, carbohydrates, proteins, fats, glycosides, saponins, tannins, resins and balsams, rubber, alkaloids and crystals subtopics (Algan & Toker, 2004). The most common are calcium oxalate crystals (Nwachukwu & Edeoga, 2006) and accumulate crystallize into salts such as calcium oxalate, calcium carbonate and calcium sulfate (Efe, 2000). In particular, the detection of crystals, protein and starch grains are taxonomic, thus benefiting society by classifying plant species (Nwachukwu & Edeoga, 2006). In addition, carbohydrates, proteins, fats have a unique position in human nutrition requirement (Omoigui & Aromose, 2012). In this context, the handling of ergastic substances is necessary to understand

* Part of this study was presented as an oral presentation at the International Conference on Science, Mathematics, Entrepreneurship, and Technology Education

† Corresponding author's address: Kütahya Dumlupınar University, Faculty of Education, Kütahya, Turkey
Telephone: +905372268191
e-mail: yusuf.zorlu@dpu.edu.tr

http://dx.doi.org/10.17220/ijpes.2021.8.1.199

the importance of organisms and life, as well as the relationships of biology. For this reason, the subject of ergastic substance should be learned at the level of concepts effectively.

An effective science education is possible by the meaningful learning of knowledge at the level of concepts rather than by memorization (Gödek, Polat & Kaya, 2018). Concepts in science that involve complex and interrelated concepts should be organized to form coherent information structures (Koponen & Pehkonen, 2010). According to Fitzgerald, Elmore, Kung and Stennen (2017), various researches have revealed that individuals have learned many concepts, especially more complex ones, by establishing relationships between concepts (by forming networks). One of the two-dimensional visual tools demonstrating the relationships between concepts by showing the names and properties of concepts and how they are used by students are a semantic mapping (İnel-Ekici, 2014). Semantic mappings are also seen as an approach for constructing the relationships and visual representations of conceptual categories (Dilek & Yürük, 2013).

In their research, Schwab and Cable (1982), recommend the implementation of the semantic mappings to students of all ages in science teaching. Semantic mappings help reaching a higher level of comprehension and thinking by using concepts, especially by grouping them and in this way regulating the structuring of the mind (Antonacci, 1991; Candan, 1998; Gödek, Polat & Kaya, 2018). They make learning more effective by providing a fun teaching process (Aktepe, Cepheci, Irmak & Palaz, 2017). In a study conducted by Avery, Baker and Gross (1997), it was concluded that the semantic mappings enable teachers and learners to understand the concepts and their experiences and they ensure the determination of learning levels according to individual differences. In the research conducted by Tuna (2013), it was found that the teaching performed using the semantic mappings method contributed more to the academic success of students compared to the direct instruction method. According to the literature, the semantic mappings are one of the tools used to identify alternative assessment and evaluation approaches and conceptual understandings that can be used in different age groups and different learning environments (Artun, 2018; Dilek & Yürük, 2013; İnel-Ekici, 2014).

In the literature on ergastic substances, it is seen that researches are carried out in the fields of biotechnology (Idu & Onyibe, 2011; Kolovrat, 2016), botany (Gill, Nyawuame, Aibangbee & Agho, 1991; Nwachukwu & Edeoga, 2006; Omonhinmin, Daramola & Idu, 2015; Scott, 1941) and medicine (Nayagam, 2015; Simon & Nayyagam, 2018). However, no studies on the subject were reached in the field of education. However, it is very important to investigate the researches on plants and plants that have a great place in human history in the field of education. Thus, following important developments in plant science and taking part in education will allow students to transfer the most up-to-date information to their social and economic life (Çelik, 2019). In addition, the presence of ergastic substances in many structures of plants and humans' most foods shows that it is very important in daily life. It can be said that ergastic substances, which we encounter in many areas of daily life, are among the subjects that should be emphasized in science education.

Considering importance and role of ergastic substances in daily life, it is understood that research on the subject should be carried out in the field of education as well. In addition, it is thought that investigating the prospective science teachers' understandings on ergastic substances will contribute greatly to the relevant area and will guide the research on this issue in the future. Accordingly, in this study, it is aimed to investigation of prospective science teachers' understandings on ergastic substances with the semantic mappings. An answer was sought to the following research question in line with this purpose.

What are the prospective science teachers' understandings on ergastic substances?

2. Method

2. 1. Research Design

The phenomenological research method focuses on how the phenomenon is perceived, depicted, judged, understood (Patton, 2014). In addition, the researchers who are the data source in the phenomenological research method are individuals who can reflect the phenomenon that is focused on the study outside (Yıldırım & Şimşek, 2011). The phenomenological research method of qualitative research method was used in this study because of prospective science teachers can reflect their understanding of this subject and the understandings in this subject are determined based with the semantic mappings.

2. 2. Research Sample

In the research, purposive sample method was used. The purposive is that the students on which the application is performed, are the prospective science teachers who take the course General Biology Laboratory-1. In line with this purpose, 38 prospective science teachers who were educated in second grade of the science teaching department of the faculty of education of a public university participated in the research. The prospective science teachers who participated in the research are 5 were male and 33 were female.

2. 3. Data Collection Method, Tool, and Analysis

Before collecting data in the study, information about the study was given and the prospective science teachers who volunteered were determined.

1. In the first week (2 hours), the prospective science teachers were given information about the semantic mappings and its characteristics and their samples were examined. In addition, experiments were determined about Ergastic Substances together with the prospective science teachers.
2. The experiments determined in the following week (4 hours) were conducted by the prospective science teachers in the laboratory environment. Information about the determined experiments by the prospective science teachers are given below.

Materials Used for Examination: Tomato, Carrot, Lemon, Potato, Bean, Rice, Rubber, Busy Lizzie and Begonia

Examination Environment: Water

Section Types: Scraping Method, Cross Section, Tangential Section, Longitudinal Section

Magnification Ratio: X10 and X40

Fabrication: The prospective science teachers have prepared slides using the appropriate sectioning method from the materials they brought, and they examined the Ergastic Substances. Slides were prepared by scraping method from tomato, carrot, potato, bean and rice plants. The substances examined were lycopene in tomato, carotene in carrot, starch grains and protein agents in potato, bean and rice. The matter of xantophyl was studied by taking a tangential section of lemon, the matter of raphide by taking a cross section from the stem of the web plate of the busy lizzie plant, druz by taking a cross section from the stem of the web plate of begonia, cystolith by cross-section from the leaf of the rubber plant and anthocyan and anthoxantin by the tangential section of the petals of the flower parts of begonia and busy lizzie plants.

3. At the end of the third week (2 hours), the prospective science teachers were asked to prepare the semantic mappings about Ergastic Substances.

In the study, the method of data collection based on the investigation was used as a method to collect data. Student products were used as a data collection tool in this method. In this research, student products are 36 semantic mappings prepared by the prospective science teachers. The prepared the semantic mappings were examined by two faculty members using content analysis method. Grouping and concepts used by the prospective science teachers in the semantic mappings were analyzed by creating themes and codes. The groupings were gathered under six themes, being "The Properties of Ergastic Substances", "The Locations of Ergastic Substances", "The Plants Containing Ergastic Substances", "The Examination of Ergastic Substances", "The Types of Ergastic Substances", and "Other Organic and Inorganic Substances". Data was given in frequency and percentage.

2.4. Limitations of Research

This research was conducted with the prospective science teachers who studied in the second year of the science teaching department of a public university. The results of this research cannot be generalized to prospective science teachers studying at other universities due to the limited qualitative research approach. Since this research investigates the prospective science teachers' conceptual understandings on ergastic substances, the results of the research are limited to the field of analysis. The prospective science teachers'

conceptual understanding on ergastic substances in this research is limited by the knowledge in the semantic mappings.

3. Findings

The findings regarding the content analysis of the groups of the semantic mapping of concepts, which the prospective science teachers prepared on ergastic substances were provided in Table 1.

Table 1. The groupings on ergastic substances

Themes	Codes	f	%
Properties of Ergastic Substances	Properties	5	2.99
	Some Ergastic Substances	3	1.80
	Color Substances	3	1.80
	Structures	2	1.20
	Groups	1	.60
	Basic Building Blocks	1	.60
	Total	**15**	**8.98**
Locations of Ergastic Substances	Location	18	10.78
	Found Substances	4	2.40
	Plants	4	2.40
	Organelle	2	1.20
	Cell	2	1.20
	Leaf	1	.60
	Epithelium	1	.60
	Vacuole Sap	1	.60
	Meristem Tissue	1	.60
	Total	**34**	**20.36**
The Plants Containing Ergastic Substances	Containing Ergastic Substances	7	4.19
	Plants	3	1.80
	Total	**10**	**5.99**
The Examination of Ergastic Substances	Examination Tools	4	2.40
	Object Examined	3	1.80
	Sectioning	2	1.20
	Total	**9**	**5.39**
Types of Ergastic Substances	Starch	14	8.38
	According to their shapes	11	6.59
	Protein	10	5.99
	Salt Crystals/Crystals/Crystal		
	Sample	9	5.39
	Ergastic Substance Sample	8	4.79
	Types	7	4.19
	Hilum	4	2.40
	Counts	4	2.40
	Protein Grains	3	1.80
	Aleurone	2	1.20
	Total	**72**	**43.11**
Other Organic and Inorganic Substances	Carbohydrate	10	5.99
	Oils	10	5.99
	Organic Substances	4	2.40
	Inorganic Substances	3	1.80
	Total	**27**	**16.17**
In All	**Total**	**167**	**100.00**

When Table 1 was examined, 34 codes and 167 frequencies were determined according to the content analysis results of the groupings in the semantic mappings of concepts prepared by the prospective science teachers about Ergastic Substances. It can be said that the prospective science teachers made 34 different groupings for the subject of Ergastic Substances. The top two themes with the most codes were "*Types of Ergastic Substances" and "Locations of Ergastic Substances"*. The theme with the least code *was "The Plants*

Containing Ergastic Substances". The theme with the highest frequency was *"Types of Ergastic Substances"*. The theme with the least frequency was *"The Examination of Ergastic Substances"* and *"The Plants Containing Ergastic Substances"*. When the frequencies of the codes belonging to the themes are examined, it is observed that the code *"Location"* belonging to the theme of *"Locations of Ergastic Substances"* has the highest frequency (f=18).The codes *"Groups"* and *"Basic Building Blocks"* belonging to the theme of *"The Properties of Ergastic Substances"*; and the codes *"Leaf"*, *"Epithelium"*, *"Vacuole Sap" and "Meristem Tissue"* belonging to the theme of *"Locations of Ergastic Substances"* have the lowest frequency (f=1). The frequency values of the codes of the themes belonging to groupings of the prospective science teachers ranged among 1-18. It may be asserted that the prospective science teachers generally make different groupings from each other.

The results of the content analysis of the concepts in the semantic mappings of concepts prepared by the prospective science teachers about Ergastic Substances are given in Table 2, Table 3 and Table 4.

Table 2. "Types of Ergastic Substances" and "The Plants Containing Ergastic Substances" themes

Theme	Codes	f	%	Theme	Codes	f	%
Types of Ergastic Substances	Simple/Semi Compound/Compound	47	4.63	The Plants Containing Ergastic Substances	Rubber	29	2.85
	Centric/Eccentric	35	3.44		Begonia	23	2.26
	Oils/Streoid/ Phospholipid/Ester Bonds/Glycerol	34	3.35		Bean	23	2.26
	Hilum/Navel/Crack Hilum	34	3.35		Potatoes	23	2.26
	Protein/Peptide Bond	28	2.76		Busy Lizzie	22	2.17
	Starch	27	2.66		Rice	19	1.87
	Single/Double/Triple/Multiple	25	2.46		Wheat	9	.89
	Raphide	21	2.07		Corn	6	.59
	Cystolith	19	1.87		Plant	5	.49
	Druz	19	1.87		Barley	5	.49
	Resin	14	1.38		Jerusalem Artichoke	4	.39
	Oil Acid/Saturated/Unsaturated Fat	10	.98		Castor Oil	4	.39
	Aleurone	8	.79		Onion	3	.30
	Gum/Musilage	6	.59		Lily	3	.30
	Tannin	5	.49		Rose	2	.20
	Glycoside	5	.49		Clove	2	.20
	Alkaloid	5	.49		Flax Oil	2	.20
	Starch Ring	4	.39		Olive Oil	2	.20
	Balsam	3	.30		Cocoa Oil	2	.20
	Assimilation	3	.30		Linden	1	.10
	Anthocyanin/Flavonoid	3	.30		Orchid	1	.10
	Spare Starch	2	.20		Horse Chestnut	1	.10
	Anthoxanthin	2	.20		Blue Violet	1	.10
	Neutral Oil	1	.10				
	Inulin	1	.10				
	Storage Starch	1	.10				
	Total	**362**	**35.63**		**Total**	**192**	**18.90**

When Table 2 is examined it is observed that there are 26 codes and 362 frequencies of these codes, belonging to the theme *"Types of Ergastic Substances"*. In the theme *"Types of Ergastic Substances"* the prospective science teachers are observed mostly to include the concepts *"Simple/Semi Compound/Compound"*, *"Centric/Eccentric"*, *"Oils/Streoid/ Phospholipid/Ester Bonds/Glycerol"*, *"Hilum/Navel/Crack Hilum"*, *"Protein/Peptide Bond"*, *"Starch"*, *"Single/Double/Triple/Multiple"*, *"Raphide"*, *"Cystolith"*, *"Druz"* and *"Resin"* in their semantic mappings of concepts. The prospective science teachers are generally observed to write most of the concepts, which are and are not in the experiments they made on Ergastic Substances in the semantic mappings of concepts. Regarding the theme *"Types of Ergastic Substances"* the prospective science teachers are observed to give place to the concepts *"Spare Starch"*, *"Anthoxanthin"*, *"Neutral Oil"*, *"Inulin"* and *"Storage Starch"* the least. It is observed that there are 23 codes belonging to the theme *"The Plants Containing Ergastic Substances"*, and 192 frequencies of these codes. The prospective science teachers used concepts

"Rubber", *"Begonia"*, *"Bean"*, *"Potatoes"*, *"Busy Lizzie"* and *"Rice"* in the theme *"The Plants Containing Ergastic Substances"* in the prospective science teachers' semantic mapping. The prospective semantic mappings of the prospective science teachers were found 23 plants containing ergastic substances.

Table 3. The "Properties of Ergastic Substances" and "Examination of Ergastic Substances" themes

Theme	Codes	f	%	Theme	Codes	f	%
Properties of Ergastic Substances	Crystal	27	2.66	Examination of Ergastic Substances	Sectioning/Transverse/Longitudinal/Tangential	11	1.08
	Color Pigments	16	1.57		Microscope	6	.59
	Lifeless	10	.98		Microscope Slide	6	.59
	Metabolic Product/Nutrient	7	.69		Coverslip	6	.59
	Amorphous/Amorphous Structure	6	.59		Razor/Microcon	4	.39
	Photosynthesis	5	.49		Optics/Objective	3	.30
	Painted Substances	4	.39		Scraping	3	.30
	Waste Substance	4	.39		Micro/Macro/Fine Tuning	3	.30
	Solution	2	.20		Preparate /Preparation	2	.20
	Round/Oval	2	.20		Section Examine	1	.10
	Abundance	2	.20		Crush	1	.10
	Replacement Product	2	.20		Lugol	1	.10
	Colorless	1	.10				
	Metamorphic	1	.10				
	Complexity	1	.10				
	Storage	1	.10				
	Total	**91**	**8.96**		**Total**	**47**	**4.63**

When Table 3 is examined it is observed that there are 16 codes of the theme *"Properties of Ergastic Substances"* and 91 frequencies belonging to these codes. In the theme *"Properties of Ergastic Substances"* the prospective science teachers were mostly used concepts of *"Crystal"*, *"Color Pigments"* and *"Lifeless"* in their semantic mapping. The codes in the theme *"Properties of Ergastic Substances"* had frequency values among 1-7. It can be said that the prospective science teachers partially include the properties of Ergastic Substances in their semantic mapping. It was observed that there are 12 codes of the theme *"Examination of Ergastic Substances"*, and 47 frequencies belonging to these codes. The prospective science teachers mostly included concepts of *"Sectioning/Transverse/Longitudinal/Tangential"* in their semantic mapping. The code number belonging to the theme *"Examination of Ergastic Substances"* and frequency range of codes varied among 1-11.

Table 4. The "Locations of Ergastic Materials" and "Other Organic and Inorganic Substances" themes

Theme	Codes	f	%	Theme	Codes	f	%
Locations of Ergastic Materials	Seed/Seed Embryo Endosperm/Perisperm	15	1.48	Other Organic and Inorganic Substances	Carbohydrate	29	2.85
	Vacuole	15	1.48		Glucose	15	1.48
	Cytoplasm	14	1.38		Polysaccharide	9	.89
	Cell Wall	13	1.28		Oxygen	8	.79
	Root	12	1.18		Cellulose	6	.59
	Stem	11	1.08		Fructose	6	.59
	Leaf/Leaf Stalk	11	1.08		Maltose	6	.59
	Cell/Plant Cell	11	1.08		Saccharose	6	.59
	Fruit	10	.98		Hydrogen	6	.59
	Chloroplast/Granum	9	.89		Minerals	6	.59
	Leucoplast	8	.79		Nitrogen	5	.49
	Cellulary Juice	8	.79		Carbon	5	.49
	Amyloplast	6	.59		Sulphur	4	.39
	Plant	5	.49		Phosphor	4	.39
	Flower	4	.39		Monosaccharide	3	.30
	Ribosome	4	.39		Disaccharide	3	.30
	Rhizome	3	.30		Enzyme	3	.30
	DNA-RNA	2	.20		Acid	3	.30
	Epidermis	2	.20		Deoxyribose/Ribose	2	.20
	Tissue	2	.20		NAD/FAD	2	.20
	Organ	2	.20		ATP	2	.20
	Tuber	2	.20		Glycogen	1	.10
	Parenchyma	2	.20		Chitin	1	.10
	Cell Membrane	2	.20		Triose	1	.10
	Transmission Bundles	1	.10		Pentose	1	.10
	Mesophyll	1	.10		Hexose	1	.10
	Stoma	1	.10		Galactose	1	.10
	Peroxisome	1	.10		Lactose	1	.10
	Plastid	1	.10		Polymer	1	.10
					Carboxyl Group	1	.10
					Carbondioxyde	1	.10
					Water	1	.10
					Potassium Iodide	1	.10
					Alcohol	1	.10
	Total	**178**	**17.52**		**Total**	**146**	**14.37**

When Table 4 was examined it was observed that there were 29 codes belonging to the theme *"Locations of Ergastic Materials"*, and 178 frequencies of these codes. In the prospective science teachers' semantic mapping, they mostly included the concepts of *"Seed/Seed Embryo Endosperm/Perisperm"*, *"Vacuole"*, *"Cytoplasm"*, *"Cell Wall"*, *"Root"*, *"Stem"*, *"Leaf/Leaf Stalk"*, *"Cell/Plant Cell"*, and *"Fruit"* in the theme *"Locations of Ergastic Substances"*. When the frequencies of the mostly used concepts were examined, they were observed to vary among 10-15. It was observed that there are 34 codes and 146 frequencies belonging to these codes regarding the theme *"Other Organic and Inorganic Substances"*. In the theme of *"Other Organic and Inorganic Substances"*, the prospective science teachers used the concepts of *"Carbohydrate"* and *"Glucose"*. The prospective science teachers gave place to 34 different inorganic and organic substances belonging to the theme *"Other Organic and Inorganic Substances"*.

4. Discussion, Conclusion and Recommendations

The importance of concept teaching in science education has been constantly increasing from past to present. In this part, the conclusions and the causes of the findings obtained from this study, which was carried out with the aims of investigation of prospective science teachers' understandings on ergastic substances with the semantic mappings were included with a discussion of literature.

The prospective science teachers made groupings considering the types of Ergastic Substances and their location in plants (Table 1). It was observed that the codes mostly used by the prospective science teachers in the theme *"Types of Ergastic Substances"*, were generally the concepts in the experiments they made (Table 2). According to the findings obtained from the research, it can be said that in the semantic mapping, the prospective science teachers used most of the concepts related to Ergastic Substances in the experiments did this study. It may be due to the fact that the prospective science teachers conducted experiments on the subject of Ergastic Substances, saw the types of Ergastic Substances and their locations in plants by using microscope and that this process attracted attention. Ergastic Substances are a subject of biology. One of the most important elements when teaching biology subjects such as Ergastic Substances is material (Berck, 1999). It is important to use real objects and models as teaching materials and tools in teaching concepts (Clements, 1999; Fidan, 2008; Nalçacı & Ercoşkun, 2005; Ornstein & Lasley, 2000; Seferoğlu, 2015). The reasons why the use of real items and models as instructional materials and tools in the lessons are effective in learning are that they concretize, provide generalization, are interesting and provide permanent learning (Çelik, 2017; Kaya, 2006; Kelly, 2006; Selvi, 2008; Senemoğlu, 2001).

The prospective science teachers usedthe concepts of *"Oils/Steroid/Phospholipid/Ester Bonds/Glycerol"* in their semantic mapping. Besides, they included 23 different plants in the theme *"The Plants Containing Ergastic Substances"* (Table 2). Within the scope of the study, the prospective science teachers conducted the experiments using 9 plants. When the semantic mappings were examined, it was seen that the prospective science teachers included 14 different plants that they did not use in experiments. In other words, the concepts which were not included in the experiments were also included in the semantic mapping. This may be due to the fact that the prospective science teachers have designed and implemented all stages, including the stage of preparing experiments themselves (experiments and semantic mapping of concepts), that learning by doing and living was realized and that they needed to investigate different sources to be able to make designing. Conducting experiments activates the acquired knowledge, develops critical thinking, understanding science, processing and psychomotor skills, encourages students to conduct research, and enables students to transfer the information to his/her life and use it (Çepni & Ayvacı, 2006; Kesercioğlu, Balım, Öztürk & Çavaş, 2004; Yazıcı & Kurt, 2018). When the related literature was examined, it was seen that there were studies indicating that the prospective science teachers' designing experiments by conducting researches using different sources also contributed to their learning the concepts not included in the experiments (Alkan, 2013; Lowe, Newcombe & Stumpers, 2012; Olympiou & Zacharias, 2012).

In the semantic mapping formed by the prospective science teachers in the theme *"Other Organic and Inorganic Substances"*, it was seen that 34 different organic and inorganic substances exist with 146 frequency distributions (Table 4). According to the findings obtained, the prospective science teachers' including organic and inorganic substances in their semantic mapping this much suggests that they repeated the information they learned in previous lessons and that they could envisage it and it was foreseen that this situation would provide many benefits to the prospective science teachers. Revitalizing the previous knowledge in the mind enables the learning to become permanent and to learn the new knowledge better based on the previous knowledge (Güneş, 2007; Köksal & Atalay, 2016; Onan, 2012). Information processing includes short memory, emotional memory and long memory. In short memory, there are more operations in data processing compared to the other memories. The information received in the short-term memory is compared and associated with the information in the long-term memory (Arslan, 2008). It could be said that the prospective science teachers integrated the information contained in the long-term memory with the information contained in the short-term memory by establishing relationships between them while preparing the semantic mapping. There is a need for structures that represent large patterns of information in memory. Data structures that represent organized information patterns are called conceptual structures, frameworks, schemas. The schema is the basic framework used to organize information. Schema about the

words that make up a hypothesis allow us to assign different meanings to the sentence. In any case, the schema that is driven by the previous knowledge and meanings influences the way we behave. Many cognitive psychologists believe that schema is the key unit of the comprehension process. Information processing theorists describe the schema as a network of concepts, relationships, and processes in individuals' memories. These semantic mapping ensure the association of relationships, propositions, processes and the newly obtained information with the old ones. In this case, the above-mentioned proposition networks can be considered as sub-sets of schemas. Schemas also directly affect the process of remembering information. The more different schemas are created about information, the faster and easier it is to remember that information. Information does not disappear in long-term memory; but it can be lost. According to Schema Theory, new information is easier to remember if it is placed in a well-developed, appropriate schema (Senemoğlu, 2007). Information should be delivered to students through multiple channels. In the teaching process, not only auditory but also visual channels should be used. These and similar applications will help students form right schemas. The correct schemas formed within this framework will have a positive effect on the schemas that will be formed in subsequent learning (Onan, 2012).

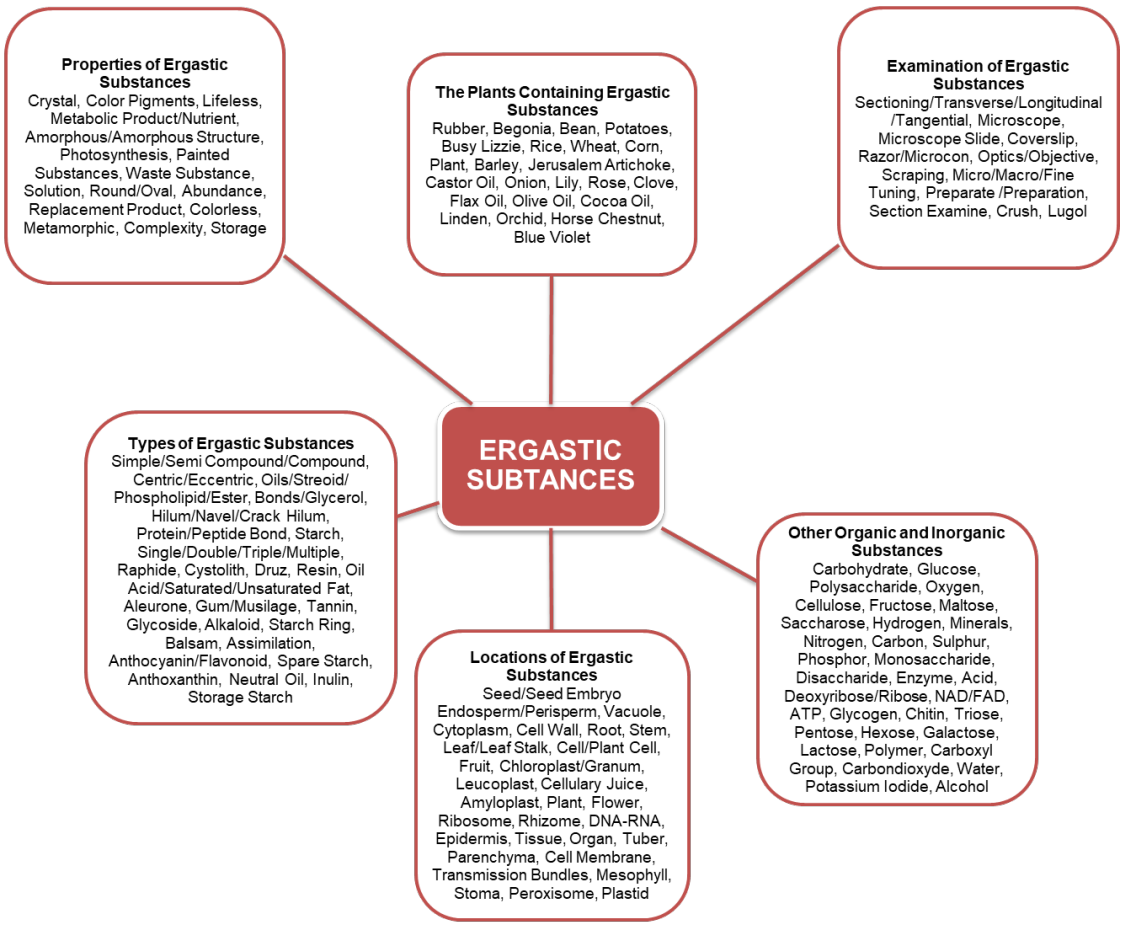
In this study, the prospective science teachers made the experiments and semantic mapping of concepts. While conducting the experiments, the prospective science teachers learned the concepts by processing information into short- and long-term memory. Regarding information that cannot be transferred to long term memory and is in the short-term memory, it may be asserted that they help its transfer to long term memory after preparing semantic mapping and finding the chance to repeat the subjects. In the process of processing information, mental functions predominantly occur in short-term memory. Short term memory has two types of information sources. Information comes from both sensory recording and long-term memory to short-term memory. For the information coming from sensory recording to be transferred from short-term memory to long-term memory, this information must be repeated mentally. Exercise based on repetition allows the information to be kept in short-term memory and the exercise based on assimilation allows the information to pass into long-term memory (Karakaş, 2000).

The prospective science teachers included the least *"Spare Starch"*, *"Anthoxanthin"*, *"Neutral Oil"*, *"Inulin" and "Storage Starch"* concepts in the theme "*Types of Ergastic Substances"* in the semantic mappings (Table 2). When the prospective science teachers examined the preparations, they prepared by tangential section from the petals of flowers under the microscope, they saw the anthoxantin substance. However, this concept was found to exist only in two semantic mapping of concepts. According to the findings of the research, it may be asserted that, while conducting experiments, the prospective science teachers did not fully learn some of the concepts or did not include them in the semantic mappings. It was seen that the prospective science teachersuse30 different places regarding the theme *"The Locations of Ergastic Substances"*, and that their number of repetitions is 178 (Table 4). According to the findings obtained from the research, it may be asserted that the prospective science teachers knew the locations of Ergastic Substances in plants but that they do not fully include them in semantic mappings. The codes mostly used by the prospective science teachersin the theme *"Properties of Ergastic Materials"*, were observed to be crystal structure, colored and lifeless. When the frequency values of colored and lifeless codes were examined, it was seen that they give very little space to these concepts except for the fact that Ergastic Substances were in crystal structure (Table 3). Regarding the properties of Ergastic Substances, explanations should be written in sentences. According to the findings obtained from the research, the fact that the prospective science teachers gave little spaces to the related concepts may be due to the fact that they do not know the definition of the concept completely or do not think that sentences can be included in the semantic mappings. In the study they conducted, Güneş, Dilek, Demir, Hoplan and Çelikoğlu (2010) stated that science teachers rarely use the semantic mappings of concepts in concept teaching. One of the main aims of science education and teaching is to teach the nature of knowledge with the concepts that are its building blocks (Kaya, 2010). The teaching of concepts should be attached more importance when conducting experiments.

According to the results obtained from the research, it can be said that conducting experiments and preparing the semantic mappings of concepts have important contributions to the teaching, researching and associating of concepts. When the related literature was examined, it was found that semantic mappings of concepts and experiments were effective in concept teaching and that their results showed parallelism with

the results of this study (Antonacci, 1991; Candan, 1998; Çepni & Ayvacı, 2006; Dilek & Yürük, 2013; Fitzgerald, Elmore, Kung & Stennen, 2017; Gödek, Polat & Kaya, 2018; Kesercioğlu, Balım, Öztürk & Çavaş, 2004; Lowe, Newcombe & Stumpers, 2012; Olympiou & Zacharias, 2012; Patrizi, Ice & Burgess, 2013; Reza & Azizah, 2019). According to the results of this research, it can be said that prospective science teachers have difficulties to prepare the semantic mappings. In order to eliminate the difficulties, intervals applications will contribute to the literature instead of one-off applications. It is thought that this study will also guide the similar studies, which will be performed in the long term.

According to the findings obtained from 36 semantic mappings prepared by the prospective science teachers on the subject of Ergastic Substances, a final semantic mapping was formed and given in Figure 1. According to the content analysis results of 36 semantic mappings prepared by the prospective science teachers, a semantic mapping containing 6 groups and 140 concepts was formed (Figure 1). The order of importance of the groups in the semantic mapping of concepts was *"Types of Ergastic Substances"*, *"The Plants Containing Ergastic Substances"*, *"Locations of Ergastic Substances"*, *"Other Organic and Inorganic Substances"*, *"Properties of Ergastic Substances" and "Examination of Ergastic Substances"* respectively. The semantic mappings in Figure 1 could be used as a guide material when teaching the subject of Ergastic Substances.



Simple/Semi Compound/Compound, Centric/Eccentric, Oils/Streoid/ Phospholipid/Ester, Bonds/Glycerol, Hilum/Navel/Crack Hilum, Protein/Peptide Bond, Starch, Single/Double/Triple/Multiple, Raphide, Cystolith, Druz, Resin, Oil Acid/Saturated/Unsaturated Fat, Aleurone, Gum/Musilage, Tannin, Glycoside, Alkaloid, Starch Ring, Balsam, Assimilation, Anthocyanin/Flavonoid, Spare Starch, Anthoxanthin, Neutral Oil, Inulin, Storage Starch, Rubber, Begonia, Bean, Potatoes, Busy Lizzie, Rice, Wheat, Corn, Plant, Barley, Jerusalem Artichoke, Castor Oil, Onion, Lily, Rose, Clove, Flax Oil, Olive Oil, Cocoa Oil, Linden, Orchid, Horse Chestnut, Blue Violet, Crystal, Color Pigments, Lifeless, Metabolic Product/Nutrient, Amorphous/Amorphous Structure, Photosynthesis, Painted Substances, Waste Substance, Solution, Round/Oval, Abundance, Replacement Product, Colorless, Metamorphic, Complexity, Storage, Sectioning/Transverse/Longitudinal/Tangential, Microscope, Microscope Slide, Coverslip, Razor/Microcon, Optics/Objective, Scraping, Micro/Macro/Fine Tuning, Preparate /Preparation, Section Examine, Crush, Lugol, Seed/Seed Embryo Endosperm/Perisperm, Vacuole, Cytoplasm, Cell Wall, Root, Stem, Leaf/Leaf Stalk, Cell/Plant Cell, Fruit, Chloroplast/Granum, Leucoplast, Cellulary Juice, Amyloplast, Plant, Flower, Ribosome, Rhizome, DNA-RNA, Epidermis, Tissue, Organ, Tuber, Parenchyma, Cell Membrane, Transmission Bundles, Mesophyll, Stoma, Peroxisome, Plastid, Carbohydrate, Glucose, Polysaccharide, Oxygen, Cellulose, Fructose, Maltose, Saccharose, Hydrogen, Minerals, Nitrogen, Carbon, Sulphur, Phosphor, Monosaccharide, Disaccharide, Enzyme, Acid, Deoxyribose/Ribose, NAD/FAD, ATP, Glycogen, Chitin, Triose, Pentose, Hexose, Galactose, Lactose, Polymer, Carboxyl Group, Carbondioxyde, Water, Potassium Iodide, Alcohol

Figure 1. A final semantic mapping of concepts in Ergastic substances

5. References

Aktepe, V., Cepheci, E., Irmak, S., & Palaz, Ş. (2017). Concept teaching in social studies and a theoretical study on techniques suitable in concept teaching. *Uluslararası Sosyal Bilimler EğitimiDergisi*, *3*(1), 33-50.

Algan, G., & Toker, M. C. (2004). *Bitki hücresi ve bitki morfolojisi laboratuvar kitabı* [Plant cell and plant morphology laboratory book] (IV. ed.). A.Ü. Fen Fakültesi Döner Sermaye İşletmesi.

Alkan, G. (2013). *How to effect using different types of experiments in academic achievement, attitudes on laboratory and science anxiety levels on primary school sixth grade students in science and technology lessons* [Unpublished master dissertation]. Institute of Educational Science and Akdeniz University.

Antonacci, P. A. (1991). Students search for meaning in the text through semantic mapping. *Social Education, 55*(3), 174-175.

Arslan, E. (2008). Erken çocukluk döneminde bilişsel gelişim. In M. Engin Deniz (Ed.). *Erken çocukluk döneminde gelişim* (pp. 2-25). Maya.

Artun, (2018). Fen eğitiminde kavram öğretimi. In O. Karamustafaoğlu, Ö. Temel and Sarı (Eds.). *Güncel yaklaşım ve yöntemlerle etkinlik destekli fen öğretimi* (pp. 52-69). Pegem.

Avery, P. G., Baker, J., & Gross, S. H. (1997). "Mapping" learning at the secondary level. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 70*(5), 279-285. https://doi.org/10.1080/00098655.1997.10543936

Berck, K. H. (1999). *Biologiedidaktik: Grundlagen und Methoden*. Wiebelsheim: Quelle & Meyer Verlag & Co.

Candan, A. S. (1998). *Teaching history based on concepts* [Unpublished master's thesis]. Institute of Social Science and Gazi University.

Çelik, L. (2017). Öğretim materyallerinin hazırlanması ve seçimi (9th ed.). In Ö. Demirel & E. Altun (Eds.). *Öğretim teknolojileri ve material tasarımı* (pp. 27-66). Pegem.

Çepni, S., & Ayvacı, S. (2006). *Kuramdan uygulamaya fen veteknoloji ögretimi.* Pegem.

Clements, D. H. (1999). 'Concrete' manipulatives, concrete ideas. *Contemporary Issues in Early Childhood, 1*(1), 45–60.

Dilek, Y., & Yürük, N. (2013). Using semantic mapping technique in vocabulary teaching at pre-intermediate level. *Procedia-Social and Behavioral Sciences,* 70, 1531-1544. https://doi.org/10.1016/j.sbspro.2013.01.221

Efe, N. (2000). *Genel biyoloji laboratuvarı.* Bakanlar Media.

Fidan, N. K. (2008). Teachers' views with regard to the use of tools and materials in the primary level. *Kuramsal Eğitim Bilim Dergisi, 1*(1), 48-61.

Fitzgerald, W. J., Elmore, J., Kung, M., & Stennen, A. J. (2017). The conceptual complexity of vocabulary in elementary-grades core science program textbooks. *Reading Research Quarterly, 52*(4), 417-442. https://doi.org/10.1002/rrq.184

Gill, L. S., Nyawuame, H. G. K., Aibangbee, M. I., & Agho, D. A. (1991). Nature of ergastic substances in some Mediterranean angiospermous seeds—vi. *FeddesRepertorium, 102*(7-8), 613-628.

Gödek, Y., Polat, D., & Kaya, V. H. (2018). *Fen bilgisi öğretiminde kavram yanılgıları, kavram yanılgılarının tespiti-giderilmesi ve uygulamalı örnekler.* Pegem.

Güneş, F. (2007). *Türkçe öğretimi ve zihinsel yapılandırma.* Nobel.

Güneş, T., Dilek, N. Ş., Demir, E. S., Hoplan, M., & Çelikoğlu, M. (2010). A qualitative research on teachers' concept teaching, misconceptions and elimination of misconceptions. *International Conference on New Trends in Education and Their Implications,* 11-13 Kasım, Antalya, Türkiye.

Idu, M., & Onyibe, H. I. (2011). Nature of ergastic substances in some Poaceae seeds. *African Journal of Biotechnology, 10*(48), 9800-9803.

İnel-Ekici, D. (2014). Kavram öğretimi. Ş. S. Anagün ve N. Duban (Eds.). *Fen bilimleri öğretimi* içinde *(pp. 381-424)*. Pegem.

Karakaş, S. (2000). Bilgi işlemede entegratif model. In S. Karakaş, H. Aydın, C. Erdemir, & Ç. Özemsi (Eds.). *Multi disipliner yaklaşımla beyin ve kognisyon* (pp. 140-148). Çizgi Tıp.

Kaya, F. (2010). *The effects of computer assisted conceptual change texts instructions on overcoming pre-service science teachers? Misconceptions of photosynthesis and respiration in plants* [Unpublished master's thesis]. Pamukkale University, Denizli.

Kaya, Z. (2006). *Öğretim teknolojileri ve materyal geliştirme.* Pegem.

Kelly, A. C. (2006). Using manipulatives in mathematical problem solving: a performance- based analysis. *The Montana Mathematics Enthusiast, 3*(2), 184-193.

Kesercioğlu, T., Balım, A.G., Öztürk, İ., & Çavaş, B. (2004). *Biyoloji uygulamaları-I.* Gema Gelişim Basım Yayın.

Köksal, O., & Atalay, B. (2016). *Öğretim ilke ve yöntemleri çağdaş uygulamalarla yöntem ve teknikler.* Eğitim.

Kolovrat, M. (2016). *Ergastične tvorevine biljne stanice* [Unpublished doctoral dissertation]. Polytechnic of Slavonski Brod Agricultural Department.

Koponen, I. T., & Pehkonen, M. (2010). Coherent knowledge structures of physics represented as concept networks in teacher education. *Science & Education, 19*(3), 259-282. https://doi.org/10.1007/s11191-009-9200-z

Lowe, D., Newcombe, P., & Stumpers, B. (2012). Evaluation of the use of remote laboratories for secondary school science education. *Research Science Education, 43*(3), 1197-1219. https://doi.org/10.1007/s11165-012-9304-3

Nalçacı, A., & Ercoşkun, M. H. (2005). İlköğretim sosyal bilgiler derslerinde kullanılan materyaller. *Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi*, *11*, 141-154.

Nayagam, J. R. (2015). Ergastic crystals in identification of costuspictus: A medicinal spiral ginger in herbal medicine. *Journal of Experimental Biology and Agricultural Sciences, 3*(4), 378-383. http://dx.doi.org/10.18006/2015.3(4).378.383

Nwachukwu, C. U., & Edeoga, H.O. (2006). Tannins, starch grains and crystals in some species of indigofera L. (Leguminosae-Papilionoideae). *International Journal of Botany, 2*, 159-162. https://doi.org/10.3923/ijb.2006.159.162

Olympiou, G., & Zacharia, Z. C. (2012). Blending physical and virtual manipulatives: An effort to improve students' conceptual understanding through science laboratory experimentation. *Science Education, 96*(1), 21-47. https://doi.org/10.1002/sce.20463

Omoigui, I. D., & Aromose, O. S. A. (2012). Nature of ergastic substances in some Nigeria nasteraceae. *Bayero Journal of Pure and Applied Sciences, 5*(2), 160-167. https://doi.org/10.4314/bajopas.v5i2.31

Omonhinmin, C. A., Daramola, F. Y., & Idu, M. (2015). Seed ergastic substances profiling and its implications for the amaranthaceae-chenopodiaceae complex. *Research Journal of Botany*, 1-10. http://dx.doi.org/10.3923/rjb.2015

Onan, B. (2012). Türkçenin ana dili olarak öğretiminde bilgi işleme süreci. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, *8*(1), 96-113.

Ornstein, A. C., & Lasley, T. J. (2000). *Strategies for effective teaching* (3rd ed.). The McGraw-Hill.

Patrizi, C., Ice, P., & Burgess, M. (2013). Semantic mapping of learning assets to align curriculum and evidence learning effectiveness in business education. *Business Education & Accreditation, 5*(1), 117-228.

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage.

Reza, N. A., & Azizah, N. A. (2019). Semantic mapping strategy on students' vocabulary learning result. *Lingua Jurnal Pendidikan Bahasa, 15*(2), 27-34. https://doi.org/10.34005/lingua.v15i2.357

Schwab, P. N., & Cable, C. R. (1982). *Semantic webbing in science.* National Science Teachers Association Baltimore Area Convention.

Scott, F. M. (1941). Distribution of calcium oxalate crystals in ricinus communis in relation to the tissue differentiation and presence of other ergastic substances. *Bot. Gaz, 103*, 225-246.

Seferoğlu, S. S. (2015). *Öğretim teknolojileri ve materyal tasarımı* (9. ed.). Pegem.

Selvi, K. (Ed.) (2008). *Öğretim teknolojileri ve materyal tasarımı.* Anı.

Senemoğlu, N. (2001). *Gelişim, öğrenme ve öğretim.* Gazi.

Senemoğlu, N. (2007). *Development, learning, and teaching: From theory to practice*. Gönül.

Simon, T. K., & Nayyagam, J. R. (2018). Ergastic crystal studies for raw drug analysis. In P. F. Builders *Herbal Medicine (pp. 31-40)*. Intech Open.

Tuna, F. (2013). The impact of concept network method on students' academic achievement in secondary school geography education and students' perceptions of implementation. *Kastamonu Eğitim Dergisi, 21*(3), 985-996.

Yazıcı, M., & Kurt, A. (2018). Investigation of the effect of using the laboratory in secondary school science teaching to the academic achievements of the students in line with the opinions of teachers and students. *Bayburt Eğitim Fakültesi Dergisi, 13*(25), 295-320.

Yıldırım, A., & Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri*. Seçkin.